DEVELOPMENT OF STANDARDISED SIZING SYSTEM AND SIZE CHARTS FOR THE PRODUCTION OF READY-TO-WEAR CLOTHING FOR GHANAIAN CHILDREN AGED 6-11

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ABSTRACT

Children experience rapid growth rate and often indulge in various physical and motion related activities in education and play spaces. Ill-fitting clothing such as very tight or unproportionally balanced clothes can cause movement restrictions, psychological challenges, and other undesirable health related issues. This makes appropriate clothing sizing crucial to address, as it gives children the right fit that allows room for movement and growth.

Effectiveness of fit is based on a sizing system and size charts that have been developed using current and accurate body measurements of a specific population since differences exist among populations. Currently, established size charts and academic publications on sizing systems in Ghana have focused on women. No national database or anthropometric study has been developed exclusively for Ghanaian children. Practitioners either take measurements on ad-hoc basis for made-to-measure outfits; or use adapted versions of the British sizing system for manufacturing ready-to-wear garments such as uniforms. This research has therefore been undertaken to develop a standard clothing sizing system and size charts for Ghanaian children between the (school) ages of 6 and 11. This will sustain the general production of reliably sized garments for Ghanaian children whiles providing appropriate fit. It will further enhance mass production of ready-to-wear garments for the apparel market in Ghana.

The study involved both secondary and primary data collection methods. An extensive review of literature was conducted focusing on relevant topics in anthropometry and anthropometric surveys for sizing creation, sizing systems, growth of children and garment fit. A comprehensive set of body measurements including height and weight of the sample population of school children were collected. A critical measurement procedural guide and two instructional videos in English and Twi (dominant Ghanaian language) were developed by the study taking into account efficacy, ethical and sustainable considerations for good practice. These were made available and guided parents/legal guardians and participants in the data collection process during fieldwork. The population consisted of primary school pupils in Ghana. A sample of 776 usable data was used for the analysis. With the IBM SPSS analytics software, appropriate statistical procedures such as means, t-test and analysis of variance tests (ANOVA) were conducted to ascertain the relationships among the variables and to obtain statistical data for the development of the sizing system. Principal component analysis (PCA) and cluster analysis were also used to aid the development of the sizing system. Centred on the PCA technique, three key dimensions (height, chest, and waist girths) were selected based on the factor loading and practicality. The study found and established significant differences between the body measurements of Ghanaian children aged 6-11 along gender lines. Using the cluster analysis technique, the selected dimensions were used to categorize the study sample into homogenous subgroups according to upper and lower body separately for both males and females. Four or five sizes were created for each cluster group, and size charts were established based on percentile values.

This study presents theoretical and empirical contributions to the body of knowledge in anthropometrics. It has modeled a guide that demonstrates the capability of remote and safe body measuring practices on children, which is particularly useful, economical, and reliable for clothing related practices that seek to employ consistent traditional manual measuring techniques. The study has created an original up-to-date anthropometric database for Ghanaian children between 6-11 years; and developed a comprehensive sizing system for wider clothing practices. In addition to providing a framework for procedures in creating children's sizing system and size chart, it establishes new size charts for both males and females aged 6-11, based on the Ghanaian population. These developments stand to increase productivity, consistency, and economic efficiency for the Ghanaian apparel industry. The study makes recommendations for extending this work to other segments of the population.

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DECLARATION

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of Manchester Metropolitan University or any other university or other institution of learning.

DEDICATION

This thesis is dedicated to my husband Mr Joseph Standford Coomson and children Maame Ama Coomson, John Nana Yaw Coomson and Grace Abena Coomson for their love, support and encouragement.

TABLE OF CONTENTS

TITLE **PAGE**

CHAPTER 3: LITERATURE REVIEW ON SIZING AND GROWTH OF CHILDREN

CHAPTER 4: LITERATURE REVIEW ON PATTERN PRODUCTION AND GARMENT FIT

CHAPTER 5: METHODOLOGY

CHAPTER 6: PRESENTATION OF RESULTS

CHAPTER 7: DISCUSSION OF FINDINGS

CHAPTER 8: PRACTICAL AND THEORETICAL CONTRIBUTIONS OF THE STUDY

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

REFERENCES

APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Clothing is a basic need of mankind that is indispensable. It forms an individual's protective shell in the environment (Gupta, 2014; Association of Suppliers to the British Clothing Industry [ASBCI] Technical Handbook, 2015). The psychologist Abraham Maslow in his hierarchy of needs put clothing as one of the important physiological needs of mankind in addition to food and shelter (Maslow, 1943; Maslow, 1999; Healy, 2016)**.** The same is also enshrined in the United Nations International Children's Emergency Fund [UNICEF] document for every child to have access to clothing, food and a safe place to live (UNICEF, 2010). Clothing is a product for the beautification of the body which plays a pivotal role in the consumer environment (Jeacle ,2003). The clothing of an individual constitutes a portable environment that is closest to the human body. This portable environment (clothing) to be physically and psychologically suitable for its wearer's needs, requires adequate fit (Watkins, 1995; Ashdown, 2014). Stamper, Sharp and Donnel (2005) added that every clothing item apart from serving the basic function of covering the body must fit its wearer well. They are important to the psychological and social wellbeing of its wearer (Johnson and Forster, 1990; Alexander, Connell, and Presley, 2005). Farmer and Gotwals (1982) added that all individuals regardless of age and gender need clothing with a good fit that enables them to function effectively in their various professions.

Clothing plays an important role in the lives of children by contributing to their health and well-being especially in learning and development (Cooklin, 1991; Stonehouse, 2008 cited in Zakaria,2016; de Campos et al., 2017). It helps to get more attention from peer groups and the identification of sex (Gautam, 2005). Clothing is very important in the formation of perception about an individual. Stone (1998) reiterated that children between the ages of 6 and 9 have preference for comfortable apparel comparable to that of their peers (Stone, 1998). The clothing of a person can convey a lot of information about the wearer, and this usually has effect on the first impression formed of the wearer (Howlett et al., 2013). Appearance plays a vital role in the lives of children (Hawkins et. al., 1998) and Feather et al. (1996) alluded by stating that the formation of a new and enhanced perception of one's body can be achieved through clothing. They added that in terms of body satisfaction it was evident that the satisfaction of the body is greater when the body is clothed rather than when the body is in a nude state. Brownbridge and Gill (2013, p. 4) stated that clothing is intrinsically linked to one's embodied identities.

In clothing the body, it is prudent to choose garment that accurately fits the body. Garment fit according to Goldsberry et al. (1996) and Mi Park et al. (2011) is an important factor that affects the quality of garment and consumer satisfaction in the apparel industry. Several researchers admit that in the evaluation of ready-to-wear apparel, fit is ranked as one of the first factors most individuals consider (Workman, 1991; Liu and Dickerson, 1999; Horwaton and Lee, 2010). Ready-to-wear apparel are produced with the intent to fit an illusory average size or groups of people whose body dimensions and physique are unknown before the commencement of production (Carr and Pomeroy, 1992; Otieno, 2008). A ready-to-wear apparel needs to fit its anticipated wearer well. Well-fitting apparel is an important attribute that makes an individual's appearance attractive, making the wearer comfortable, offering freedom of movement (Stamper et al., 1991; Goldsberry et al., 1996; Ashdown and O'Connell, 2006; Klepp 2008; Gill, 2011; Gupta, 2014) and enhancing an individual's mental and social well-being (Feather et al., 1997; Alexander et al., 2005) as well as promote the growth and development of a healthy body.

Adding to the benefit of well-fitting apparel, several researchers agree that well-fitting apparel aids free movement in children during physical activities (Ryan, 1966; Cooklin, 1991; Gautam, 2005; Chung, Lin, and Wang, 2007; Bezerra et al., 2017; Bezerra et al., 2018). Gill (2011) concurred by stating that an apparel that does not fit well may be unsafe to the wearer. For instance, apparel that is too loose can obstruct the movement of the wearer or be trapped in machines whereas an apparel with a tight fit may cause restriction in movement and/or pressure on the skin that may be uncomfortable (Daanen, and Reffeltratht, 2007; Gill, 2011). The effect of wearing tight clothing is affirmed by the experimental work by Eungpinichpong et al. (2013) with the aim to study the consequences of putting on tight pair of trousers during manual handling and its effect on lumbar spine movement, torso muscle motion and lower back discomfort (LBD) among young adults. The result of their study indicated that restraint of the movement of the hip because of the tight pair of trousers led to heightened lumbar motion in addition to reduced lower torso muscle stimulation levels. This adjustment of hip and spinal actions could possibly cause lower back distress. If tight clothing can have adverse effect on young adult population, then in the case of children who engage in a lot of physical activities as they play, tight clothing needs to be avoided.

The growth rate of children is rapid and in different ways (Eveleth, 1990; Winks, 1997; Ashia, 2020). Children of the same age group may have different features; thus, making clothing sizing significant in giving children the right fit that allows room for growth. A study by, Hsu and Burns (2002) affirmed that of the twelve clothes purchasing criteria surveyed among two groups, size and fit were appraised as the two most important. In the design of apparel that fit well, the body shapes and sizes of the target population must be understood. This can be achieved through the scientific measurement of a sample of the target population termed as anthropometry (Beazley, 1997; Gupta, 2014). Anthropometry is designed to provide current and accurate body measurements needed to provide a good fit of apparel to a target population and aids in the understanding of the body shape and sizes that exist in the population (Pheasant and Haslegrave, 2006; Gupta, 2014). After the acquisition of the consistent and accurate measurements of the target population, these dimensions need to be studied to develop standard sizes. The analysis of the size and shape within a population is a complex process. In the apparel industry, this complex process is carried out with the aim to ascertain statistically significant average sizes and shapes within a target population (Taylor,1990) and to produce apparel in a variety of sizes to fit many people within a target population (Ashdown, 1998). This process usually results in the creation of standard sizes. Standard sizing according to Labat (2007) is a method of categorising body shapes and providing size increments to produce apparel. To be able to develop a standard sizing, measurements are obtained from the population for which the standard sizing will be develop for. Anthropometric data and a corresponding sizing system has influence on the quality of clothing (Lee, 2004; Bye, LaBat and Delong, 2006). Tait (1998) and Bye et al. (2006) stressed further that the process of measuring the body and its interpretation thereof is crucial to the development of garment patterns.

An anthropometric survey, especially for making children's clothing sizes should be carried out on every population as it is an established fact that body shapes and sizes of populations differ from one geographical area to another based on factors such as diets, lifestyles, ethnicity and social- cultural values (Ashdown, 2007; Tamburrino, 1992b). Thus, knowledge that inhabitants in in a country have different body sizes and proportions justifies the differences in clothing sizes. Also, childhood is an important phase of the human growth process marked by constant changes in body size and shape which requires comfortable apparel that reflect the children’s growth as well as aid free movement (Chung et al. 2007). Anthropometric survey on children’s population helps generate measurement data that is analysed to develop apparel sizes with good fit as well as promote growth as adopting sizes from other populations will result in uncomfortable and unfit clothing especially for the children's population where variations are widespread (Zakaria, 2016). Further justification for surveys to be conducted on children and on an entire population as a whole is captured in the importance of anthropometric survey in chapter two (section 2.5).

This study seeks to establish anthropometric database as a basis for the development of standardised sizing systems and size charts for the children's apparel market in Ghana as currently there is no national anthropometric database or sizing system for Ghanaian children. (Elaborated further in section 1.2). The provision of uniformity and precision in clothing sizes and size labels provided to the apparel consumer and to provide apparel that fit adequately a large segment of a target population are the aims of standard sizing (Labat, 2007).

Developing clothing sizing system with better quality and fit is feasible if anthropometric data are collected on the target population (Ashdown et al., 1995; Otieno, 2008; Bari et al., 2015; Bye et al., 2006; Makhanya, et al., 2014; Zakaria, 2016). Gupta (2008) agreed by stating that the two most important element that determines the accuracy of apparel is the anthropometric data and the method used for data analysis and interpretation. Anthropometry relates to the study of human body measurements, and it involves the systematic collection and correlation of precise measurements of the human body for several purposes such as anthropological research, sizing of clothing and the creation of dynamic environments that provide safety and efficiency (Ulijaszek and Mascie-Taylor, 1994). To Roebuck (1995), anthropometry is the science of measurement and the application that establishes the physical geometry of the human body. Research has shown that body dimensions change over time therefore to ensure the accuracy of measurement of a population, anthropometric survey must be conducted on the population

(Roebuck, 1995; Oborne, 1982). Anthropometric surveys are conducted basically to have a good knowledge of the human silhouette, to be able to develop sizes based on the population measures in a country (Zakaria, 2010). As stated by Lee (1994) and Istook and Hwang (2001) comprehensive anthropometric data and apparel sizing are important component of clothing quality.

1.2 Problem statement and rationale of the study

The introduction of mass production in ready-to-wear clothing has rendered the practice of taking physical body measurement for manufacturing purposes unfeasible. Mass production strategies have advocated for a garment made to size rather than a garment made to fit (Istook, 2000). According to Dickerson (2000), the standardization of clothing has become an imperative issue for the ready-to-wear clothing market resulting in the development of a varied set of body dimensions. Sizing, the basis for the mass-production of ready-to-wear apparel (Pei, Fan and Ashdown, 2020) has been used to divide standardised body measurements and clothing dimensions into groups for fast and enhanced production and retailing of clothes (Beazley, 1997). According to Wadiyanti et al. (2017) accuracy, efficiency, marketability, and profitability are all affected when there are no size standards for mass production.

The motivation to address the issue of children's clothing sizing system and size charts in Ghana is principally based on the absence of a national sizing system and size chart for clothing purposes. Additionally, enthusiasm to undertake this study was strengthened based on the researcher's observations, experience as a practitioner, critical conversations with apparel experts and Ghanaian parents. With the experience and knowledge gained over the past 15 years as a fashion lecturer and an apparel manufacturer, the researcher identified several fit issues with children's ready-to-wear garments. Most industry experts complain of the need to have a sizing system developed based on the body measurements of Ghanaian children for effective production of ready-to-wear garments and to render good fit to the children population. Some parents expressed challenges with purchasing ready-to-wear clothing for their children due to fit issues. Most of the ready-to-wear apparel or mass-produced garments have issues with fit and parents attributed this fitting problem to the sizing system used for production of the garments. Currently, ready-to-wear apparel manufactured in Ghana are based on Caucasian sizing systems which do not fit Ghanaian children appropriately. Based on my line of work as a fashion lecturer and a manufacturer of children's clothing, I often encounter Ghanaian parents who mainly complain of problems with the waist girths and leg lengths of the children's ready-to-wear garments they purchase for their children. These parents in most instances buy and alter to fit or arrange with seamstresses and tailors to produce apparel for their children.

Another typical example that motivated the researcher to undertake this study is the numerous fit issues with the mass-produced free school uniforms supplied by the government of Ghana to public primary schools. These, mostly due to the lack of standard sizing system in the country are manufactured with sizing system from different countries and the result is uniforms that do not fit the children well. Koranteng's (2015) study referred to Daily Heritage newspaper publication on 9th April 2014 p.1, 2, that the free school uniforms supplied by the government of Ghana did not fit pupils in the Okaikoi South Education Sub-Metro schools in Accra because the uniforms were undersized or oversized. Most of the uniforms supplied are either over-sized or too tight which according to Barbosa and Guedes (2007) as cited in Bezerra et al. (2017) can impede the movements of children and could cause health-related problems, such as posture, allergic reactions, poor circulation in the case of tight garment on children and psychological problems. Heinrich, Carvalho, and Barroso (2008) and Silveira (2008) cited in de Campos et al. (2017) added that clothing can cause uneasiness and affect the wearer's physical and emotional wellbeing if it does not conform to the wearers body type and fit. This is concurred by Cooklin (1991) stating that apparel that fit the body of a child will aid in his or her growth and the improvement of a healthy body. Adding that injuries such as falls can be minimized when children are in apparel that fit their body size very well. Mortimer-Dunn (1996) further stated in her book that apparel meant for children should be simple, comfortable, easy to maintain, and should not restrict the movement of the child. Smathers and Horridge (1978) and Tongue, Otieno and Cassidy (2010) reiterated that well-fitting apparel is imperative to an individual’s psychological and social well-being.

According to Ashong (2004), Kuma-Kpobee (2009) and Adu-Boakye (2012), clothing fit problems in Ghana are as a result of the country not having a national sizing system. To Adu- Boakye (2012), clothing companies usually adopt and modify size charts from developed countries and international standards to produce apparel for Ghanaians. Zwane and Magagula (2007) admitted in their paper that most countries in Africa make use of adapted versions of the British sizing system because of figure type variations. Foster and Ampong (2012) noted that it was not uncommon to see garments produced with patterns cut with instructions based on American and European anthropometric data and sizing systems, which do not adequately fit Ghanaian clients. Wagner and Heyward (2000) concurred by stating that lifestyles, environmental conditions, and genetic makeups of Black Africans are not the same as those of the Caucasians. Growth patterns differ for every ethnic group or country. Studies by Tamburino (1992b); Miller (1993) cited in Kuma-Kpobee (2009); Lee et al. (2007); Shin and Istook (2007); Yim Lee et al. (2007); Sampei (2008); Taifa and Desai (2016); Hamad et al. (2017) and Cheng et al. (2019) all admitted that differences of body shapes exist within and between populations. The study by Ball et al. (2010) confirmed this assertion by establishing significant difference in the head shape of Chinese and Caucasians.

Globally, researchers have established the need for distinct national standards (Otino,1999; Anbahan Ariadurai et al., 2009; Bayat et al., 2012; Zakaria, 2016). To Wagner and Heyward (2000), one is not expected to get a good fit if cutting procedures for garments meant for black Africans are based on anthropometric data and sizing system of Caucasians. Anthropometric data is the point of reference for the production of numerous products, importantly clothes (Ujevic et al., 2006) and the effectiveness of any anthropometric measurement is to resolve challenges with design (Kemsley, 1957). To improve the fit of clothing, it is effective to produce basic patterns from standard sizes and measurements developed for a particular population. Igbo (2005) and Domjanic and Ujevic (2018) agreed by stating that the efficiency of patterns is increased when pattern makers use standard sizes and measurements to draft basic patterns. To Bezerra et al. (2017) and Cooklin (1991) through pattern design, and going by the proper use of anthropometric measurements, varied shapes and volumes can be introduced to give freedom of movements to children.

In this current era, most apparel manufacturing houses in Ghana rely on taking individual body measurements of clients for mass production. A typical example are producers of school uniforms. This category of producers depends heavily on taking physical body measurements of pupils to mass-produce uniforms. Due to the significant number of uniforms manufacturers must produce within a stipulated time frame, this method of production is not economical at all. Also, apparel producers and manufacturers of children’s clothing knowledgeable in sizing resort to different size charts developed for different populations especially developed countries. Manufacturers of children’s garments in Ghana are constantly faced with the problem of what sizes to create during mass-production of apparel. Newcomb and Istook, (2004) are of the opinion that inconsistencies in sizing standards used by fashion houses in their pattern designs are based on old anthropometric data. These problems and related issues will be curtailed with the development of accurate and current anthropometric data on Ghanaian children population.

Construction of sizing system has comprehensively been studied in most countries for years, for improving fit by testing many methods to improve their accuracy and fit (Otieno and Fairhurt, 2000; Otieno, Harrow and Lea-Greenwood, 2005; Zakaria, 2016). In Ghana, a few academic researchers have conducted small-scale surveys to develop anthropometric data and sizing systems for some sections of the population. For example, Kuma-Kpobee (2009) undertook the first anthropometric survey on the female population in Ghana where she developed a sizing system for females aged 20-54 using a sample of six hundred (600) women. She measured 21 body dimensions using manual anthropometric equipment. Her study has implication for the development of the traditional dress (kaba and slit) of Ghanaian women to produce quality and well-fitting apparel. Likewise, Adu-Boakye (2012) also undertook a study to successfully developed a conceptual framework to be used by the ready-to-wear clothing industry for Ghanaian women. As part of her study, she developed size chart for Ghanaian women aged 16-35 to improve fit and quality of apparel for consumer satisfaction. Her study collected thirty-two (32) anthropometric body measurements from eight hundred and forty-two (842) Ghanaian women using the manual anthropometric procedures. Both studies have contributed immensely to knowledge by providing a detailed procedure in the development of anthropometric research in Ghana. Adu-Boakye (2012) recommended that national anthropometric surveys for men and children need to be conducted in Ghana.

In the area of anthropometric data on Ghanaian children, very little has been done to date. On the age range selected for this study, no anthropometric data has been gathered on them. Many countries have collected anthropometric data on their children's population for better fit and improved quality of apparel. For example, Huyssteen (2006) conducted an anthropometric study for the development of standardised sizing systems for the South African children's wear market. The focus of Huyssteen's (2006) study was to develop consistent and precise body measurement tables that could be used for the creation of new and accurate sizing systems for the onward production of better-quality fit dummy ranges based on the South African children's body measurement. The population for her study included both males and females between the ages of 2 and 14. Accurate body measurement tables were developed that further led to the development of new height-based sizing system linked with both age ranges as numerical size indicators. Three-dimensional fit dummy prototypes were developed. Based on her study, the South African children's wear consumer has access to more comprehensive and accurate information regarding the size and shape of the typical South African child (Huyssteen, 2006).

Bari et al. (2015) undertook an anthropometric study with the aim to observe the anthropometric measurements of pre-school children for the development of garment sizes where they measured 107 males and 113 females from kindergartens in Malaysia. The study collected forty (40) body measurements using manual anthropometric equipment and the statistical package for social sciences (SPSS) program to analyse the data. Three sizes were developed; small (S), medium (M) and large (L) based on Beazley's model of addition or subtraction based on standard deviation (Beazley, 1999). Just like Bari et al. (2015), Bilhassan et al. (2018) undertook anthropometric study in Libya where they development clothing sizing system for Libyan children aged 9 to 11 using anthropometric body measurements of Libyan school children. They used the mean values and the standard deviation to generate three kinds of sizes namely L (large), M (medium) and S (small). Their study ascertained that significant differences exist among children of different age groups for most of the anthropometric measurements collected. Differences were also observed between the genders for some measurements (Bilhassan et al., 2018). Also, Zakaria (2016) in her study proposed a sizing system for school age children between the ages of 7 to 17 in Malaysia. Her study measured 1034 males and 1001 females randomly from 29 different schools within urban and rural districts in Malaysia.

Another precedent children's study was conducted by Widyanti et al. (2017) in Indonesia on the development of anthropometric data and clothing sizes for Indonesian Sundanese children ages 6-10. Their study collected forty-nine (49) anthropometric dimensions from three hundred and fifteen (315) male and three hundred and thirty-nine (339) female Indonesian Sundanese children. Their study also deployed manual anthropometric method. They observed differences between male and female data in nearly all anthropometric dimensions collected necessitating separate sizes based on gender. Their study also produced three sizes: small (S), Medium (M), and Large (L) with a population coverage of 75%.

Based on these cited instances of anthropometric surveys on children, it is evident that the development of standardised anthropometric database for the establishment of children's clothing sizes for the production of well-fitting garments for Ghanaian children is long overdue, giving impetus and purpose to the work undertaken and reported in this study. The anthropometric database generates a scientific basis for the apparel industry and subjecting the data to statistical treatments, standardised sizes of the population were generated, and this clearly specify what sizes are in the children's population. It is therefore of great importance that a study was undertaken to develop a sizing system and size charts to produce apparel for Ghanaian children between the ages of 6 and 11 through an anthropometric survey.

1.3 Aim and objectives of the study

The aim of this study was to develop a new accurate national body sizing system and size chart for Ghanaian children aged 6-11 to aid mass production of ready-to-wear garments for the apparel market; something which has not been undertaken for Ghanaian children before.

To fulfil this aim, the study developed five objectives which sought to:

1. Develop standardised measuring procedures applicable for measuring children between the ages of 6-11 remotely.
2. To develop anthropometric database of Ghanaian children aged 6-11 years.
3. Analyse anthropometric data to establish tables of body measurements for Ghanaian children aged 6-11.
4. Analyse anthropometric data to generate comprehensive sizing system based on anthropometric body measurements of Ghanaian children from 6-11 years.
5. Establish size charts for clothing pattern production for Ghanaian children aged 6-11 based on analysed data.

1.4 Research questions

Three main research questions were probed to aid in the achievement of aim of the study:

1. Are there any differences in the body measurements of males and females aged 6-11 in Ghana?
2. Are there any differences in the body measurements of children in the three regions sampled?
3. Are there any differences in the body measurements of children selected from the metropolitan areas and children selected from the municipal districts?

1.5 Significance of the study

The study aimed to contribute to knowledge in the following ways:

To develop an original up-to-date database of children's sizes for the apparel industry in Ghana. This stands to increase efficiency in the apparel market. The database will also enable clothing producers and retailers to identify specific areas of growth in this market over time to be able to improve the fit and sizing of apparel. This database will aid in the development of products that are suitable and comfortable for its users as commonly, product development in Ghana depends on outdated anthropometric database on a different population rather than current anthropometric data of the Ghanaian population.

Anthropometric data generated by this research will serve as a standard against which new survey data can be compared particularly because there is no existing data on this section of the population. The research provides the basis upon which new surveys can be conducted by reviewing the methodologies to be able to predict suitable methodologies in years to come (Roebuck, 1995) and substantiating levels of data analysis (Otieno, 2008). Also, the data can be compared to ascertain any developmental changes across the population over time. This is of great importance as size charts should be verified every 5 to10 years (Beazley, 1998; Workman and Lentz, 2000). Additionally, the study will serve as a guideline for appropriate sizing system, size labelling and size charts.

By establishing practical size charts for the local population, this study stands to enhance the apparel industry in Ghana by creating opportunities for fashion practitioners and entrepreneurs to trade in commercially available patterns and garments based on body measurement data of the local Ghanaian population. Additionally, this study has implication for the production of mannequins to support fashion businesses, based on anthropometric data. Anthropometric mannequins can be produced for different sizes and gender. It will also offer the Ghanaian apparel importers with relevant anthropometric data on Ghanaian children. Further, the generated sizing system will serve as a communication tool for all stake holders in the clothing industry and will help the apparel industry in Ghana to come together to develop a full national sizing system that will cater for all ages and gender. The sizing system and size charts developed will serve as a significant reference for the production of different apparel especially school uniforms for both males and females aged 6-11. This will guarantee improved fit of particularly of mass-produced apparel for children and afford flexibility in sizes selection.

As a country or community develops, it is very important to check the social and economic situations in the country or community. Anthropometric data mainly for children and youth in a country or community are very valuable for checking social and economic situations in the country. This is clearly described by Lohman et al. (1988:100) that developmental processes are quite plastic and pliable, responding readily to environmental stress. An extension of this relates to the monitoring of anthropometric changes over time. Analysis of intergenerational changes or secular trends can reveal increases in size, reductions in size, or lack of change. This significance of anthropometric study is affirmed by Ujevi´c et al. (2011) when they stated that besides monitoring changes in the physical growth of the body, the anthropometric study will help to identify variations occurring progressively in generations to come.

The study is an original project that developed a national sizing system and size charts for Ghanaian children between the ages of 6-11 using parents/legal guardians in the collection of anthropometric data in the phase of Covid-19 pandemic and as a means of safeguarding the researcher and participants. This procedure can be used to undertake safe, reliable, and cost-efficient manual anthropometric studies in a pandemic era. The systematic methodology utilised in this study can be replicated to create sizing systems for different populations regardless of geographical location.

Although this anthropometric research is designed with the sole purpose of developing clothing sizes for children, the data analysed in this study has additional implication for nutritional assessment in children. The anthropometric data collected and analysed include growth characteristics such as weight, height, head girth, chest girth and circumference of bicep. These anthropometric data can be used for nutritional assessment by nutritionists and researchers in nutrition. The data collected can be analysed to show the general health status and dietary adequacy in Ghanaian children. Analysis from the data could be used to track trends in growth and development of Ghanaian children over time. Measurement of stature and weight will allow for the revision of growth chart on children (NHANES, 2017; Woodruff, 2000). Kyle and Kiel (2020) further noted that these measurements denote the criteria for obesity, nutritional status of children, standard for physical fitness and measures of fitness.

Finally, findings from this study further contribute to general and specific knowledge in anthropometric surveys, anthropometric data generation and the creation of sizing systems. This point was buttressed by Bougourd and Treleaven (2014) when they stated that anthropometric surveys offer researchers/ research teams experience in the organization and implementation of surveys using various techniques including both manual and digital.

1.6 Structure of the thesis

This section describes the sequence and components of this thesis. Topics covered in this study revealed research development and knowledge gaps in this field of research. Chapter one comprises the background, problem statement and rationale, aim and objectives, and structure of the thesis.

Chapters two, three and four critically review relevant literature. All three chapters present theoretical foundations for the research. Chapter two, broadly discuses anthropometry, which is a critical aspect of the aim of this research. It touches on the historical overview of anthropometry, anthropometric surveys and its data as well as the usefulness of such data. Chapter three broadly focuses on relevant aspects of sizing. It outlines a brief history of sizing, sizing systems, size charts, methods used to devise sizing systems and size designations. Human growth and development are also discussed in this chapter outlining their effect in creating a sizing system for children.

Chapter four of the literature review concentrates on pattern production and basic block patterns. These are valuable to the verification of sizing systems and development of size charts. The chapter also evaluates fit of garments created from the sizing processes and established pattern blocks within this work.

Chapter five presents the methodological procedures for this study. The chapter consists of the research design, sampling, instrumentation, detailed analysis of how the fieldwork was conducted and the methods used in collecting and analysing the primary data. A pilot study, its analysis and ethical considerations pertaining to this study have also been discussed.

The results of the study are presented in chapter six. This section clearly indicates the various statistical analysis conducted to fulfil the study objectives. Descriptive statistics were presented to summarise the dataset. Key measurements were identified as a point of departure for the establishment of the size systems and the onward creation of size charts for the construction of basic pattern blocks to validate the developed size charts.

Chapter seven discusses the findings of the statistical analysis in relation to the objectives stated in chapter one. Chapter eight explicitly shows the researcher’s contribution to new and original knowledge within the perspective of the current knowledge base in clothing anthropometry. Chapter nine talks about conclusions drawn from the study. It also outlines recommendations for further studies and Implications for industry. The diagrammatic structure of the sequence and components of the thesis is illustrated in Figure 1.1.

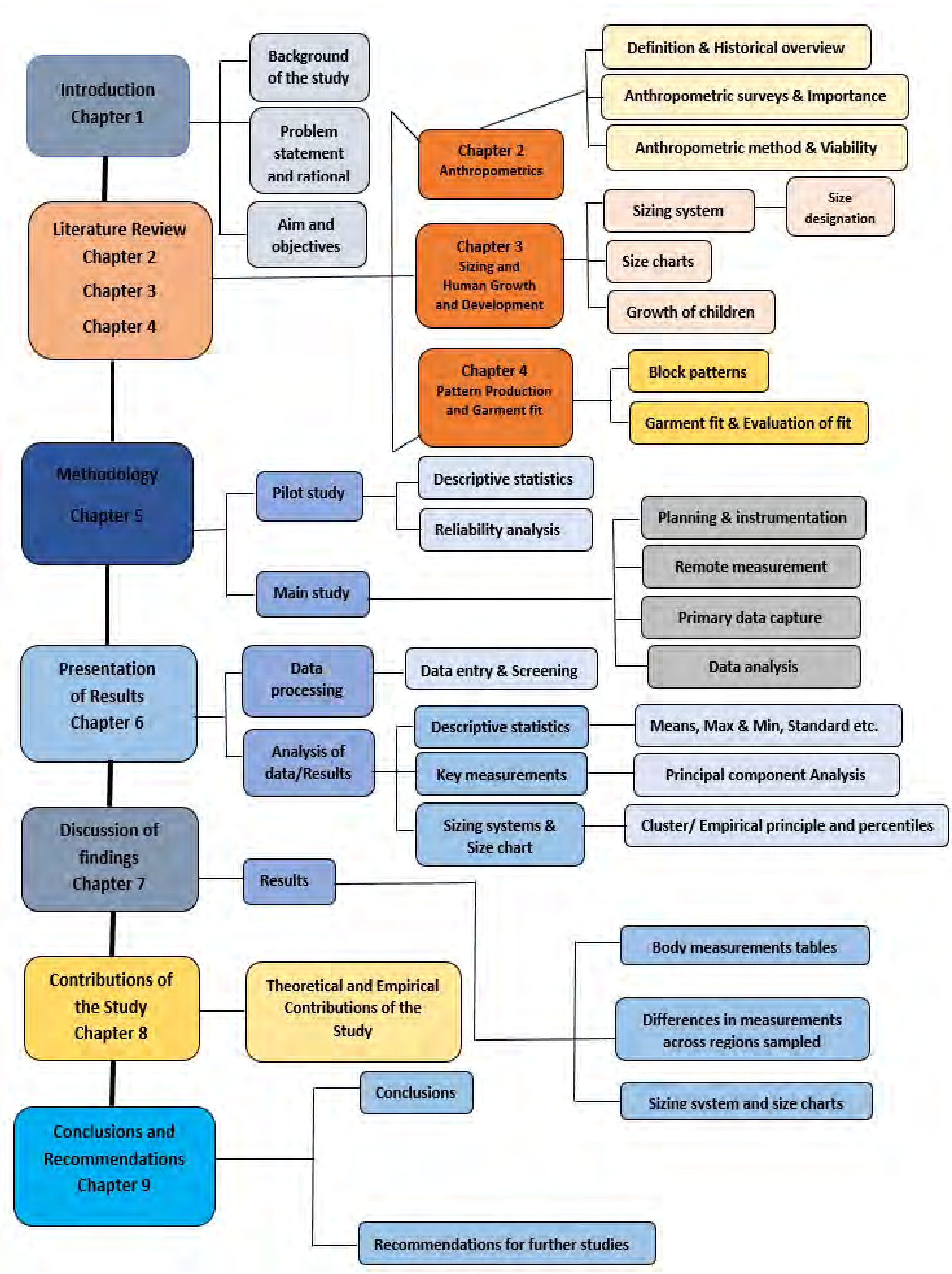


Figure 1.1: Structure of the thesis

CHAPTER TWO

LITERATURE REVIEW ON ANTHROPOMETRICS

2.1 Introduction

The chapters in this section reviews literature broadly on anthropometrics, sizing and garment fit. This has been split up into three separate chapters (two, three and four). Exploration of related literature is done in line with anthropometrics in general and narrowing down to clothing anthropometry. The topics reviewed encompasses definitions and meaning of anthropometry, historical overview of anthropometry, clothing anthropometric surveys on children, importance of anthropometric surveys, types of anthropometric data, and reasons for anthropometric variations. This session also comprehensively review literature on manual/traditional anthropometric method whilst touching briefly on non-contact methods of anthropometric data collection.

2.2 Definitions and meanings of anthropometry

There are a number of situations where it is possible to design a product for a single user. For a few who happen to be physically challenged, the luxury of custom design becomes a necessity. However, in the great majority of people, design problems are concerned with a population. Products must be designed to be adequate for majority of the target population. The desire to produce products to suit a target population led to the study of anthropometry (Pheasant and Haslegrave, 2006). Anthropometry is centred on three design principles that are often utilised in the design of products and workspaces. These are design for the average, design for specific population percentile and design for extreme (Cho et al., 2007; Taifa and Desai, 2016). Design for the average principle is used in the development of clothing sizing system. Ulijaszek and Mascie-Taylor (1994) added that the main idea about anthropometrics is that any aspect of physiological function depends on the underlying morphology, the objective way of evaluating and comparing aspect of morphology is measurement and in humans this is termed anthropometry. The etymology of the word anthropometry is traced to the Greeks. The word is derivative from a combination of two words “anthropos” which means human and “metron” meaning measure. (Ulijaszek and Mascie-Taylor, 1994; Roebuck, 1995; Kohlschütter, 2012; Gupta, 2014; Diet, anthropometry, and physical activity (DAPA) measurement toolkit, 2020).

The word anthropometry has been defined by numerous authors in different ways. It is described by Eberle et al. (2014) as the study of the proportion and sizes of the human body. According to Jones and Rioux (1997) it is the study of human beings that focuses on the measurement of individuals in order to understand their physical variations. Roebuck (1995), Kroemer and Grandjean, (2005), and Gupta (2014) all describe anthropometry as the science of measurement and the art of applying them to create physical geometry, mass properties, and strength capabilities of the human body. Pheasant and Haslegrave (2006) define anthropometry as a branch of human science that is concerned with body measurements particularly of body sizes, shapes, strength, mobility, flexibility and working capacity. According to ASBCI (2015) and Solo Abadi (2018), anthropometry is the science of human physical variation and the frequency distribution of human body dimensions across a population. The NHANES (2007) explain anthropometry as the study of human body dimension of bone, muscle and adipose (fat) tissue. The definition by Roebuck (1995), Kroemer and Grandjean (2005) and Gupta (2014) can be described as in-depth and applicable in the apparel industry as they all describe anthropometry as a science and an art affirming the proposal by Kunick (1984) that the scientific application of anthropometric data through statistics only will not resolve all issues. He adds that the effect of art, craft and fashion are to be considered in the application of the analysed data for the apparel industry.

Judging from the various definitions, it is obvious that anthropometry is a field that includes several human body measurements including but not limited to height, weight and size encompassing length, breadth, skinfold thickness and circumferential measurements (McDowell et al., 2008). Anthropometric measurements are therefore the chain of quantitative measurements of bones, muscles and fat tissues for body composition assessment mainly dealing with several measurements of which height, weight, body mass index, body circumference (hip, waist and limbs) and skinfold thickness are prominent (Kyle and Kiel, 2020). In simple terms according to Kroemer et al. (1986) anthropometry is used to describe the dimensions of the human body. The process is aimed at accurately collecting body measurement data, statistically analysing the data to ascertain the body shapes and sizes within a population and utilising this information in the design of products to suite the user's requirements (Gupta, 2014). This measurable characteristic of the human body that can be demarcated, standardised, and denoted by a unit of measurement is termed an anthropometric variable (Gupta, 2014).

2.3 Historical overview of anthropometry

Anthropometry is generally described as having originated from physical anthropology, a discipline that emerged during the nineteenth century and among other things focuses on the physical variations between people of different ethnic groups (Tiley, 2002). With anthropology focusing on the study of human beings (Elbert et al., 2018), anthropometry is about human measurements. The evolution of anthropometry has come a long way. Anthropometry according to Tanner (1981) is art permeated by the spirit of Pythagoreanism, and not science. Pythagoreanism is the philosophy that recommends an extremely structured way of life and the believe of the rebirth of the soul after death into another body be it human or animal (Huffman, 2019). Tanner related that in the quest to get instructions about the relative proportions of the human body parts to assistance painters and sculptors in their work as they considered the occupation of making life-like images brought about the study of anthropometry. Pheasant and Haslegrave (2006) concurred by stating that it began in ancient times as an art with artist and sculptors using human proportions in their work. Painters in ancient Egypt deployed the use of modular grids to paint tombs. However, this measurement unit was lost to people for some time until the Renaissance and Baroque period, when most detailed body proportions where written. Leonardo da Vinci upgraded Vitruvius Human Proportions by drawing the Vitruvian man in which a male figure was drawn circumscribed within a square and a circle (Figure 2.1) also known as the theory of human proportions (Pheasant and Haslegrave, 2006; Richman- Abdou, 2018). The Vitruvius Human Proportions is based on *De Architectura*, which is a building guide document written by the Roman architect and engineer Vitruvius between 30 and 15 BC (Richman-Abdou, 2018).

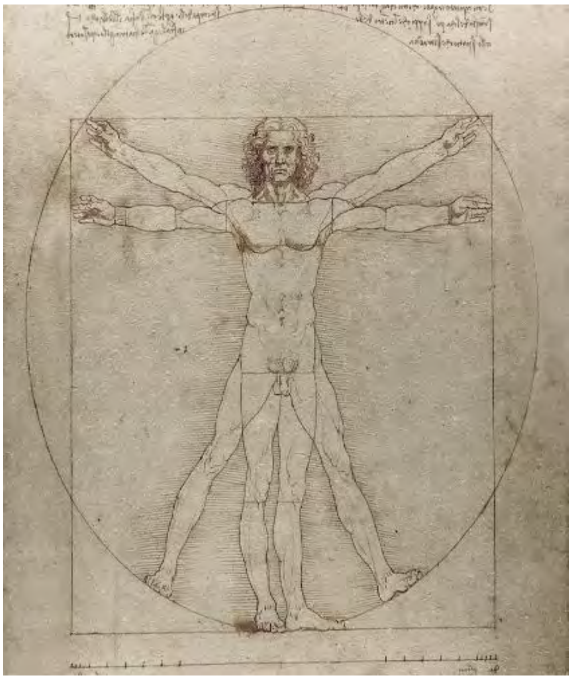


Figure 2.1: Image of the Vitruvian man by Leonardo da Vinci (Richman- Abdou, 2018)

The study of anthropometry was seen by other authors as more of science than art. Pheasant and Haslegrave, (2006) said Albrecht Dürer with his four books of human proportions begun to oppose Leonardo da Vinci's position. Dürer tried to sort and record the variety of human types, illustrations and matter based on systematic observation and measurement of people. Vitruvius, Leonardo da Vinci and Albrecht Dürer according to Winks (1997) all made use of the rule that says the distance between the crown of the head and the chin is one-eighth of the body height and these guidelines have been used as a factor in garment production up to today. Kohlschütter (2012) asserted that the four books of Dürer on human proportions was the initial important effort at structuring the study of human size and shape. Cameron (1982) also traced the origins of anthropometry as a science in a lot of diverse ways to three men who initially studied longitudinal growth of people using measurements. The three were Count Phillibert Gueneau de Montbeillard (1720-1785), the Duke of Wurttemberg, Carl Eugen and Adolphe Quetelet. According to Cameron (1982), Count Phillibert used a standard measurement technique to measure the growth of his son at half-yearly intervals; the Duke of Wurttemberg, Carl Eugen introduced *Carlschule in Stuttgart* between 1772-1794 where pupils were measured at regular intervals and Adolphe Quetelet in 1870 measured his own son and daughter and other two daughters of a friend aged between 5-17 years until maturity (Cameron, 1982).

The acceptance of anthropometry as a science started in the mid-1800s by Adolphe Quatelet, a Belgian mathematician who applied statistics to anthropological data of human measurements (Geršak, 2013; Elbert et al., 2018; Solo Abadi, 2018). This marked the commencement of contemporary anthropometry with the measurement and depiction of the human body. Quetlet started the project in the field of anthropometry publishing his first work in 1870 entitled Anthropomtrie. He is recognized as being the one who founded and formalized as well as crafted the term Anthropometry (Elbert et al., 2018; Solo Abadi, 2018). According to Elbert et al. (2018), the end of the nineteenth (19th) century saw anthropometry being extensively an applied scientific discipline focusing on the measurement of bones of people and the assessment of body size and proportions.

Aside from being a developing Science, some aspect of anthropometry qualifies it as a historical science. Roebuck (1995), stated that, in the same way that continents move almost imperceptibly, individuals and groups of people constantly undergo change. Anthropometric surveys whether large or small in scale are historic events and can never be repeated in the same way even on the same people because features of the people would have changed. These changes according to Roebuck (1995) are caused by normal physiological variation or aging process. This is the reason why populations are often identified by year of measurement as well as by occupation and ethnic group.

2.4 Anthropometric surveys

Many nations across the world have conducted anthropometric surveys on their population and the findings published (Fernandez, 1995; Winks, 1997; Otieno, 2008, Zakaria, 2016; Kim, You, and Kim, 2017; Cheng et al., 2019). Anthropometric survey is a multifaceted activity which consists of varied activities ranging from measuring human bodies through to analysis of captured data. In all fields that utilise anthropometric data, anthropometric surveys are conducted on a specific target population. In clothing, anthropometric surveys consist of the measuring of human bodies, capturing and analysing data to generate a sizing system (Hyussteen, 2006; Gupta, 2014). A range of body measurements are developed through statistical methods, and these are categorised in different sizes with exact intervals between the sizes (Hyussteen, 2006).

Anthropometric surveys are difficult and capital intensive when undertaken on civilian populations even with fewer numbers (Winks, 1997). TC2 (2004) cited in Xia and Istook (2017) concur by stating that the conduct of national anthropometric survey come with high cost thereby making the number of these surveys enumerable. With the advanced technology gaining grounds in the mid-20th century, different apparel manufacturers and government departments all over the world came together to conducted numerous anthropometric surveys (Winks, 1997).

The UK in the 1950s published an anthropometric survey of 5000 women sponsored by the Board of Trade where 126 sizes which catered for 98 of female adult population was taken. The research further indicated that the smallest range of 46 sizes reduced the female population coverage to 80% (Winks, 1997). In 2004, the UK government in collaboration with major UK retailers, academics and technological companies undertook a national sizing survey (SizeUK) of 11,000 participants (Apeagyei, 2010) using 3D whole body scanners. One hundred and thirty body measurements were extracted from each participant. Manual measurements were about 8-10 comprising height and weight. The shape of the population was captured and analysed through SizeUk which also serves as the country's first national sizing survey. The survey consisted of 50% males and 50% females with the participants wearing underwear and scanned in two poses namely standing and seated (Bougourd and Treleaven, 2010; SizeUK, n.d.).

In the USA, the initial information of anthropometric survey for clothing standardised sizing system was conducted in 1921 using 100,000 men from the US Army (Zakaria, 2016 cited in Yu, 2004). To Zakaria, the period between 1939 and 1940 saw the first survey on women garments and pattern construction published in 1941. In all, 10,041 women were involved. In the same period, the Bureau of Home Economics of the US Department of Agriculture conducted an anthropometric survey with 15,000 women to develop sizing of pattern for women.

According to O'Brien and Shelton (1941) cited in Winks (1997), 1946 witnessed the conduct of a survey amongst the US army Quartermasters Corps where 100,000 were measured on demobilization. In 1950, the US Airforce did another anthropometric survey amongst 4000 aircrew. Further between 1965 and 1970, another survey was done with 19,000 men from the US Army. Like their British counterparts, SizeUSA was also a national sizing survey conducted in 2002 sponsored by clothing and textile companies, the Army, Navy, and many universities. SizeUSA was a national sizing survey on the American population since the Second World War, which measured over 10,000 men and women in 13 cities with the aid of light pulsing 3D scanner. This survey grouped participants under gender, six age groups, and four ethnicities, behaviour and anonymous demographics (Ashdown, 1998; Zernike, 2004; Yu, 2004c).

Conversely, the SizeGermany survey was the biggest sizing survey undertaken in Germany between September 2007 and February 2009. It was conducted by the Hohenstein Institute and Human Solutions in collaboration with industry partners. This anthropometric measurement survey measured over 13000 men, women, and children between the ages of 6 and 65 across more than 30 locations across the country. The study deployed the use of 3D body scanners to take over 80 body measurements (Innovation in textiles, 2014; Balach et al., 2019). Balach et al. (2019) added that the of result of this survey provided the apparel sector in Germany with updated body measurement statistics that is ISO 8559 compliant and provided an updated secular growth prognosis model for the population which will last till 2040.

France had done several anthropometric surveys culminating into what is now called GO3-series of ‘normes experimentales’ produced by the French standards body AFNOR (Wicks 1996, Yu 2004c). The standards included surveys conducted by the Centre d’Etudes Technique des Industries de l’Habillement (CETIH) between 1965 and 1966 published in 1968. The survey used

7283 male participants between the ages of 22 and 64. Two more surveys of 8037 adult females aged between 18 and 65 were conducted in France in 1969 and 1970.

A novel sizing system of women made from women's anthropometric survey piloted on 1000 respondents with 40,000 measurements was published in 1977 by the Swedish Textile Research Institute (TEFO) and the Clothing Institute Federation (KIF) in Sweden (Winks, 1997; Yu, 2004c). In Japan, 35,000 participants were anthropometrically measured in 1966/67. An improved study was conducted between 1978 and 1981 on 50,000 participants made up of male, female, children and infants (Winks, 1997). However, the first time that Japan used 3D body scanning technology to conduct anthropometric survey was between 1992 and 1994 published by the Human Engineering for Quality Life. The survey was to find out changes that had occurred in Japanese sizes and shapes over the period. In all, 19,000 Japanese males and females from ages of 7 and 90 years, were measured by capturing 178 measurements with both a 3D scanner and manual methods. The result of the survey was that the structure of Japanese had grown over the last 100 years by more than 10cm (Yu, 2004). In a bid to establish a National Anthropometric Database to resolve inadequate clothing sizing system and fit in South Africa, a controlled anthropometric survey of black miners numbered 669 were measured in 1980 by the African Body Dimensions (ABD). The survey was conducted to launch, sustain and achieve the national anthropometric database and its interpretation (Yu, 2004c). According to Zakaria (2016) China published its national sizing survey of 14,000 respondents made up of men, women and children in 1987.

To ensure that the correct measurements are used, there is the need to update anthropometric data regularly since changes take place as humans grow and this in turn affects the distribution of body dimensions (Oborne, 1982; Roebuck, 1995). For instance, from the Size GB (2009) national anthropometric survey on children in the United Kingdom, it was realised that data from 1952 survey compared with the Size GB, showed an increase of 6 inches (15.2cm) in the waist measurement and an increase of about 1½ inches (3.8cm) in the chest and hip measurements. This shows that children in Great Britain are large in these girth dimensions compared to children around 1952. Further, the empirical study by Brownbridge (2012) opined that the size and shape of inhabitants' changes with time. Lee (2013) stressed that the Korean government, realizing the need for current anthropometric data, conduct national anthropometric survey on the populace every five or six years.

2.4.1 Anthropometric surveys on children

Several countries have conducted national anthropometric surveys on children. Between 1937 and 1939, the first anthropometric survey on children was conducted by the Textile and Clothing Division of the US Department of Agriculture (O'Brien et al., 1941; Otieno and Fairhurst, 2000; Zakaria, 2016) involving 147,000 males and females (Zakaria, 2016) with the aim to establish consistency between manufacturers of children's apparel and develop a sizing system founded on height and hip girth (Otieno and Fairhurst, 2000). In 1977, France conducted an anthropometric survey of males and females between the age of 4 and 21 with 14,000 respondents captured in the GO3-series.

The UK has the most current and the first ever large-scale national children's anthropometric survey in the world dubbed 'Shape UK' survey (Shape GB, 2020; Zakaria, 2016). Phase one of the survey measured 2,500 males and females aged between 4 and 17 years across UK in 2010. Measurements were taken with 3D body imaging scanner for accurate body measurement. This National Children's wear survey launched in 2009 was conducted by the government with the support of institutions such as Next, Monsoon, George at ASDA, Shop Direct, University of

Hertfordshire, Manchester Metropolitan University, Loughborough University, University of Hull, Aston University and Select Research, specialists in 3D scanning and sizing surveys. The second phase of the survey that manually measured 600 babies and toddlers aged 0 to 4 years was completed in 2016 (Shape GB, 2020).

Several academic researchers have also undertaken small-scale surveys on children in different countries. Bari et al. (2015) conducted an anthropometric survey on preschool children in Malaysia where they measured 220 children consisting of 107 males and 114 females. The survey used the manual method making use of equipment such as tape measure, in taking 40 body measurements from the participants who were between the ages of 5-6. The study hoping to be representative of the population, sample for the study consisted of a total of 114 respondents from rural areas and 106 respondents from urban areas.

Similarly, an anthropometric survey was conducted on South African children's population by Huyssteen (2006) under the topic 'Development of standardised sizing systems for the South African children's wear market'. The survey was undertaken to fulfil the need of the children's ready-to-wear industry in South Africa for a current sizing system in addition to new and enhanced fit dummy ranges. The anthropometric survey was performed via measuring children between the ages of 2 and 14 manually and adhered to international anthropometric standards. A field worker manual was developed and used in the training of research assistants who helped in the data collection process. The study proposed a sample size of 2600 children, however a total sample of 2678 children were finally measured during the data collection process. This involves thirty-seven (37) nursery, primary and secondary schools with twenty-two (22) of these schools in Western Cape and fifteen (15) in Gauteng. In all, forty-seven (47) body measurements were collected from each participant including weight from 38 measuring centres. This survey was funded by Leading South African children's wear retailers. Apart from the few anthropometric surveys discussed, other surveys that have been conducted across the world have been captured in Table 2.1.

Table 2.1: Anthropometric surveys on children

Country	Year	Institution(s)/ Person(s)	Participants	Uses	Reference
Libya	2017 to 2018	Bilhassan, S., Elmabrok, A., Elmehashhsh, K., Ali, H., Kaddom, A., Elhouni, H.	Measured 180 females aged 12-14	Development clothing sizing system	Bilhassan et al., 2018
Indonesia	Unknown	Widyanti, A., Mahachandra, M., Soetisna, H. R. and Sutalaksana, I. Z.	Measured 315 males and 339 females aged 6-10	Development of garment sizing system	Widyanti et al., 2017
Malaysia	Unknown	Norsaadah Zakaria	Measured 1034 males and 1001 females aged 7-17	Development of garment size system	Zakaria, 2016
Malaysia		Bari, S. B., Salleh, N. M. Sulaiman, N. Othman, M.	Measured 107 males and 113 females	Development of garment sizes	Bari et al., 2015
United Kingdom (UK)	launched in 2009	The UK government and other institutions such as Next, MMU	Measured 2,500 males and females aged 4-17	Development of standardised sizing systems for apparel production	Shape GB, 2020; Zakaria, 2016
South African		Huyssteen, S. V.	Measured 2678 children aged of 2 and 14.	Development of standardised sizing systems for fit dummy production	Huyssteen 2006
Hong Kong	1961-1967	Unknown	School children and university students	Published anthropometric information on children	So et al., 2004
Hong Kong	1981-1986	Pheasants	Hong Kong Chinese population	Publishing anthropometric of the population	So et al., 2004

India	1991-1992	National Urban and Rural growth data	835 males and 894 females ages 3 to 20 years	Analysing the average growth pattern of children	Begum and Choudhury, 1999
Iran	1990-1992	National Health survey	1702 males and 1599 females ages 2-18 years	Developing body mass index chart for children	Hosseini et al. 1999
France	1977	CETIH	Measured 14,000 males and females Ages 4-21	Developing G03	Winks, 1997
Kenya	1999	Otieno, R.B. and Fairhurst, C.	Measured 618 females Aged 2-6	Development of garment size charts	Otieno and Fairhurst, 2000
Korea	1998	Ministry of Education	Children ages 4-12 years	National Anthropometric Survey	Kang et al., 2001
Mexico	1992-1993	Educational institutions in Mexico and the USA	Measured 349 Males and 162 females ages 6-12 years	Assess growth status of urban Mexican children	Pena Reyes et al., 2002
South Africa	1935	Cape Provincial Department of Education	Measured 1800 Males and females ages 6-18 years	Measurement comparisons with Australia, England, and US	Grobbelaar, 1964 cited in Huyssteen, 2006
South Africa	1993	Academic institutions in South Africa	Measured 542 Males and 466 females ages 7-19 years	Comparison of stature, sitting height and leg length of Northern Sotho children	Monyeki et al., 1997 cited in Huyssteen, 2006
South Africa	1996	Academics in South Africa and The Netherlands	Measured 408 Females ages 4-10 years	To assess the stability of somatotypes of rural South African females	Monyeki et al., 2002 cited in Huyssteen, 2006
South Africa	2000	Academic institutions	Measured 523 Males and 451 females ages 3-10 years	Anthropometric indicators of the nutritional status of rural African children	Monyeki et al., 2000 cited in Huyssteen, 2006
USA	1937-1939	Clothing and Textile Division of the US Dept. of Agriculture)	National survey with 147 088 males and females participating	Establishing a sizing system for children’s clothes based on height and hip girth	O'Brien et al.,1941

2.5 Importance of anthropometric data

Anthropometric data are the basic consideration in the design of apparel and other related products. Anthropometric surveys have become an integral part of the process of design and production of products to suit the needs of mankind. Anthropometric measurements are very valuable in studying groups as several factors influencing the characteristics of different groups can be seen from it (Singh and Mehta, 2010). The issue of lack of recent anthropometric data on the population in addition to the nonexistence of information on the fit needs of the population are two factors that have been identified by several researchers as hampering the clothing industry from resolving the issue of fit (LaBat and DeLong, 1990; Workman and Lentz, 2000; Devarajan and Istook, 2004; Ashdown et al., 2005; Schofield and LaBat, 2005; Shin and Istook, 2007).

To understand the physical characteristics of a specific population, anthropometric data must be collected on the population through an anthropometric survey. Anthropometric surveys are carried out for clothing and ergonomics purposes and to govern the growth rates of populations in relation to age and diet by nutritional experts (Taylor, 1990). According to Nadadur and Parkinson (2013), the fitness and physical endurance of a design is hinged on the use of anthropometric data. Kim et al. (2017) added that it helps extend the durability of products and boost the adaptability of product to satisfy varied consumers (Kim et al., 2017). de Campos et al. (2017) are of the opinion that undertaking suitable anthropometric studies of a target consumer coupled with the production of specific table of measurement will result in the success of the clothing industry and an upsurge of ergonomic clothing. These would culminate in product quality in terms of comfort, functionality, and usability. Singh and Mehta (2010) added that anthropometry in one way or the other is involved in everything that has been made for the use by humans. They categorise the benefit of anthropometric survey under the following subheadings: growth and development, prediction of adult height, physique and disease, nutritional status, estimating skeletal frame size, obesity, chronic illness and disease, sports, human dimensions for design solutions, and appliances for left hander. Bougourd and Treleaven, (2014) on the other hand group the merit of anthropometric surveys under the following government, academia, apparel industry and consumers. In this study, the importance of anthropometric survey is reviewed under the following headings: Clothing industry, growth, physiques and diseases, nutritional status, sports, human dimensions for design solutions, government and academia.

2.5.1 Clothing industry- To understand body shapes and sizes of a particular population, an all-inclusive anthropometric survey must be carried out. Among the initial commercial use of anthropometry was in the area of apparel sizing (Gupta, 2014). Analysed and interpreted data of body shapes and sizes forms an easy basis for the development of a sizing system for the production of correctly sized garment (Zakaria, 2014). Bougourd and Treleaven, (2014) concur by stating that better body data for the apparel industry has been the main impetus behind the increase in the number of anthropometric surveys in recent times. They added that conducting anthropometric surveys on regular basis provides data to designers and technologists to make well- fitting, ready-to-wear garments for all consumers in a population. Ruto (2009) cited in Bougourd and Treleaven (2014) opined that with new shapes and sizes for clothing design, anthropometric surveys help in structuring the basis for new shape and sizing systems, understanding the impact of shapes through the ageing process, ascertaining shapes in segmented markets, echoing shapes and sizes of physical fit models, automating block pattern generation among others.

2.5.2 Growth and nutrition- The growth and development trends of school-aged children and teenagers has been studied using anthropometric data (Woodruff, 2000). As children grow, doctors and parents check the growth rate of children by comparing their anthropometric measurements with standard pattern of growth to determine their growth status. This is done using the "growth charts" to measure the physical development of children (Kelly, 2005). According to Singh and Mehta, (2010), the knowledge of children's growth is seen by measuring their weight, height, and other body dimensions. According to Gorstein and Akré (1988), children's growth pattern in the early stages of life are assessed by the use of anthropometric data. These growth assessments which gives details into nutritional and health status can then be generalized to cover the population.

Anthropometric measurement is classified safer, easier, less expensive, and relatively effective way of assessing the nutritional status of people with measurements such as height, wait, adipose tissues and upper arm circumference (Singh and Mehta, 2010; Bhattacharya et al., 2019). Gorstein and Akré added that, in assessing individual nutritional status, anthropometric pointers are less precise than clinical and biochemical methods. Gripp et al. (2013) stressed that accurate physical body measurements can convey and communicate information on growth, and proportion as well as disruptions of the process of developmental using quantitative figures.

2.5.3 Physiques and Diseases- Singh and Mehta, (2010) comment that specific types of physiques provide fertile ground for a particular disease or identifies with certain types of diseases which may afflict them. According to Gaur and Sarkar (1998) cited in Singh and Mehta, (2010), solid links between somatotype/physique and diseases can be traced through anthropometric surveys.

Anthropometry is therefore fundamental to understanding the health of a population (Haddad et al., 2022). According to Utkualp and Ercan (2015), anthropometric measurements are used to evaluate morbidities of persons in all walks of life especially for human health as the medicine field needs continuous improvement and renewal.

2.5.4 Sports- Athletes are selected and trained to become world champions based on certain body measurements and characteristics based on anthropometric measurements. Certain physiques and physical structure have great advantages in certain sports than others. Collecting anthropometric data on the population will aid to portray the stature and feature within the population.

2.5.5 Human dimensions for design solutions- Anthropometry is very useful in all the sectors of the world economy including the automobile, space, air, health, agriculture, industrial, service, military, and the clothing sectors. Data on the population is required in all these sectors to develop products for the populace. Anema et al. (2004) opined that workplace hazards, human error during system performance and harmful health effects have been lessened through the use of anthropometric and ergonomics in system design and this has increased productivity.

2.5.6 Government- In addition to giving governments an opportunity to foster innovation and to support the use of new technology, anthropometric surveys create great interest in several areas including scientific applications and provision of credible data on a population (Bougourd and Treleaven, 2014).

2.5.7 Academia- In the field of academia, Bougourd and Treleaven (2014) said anthropometric surveys provides researchers/ research teams experience in the organization and implementation of surveys using various techniques including both manual and digital means. Data gathered is used to continue the development of new products and services as well as for the advancement of knowledge (Tahan et al., 2003; Simmons and Istook, 2003; Ball et al., 2012). Several researchers (O'Brien et al., 1941; Beazley, 1997; Bari et al., 2015; Bilhassan et al., 2018; Otieno and Fairhurst, 2000a; Kuma- Kpobee, 2009; Adu-Boakye et al., 2011; Zakaria, 2016) have undertaken anthropometric research in the field of Fashion that helped in the development of well fitted clothing and adds to knowledge in the area of clothing anthropometry.

2.6 Types of anthropometric data

Pheasant (1986) categorise the process of obtaining anthropometric data into two namely static or structural anthropometry and dynamic or functional anthropometry. Singleton (2010) on the other hand divided the process of obtaining anthropometric data into three, namely structural anthropometry usually referred to as static anthropometry, functional anthropometry also known commonly as dynamic anthropometry and Newtonian anthropometric data.

2.6.1 Structural (static) anthropometric data

Body measurements taken in volumes, lengths and circumferential on a still human body is referred to as static or structural anthropometry (Oborne, 1982; Gupta, 2014). This type of anthropometric data is essential for the production of wholesale clothing manufacture (croney, 1980; Beazley 1997) focusing on the measuring of dimensions of a human in a fixed position (Beazley, 1997). Static or structural anthropometric method is classified as the traditional and commonest ways of collecting anthropometric data (Gupta, 2014; OpenEgonomics, n.d.). Singleton, (2010) concur by stating that structural (static) anthropometry has to do with the simple dimensions of the human body. These include length, depth, and circumferential measurements. This research focuses on collection of anthropometric data for clothing sizing purposes. It does focuses on the use of static posture for measuring the participants as shown in Figure 2.2. Images of manual measurements collected in the static posture can be found in the body measurement guidebook at Appendix 2.

Figure 2.2: Image of a boy and a girl in a static posture

2.6.2 Dynamic (functional) anthropometric data

Dynamic (or functional) anthropometry on the other hand is concerned with the measuring of the stretch and movement of the human body whiles in motion or engaged in various actions or tasks (Pheasant, 1986; Todd and Norton, 1996; Beazley, 1997a; McGraw-Hill Dictionary of Scientific and Technical Terms, 2003; Gupta, 2014). It can also be viewed as the anthropometry that is focused on dynamic reaches and strength measurement (OpenEgonomics, n.d.). Dynamic (or functional) anthropometry applies kinanthropometry. This is defined by Sands, Caine and Borms (2003) as the quantitative connection between human physique and function. Adding that this scientific field makes use of measurements to evaluate the size, shape, proportion, growth, composition, and overall function of the human body. Tsang, Chan, and Taylor (2000) and Singleton (2010) added that functional anthropometry goes beyond structural anthropometry and focuses on measurements which cannot be forecasted from a set of structural data. This process is task specific and is involved in the selection of movements in body joints and muscles where dimensional changes are captured and measured to reflect actual situations. Movements include bending stance, reaching out and presence of accessories, among others (Gupta, 2014). Functional anthropometry relates to the design for specific tasks or activity (Gupta, 2014). This task specific anthropometry is used mostly in the design of sport costume where the motions of an athlete undertaking a specific sport is studied in the process of designing the costume.

Figure 2.3: Dynamic anthropometric posture
Source: Adapted from Urban Design Lab (2022)

For instance, in the development of swimsuits, the movements of the swimmer are studied to be able to design apparel that will complement the body movement of the wear. A bending stance is illustrated in Fig 2.3 where the back is straight, but the legs are bent. Croney (1980) added that static and dynamic anthropometric data provides the designer with a framework of dimensions around which ideas can be developed. This study, as mentioned in the preceding section deployed the use of only static (or structural) anthropometric method in data collection.

2.6.3 Newtonian anthropometric data

This is a form of anthropometric data that has to do with body segment mass and data related to forces that can be applied in different tasks or postures. This data is employed in the assessment of load handled by the human body (Caca, 2021). This type of anthropometric data is used in the comparison of the loads on a section of the body such as the spine stemming from different techniques of lifting (Bridger, 2003).

2.7 Anthropometric methods

The instruments used in the collection of anthropometric data help to classify the methods of data collection into two, namely contact and non-contact method (Roebuck, 1995). With the contact method, there is physical contact between the measurer with the surface of the participants body or his/her clothing. Non-contact methods on the other hand use equipment such as camera or body scanners for the collection of body measurement from the participants (Roebuck, 1995; Mckinnon and Istook, 2002; Pechoux and Ghosh, 2002; Simmons and Istook, 2003). The methods of collecting anthropometric data are also termed by Zakaria (2016) as manual and computerized methods.

2.7.1 Manual anthropometric method

The conduct of traditional anthropometry has to do with close body contact with participants in minimal clothing for landmarking of the body and the actual measurement process (Kuma-Kpobee, 2009). The traditional anthropometric method also known as the direct method (Lescay et al, 2016), is a manual method that obtains anthropometric data straight from participants' anatomical points manually. Before the advent of digital means of collecting anthropometric data, the manual anthropometric method was the only technique used for measuring participants in clothing anthropometric survey. This method although is used today are largely used for small-scale anthropometric surveys (Taylor, 1990). With the manual or traditional anthropometric method, measurers choose anatomical points for measurements to be taken manually between body landmarks using a variety of equipment such as tape measures, stadiometers, anthropometers and callipers (Sims et al., 2012; Kouchi, 2014). According to Azouz et al. (2006), manual anthropometric method is the measurement of ranges of repetitive linear distances between the anatomical points and circumference value at predetermined places. Instruments used under this method are less expensive, handled physically by a trained measurer to take the body measurements of people of defined area and population. These tools and equipment make it possible to measure all anthropometric dimensions.

Although there have been tremendous improvements in the 3D scanning technology, the statement by Robinette and Daanen (2003) is still very applicable in recent times. According to them, although 3D scanners that can recognise pre-marked landmarks are available, it will take a long time for it to be readily available to everyone. The traditional/manual measurements have been used concurrently for many years. Robinette and Daanen (2003) therefore emphasized the need to collect certain measurements using the traditional method in the CAESAR project resulting in the collection 40 measurements using callipers and 59 measurements with tape measure.

Kouchi (2014) stressed that measurers take the decision on the landmark locations and measure manually using manual equipment which are cheaper but time consuming and error prone. According to Sims et al., (2012) there can be differences between measurements taken by different individuals, but this problem can be reduced with consistent training of the measurers. The study by Ghoddousi et al. (2007) compared measurements obtained using manual equipment such as a tape measure and a ruler as against measurements obtained from a 3D system and though the mean difference was significant compared to the p-value, using a one-sample t-test, the difference was not to be expected to have effect on their clinical study. They, however, concluded that most of the discrepancies are because of landmark identification brought about by human error which could be minimized with proper training.

2.7.2 Non-contact anthropometric method

With the advancement in technology, anthropometric data can be collected indirectly through computer devices also known as digital method (Lescay et al., 2016). This non-contact measuring equipment comes in a variety of types. The photographic method was the initial development of a non-contact method of obtaining body dimensions. This technology was introduced in the early parts of the nineteen-nineties, where videos were captured of participant’s body and later translated into black and white photos. With the aid of callipers, lengths, widths, and depths measurements are taken on the photographs. Computerised analysis is then run to determine the angles and diameter of the body (Pechoux and Ghosh, 2002). The photographic method has been developed and used in clinical assessment. This method uses accurate physical measurements derived from a standardised photograph in a method term as photogrammetric anthropometry (Gripp et al., 2013). Photographs are taken of the participant at some poses and indirect measurements obtained from the photograph or projections. This method has the participant positioned on a turn table adapted to each required pose so that the participant does not change position (Weissman, n.d.). Weissman (n.d.) stated further that other methods make use of photometric camera specifically built to give four images from just a shot. Gripp et al. (2013) added that the Photogrammetry anthropometric method which is not an ordinary practical approach is expensive and requires standardised cameras and computational technology. Kohlschütter (2012) added that the camera used must also be perfectly calibrated.

The resent and most scientific method of collecting anthropometric data is by the use of 3D body scanners (Wang et al., 2007; Pechoux and Ghosh, 2002; Connell et al., 2006). These scanners are targeted for different parts of the human body such as head, foot, or full body for clothing purposes (Spahiu et al., 2015). With this method, there is no body contact between the measurer and the participant. Thus, the 3D scanners are non-invasive (Wang et al, 2007) equipment that require the person being scanned to be in nominal form fitting clothing for the scanner to capture data from the exterior of the body (Heymsfield, 2018).

Equipment used for taking anthropometric measurement includes Infrared thermography machine, SYMCAD and Body Scanner. The Infrared thermography machine is a thermal imaging camera that uses wavelength bands to capture objects through resonant oscillator and two-dimensional reflecting scanner (Arellano, 2009 as cited by Lescay et al., 2016). There is the SYMCAD technology which does not use harmful radiations. This technique projects bands with natural light by extracting for detecting anatomical points and calculating measurement according to ISO- 7250 e ISO 8559 regulations (Arellano, 2009; Vicente, 2015 as cited by Lescay et al., 2016). Lescay et al., (2016) further stated that, the 3D body scanner is another equipment used as a digital tool to capture 3D body surface shape and landmark locations. The surface digitizing technology of human body by 3D body scanners gives a more comprehensive information regarding the body shape of scanned participants compared with the traditional anthropometry (Spahiu et al., 2015; Istook and Hwang, 2001). Connell et al. (2006) and Istook and Hwang (2001) further add that this method enables researchers to extract body measurements, precisely view body shapes and analysed these shapes from a more comprehensive anthropometric perspective. This technology aside helping apparel consumers attain well-fitting garments also help apparel manufacturers attend to the fit preferences of each consumer by rendering customised products (Xu and Huang, 2003). The body scanning technology has been used globally to collect anthropometric data during sizing surveys (Fan et al., 2004) and according to several researchers (Winks, 1984; Istook and Hwang, 2001; Mckinnon and Istook, 2002; Simmons and Istook, 2003; Xu and Huang, 2003; Chi and Kennon, 2006; Bretschneider et al., 2009; Connell et al., 2006; Makhanya et al., 2014), it is the most precise, fast and accurate method of measurement.

Scanners are more expensive but quicker compared to the traditional method. It takes more measurements in a very short time. Manipulation of data is minimal resulting in reliable results (Otieno, 2008). Accurate body shapes and sizes are captured within seconds recently with the introduction of advanced technology such as the 3D body scanners to develop 3D body models (Apeagyei, 2010). A wide range of information such as anthropometric dimensions and morphology are also generated to solve fit problems. This according to her will offer a realistic approach to mass customisation and the facilitation of virtual model fit trials online. In general, the method used to collect anthropometric data depends on the purpose of the measurement. Even in the face of technological improvement, certain anthropometric data are gathered using the manual anthropometric method (Otieno, 2008).

Song and Ashdown (2013) numerated two benefits that the 3D body scanning technology has over the manual measuring method. Firstly, the 3D body scanners in terms of speed can scan images in five to fifteen seconds and in one to two minutes automatically generate over hundred body measurements. Due to the very short time required to capture and generate body measurements, the body scanner has removed several expenses related to large scale surveys. Secondly, aside the speed, the 3D body scanner can capture 3D visual image. These visual data can aid in the identification of the body shape and proportion of clients for ready-to-wear companies and help to improve the sizing systems. In addition to the merits, Wang et al. (2007)

stated that 3D body scanners afford it users' repetitive retrieval of data and enormous quantity of body measurements in different forms such as one, two or three dimensional based on the needs of the user.

The 3D body scanners on the other hand are not also completely free of errors. According to Bragança et al. (2016), Daanen and Ter Haar (2013) and Wren (2017) 3D body scanners rated as best compared with manual method cannot be described as completely free of errors, as problems of exactness and accurateness has been raised (Simmons and Istook, 2003; Chen, 2007; Wren, 2017).

2.8 Anatomical position and landmarks

Anatomical position is the notion that characterise the descriptions of locations within the body. This position is likened to the famous Vitruvian Man by Leonardo da Vinci, though less energetic. The anatomical position encompasses a person in an upright position facing forward with arms straight, palms facing forward with feet parallel and toes pointing forward (Teachmeanatomy, n.d). Bone drawings used to show the location of key points on the human skeleton, are presented by several authors in literatures such as BSI (1990: 175-6) and O'Brien et al. (1941). This study adapted that of Kunick (1984) due to its applicability. Further information and images on the anatomical position can be seen in the developed body measurement guidebook at Appendix 2.

Some anatomical terms are very essential in describing the relative location of different body parts in relation to anthropometry. Kenhub (2020) describes anatomical terminology as terms that describe the human anatomy in relation to anatomical structures, regions, directions, plane, and movement of the body. To be able to locate landmarks accurately on the human body during an anthropometric study, some anatomical terminologies must be comprehended. Wren (2017) in her study stated that landmark can be effectively position or placed if one is well acquainted with the varied landmark terminologies and different surface anatomies. Anatomical regions are described as areas of the human body distinct by landmarks provided by apparent structures that are easily visible (Kenhub, 2020). Landmarks on the other hand are locations on the human body that enables body measurements to be taken. According to Brownbridge (2012), points on the human body from which measurements are taken from one location to the another is referred to as landmarks. For example, knee to ankle measurement will have the landmarks being the knee and the ankle. These are identifiable points on the human body and can be identified by bone structure underneath the skin. These points aid measurements to be precise and reliable with the use of standard tools (Gupta, 2014). The identification of consistent body landmarks that directly relate the human body to a pattern is the precursor to convert body measurements to clothing pattern (Bye et al., 2006). In the location of landmarks, some researchers conducted manual anthropometric surveys on populations years back and they developed documents on the procedures for locating landmarks on the body (O'Brian and Sheldon 1941; Kemsley 1957; Croney, 1980; Lohman, 1988; Beazley 1996). In the process of landmarking the body, protrusions of bones or joints in the body tend to indicate identifiable landmarks (Gupta, 2014). Bye et al., (2006) added that sections on the body that are fleshier in nature are difficult to locate.

To Beazley (1997), the traditional method of landmarking the human body with pen was a little difficult to remove, instead an adhesive circle with a cross marked at the centre was ideal. In the marking of landmarks for a measurement process, several authors state that exactness of the landmark is vital in the acquisition of body measurements that truly represent the key measurements required for garment pattern (Tamburrino 1992a; Beazley 1996; Bougourd et al., 2000; Simmons and Istook, 2003; Connell and Presley 2005; Honey and Olds 2007, Gill, 2009).

2.9 Anthropometric tools and equipment

Tools and equipment used for measuring participants during anthropometric surveys varies ranging from simple to more complex based on technology (Otieno, 2008). In taking anthropometric measurements using the traditional method several researchers (Fan et al., 2004; Gupta, 2014; Zakaria, 2016; Casadei and Kiel, 2020) report that there are several instruments used and they include calibrated non-stretchable plastic measuring tapes, anthropometer, stature meter, height scale with movable head piece (stadiometer), long rule, elastic tapes, digital weighing scale, callipers and spreading callipers. Robinette and Daanen (2003) and Mokdad and Al-Ansari (2009) describe manual anthropometric equipment as uncomplicated, inexpensive, and easy to move about.

In addition to the manual anthropometric equipment stated, the study by Beazley (1997) used an adjustable square to measure the slope of the shoulder. In manual anthropometric data collection, a full-length mirror is one of the necessary equipment as it will aid in the precision and reliability of measurements. During measurement session a full-length mirror should be placed behind the participant being measured and more to the side. This will afford the measurer the opportunity to detect the level and location of the measuring tape on the reverse side of the participant (Beazley, 1997). Beazley's (1997) study further made use of a tape measure attached to a harness and a metal tape to measure the surface of the body contour which she described as more appropriate for clothing.

The tape measure was the earliest scientific tool invented in 1820, used to take girths and length measurement of the human body in a precise and reliable way (Gupta, 2014). Although a lot of technological advancement has been made regarding tools and equipment used in the collection of anthropometric data, Robinette and Daanen (2003); Ghoddousi et al. (2007); Mokdad and Al-Ansari (2009) and Widyanti et al. (2015) all states that the manual tools are fairly simple to use, inexpensive, consistent and precise as the high-tech anthropometric equipment. Gupta (2014) report that the tape measure is the most widely used tool for liner measurements. Images of some manual anthropometric equipment can be found in the body measurement guidebook at Appendix 11.

2.10 Measurements collected in an anthropometric survey

The type of data collected during anthropometric survey varies. In the design of some products, a univariate data or just one body dimension is enough to size the product. These types of data are mostly applicable in designing product for 'extremes' thus, the 5th and the 95th percentiles. One dimensional data are comparatively simple to use and applicable for wide-ranging design requests but non-effective in designs that entail comprehensive information about the size and shape of a target population (Gupta, 2014). Bivariate analysis or two-dimensional anthropometry on the other hand is applicable for the design of product that require the use of two key body measurements.

In anthropometric studies, multivariate analysis is used in intricate design situations. Multivariate analysis has been used by several researchers in the development of apparel sizing system. Gupta (2014) adds that the PCA is an efficient technique in determining the relationships between measurements, it's efficient in describing the three-dimensional shape of the human body.

Kunick (1984) states that there is no specific number of body measurements required for the creation of a particular size chart. Adding that authors choose body measurements that are vital and very pertinent based on the specific end use and purpose of the size chart to be created. Researchers in clothing anthropometry have used different number of body measurements in their anthropometric surveys. For example, Beazley's study collected seventy (70) body measurements from each participant while Chung et al. (2007) in their development of clothing sizing system collected 36 anthropometric dimensions.

2.11 Factors that affect the variability of anthropometric data

Regardless of the source of the anthropometric data, there are factors that can affect the accuracy and exactness of the anthropometric data (Gupta, 2014). There are many forms of variability in human population; these include age, gender, occupation, body size, shape, lifestyle, and economic status (Fernandez, 1995; Otieno and Fairhurst, 2000; Apeagyei, 2008 and 2010; Nadadur and Parkinson, 2013; Gupta,2014). The study by Zernike (2004) and Sajib, Islam and Nizam (2018) confirms that age, ethnicity and race were the main contributing factors to the variations in body sizes for the sizeUSA. Cheng et al. (2019) adds that nutrition, living standard and one's environment are all possible factors that contribute to variability body dimensions and size. Gupta (2014) adds that the body is volatile to change in both static and dynamic form. Anthropometric measurements are affected by factors such as age, gender, ethnicity, lifestyle, social class, occupation (Fernandez, 1995; Gupta, 2014).

2.11.1 Age- Age is an important factor that has effect on anthropometric dimensions of the human body. Dimensions increase or decrease depending on age (Gupta, 2014; Larasati, 2018). From birth, children grow, and their body dimensions increase with age. After attaining the age of 50 and above the human body diminishes in size (Larasati, 2018). Larasati (2018) stated that in taking the body measurement of humans, their age must be noted. Human growth is marked by five phases, namely infancy, childhood, teenager, adulthood and old age as illustrated in Figure 2.4.

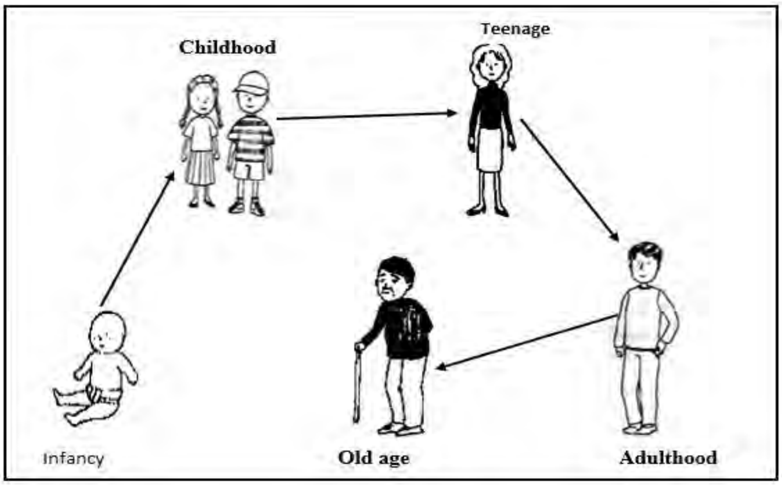


Figure 2.4: The five stages of human growth
Source: Adapted from https://www.yumpu.com/en/docu40893/5-stages-of-human-growth

2.11.2 Gender

Gender also gives variation of data. Fundamentally, the body measurements of females are usually smaller compared with their male counterparts except for the bust and hip dimensions (Larasati, 2018).

2.11.3 Ethnicity

Physical features for ethnic groups are different and therefore garment designers must know these characteristics and design garments to fit them (Gupta, 2014). He added that designers in mixed ethnic areas must take into consideration the anthropometric features and distribution to design garment that fit well.

2.11.4 Occupation

The type of job that one is engaged in may have effect on his or her anthropometric data. According to Gupta (2014) the continuous movement of the body in a specific motion helps in the formation of muscles in a particular way. Cutlip et al. (2000) ascertained significant differences in muscle strength capacity among participants selected from construction and manufacturing sector. The paper by Hsiao, Long and Snyder (2002) report anthropometric variations among professions. Their paper discovered significant differences in several body dimensions between occupations in USA. Comparing people in the agriculture sector to other professions, they noted that in terms of height, agricultural workers were averagely 2.5cm shorter with broader wrist breadths compared to other professions. They also identified that Protective service workers such as firefighters and the police were taller and heavier with males 7 kg heavier whilst females were over 10kg heavier (Hsiao et al., 2002).

2.11.5 Individuals with specific conditions

Body shapes and dimensions can also change due to other conditions such as disability and pregnancy. Specialised garment products are made for this class of people through anthropometric surveys conducted on individuals with such conditions. The ANSI A1171.1-1980 Standard provide guidelines to aid manufactures to create products to fit individuals in these health situations.

CHAPTER THREE

LITERATURE REVIEW ON SIZING AND GROWTH OF CHILDREN

3.1 Introduction

This section reviews literature holistically on sizing. It discusses the historical overview of sizing, sizing system, size charts, methods of sizing, procedures and methodologies used in the development of sizing system focusing on control/key measurements, size designation system among others. The significance of sizing to the clothing industry is also discussed. Literature is reviewed on human growth and development touching on the differences between males and females during the growth process.

3.2 Historical overview of sizing

Sizing is a multifaceted topic that has to do with a lot of inconsistencies, changing body sizes amongst persons, populations and generations, variances in collected and processed data amidst disparities in the analysis and interpretation of anthropometric data into sizing systems (Le Pechoux and Ghosh, 2002). Until the 1850's, apparel was hand produced mainly for specific individuals (Tamburino, 1992a; Aldrich, 2007) with ready-to-wear clothing seen as an improper garment for others (Aldrich, 2007). Sizes were originally developed based on the experience of tailors (Hsu and Wang, 2005; Aldrich, 2007). During this period, the proportional scaling method was used for the creation of sizing systems (Aldrich, 2007). This method of sizing system according to Aldrich (2007) did not precisely meet the needs of apparel consumers. The production of simple sizing systems started with the Army and Navy during wars such as the Napoleonic war in Europe. The demand for clothing for the Army and Navy fast-tracked the production of ready-to-wear clothing (Aldrich, 2007) for the military in large quantities (Aldrich, 2007; Zakaria and Gupta, 2014). This according to Aldrich (2007) necessitated the enhancement in size creation.

It is asserted by Tamburino (1992a) that during the production of ready-to-wear apparel, it was evident that the garments could not fit all body types flawlessly. This precipitated the need for a suitable sizing system to be created in conjunction with apparel making industrialization process (Tamburino, 1992a). Pandarum and Yu (2015) and Sizolution Team (2019) also added that the United State civil war contributed to the development and use of sizing system. They added that during this civil war, there was the need to clothes the Army. Body measurements were therefore collected from the recruits. These collected measurements portrayed a pattern in combined chest, waist and leg measurements. This happened to set the pace for a single set of sizes that was later transferred to civilian population (Pandarum and Yu 2015; Sizolution Team, 2019).

The switch from custom-made clothing was also influenced by the Industrial Revolution. This is the period where the process of production moved from an agrarian and handicraft economy to a mechanised economy (Britannica, 2021). This era introduced the production of factory-made apparel. The introduction of the sewing machine around this era fast-tracked the mass production process for garments and this augmented the need for a sizing system as a communication tool (Otieno, 2008; Frings, 2014). This also brought about more effective and quicker means of producing garments (Kidwell and Christman, 1974; Adburgham, 1981). In the assertion of Datta and Seal (2018), the industrial revolution brought with it the quest to standardised clothing patterns for the ready-to-wear apparel market. These preliminary efforts to standardised apparel patterns contributed to the standardised size charts developed for places such as United States and United Kingdom.

Also, during this era, women's status changed, and they began to work outside the home. They therefore had limited time to sew for their children. This situation transformed the apparel worn by their children and gave rise to mass production of children's clothing (Zakaria, 2016; How products are made, n.d.). By the end of the 18th century, sizing system had first been published in pattern books (Aldrich, 2007). During the mid-20th century, sizes were produced from body measurements using statistical procedures (Aldrich, 2007). According to Aldrich (2007) the awareness of body dimensions and the use of statistical methods from other fields of study for instance health, education and ergonomics all pushed the goal of achieving a better sizing system. Measurement studies were carried out using standardised anthropometric equipment with statistical data offered in means and percentiles. Aldrich (2007) concludes by stating that clothing sizing system from that time was founded on body dimensions and not on clothing dimensions. A lot of new and sophisticated methods to addressing the issue of sizing for pattern production have evolved in the twenty-first century. These modern methods according to Aldrich (2007) trace their roots from early methods, since the ideas and method for handling problems related to sizing for pattern production formed the basis for modern methods. Salusso et al. (2006) further added that the first available sizing system in the U.S. was published in 1958 and it served as a template for other nations from time to time.

3.3 Sizing system

Sizing system according to Petrova (2007) and Yu (2004c) is a table of numbers that shows the value of individual body dimensions used to group bodies encountered in a specific population. Schofield and LaBat (2005) explained sizing system as the establishment of a size chart using measurements of important body dimensions for the construction of different apparel sizes. Huyssteen (2006) on the other hand, defines a sizing system in relation to apparel as body dimensions representative of definite target population captured as a size range with size intervals for use in a specific market sector of the garment industry. Gill (2015) described a sizing system as the segmentation of a specific population into subgroups centred on similar body feature which are often uniformly grouped to aid the provision of ready-to-wear apparel. The various descriptions of sizing system affirm Kunick's (1984) assertion that an ideal sizing system is created based on the body measurements taken on a cross-section of a population. Otieno (2008) agrees by stating that the provision of valid sizing depends on precise and current measurement of the target populations for the development of size charts. A sizing system consist of a set of size charts, with each chart made to cover a category of body type within the populations (Schofield and LaBat, 2005) and a range of sizes beginning from the smallest to the largest based on constant intervals between adjacent sizes (Winks, 1997). Also, a sizing system is develop based on a type of apparel. Countries in the creation of a sizing system categorise apparel in different ways. According to Chun-Yoon and Jasper, (1993) most sizing systems including the ISO categorised apparel into outerwear, underwear, and others. These categories are sub divided into upper-body, lower-body, and whole-body garments apart from the Japanese sizing system that categorises apparel based on item type such as skirts, pants, jacket, swimwear among others (Chun-Yoon and Jasper, 1993).

In the creation of a sizing system, a three-dimensional effect must be targeted, by using the bust or chest, waist, hip girths, and height as the main control measurements (Kunick, 1984; Tamburino, 1992a; Ashdown, 1998; Gupta and Gangdhar, 2004). It is always prudent basing a sizing system on close fitting clothing rather than loose fitting clothing. This should culminate in sizes that are very close together and a sizing system that makes room for all degrees of fit (Taylor, 1990). According to Ashdown (1998) sizing system is created to ascertain the best number of size groups that adequately describes many shapes and sizes categorised into diverse population and afterwards grouped into homogenous subgroups (McCulloch et al., 1998). In a sizing system, the number of sizes created termed as the size roll (Zakaria, 2016) is of great importance and this is determined by the size range and the intervals (Petrova, 2007). Size range is the difference between smallest and the largest body dimension of specific body measurement whereas size intervals are the increments either constant or variable used to categorise the size range into appropriate sizes (Petrova, 2007; Xia and Istook, 2017).

More succinctly put by Otieno (2008), a sizing system must generate apparel that matches the fit expectations of population. If more sizes are developed in a system, it could afford consumers varying sizes to choose from, but this will also mean that consumers may have a tough time selecting their appropriate sizes and shape from the vast number of sizes. Ashdown (2014) added that developing more sizes in a system will increase production and distribution cost.

The process of compiling a good sizing system starts with the determination of the scope of the sizing system. According to Kunick (1984) and Beazley (1997a), the number of sizes will be derived from a target population sub-divided into groups for a size range to resolve the needs of a particular population target. Following the scope is the determination of measurements contained in each size. The basic principle of the three-dimensional figure comes to play to meet the needs of a target population. The determination of garment labelling is the last stage. For immediate recognition of sizes that fit, garment labelling should be done. These three stages are all dependent on each other for a well-structured sizing system.

Kohn and Ashdown (1998) outlined four processes to be carried out in the conduct of an all-inclusive evaluation process. The first stage is obtaining anthropometric data on the target population. The second step is the production of the prototype. The third is fit models to try on prototype and assess in terms of comfort, fit and functionality and the fourth is for experts to assess the visual characteristics of the prototype on the fit models.

Beazley and Bond (2003) outlined five steps to be followed in the development of sizing system beginning with obtaining of raw data; analysis of the data; addition of ease allowances; formulation of size charts; and finally conduct of fitting trials. A few years down the line in the study by Otieno (2008), she came out with a more encompassing six steps to use in the conduct of anthropometric research as planning and preparation, identification of measurements and procedures, collection of raw data, analysis and creation of size charts, fitting trials, and confirmation of size charts. Zakaria (2011) on the other hand categorises the process into four namely, anthropometric survey encompassing anthropometric planning and protocols; anthropometric data analysis involving both descriptive and inferential statistics; creation of sizing system touching on size range, size interval, size roll among others and concluded with the validation of the sizing system looking at accommodation rate, aggregate loss and total number of sizes. Observing all the procedures outlined by the authors (Beazley, 1997a; Kunick, 1984; Beazley and Bond, 2003; Otieno, 2008; Zakaria, 2011),it is evident that the mode of classifications differ however, the procedure for creating a sizing system remains the same. Beazley and Bond (2003) may not have categorically stated planning and the protocols of data collection, but anthropometric data cannot be collected without adequate planning.

Once data is collected from the target population, the next important phase of the sizing process is the analysis of the data. Different statistical procedures have been used to develop sizing system. The method of using the mean as the average and minimum value and maximum value for the creation of size steps has been used by several researchers (Beazley, 1998; Otieno, 2008; Gupta and Gangadhar, 2004; Kuma- Kpobee, 2009; Adu-Boakye, 2011). However, the study by

Bari et al. (2015) points out merits and demerit of the sizing system developed by Beazley (1997) founded on the mean and the minimum and maximum values. The study went further to state that since the minimum and maximum values were used in the creation of sizes, Beazley's study adequately catered for the small and the big body sizes. Nevertheless, with the determination of the medium (M) size the mean was not used instead the minimum was subtracted from the maximum. Bari et al. (2015) concludes that the height measurement for the medium (M) may not represent that of the target population studied. There has been a lot of advancement in terms of methods of analysing anthropometric data for the development of a sizing system.

Beazley (1997) reiterated that Kunick (1984) stated in the twentieth century that the problems of sizing cannot be resolved with only statistics since in this industry, art, craft, and fashion are to be considered as well as the expert knowledge of the technician must be used to connect these designing factors together. Sizing systems have been developed by several researchers (Otieno, 1996; Chen, 1998; Beazley 1999; Laing et al., 1999; McCulloch et al., 1998, Kuma- Kpobee, 2009; Gupta and Gangadhar, 2004; Adu-Boakye et al., 2012; Bilhassan et al., 2018; Zakaria, 2016) through procedures as the collection of raw data, cleaning of the data through elimination of outliers, identification of false or missing values. After screening of the data, then comes the selection of descriptive statistics such as frequencies, means, medians, standard deviations, minimum and maximum values, and percentiles. Different statistical methods such as percentile analysis, correlation analysis, principal component analysis (PCA), linear regression, cluster analysis and decision tree analysis have been used by different researchers to create a sizing system (Beazley, 1997; Yoon and Jasper 1996; Otieno and Fairhurst, 2000b; Gupta and Gangadhar, 2004; Zakaria, 2016). The development of a sizing system requires that the many body dimensions analysed are condensed into a single girth and a single vertical measurement. The girth measurement is a vital dimension required to fit the apparel. The essential girth measurements are chest or bust, waist, hips and neck (Tamburino, 1992a). Percentiles on the other hand have implications for the base size making their selection critical. That is, if a large percentile is selected, a bigger base size will be churned out and if a smaller percentile is also selected a smaller base size will be produced (Otieno, 2008). After running statistical test, the selection of the control or key dimensions is based on the type of clothing, the size range, the size intervals, the sizes roll, the secondary dimensions, and the method of size labelling (Petrova, 2007; Zakaria,2016). Sizing systems vary in the body dimensions used to divide the population; however, their basic structure and procedures are similar (Ashdown, 1998; Petrova, 2007).

Based on empirical evidence, several researchers (Beazley, 1997; Istook et al., 2003; Mpampa, Azariadis, and Sapidis, 2009) have stated that anthropometric measurements need to be updated frequently in other to gain current and accurate data on any population under study. Even though, different countries have developed their own standardised sizing system, the use of a standard sizing system published by different countries is not compulsory but completely voluntary (Ashdown, 2014). Winks (1997) and Alexander et al. (2005) added that most apparel manufacturers do not adhere strictly to the published standards.

3.4 Size charts

A size chart according to Beazley (2007) is created when a set of measurements are divided artificially. It is targeted to fit majority of the target population using fewer number of sizes (Beazley, 2007; Kunick, 1984). Size charts consist of garment measurements that contain ease allowances (Otieno and Fairhurst, 2000). For a size chart to be useful to apparel manufacturers and retailers, the chart must be precise, the number of sizes termed as the size roll must not be too many, the chart must be simple to read and the intervals between the sizes also known as the size interval must be constant (Beazley, 1999c; Kunick, 1984). The development of accurate size chart for clothing purposes is dependent on the availability of accurate and resent scientific data on the population gathered through anthropometric survey (Kunick 1984; Taylor, 1990; Beazley, 1997a).

Important information needed for pattern drafting are contained in a size chart. Size chart also indicate incremental changes between the sizes and increment for the grading of patterns (Taylor, 1990). Size charts comes in different forms and their uses are explicit. They are associated to definite body silhouettes such as children, women, and men (Beazley, 1998c). Aldrich (2007) and LaBat (2008) have suggested that due to the huge cost associated with the conduct of anthropometric studies historically, most fashion industries do not carry out autonomous anthropometric studies on their consumers to develop a size chart for them, rather they resort to developed size standard by testing and standards agencies. Most of the measurements used for determining sizes are based on garment measurements rather than body measurements (Workman and Lenz, 2000).

Mullet, Moore and Young (2009) stated that it is important to standardize clothing sizes based on body shape system founded on statistical averages resulting from anthropometric surveys for the production of apparel. The sizes of men, women and children are usually based on different systems. The clothing sizes for men are normally based on body measurements such as chest size while that of women are normally stated in code numbers representing bust, waist, hip, and height measurements (Sizolution Team, 2019). Gender variances existed in the size charts sampled by Lim and Cassidy (2015). They noted that brands meant for infant did not have the gender division.

A developed body measurement chart must be reviewed at least every 10 years (Tamburino 1992b; Workman and Lentz, 2000; Huyssteen, 2006; Brunn, 1983 cited in Ashia, 2020). To Pechoux and Ghosh (2002), the size of an individual is not static but rather changes during his or her lifetime. It can also vary from one individual to the other and from one generation to the another. They went further to state that other marketing matters coupled with consumer education and behaviour all affect sizing. Otieno (1999) and Vronti (2005) added that fashion trends are global, but size charts are local.

3.5 Methods of sizing

According to Beazley and Bond, (2003); Petrova and Ashdown (2012) as well as Xia and Istook (2017) sizing system can be categorised into two, namely body sizing system and garment sizing system. Whilst the body sizing system is body measurement taken from people in a tight clothing considered as close-to-body measurements, a garment sizing system starts with a body sizing system. Garment sizing system is therefore based on the body sizing system. Petrova (2007) described the process of generating body sizing system as beginning from the collection and analysis of anthropometric data, followed by the selection of control variables and the decision of the range for the control variable, classification of the population based on intervals and size numbers and ending with sizing system designation. To Zakaria (2016), a body sizing system is premised on skin measurements that are grouped into a particular uniform subgroup in a population whilst a garment sizing system considers ease and allowance added to the body or skin measurements for a garment to be produced in a particular shape.

Beazley (1999) added that the body sizing system is beneficial primarily to pattern makers, graders and designers since the majority of apparel are a little larger in comparison with the body to give room for expansion, style, and movement. There is the need for added measurement to the body measurement termed as ease allowance. The ease allowance is categorised into two namely, wearer ease allowance and design ease allowance. The former is added to accommodate movement of the body whereas the latter is added based on exact style (Beazley, 1999c). Ease is discussed comprehensively under garment fit in chapter four, section 4.5.1.2. Xia and Istook (2017) reported that most current sizing systems published are based on body sizing systems and not garment sizing systems.

3.6 Sizing standard

A method of categorising body shapes and providing size increments to produce apparel is termed standard sizing (LaBat, 2007). Tables of body measurement and size labels or designations are the two main types of sizing standard.

3.6.1 Body measurement tables

Body measurement tables are used to describe the initial tables generated consisting of the mean values from the analysis of the anthropometric data without any addition of ease. These tables are used as a starting point for the development of the standard sizing system (Aldrich, 2007; Otieno and Fairhurst, 2000; Huyssteen, 2006). The body measurement tables indicate the minimum and maximum values for each key dimensions collected. The creation of tables of body measurements is feasible due to the availability of small units of measurement such as centimetre and inch (Aldrich, 2007).

3.6.2 Size designation systems

Size designation system is a constituent of a sizing system. It is also termed as size label (Winks, 1997; Zakaria, 2016). This is a system of size labelling used for apparel or other clothing related accessories (Winks, 1997). According to Zakaria and Gupta (2000) and Winks (1997), it is used to identify each size on the clothing or tag. Size designation system offers the size description that enables consumers to accurately choose the correct sized garment or accessory (Sieben and Chen-Yu, 1992; Chun-Yoon and Jasper, 1995; Winks, 1997; Workman and Lentz, 2000; Alexander et al., 2005; Brown and Rice, 2014). According to Huyssteen (2006), the size designation used by apparel manufacturers and retailers is a subjective decision that is partially contingent on the decision concerning allowable tolerances. Most apparel users complain of difficulty in selecting a suitable apparel size based on the size label. In designating apparel, any size label used must render accurate identification in order to avoid misinformation that can lead to consumers selecting apparel that will not fit them well (Chun-Yoon and Jasper, 1995; Bubonia, 2014). The issue of size nomenclature according to researchers have been a problem for both apparel manufacturers and consumers (Yoon and Jasper, 1996; Ashdown, 1998; Otieno and Fairhurst, 2000; Otieno, 2008). Precise and explicit system of garment labelling is important (Yoon and Jasper, 1996; Otieno and Fairhurst, 2000; Huyssteen, 2006) and must be centred on body measurements and not on garment measurement (Geršak, 2013; BS ISO 8559, 2017). Size designation or label can be denoted by number, letter/alphabet, code, graphical representation, a body dimension (neck measurement for shirt) or even by age (usually for children's clothing) which has been discouraged by several researchers (Brown and Rice, 2014; Carr and Laing, 2012; Zakaria and Gupta, 2014).

3.6.2.1 Numbered sizing

This is also referred to as numeric sizing. It is a method of size labelling commonly used to mass-produced apparel (Brown and Rice, 2014). Number sizing is size designation that is based on body dimensions or product dimensions recorded in inches or centimetres and associated with one or more of the key dimensions (Bubonia, 2014). For instance, measurement for waist and length are designated as 28W and 30L (Bubonia, 2014). Sizing for children's clothing is mostly specified in numbers that relate to a set of body measurements (Brown and Rice, 2014).

Continental sizing is another method of numbered sizing where the numbers used for the labelling do not relate with the body dimensions of the consumers (Brown and Rice 1998; Winks, 1988). The communication of the sizes of apparel is done through size codes (Brownbridge and Gill, 2013). However, this method does not relate generally to any set of body dimensions thereby resulting in variation and non-standardisation (Brownbridge and Gill, 2013).

3.6.2.2 Lettered sizing

This type of sizing is also termed as alpha sizing (TAAS. Inc, 2019). It is a type of sizing that makes use of lettering such as small (S), medium (M), and large (L) (Brown and Rice, 2014; Bouchez, n. d.; Stamper et al., 2005; Carr and Laing, 2012; 1991; TAAS. Inc, 2019) or 1X, 2X, 3X (Bouchez, n, d.) in the designation of apparel. It typically includes extended designations such as extra-large (XL), extra extra large (XXL) extra extra extra large (XXXL or 3XL) and extra small (XS) (Brown and Rice, 2014; Bubonia, 2014). Lettered sizes reduce the number of size categories of about seven or eight to only three or four. This according to Brown and Rice (2014) is favoured by retailers as it makes simpler the display of merchandise and decreases inventory. This sizing method does not usually indicate differences for unisex garments in children. This is commonly used for apparel such as sweaters, knit shirts, night clothes among others (Brown and Rice, 2014; Stamper et al, 1991). Brown and Rice (2014) and Bouchez (n, d.) underscored that letter sizing has no general standards. This type of size designation though has been used widely, is described by Huyssteen (2006) as not an ideal size pointer as labels give an imprecise information about a size. Brown and Rice (2014) added that lettered sizing is sometimes used by apparel manufacturers to designate the length of apparel in instances where length is not in inches. Garment lengths are designated with letters such as ‘P’ for Petite or ‘S’ for Short, ‘A’ for Average or ‘R’ for Regular, and ‘L’ for Long or ‘T’ for Tall. The authors noted that the use of lettered sizing for international trade is not informative enough due to variations in population unless the sizing is designed specifically for the international market in mind.

3.6.2.3 Graphical sizing

In graphical size labelling, the body measurements are designated on an image of the human body crucial to the fit of the garment (Brown and Rice, 1998; Brown and Rice, 2014). This type of labelling makes use of the pictograms. This is a representation of the human body silhouette in a figurative form indicating the positions and values of certain key dimensions as shown in Figure 3.1 (Geršak, 2013). This type of labelling in addition to the key dimensions also indicate a numeric or numbered system. Different authors have indicated that the use of pictogram is easy for consumers to comprehend and helps to overcome language barriers (Brown and Rice, 2014; Zakaria and Gupta, 2014, Zakaria, 2016). Pictograms readily suggest to the apparel consumer who knows his or her measurement whether a garment will fit, and they give useful information about size because they are based on body measurements. This size designation has additional merit compared to other methods of size designation since it aids in the simplification of size designation to apparel shoppers and illustrate the key measurements used on the mondoform (Zakaria and Gupta, 2014).

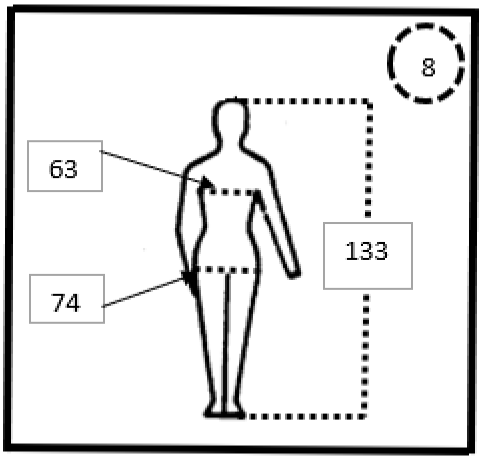


Figure 3.1: Mondoform labelling

3.6.2.4 Vanity sizing

Vanity sizing is a sizing designation method that is used by retailers. Vanity sizing sought to adjust size codes of larger sizes to indicate smaller sizes (McRoberts, 2005; Pisut and Connell, 2007; Rickey, 2007; Treleavan 2007; Weidner, 2010; Ennis, n.d.; Keiser et al., 2017). This tactic is used to usually compliment the egos of consumers especially women into believing that they are a size smaller than they truly are (Alexander et al., 2005; Treleavan 2007; DesMarteau, 2000; Bubonia, 2014). This is affirmed by Dockterman (n.d.) where he harshly referred to vanity sizing as a 'madness' that is partially caused by the desire of consumers to purchase apparel designated with small sizes as it increases confidence level. To Apeagyei (2008) this is a marketing tool deployed by apparel retailers to promote sales. She added that the use of vanity sizing has been feasible partly because of the lack of conformity to regulations regarding apparel sizing standards. Weidner (2010) and Brownbridge and Gill (2013) assert that vanity sizing is one possible source of inconsistency in sizing. This has brought about discrepancy between real shape and size of apparel consumers and apparel offered them (Ross, 2003). Bouchez (n, d.) terms vanity sizing as a label game as it can make it more difficult to find an apparel with the correct size.

3.6.2.5 One size fit all

This sizing concept came into existence in an attempt by apparel producers to limit the numbers of sizes through the introduction of apparel with elastic properties to fit varied figure type and sizes (Brown and Rice, 2014). To Bouchez (n. d.), this notion of sizing is not applicable, adding that unless the apparel consumer does not care about obtaining the right fit since the chances of obtaining an apparel with the right fit is not good regardless of the percentage of spandex used. In the view of Brown and Rice (2014) an accurate label for this type of sizing is "one size fit most" which is ideal.

3.6.3 Key dimensions

In the process of creating a sizing system, there is the need to select key measurements (Workman, 1991; Yoon and Jasper, 1996; Winks, 1997; Ashdown, 1998; Otieno and Fairhurst, 2000; Petrova, 2007; Zakaria, 2014). These according to several researchers (Chun-Yoon and Jasper, 1993; Winks, 1997; Beazley, 1998b; Otieno, 1998; Aldrich, 2009; Petrova, 2007) are the body dimensions used to designate a garment size and to enable apparel consumers to select clothes that fit. The key dimensions help to effectively describe the body size for everyone in a study sample (Carr and Laing, 2012; Xia and Istook, 2017) and are the basis for the assignment of appropriate garment size to a wearer (Chun-Yoon and Jasper, 1996; Winks, 1997; Workman and Lentz, 2000; Carr and Laing, 2012; Xia and Istook, 2017). Key dimensions are used to predict the measurements of other parts of the body. They must have high level of correlation between the key dimension and other measurements that are vital in sizing and design (McConville et al., 1979; Robinette, 1986). Key dimensions are linked to essential parts of an apparel and must be easy and convenient to measure (McConville et al, 1979; Chun-Yoon and Jasper, 1996; winks, 1997; Workman and Lenz, 2000; Carr and Laing, 2012; Zakaria, 2014; Xia and Istook, 2017).

From among the key dimensions, the control dimensions are selected. The control dimension(s) is/are the body dimension used for the size categorisation (Petrova, 2007; Aldrich, 2009). Chun-Yoon and Jasper (1996a) added that apparel consumers must also be able to correctly measure a control dimension with ease. It must be noted that when the design of the sizing system changes from its intended style, the control dimension may also change (Xia and Istook, 2017; Zakaria, 2014). In other words, control dimensions are selected based on the type of clothing item being produced. According to Aldrich (1999), the control dimension(s) used in size designations should be stated in centimetres. She added that garment measurements may be added as extra information for the customer, and these should be distinctly specified. Chun-Yoon and Jasper (1996a) numerated two key functions of a control dimension. They stated that the control dimensions offer the basis on which size categories are created and helps apparel consumers to select garment sizes that fit well. These functions of the control dimension numerated by Chun-Yoon and Jasper (1996a) are concurred by Xia and Istook (2017).

In terms of correlation of the body measurements, researchers have stated severally that key dimensions must have a high degree of correlation with other body dimensions central in apparel sizing and design but must not correlated with one another (Robinette, 1986; Workman and Lenz, 2000; McConville et al.,1979; Beazley, 1998; Otieno and Fairhurst, 2000; Petrova, 2007). Studies by Beazley (1998) and Petrova (2007) indicated that horizontal body measurements such as chest girth, hip girth among others correlate well with one another whilst the vertical body measurements such as height, waist to ankle correlate well with each other. These key dimensions help to designate the body shape of a population (Ashdown, 1998; Workman, 1991; Petrova, 2007). Measurements of areas such as bust, waist, hip girths and height are very useful key dimensions to use as control dimensions (Ashdown, 1998; Beazley, 1998; 2004; Petrova, 2007; Otieno, 2008; Gupta and Gandhagar, 2004; Workman 1991; Tamburino, 1992a). From the study of Chung et al. (2007) they asserted that both males and females under the age of 13 years develop rapidly in both vertical and horizontal dimensions. They added that in the creation of a sizing system for children aged between 6 and 12, control dimensions should include both vertical and horizontal dimensions.

Studies by Aldrich (1999) and Huyssteen (2006) recommended that height is used as a control measurement in children's clothing. ISO/TC133 also affirms the use of height as a control dimension for growing children. This is in accordance with the findings of Lim and Cassidy (2015) of which they observed that most children apparel are designated with specific body part measurement in addition to height, which is considered the primary dimension. They added that height is used as a primary dimension for both males and females. Chung et al. (2007) opined that, weight is used in addition to height as the control dimension since a combination of height and weight could clearly describe the body shape of pre-school pupils. Also, the control dimensions differ based on the type of clothing. The neck girth measurement for instance, is used as the control dimension in the sizing of apparel that require close fit at the neck area such as men's shirts with collar. Also, men's trousers are sized by the inside leg length whereas women's trousers are designated by the outside leg length (Winks,1997).

In the determination of control variables in a sizing system, a method of factor analysis that aims to replace all data with a smaller number of uncorrelated variables termed as the principal component analysis (PCA) is frequently used (Xia and Istook, 2017). Control measurements are mainly categorised into three namely, primary, secondary, and tertiary control measurements (Beazley, 1997; Winks, 1997; Zakaria, 2014).

3.6.3.1 Primary control measurements

This is the body measurement(s) used to designate the size of an apparel for a consumer (BSI, 2001; BS ISO 8559, 2017). Primary dimensions according to Zakaria (2014) are the measurements that are used to link apparel consumers to the correct garment size, and these have effect on the goodness of fit of the apparel making them central to body size (Winks, 1997). Consumers must be conversant with the primary control dimensions as it makes it simpler for them to select the suitable size clothing (Zakaria, 2014). Although according to several authors, age is not a suitable criterion to use in sizing children's apparel (Kunick, 1984**;** Winks, 1997; Aldrich, 2009; Huyssteen, 2006; de Campos et al., 2019), James and Stone (1984) are of the opinion that, when age is added to size children's apparel, it makes it easy especially for people to purchase apparel for kids who may not be their relation by just knowing their ages. This assertion is not completely true, as children of the same age can have different body dimensions (O'Brien et al., 1941; Kunick, 1984; Winks, 1997; Huyssteen, 2006; Brown and Rice, 2014; de Campos et al., 2019). The body sizes of the image of three females of age eight shown in Figure 2.3 shows a conspicuous difference in body shapes and sizes although their ages are the same. Kunick (1984) and Winks (1997) stated categorically that the use of only age to designate an item of clothing is unreliable as it may not show the body dimensions and shape diversities. An empirical study by Tongue et al. (2010) found out from parents which method they prefer for the designation of children's clothing and eight parents out of a total of ten preferred the use of age for designating children's clothing. Two out of the total preferred the height-based sizing. A further probe as to the choice indicated that parents who preferred the age-based sizing system said so not because it helps them select apparel that fit well for their children rather because they were used to it as common practice. Others indicated no knowledge of the height of their children and not conversant with the metric system of measurements. However, parents who chose the height-based system did so as height is precise to the body type of their children. They however concluded that as used in the United

Kingdom, the preferrable method for designating children's clothing is by using height as it helps with the uniformity of pattern grading as well as it easily keeps to the development of children (Tongue et al., 2010).

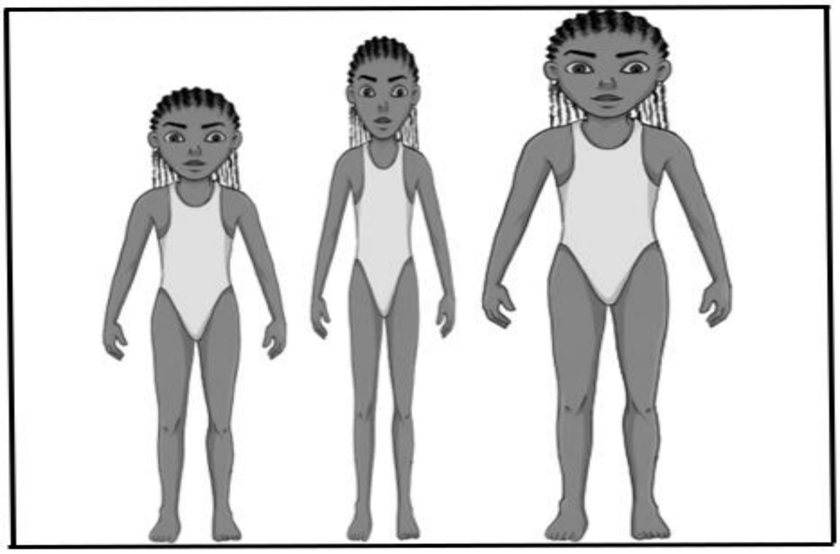


Figure 3.2: Illustration of three females of age eight (adapted from O'Brien et al., 1941)

Also, according to Bilhassan et al. (2018) based on studies conducted by several researchers including Gupta and Gangadhar (2004), Chung et al. (2007), Zakaria (2011), Gupta and Zakaria (2014) and Bari et al. (2015) proved that there are significant differences between measurements and age, they concluded that children of the same age may possess different body measurements. However, most researchers agree that sorting out data according to age helps with the analysis of data (Kunick, 1984; Aldrich, 2009; Otieno and Fairhurst, 2000). Height is the primary control or key dimension used in children's clothing (Aldrich, 1999).

3.6.3.2 Secondary control measurements

These are used in addition to a primary control dimension to designate the size of an apparel (BSI, 2001; Zakaria, 2014; BS ISO 8559, 2017). Patterns cannot be constructed using only the primary control variables. Secondary dimensions are required to adequately describe the shape of a body. These dimensions have strong correlation with the primary control variable(s) (Petrova, 2007). The classification of secondary dimensions is based on the specific item of clothing, that is whether it is worn on the torso like blouses or lower section of the body like shorts (BSI, 2002).

3.7 Significance of sizing to the clothing industry

Ashdown (2014) numerated some benefits of sizing system by stating that a developed sizing system offers apparel consumers with the best fit. It provides sufficient variation that will fit customers and at the same time limiting the number of sizes produced for efficient production and distribution purposes. Widyanti et al. (2017) viewed the practicality of sizing systems and economic matters as the key problem confronting the apparel industry. They added that devoid of standard sizing system, the accuracy, efficiency, and saleability of mass production can be greatly hampered making it less lucrative. This is further reinforced by Otieno (2008) that accurate and effective sizing and fit is seen as a marketing tool that helps in the establishment of niches and targeting customers. Chen-Yu, Williams, and Kincade (1999) added that a good sizing system is beneficial to apparel manufacturers and consumers.

3.8. Growth of children

Hildayani (2007) cited in Kusitiawan (2020) define growth as the physical development and change that takes place in an individual's body. It is a constant increase in size that is irrevocable (Balasundaram and Avulakunta, 2021). Growth, the essence of the developing organism (Gripp et al., 2013:4) is a complex process (Tanner, 2021). A good knowledge of the human anatomy and kinetics of parts of the body is the first prerequisite for the development of successful apparel (Jones, 2005; Brownbridge, 2012). According to Winks (1997), the human body changes in shape, differentiates in structure, and increases in size as it moves through the life cycle. Gripp et al.

(2013) added that during normal growth and maturation, various sections of the human body follow a predictable process. An understanding of these changes is very important for the construction of clothing that fits at each stage of the life cycle. Updates of these changes are required overtime to consider the growth rate from one generation to the other. Otieno (1999) affirmed that, the apparel production process must always begin with a study of the human body. In the conduct of anthropometric survey for clothing purposes, the child's growing body should be considered (Aldrich, 2009). Aldrich further stated that children of similar height can have different arm and leg length with variations in limb length becoming more prominent as children grow.

Like all living things, humans develop through an expected course. The human life develops through four stages namely infancy, childhood, adolescence, and adulthood. According to Article One of the United Nations Convention on the Rights of the Child (UNICEF, 2010), a child is every human being below the age of 18. There are vital changes in body size and proportions within the age bracket from zero to 18. These changes are classified under the first three stages of human growth and development consisting of infancy, childhood, and adolescence. Human growth and development are characterized by the way in which people change in size, shape and maturity relative to the passage of time (Cameron and Bogin, 2012). The changes that occur in children's body is frequent and rapid with their growth at different speed depending on the age of the child (Magnetnat, 2005).

During the childhood stage where this study focused, children begin to discover and advance a sense of independence leading to them making their own decisions and taking responsibilities for them. Medline Plus (2022), describes childhood development as the expected physical, emotional, and mental abilities of children aged 6 to 12. Medline Plus (2022) further stated that children in this age bracket have smooth and strong motor skills but their coordination, endurance, balance, and physical abilities vary. These skills can touch a child's ability to dress properly and do certain chores. It further stressed that there are significant differences in height, weight, and built among kids of this age range although genetic background, nutrition and exercise may affect a child's growth.

Significant physical development becomes very prominent during the stage of childhood between the ages of 6 and 11. At this stage, the child's body does not have shape proportion as that of an adult. The head of the child forms a larger proportion of the child's total body (Aldrich, 2009; Magnetnat, 2005). Tanner (2021) concurred, adding that the head of a newborn child is about one quarter of the child's total height whilst in adults the head form about one seventh of the total body. Thus, the physical development of humans is termed as following the cephalocaudal principle. This simply means that the growth process of humans follows a pattern based on head-to-toe progression (Santos and Noggle, 2011), where the head and upper part of the body are the foremost part to develop, making the upper part look bigger in relation to the lower body (Kusitiawan, 2020). During the growth process, the head of the child does not enlarge much as the child grows rather, the legs grow more than any other part of the body. The head through this growth process will become proportionately smaller to the whole body (Magnetnat, 2005). Magnetnat added that the body experiences uneven body shape with fat distribution developing gradually. According to Riley Children's Health (2020), children grow a little more than 5cm and put on 3kg weight on the average each year between the ages of 6 and 11. This also comes with increase in head size by 2.5cm. Riley Children's Health (2020) further declared that this growth happens sparingly within each year of growth heading towards puberty.

Human growth and development as described earlier is not a straightforward process rather it is a complex phenomenon that is genetically and environmentally influenced. One's environment can change his or her genetic potential of acquiring a particular size and shape. When the environment is neutral and does not impact negatively on the growth process then the genetic potential can be fully realised (Cameron and Bogin, 2012). Based on the discussion on growth, it is evident that Chun-Yoon and Jasper's (1995) statement that due to the rapid growth rate of children and the huge number of sizes that must be provided, sizing for children and babies is regarded as the most difficult.

3.8.1 Differences between males and females

Faster human growth and puberty comes at different times and ages for males and females. To Chung et al. (2007) age and gender are the two significant variables that affect the physique of children. Smith (2013) admitted that there are differences between males and females as they grow and noting that the maturation process for females is much faster than males. According to the International Athletics Association Federation [IAAF] (2009) and Magnetnat (2005) males commonly begin and end the stages of puberty and adolescence later than females due to changes in hormones excreted by the body. Riley Children's Health (2020) buttressed this point that, in females, the development of breast may start at the age of 8 whilst age 10 is the average. Chung et al. (2007) concurred, stating that females begin to grow between the ages of 8 and 12 years, attaining puberty about two years earlier than males. Males on the other hand attain puberty at 9 years whilst age 11 mark the average with the enlargement of the testicles, thinning and reddening of the scrotum. Cameron and Bogin (2012) agreed with this fact that males upon attaining growth spurt grow faster and attain 2-3cm of adult stature compared to females.

The growth spurt and puberty occur at different ages for females and males. Females usually start and finish the stages of puberty and adolescence earlier than males. The characteristic differences between males and females occur at puberty in response to changes in hormones produced by the body. Typically, this results in broader shoulders and little change in hip width in males and broader hips and little change in shoulder width in females. Research by Lee et al. (2014) indicated that there are several instances where the growth of children's body proportions are not based on the predicted body development but on other factors such as genetic background, nutrition and exercise. Children below 11 years of age among Black African/Caribbean in the UK stood considerably taller, heavier and had larger body size than children of other ethnicities including larger waist, limb girths and longer legs (Lee et al., 2014). Restricted nutrition and sickness may both affect the way in which a child grows and develops. According to IAAF (2009), the legs of children are almost one third the length of the body at birth and one half in the adult as the body sizes change. Changes in the size and shape of the body are also caused by different segments growing at different times.

3.8.2 Implications of children's growth and development on clothing

Based on literature on growth and development of children, it is imperative for designers of children's apparel to have adequate knowledge on body shape changes that occur as children grow. Aldrich (1999) stated that a well-designed apparel for children must always factor the child's constantly changing shape. Apparel designers must be able to identify a child's shape at a specific stage of the growth process (Aldrich, 2009). A child's growth rate is around 8cm up to the age of three. This however declines to 3cm around the age of 10 (Aldrich, 2009). Knowing the growth pattern of children and the understanding that children's figure types come in numerous variations, it is prudent to develop sizing systems for children based on variations in figure types rather than following the sizing systems developed for adults (Chung et al., 2007). Thus, children's body shape needs to be clustered by grouping similar body dimensions and proportions together in the development of sizing system (Keiser et al., 2017). James and Stone, (1984) added that children of the same age may possess different heights and body proportions as illustrated in Figure 2.6 and all children may not certainly fit into apparel made for their age group (Le Pechoux and Ghosh, 2002).

Chapter Four

Literature Review on Pattern Production and Garment Fit

4.1 Introduction

This section reviews literature on historical overview of pattern making, methods of obtaining patterns, basic block patterns for children, and the importance of pattern making. literature is reviewed on garment fit, garment fit evaluation focusing on the element used in the evaluation of fit. How to evaluate fit of garment was also discussed touching on both manual fit assessment and virtual fit assessment.

4.2 Pattern making and its historical overview

Pattern making is the graphical representation indicating the process of construction of parts of garment which in turn serve as the blueprint of a garment (Geršak, 2013). According to Datta and Seal (2018) pattern making is the art of producing patterns through the use of templates from which items of clothing and craft can be seamed. To Zaman (2014), the process of converting a two-dimensional design into a three-dimensional garment is termed as pattern making.

The history of pattern making in apparel production is not clear cut. Some events and inventions led to the development and use of patterns for apparel construction. Like the historical overview on sizing (section 3.2), the sewing machine industrial revolution in 1845 and civil wars contributed to the introduction of pattern in apparel production (Stamper et al., 1991). Kennedy (2015) adds that the creation of the tape also contributed to the revolution of patternmaking. The need for pattern drafting systems were influenced by the development of the ready-to-wear industry (Watkins, 2006). This industrial method of production also led to the production of patterns for children's clothing (Buck and Cunnington, 1996).

The process of drafting pattern used between the 18th and 19th centuries were the proportional and the direct-measure system (Kidwell and Christman, 1974; Kidwell, 1979; Aldrich, 2007; Shin, 2007; Carufel and Bye, 2020). Direct-measure system according to Carufel and Bye (2020) is the encapsulated versions of custom-made with the proportional system assumed proportionality of the human body and the notion of a single body dimension to forecast the other body dimensions. This technique of drafting culminated in proportional sizing (Kidwell and Christman, 1974; Aldrich, 2007; Carufel and Bye, 2020) and later the hybrid system (Kidwell, 1979; Shin, 2007). In the mid-19th century, paper patterns made its debut. These tissue patterns through World War II were pre-cut, with notches and drill holes to illustrate tailor's markings until the latter part of 1940 where most companies shifted to printed patterns (Vintage Fashion Guide, 2013). The clothing manufacturing process has advanced in technology particularly in the area of pattern design where the process is mainly Digitised (Petrac and Rogale, 2001). Igbo (2005) emphatically stated that without the use of patterns mass production of apparel becomes unfeasible.

4.3 Methods of obtaining patterns

There are different methods used in the production of pattern in the garment industry (Watkins, 2011). These methods of obtaining basic patterns for clothing purposes have been categorised by different authors using different synonymous terms. Naznin (2018) grouped the methods of obtaining basic patterns into three, namely paper pattern making, draping and digital pattern making**.** Patterns for apparel can be developed by drafting basic blocks, use of flat patterns and modelling or draping on the dress form (Shin, 2007; Watkins, 2011). Kennedy (2015) reiterated that though the methodologies used in the construction of the various techniques of pattern production vary. The basic goal of all the techniques is to produce the best possible 2D pattern shape to outline exactly where the fabric is cut.

Drafting is an empirical procedure used in the construction of basic pattern block. The pattern produced are very basic with no style features and are used as a basis for style development (Watkins, 2011). Modelling, a method of obtaining patterns by draping directly on the human body or dress form to capture the body in a 3D state (Silberberg and Shoben, 1998; Gupta, 2014; Duburg, 2014). Researchers have acknowledged the benefit of modelling with dress form that is characteristic of the preferred body silhouette and size (Silberberg and Shoben, 1998; Di Marco, Yuille, and Kozarova, 2010). Kennedy (2015) added that this method of pattern making always changes back to a flat pattern prior to cutting out of the clothing material. With technological advancement draping can now be created on an avatar to create a block pattern. This three-dimensional shape created on the avatar is flattened to create a two-dimensional pattern (Huang et al., 2012; Sul and Kang, 2006).

4.4 Basic block patterns

Pattern making begins with the construction of basic garment blocks (Watkins, 2011; Wren, 2017). In the process of pattern construction, 3D body dimensions are transformed into 2D patterns for the manufacture of apparel using woven fabrics (Brownbridge, 2012). A representation of the human body measurements in a flat 2D geometric shape with the addition of basic ease is termed as a block pattern (Gill, 2009; Wren, 2017). Brownbridge (2012) described basic block as a pattern tool built on anthropometric dimensions and used to establish the fit of apparel. Basic block patterns come in simple shape with no design features and styles are developed out of them (Beazley,1999; Watkins, 2011; Wren, 2017). Usually, in the construction of patterns, a Cartesian coordinate system is followed. The X coordinate represent the girth dimension such as chest whilst the Y coordinate is used to illustrate the height (Tamburino, 1992b).

Anthropometric measurements are used by patternmakers to develop accurate pattern pieces envisioned to give the anticipated design and fit (Simmons and Istook, 2003; Connell, 2006; Kennedy, 2015; Wren, 2017). Block patterns are constructed based on body measurements and instructions from pattern drafting books (Aldrich, 2008; Armstrong, 2014). Beazley and Bond (2003) stated that prior to the production of basic block patterns, some factors need to be considered. These are garment balance, ease allowance, suppression, and the impact of the fabric to be used. All these factors impact the effectiveness of developed block patterns. Garment balance and ease allowance have been discussed briefly in subsequent sections of the literature (section 4.5.1.5 and 4.5.1.2 respectively). Beazley and Bond (2003) added that posture, silhouette and body movement are equally vital factors to be understood in the production of patterns.

Developed patterns are graded to obtain different sizes. Grading is the process of systematically increasing or decreasing a base or sample size pattern to obtain different sizes that adequately complete a size range (Frings, 2014) by following specific instructions (Datta and Seal, 2018). Grading can be carried out manually or using computerized pattern making software (Datta and Seal, 2018) such as Gerber AccuMark.

Drafting, a process used in this study to construct basic block patterns, is a mathematical construction process that depends on precise computation of measurements from size charts or an individual's measurement (Beazley and Bond, 2003). These developed blocks have ease added (Gill, 2011) and are assessed for fit through sample garment trials and successive pattern adjustments (Sayem and Scott, 2018). The body dimensions of an individual can also be used to produce basic blocks for construction of made to measure clothing (Aldrich 2004; Armstrong 2010; Brownbridge, 2012). In the production of patterns, Brown and Rice (2014) noted that the bodies of children are not proportionate as that of adults therefore in the construction of patterns, pattern makers must understand the differences in children's bodies to be able to produce clothing that fit children well. The size of pattern pieces includes ease, the extra dimension that is either added to or subtracted from a body measurement (Beazley, 1999; Chen et al., 2008; Gill, 2011). Wren (2017) explained a block as a flat 2D geometric shape that is constructed from body measurements plus the inclusion of functional ease. Constructed basic blocks are first tested through the production of sample garments (Beazley and Bond, 2003). Block patterns provide perpetual evidence of the precise fit and copy of the block should be kept for future use (Beazley and Bond, 2003).

4.5 Garment Fit

The fit of a garment is an important component in judging the quality of an apparel. As stated by Lee (1994) an apparel can be ranked as top quality if it fits the potential wearer well. It also indicates the satisfaction of customers in the apparel industry (Song and Ashdown, 2010). Apparel fit is a term that is complex to define; however, fit according to Daanen and Reffeltratht (2007: 203) is the relation between body dimensions and clothing dimensions. It is the conformity of an apparel to the 3D human body (Huck et al.,1997; Workman and Lentz ,2000; Yu, 2004a; Keiser and Garner, 2008; Brown and Rice, 2014; Zakaria, 2016; Evidhya, n.d.; Wang et al., 2021). Pei et al. (2020) described fit as the conformance of an apparel to the body as well as how it looks on the body. Chen (2007) explained fit as the relationship between the size and silhouette of an apparel and the human body. To Erwin and Kinchen (1974) fit is defined as a combination of five factors; ease, line, grain, balance and set. Garment fit encompasses the direct association between the body, garment dimensions and fit preference of the wearer. Fit preference is a subjective process (Watkins, 2006; Otieno, 2008; Horwaton and Lee, 2010; Lee and Steen, 2015) that is difficult to assess as it is based on personalized perceptions. Fit preference is the expectations a wearer of an apparel has on fit of his or her garment (Ashdown and Dunne, 2006; Ashdown and O'Connell, 2006; Ashia, 2020). Whereas some individuals prefer garments that fit loosely on their body shapes others fancy garments that fit closely to their body shapes (Feather et al., 1996; Stamper et al., 1991; Brown and Rice, 2014; Song and Ashdown, 2010). The subjective issue of fit is as a results of the wearer's discernment of fit and also influenced by several other factors (Song and Ashdown, 2010; Stamper et al., 1991; Brown and Rice, 2014) such as fashion, style, fabric (Song and Ashdown, 2010; Stamper et al., 1991) gender, age, body shape, lifestyle (Brown and Rice, 2014; Stamper et al., 1991) religion, occupation and race (Stamper et al., 1991). Additional factors that relate to fit preferences are culture, fashion, norms (Zhang, Zhang and Xiao, 2011) and occasion (Shin and Damhorst, 2018).

A study by Ashdown and Delong (1995) also revealed that individuals have different preferences for tolerance of fit based on their body parts and fit preferences also differ from one nation to another (Winks, 1997). According to Apeagyei (2010), accurate clothing fit hinges on the measurement and classification of the human body which is central to the manufacturing and consumption of garments. Sindicich and Black (2011) concurred, stating that there is an interconnection between sizing and fit as the suitability of fit is strongly affected by an apparel's size. In the view of Gribbin (2014), accurate fit of apparel is centred on the body silhouette and not size or dimensions. Gribbin added that increasing the prospect of good fit, can be achieve if garment patterns are characterised by the three-dimensional human body however, contrary, proper fit is contingent on several factors of which body silhouette is key, but size and measurements are equally important since they are crucial in the pattern production process. Additionally, the final good fit of an apparel is dependent on the relationship between materials used in conjunction with body form, pattern production and fashion trends (Jevšnik et al., 2015). Fit adverse issues are not only born by consumers but retailers and manufacturers in returned goods and lower profits (Mcvey, 1984). Chung, Lin and Wang (2007) acknowledged that when an item of clothing has a good fit it does not disturb the growth and movement of the child's body. To conclude, good fit is desired by individuals of all ages especially during childhood as this phase is marked by high growth rate and body development (Kang et al.,2001).

4.5.1 Garment fit evaluation

Fit evaluation is an intricate process. This is the process through which the interaction of the human body and garment is judged (Ashdown and DeLong 1995; Loker et al., 2004; Alexander et al., 2005). Fit evaluation looks at the construction of the apparel and its comfortability on the wearer (Pritchard, 2013). This process is described by Otieno and Fairhurst (2000) as investigational studies conducted to methodically investigate a product using a sample of the product. Janice, Oprah, and Younghee (1997) asserted that appropriate garment fit hangs on the relationship of the apparel size in relation to the wearer's body size. According to Brlobašić Šajatović et al. (2019) the fit of apparel is evaluated based on a variety of factors linked to the overall construction of the apparel. As espoused by Stamper et al. (1991); Shen and Huck (1993) and Song and Ashdown (2010) garment with a good fit offers a smart and smooth appearance, provides extreme comfort and enables the wearer to move freely. This is affirmed by Laitala, Klepp and Hauge (2011) that a good fit is accomplished when the garment offers freedom of movement and comfort to the wearer.

Developed sizes can be validated through mathematical formula or fit trial. With the use of mathematical formula, Gupta and Gangadhar (2004); Zakaria (2016) use aggregate loss of fit to validated developed sizes. This study however, evaluated developed sizes through fit trial. In the conduct of fit trial, the fit of an apparel could be assessed objectively and subjectively (Jevšnik et al., 2015). Fit trial can be carried out through the use human fit model, dress form (Pheasant, 1986; Le Pechoux and Ghosh, 2002; Bougourd, 2007) or virtually (Watkins, 2011). Jevšnik et al. (2015) enunciated that a live fit model can be any person regardless of age, gender and built. Fit models are a representation of the statistical average based on both body dimensions and shapes (Crawford and Kung, 2010 cited in Kennedy, 2015). In 3D virtual fit testing, a 2D garment pattern is virtually sewn onto a parametric mannequin to assess the fit of the patterns (Watkins, 2011).

Evaluation of fit is done by experts, the fit model and the final consumer at different phases and with each having distinct aims (Hernández, 2018). To assess fit objectively, Ashdown et al. (2004) stressed that the use of trained persons as judges in the evaluation of fit render data that is valid and consistent. Ashdown et al. (2004) emphasized that during fit evaluation, the correlation between the body and the apparel is judge based on the criteria for good fit. Thus, a well-fitting apparel transcends the interaction between body and apparel dimensions.

In fit evaluation of apparel, all sections of the apparel are assessed (Brown and Rice, 2014). To carry out fit trials of developed sizes, the base size is selected from the size range and used for the production of sample garment that will be tried by a live fit model (Workman and Lentz, 2000). A well fitted apparel is comfortable when worn with enough roominess to allow for easy movement, consistent with current fashion and without unpleasant wrinkles bulges and sags (Stamper et al; 1991). Rasband and Liechty (2006) emphasize that apparel with good fit does not cling, pull or twist when worn but rather drapes smoothly over the contours of the body and it is an important component of customer satisfaction (Marshall et al., 2004). Thus, garment fit is greatly influenced by the dimensional tolerance allowed between human body and apparel (Aplin, 1984). Besides the personal and social factors that have effect on the standard of fit, several researchers (Stamper et al., 1991; Yu, 2007; Chen, 2007; Brown and Rice, 2014) numerated five factors that is used to evaluate good fit in apparel originally espoused by Erwin and Kinchen (1974). These are grain, ease, line, set and balance and these factors are interrelated and used in the evaluation of different but connected parts of garment. After the fit of the sample garment has been certified, the corrected pattern shape can be transferred to cardboard as durable pattern template for production (Kennedy, 2015). Beazley and Bond (2003) added that grading rules can be applied after validating the pattern.

4.5.1.1 Grain

To evaluate the fit of apparel, the fabric grain is a vital element to consider in the construction of apparel with a good fit (Stamper et al., 1991) and garment quality (Brown and Rice, 2014). Brown and Rice (2014) stated that, to obtain an accurate fit the apparel must be cut on-grain since such apparel have smoothly and symmetrical on the body. Grain is the orientation of the yarn that make up a fabric (Brown and Rice, 2014 p. 160). Two set of yarns are present in woven fabrics. There are three types of grain found in fabrics, namely straight or lengthwise grain, the cross grain, and the bias grain. Straight or lengthwise grain runs parallel to the selvedge and when followed to cut out apparel they run perpendicular to the ground (Brown and Rice, 2014; Stamper et al., 1991).

4.5.1.2 Ease

The difference in dimension between the body and the clothing of a potential wearer is termed as 'ease' (Huck et al., 1997; Alexander et al.,2005; Daanen and Reffeltratht, 2007; Petrova, 2007; Otieno, 2008; Brown and Rice, 2014; Bubonia, 2014; Keiser, Vandermar, and Garner, 2017; Datta and Seal, 2018; Hernández, 2018; Naznin, 2018). Chen et al. (2008); Gill and Chadwick (2009);

Wren (2017); Kim, Nam, and Han (2019) all define ease as the addition of extra dimension to the body size to make allowance for body movement, to control micro-climate (Kim et al., 2019), extension, and expansion. Sindicich and Black (2011) noted that the correct ease is a prerequisite for good fit. Ease is vital in the evaluation of fit of an item of clothing and the amount required in an apparel is a problematic matter (Branson and Nam, 2007). It is subjective (Alexander et al., 2005) when it comes to individuals. Some individuals prefer loose fitted clothing whereas others like tight fitted clothing. Ease has a correlation with the style of an apparel and the personal preference of the consumer (Petrova, 2007; Xia and Istook, 2017) and it is mainly added at the pattern construction phases (Gill, 2011). The amount of ease allowance needed in an apparel hinge on the location on the body, style of apparel and type fabric (Beazley, 1998; Otieno, 2008; Datta and Seal, 2018). The amount of ease allowance also depends on figure type. According to Bray (2003) larger figure types need more ease allowance for expansion.

Ease is mainly categorised into two as basic or fitting ease and design ease (Beazley, 1998; Stamper et al., 1991; Otieno, 2008; Brown and Rice, 2014; Petrova and Ashdown, 2008). Chen et al. (2008) and Kim et al. (2019) on the other hand, grouped ease into three with Chen et al. (2008) categorising theirs as standard ease, dynamic ease, and fabric ease and Kim et al. (2019) naming theirs as motor functional ease, comfort ease and styling ease. Basic or fitting ease also termed as wearing or garment ease is the amount of ease added to the actual body dimensions of the apparel consumer to give room for rudimentary movements like walking, reaching, sitting, and breathing (Marshal et al., 2004; Branson and Nam, 2007; Song and Ashdown, 2010; Brown and Rice, 2014; Bubonia, 2014). Petrova and Ashdown (2008) added a twist to the definition of wearing ease with the inclusion of the concept comfort, by describing it as the extra fabric required for comfort, mobility, and drape of the garment. This definition is apt as the absence of basic ease will result in uncomfortable apparel that is tight, wrinkled and easily wears out. Basic or fitting ease is the same as what Chen et al. (2008) termed as standard ease and Kim et al. (2019) called motor functional ease. This type of ease is required in most apparel without spandex regardless of the style (Brown and Rice, 2014). Basic ease is added to some circumferential as well as vertical measurements. Circumferential measurements requiring basic ease include chest/bust, waist, hip, neck, biceps and thigh girth whereas vertical measurements requiring ease include shoulder to waist and waist to crotch (Brown and Rice, 2014). Fitting ease vary between men, women, and children. Besides the fitting ease, is the design or style ease. This type of ease assimilates the fitting ease together with any added or extra fullness required to accomplish an anticipated design or silhouette (Song and Ashdown, 2010; Brown and Rice, 2014; Bubonia, 2014). Design or style ease commensurate with what Chen et al. (2008) termed as dynamic ease. Fabric ease on the other hand, considers the effect of mechanical properties of fabrics used in the apparel (Chen et al., 2008). 'Comfort ease' by Kim et al. (2019) is synonymous to Chen et al.'s (2008) 'fabric ease'. They noted that this ease has to do with the control of microclimate in an apparel and the avoidance of friction building up between the wearers body and the fabric.

A study by Ashdown and Delong (1995) also revealed that individuals have different preferences for tolerance of fit based on their body parts. Ease allowance is added to various body dimensions to create a garment measurement chart (Gupta and Gangadhar, 2004, Beazley, 1998). Close-fitting apparel needs less fitting ease as compared to a loose-fitting garment (Otieno, 2007; Beazley, 1998). Also, in the determination of ease allowance, the apparel underneath must be reflected upon as this may necessitate an additional measurement to cover the garment under (Aplin, 1984).

4.5.1.3 Line

Line is important in garment fit (Stamper et al., 1991). This is the configuration of the structural line of the garment as against the hypothetical lines of the body (Brown and Rice, 2014). Line is made up of seams, darts, hems, grain of fabric, tucks, fabric folds (Stamper et al., 1991) that are applied to the 2D fabric for it to fit the contours of the body to help bring out the shape of the silhouette. Lines that run vertical on the body such as side seams and centre front and back lines should hang straight on the body and perpendicular to the floor. Curve lines as girth seams at the waist, armholes and necklines must lie flat and smooth on the body (Brown and Rice, 2014).

4.5.1.4 Set

This is one of the elements that is used in the assessment of good fit. This has to do with the smooth fit of an apparel on the body free from unpleasant wrinkles in all directions (Brown and Rice, 2014; Stamper et al, 1991). This type of wrinkles arises as a result of the apparel being too large or too tight on the intended wearer with the direction of the wrinkle serving as a clue in the analysis of fit issues (Brown and Rice, 2014; Stamper et al., 1991).

4.5.1.5 Balance

Balance according to Stamper et al. (1991) and Rasband and Liechty (2006) is the proportional relationship between a garment and its wearer's body and how it fits. Balance focuses on parts of an apparel possessing equal visual weight. (Principles of Fashion Design, 2020). Brown and Rice (2014) noted that balance correlate strongly with line and grain. Adding that in instances where structural lines in an apparel does not match lines of the body, the hang of the apparel will be out of balance. In the same instance, apparel cut off-grain will be out of balance and with an irregular hang.

CHAPTER FIVE

METHODOLOGY

5.1 Introduction

This section focused on the procedure deployed in undertaking this research. The chapter outlines the methodological approach to the study, research design, the study locale, population, sampling, procedure for collecting primary data, methods of data analysis and ethical considerations. It demonstrates how the research results were obtained in connection with the research objectives. The research methodology utilised in this research was guided by international anthropometric standards.

5.2 Framing of the study

Based on the purpose of this study to develop accurate national sizing system and size chart for Ghanaian children to aid mass production of ready-to-wear garments for the apparel market, the framework proposed by Ashdown (2002) serves as a strong basis for this empirical study and informed the methodological approach used for this study. Ashdown's (2002) framework shows the factors that relate with the creation of a sizing system. The framework by Ashdown identifies how sizing systems are established on current and accurate body measurements as well as the need for good representation of the population. According to Ashdown (2002), the determination of ranges in a sizing system (smallest to largest) and variations (differences in proportions) in populations are centred on population measurements. Anthropometric data on the population are obtained through traditional tailor's measurement, traditional anthropometry, or three-dimensional body scanning. In the traditional tailor's method, a measuring tape is used to take body measurements with the hand along contours of the human body between two points. Ashdown (2002) noted that measurements of a particular body part may vary from a measurer to the other as landmarks and placing of the tape measure may differ. Adding that posture moves can notably decrease the accuracy of measurements taken with this method. Therefore, in the collection of anthropometric data using the traditional method, precautions must be in place to minimize errors. In contrast to the traditional tailor's measurement method is the anthropometric measurement method where several anthropometric tools such as anthropometers (a standing tool that measures straight linear distances), callipers (measures linear depths and widths), and calibrated measuring tapes are used to take body measurements (Ashdown, 2002). These tools were developed to make data collected from the population as valid and reliable as possible. The third is the use of computer aided methods where anthropometric data are collected through a non-contact and indirect means such as three-dimensional body scanner (Lescay et al., 2016, Wang et al., 2007; Le Pechoux and Ghosh, 2002; Connell et al., 2006).

To obtain a garment that fit a population, a sizing system needs to be developed bearing in mind the functional needs of clothing which include provision of freedom of movement to it wearer and to make the wearer safe from the vagaries of the weather. In this sense, garment sizing plays a critical role as poor fit may defeat the purpose of protection and safety of the wearer (Laing and Sleivert, 2002). To Watkins (2006); Otieno (2008); Horwaton and Lee (2010), the preference for fit is subjective and very difficult to assess because it is centred on individual's opinions for both the wearer and an expert. A successful sizing system is attained when a wearer feels satisfied in his or her garment (Emanuel et al.,1959). A good sizing system must be communicated to customers using tools such as labels after its successful development (Chun-Yoon and Jasper, 1993) and this should be simple and self-explanatory for consumers to effectively select the appropriate sizes.

5.3 Methodological approach to the study

As espoused in the preceding section, the approach to this study's methodological design was guided by Ashdown's (2002) theoretical framework on sizing systems. To fulfil the main aim of this study which sought to develop an accurate national body sizing system and size chart for Ghanaian children aged 6-11, a hypothetical framework (Figure 5.1) was established that outlined the main variables and critical areas probed.

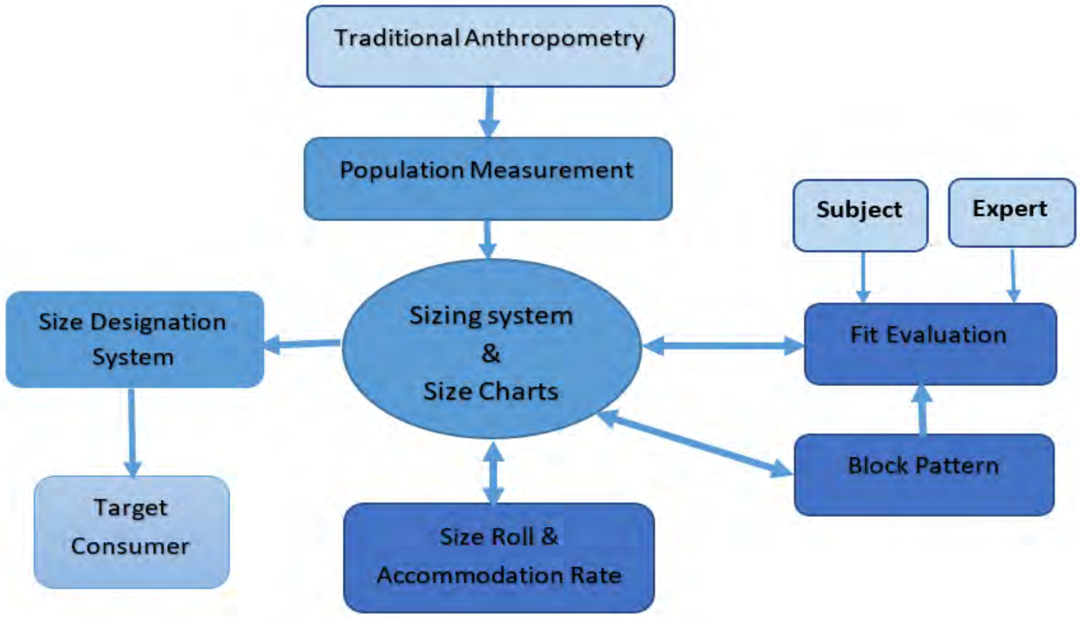


Figure 5.1: Hypothetical framework

The central focus of this hypothetical framework in Figure 5.1 is the sizing system and size charts which is the goal of this study. The framework shows interconnection and interaction of sizing systems with block patterns and fit evaluation process. Sizing systems and size charts are obtained from accurate and current data collected through traditional anthropometry in the form of population measurements. These are analysed into sizes that are used in the construction of basic block patterns for the production of sample garments to evaluate the fit of the developed sizes.

The traditional anthropometric data collection procedure aided in the establishment of current population measurements on Ghanaian children population. Accurate and current data on the population plays a very crucial role in developing a good sizing system. Researchers (Ashdown, 2002, 2008; Zakaria, 2016) have posited that the quality of the sizing system is dependent on the quality of the data collected which should be current and representative of the target population. To obtain representative data on the population for this study, data collection cut across children's population ethnically, religiously, and geographically.

After obtaining the accurate and current population measurements, the data was processed through statistical analysis to generate body measurement tables which were further processed through various statistical methods to identify key dimensions for classifying the population from which sizing systems were developed. The developed sizes were labelled resulting in the generation of size designation system which is the last process in the generation of sizing system. This is the aspect of the sizing system that is communicated to the target consumer on the apparel labels. Once the sizing system is developed and labelled, the next phase is to validate the sizes. Sizes were validated first through the sizes roll and accommodation rate. Validation through sizes roll and accommodation rate goes back to the sizing system if there are amendments to be made. For example, if a size accommodates less than one or two percent of the population, that size is eliminated, and this also affect the size roll (number of sizes).
For fit evaluate of developed sizes size charts which include the addition of ease to create garment measurements were developed and used to construct basic block patterns to ascertain the fit of developed sizes through fit trials. Fit evaluation is done using participants and experts. The outcome of the fit assessment influences the developed sizing system as illustrated in Fig 5.1. That is issues with the fit of sample garments goes back to the sizing system and size charts. The pattern may be altered, and the fit trial repeated if a good fit is not achieved.

5.4 Procedure to undertake anthropometric study

Bougourd et al. (2000), Honey and Olds (2007) and Ujevi´c et al. (2011) all asserted that in the conduct of anthropometric research, definite procedures need to be followed to attain standardised, precise, and consistent data comparable with different populations. The research methodology utilised for this study is discussed in detail following the diagram in Figure 5.2. under the broad heading; primary data collection procedures in anthropometric survey.

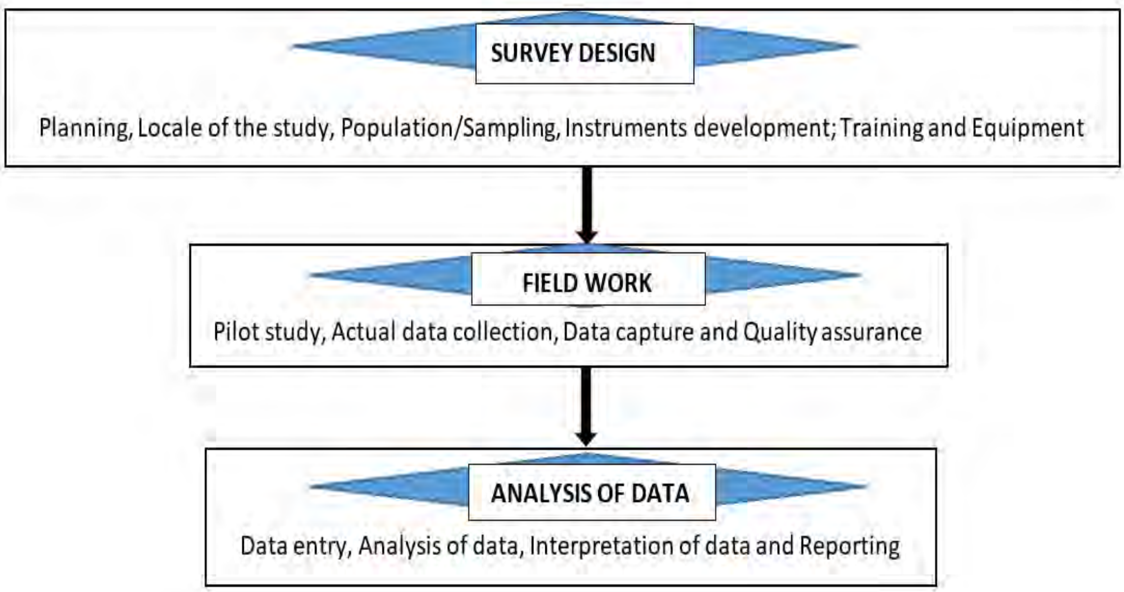


Figure 5.2: Primary data collection procedure in anthropometric survey
Source: Adapted from WHO and UNICEF (2019)

5.5 Survey design

There are different methodologies available to select from in the conduct of research and this may depend on the aim of the research. This study used the survey design as stated in Figure 5.2. A survey design is among the commonest and widely used designs in social and behavioural science research (Babbie and Mouton, 2007; Vogt, Gardner and Haeffele, 2012). Survey is the gathering of information regarding the characteristics, actions, or sentiments of a sample of pre-determined population (Kelly et al., 2003; Pinsonneault and Kraemer, 1993 cited in Glasow, 2005) and using the information to make inferences on the wider population (Kelly et al., 2003; Dawson, 2017). Survey design was economical (Kelly et al., 2003; Vogt et al., 2012; Dawson, 2017) and applicable to use to collect data from a large section of the population in a comparatively short time frame (Mentz, 2012). It permitted the use of diversity of methods in the selection of participants and the use of numerous survey instruments in the collection of data (Ponto, 2015). According to Vogt et al. (2012) survey as a research design has some demerit associated with its use. These are related to clarity of information on the instrument for data collection, nature of the information thus, difficult to recollect or sensitive and the type of responses given by the research participants. With these demerits in mind, the survey instruments for this study were designed considering the target population (Mentz, 2012).

Surveys are classified according to the time dimensions under longitudinal and cross-sectional. Cross-sectional survey was used in this study as data was collected from a cross-section of the population at a single point in time (Ary, Jacob and Razavieh, 2002; Punch, 2003; Gripp et al., 2013). According to Kroemer et al. (2018), body proportions of individuals vary in precise measurements in arm length, height, among others hence gathering data from the population must generally be by cross-sectional survey where participants are measured around the same point in time. Hulley et al. (2007); Campbell et al. (2007); Gripp et al. (2013) further confirmed the duration by stating that in cross-sectional design, measurements are taken at one point in time without any follow-up. The research used the cross-sectional design as it does not require years to complete hence less expensive.

This survey though conducted using a modified method for anthropometric research due to the Covid-19 pandemic, where parents/legal guardians were trained to assist in the collection anthropometric measurements (detailed description in section 5.5.7- procedure for data collection), the researcher ensured that international standards were used to ensure validity and reliability of the results. This survey was carried out in conformity with BS EN 13402 (2001) standard. This standard focuses on manual measuring procedures, landmarking and suitable garment to be worn for the measurement process. Survey research can deploy research strategies such as quantitative, qualitative, or mixed methods (Ponto, 2015) and this study basically focused on quantitative research strategies.

5.5.1 Quantitative research design

The quantitative research approach was used for the study as the study focused on the collection of numerical data in the development of sizing system and size charts. The quantitative research design according to Ary et al. (2002), Gaur and Gaur (2009) and Babbie (2016) focuses on the use of objective measurement and statistical analysis of numerical data to interpret a phenomenon that is reflected in the observation. Quantitative research involves the quantification and subjection of collated data to statistical treatment in order to support or counter alternate knowledge claim (Creswell, 2003). To Leedy and Ormrod (2001) quantitative research builds on existing theories and is exact in it surveying and experimentation. Collection of data is numeric with the researcher using mathematical methods in the analysis of data (Creswell, 2003; Punch, 2003). Ary et al. (2002) added that quantitative research design requires a well-controlled setting.

5.5.2 Planning

In the conduct of a successful anthropometric survey, the first phase is planning. The planning phase embodies thinking through all the other processes such as the area(s) to conduct the survey, the population to work with, the sample to use, development of all required documents, training, and selection of equipment. The decision to conduct preliminary study is also done at this stage. Zakaria and Gupta (2014) concurred by stating that anthropometric planning phase consists of the preliminary study, determination of sample size and coordination of all field activities. This study was planned thoroughly to ensure that body measurements collected from the children epitomized children in the general population in Ghana and less of errors. Also, due to the covid -19 pandemic, the methodology that is commonly used to collect anthropometric data from a target population had to be modified and this entailed a lot of planning to arrive at a procedure to conduct the survey in a safe and valid manner.

5.5.3 Locale of the study

The primary data for this study was collected in Ghana, a country located in West Africa with Burkina Faso to the North, Cote d'Ivoire to the west, Togo to the east and the Gulf of Guinea to the south. It resides on a land area of 238,538 square kilometres. Ghana has a tropical climate controlled by dry northeast continental air mass and moist equatorial system from southwest. The country basically has two seasons, the dry and rainy seasons with a mean annual temperature between 26^{O} and $29\,^{O}C$ (Berry, 1995). The country is divided into 16 regions (Figure 5.3), with Accra as its capital town. The population of Ghana is heterogenous consisting of a considerable number of ethnic groups (Lentz and Nugent, 2000). There are several linguistic groups in Ghana with English as the official language. Ghana is a religious country with Christians constituting 71.2% of the population, Muslims represent 17.6%, African traditionalist are 5.2%, and the remaining 6.2% making up other forms of religions (Ghana Statistical Service [GSS], 2021).

Ghana, the first black African country south of the Sahara to gain its independence from colonial rule in 1957 had a period of political instability after the overthrow of the first president in 1966. The first, second and third republican constitutions were also overthrown by the military until the fourth. The fourth multi-party republican constitution has been in force since 1992 stabilizing the country. The country's population has grown over the years. It was estimated at 6.7 million in 1960. By 1970, the national census registered 8.5 million people representing a 27 percent increase. This further increased in 1984 recording 12.3 million people. In 1990, the population of Ghana further increased to 15 million. Ghana's official population during the census in 2010 was estimated at 24,658,823 (GSS, 2012). The population of Ghana has grown over the years, according to the GSS (2021) as of 2021 the population was estimated at 30,832,019. The population of children between the ages of zero and 14 is 38.01% of the population whilst 18.63% are between ages 15 and 24. The population of people aged between 25 and 54 is estimated at 34.15% (Index Mundi, 2019). The percentage of children is very significant in the Ghanaian population.

5.5.4 Population and sampling

Just like other anthropometric studies on children (Zakaria, 2016; Widyanti et al., 2017; Bilhassan et al., 2018) the population for this study consisted of male and female pupils from both public and private primary schools in Ghana between the ages of 6 and 11. This age range was selected based on the International Association of Athletics Federation's [IAAF] (2009) description of the stages of growth and development from childhood to adulthood. To them, age 10 marks the childhood limit for females while age 11 marks the same for males. This study therefore made the age range for participants from 6-11 so that both males and females are adequately catered for. Additionally, the age range of 6-11 was used as that marks the beginning and end of age range for primary education in Ghana (Ministry of Education, 2019). Ghana a former British colony had its school system fashioned after the British educational system until 1st September 1987 where the system was changed. Currently, the country runs two years of pre-primary education, six years of primary education followed by three years of Junior High School

(JHS) education after which learners proceed to do three years of Senior High School (SHS) education. Generally, pre-primary education starts at age three and ends at age five with primary education beginning from age six to eleven, junior secondary education begins at 12 to 15 and senior secondary education from age 15 to 18 or 19 from which student proceed to tertiary institutions. Thus, formal structure of education in Ghana operates on a 2-6-3-3-3 or 4 - System. Data for the population was based on Enrolment Data of 2018/2019 academic year. The population of public primary school pupils as at 2018/2019 academic year was 3,217,783 whiles that of privately own primary schools was 1,293,485 making a total population of 4,511,268. Table 5.1 gives the breakdown of the enrolment data of 2018/2019 academic year of primary schools in Ghana.

Table 5.1: Enrolment in primary schools by type of education in Ghana-2018/2019 academic year

Data on public schools							
Gender	**Classes**						**Total**
	P1	P2	P3	P4	P5	P6	
Males	274,368	271,117	283,377	248,176	271,337	257,114	1,641,489
Females	262,446	261,385	270,983	271,673	261,982	247,825	1,576,294
Total	536,814	532,502	554,360	555,849	533,319	504,939	**3,217,783**
Data on Private schools							
Gender	**Classes**						**Total**
	P1	P2	P3	P4	P5	P6	
Males	131,746	120,471	111,757	103,586	94,130	83,461	645,151
Females	130,143	120,192	112,600	104,419	85,075	85,075	648,334
Total	261,889	240,663	224,357	208,005	190,035	168536	**1,293,485**
Grand Total (public and private schools)							**4,511,268**

Source: Ministry of Education [MOE] (2019)

Sampling is the process of extracting a subset from a sampling frame or target population for the purpose of investigation (Taherdoost, 2016; Mohsin, 2016). Sampling is one of the important subjects of research designs since in most instances it is unfeasible to study an entire population

(Sarantakos, 2005; Ary et al., 2002). Sarantakos (2005) added that sampling must be selected in a very systematic and unbiassed manner ensuring that the process is well-defined. The selection of sample for anthropometric survey needs to be carried out cautiously since factors such as gender, age, ethnic origin, and socio-economic status are used to group participant for an efficient data collection and analysis (Ashdown, 1998; Gupta, 2014).

The sample size for the study was calculated using Taro Yamane's formula for sample size determination (Yamane, 1967). This equation has been used to select sample size in different anthropometric studies (Mokdad and Al-Ansari, 2009; Odunaiya, Owonuwa, and Oguntibeju, 2014; Taifa and Desai, 2016). The study was based on a confidence level of 95% with an error margin of 5% (0.05). The Taro Yamane formula is presented as;

$$n = \frac{N}{1 + N\,(e)^2}$$

Where:

n = Sample size

N = Population

e = Margin of error

Substitution of numbers in formula for the sample size for pupils in public primary
b schools

$$n = \frac{3{,}217{,}783}{1 + 3{,}217{,}783\,(0.05)^2}$$

$$n = \frac{3{,}217{,}783}{1 + 3{,}217{,}783\,(0.0025)}$$

$$n = \frac{3{,}217{,}783}{8{,}045.46}$$

$$n = 399.99$$

$$n = 400$$

Substitution of numbers in formula for the sample size for pupils in private schools

$$n = \frac{1,293,485}{1 + 1,293,485\ (0.05)^2}$$

$$n = \frac{1,293,485}{1 + 1,293,485\ (0.0025)}$$

$$n = \frac{1,293,485}{3,234.71}$$

$$n = 399.87$$

$$n = 400$$

The total sample size for the study consisted of the sample size calculated for public school plus the sample size for private schools bringing the total sample size to 800 participants. According to Pheasant (1990) in the conduct of anthropometric survey, a sample of 500 to 1000 participants could be adequate. The sample size of 800 was used for this study considering the five main points outline by Daniel (2012) which include the objective of the study, type of the population, the research design, resources, and ethical concerns.

The estimated sample size was adjusted upward by 20% to cover for non-response and ensure that minimum sample size does not drop drastically in other to affect the power of the study. According to Bujang (2021), after obtaining the minimum sample size, it is necessary to add extra to accommodate potential non-responses from participants. This is to prevent underestimation of sample size as non-responses are an anticipated problem in research. Bujang (2021) suggested recruiting a percentage of 20 to 30 more participants in addition to the minimum sample size.

Based on the novelty of this study's methodology, the volunteer recruitment method of selecting participants and suggestion by Bujang (2021), all culminated in the decision to increase the estimated sample size upward by 20%. The number of participants used in anthropometric study is a replication of the anthropometric dimensions in the survey population. Thereby the larger the samples size the more precise the collected anthropometric data will be (Beazley, 1997; Hsu, Lin and Wang, 2007). Carufel and Bye (2020) concurred by stating that good quality sizing system is built on anthropometric data collected from a large and representative target population.

The study deployed a multistage sampling procedure. Sample was drawn through a mix sampling approach using purposive sampling, a non-probability sampling method and random sampling a probability sampling strategy. Selection of participants was solely dependent on their willingness to take part in the study (Gerring, 2012). Participants were selected without any cognisant bias; as participants who volunteered to be part of the study were included in the study sample. To ensure reliable population spread in this study, the study's sampling was carried out in four stages: selection of regions, selection of metropolitan areas and municipal districts, selection of schools and finally selection of participants. As alluded by Mcleod (2015), the generalisability of research outcomes to the target population is feasible if sample used in a study is representative of the target population. The study adopted the segmentation of the country into three by the Ministry of Special Development Initiatives (MSDI) (2019) based on the geographical locations of regions. The ministry has segmented the country into three areas, namely Coastal Development Authority area, Middle Belt Development Authority area and Northern Development Authority area as illustrated in Figure 5.3.

Purposive sampling method was used to select one region from each developmental authority area due to the nature of the study. In developing a sizing system for a nation that is multi-cultural, it is necessary to select samples from regions that are more heterogeneous in nature and densely populated. Purposive sampling is a sampling procedure in which elements are carefully chosen from the target population based on their suitability with the purposes of the study. In purposive sampling elements are not selected simply based on their availability and convenience but rather, the researcher purposely selects the elements because they fulfil specific inclusion and exclusion criteria for participation in the study (Babbie and Mouton, 2007; Daniel, 2012; Denzin and Lincoln, 2013). Laher and Botha (2012) added that in quantitative research, sample selected should best estimate the characteristics of the study population. To obtain a representative sample of the Ghanaian population for children, Greater Accra, Ashanti, and Northern regions with their multi-cultural status were selected for the study.

Greater Accra region was purposively sampled from Coastal Development Authority area. Tuoyire et al. (2018) in their study stated that, Accra is a cosmopolitan area that give a relationship between traditional and modern cultures due to urbanization and accompanying social changes. This makes the area an ideal place to carry out research related to body sizes. Greater Accra region host the capital of Ghana and according to the 2021 Population and Housing Census the region is currently the most populous region in Ghana (GSS, 2021). Ashanti Region was selected from Middle Belt Development Authority area. The region is the second most populous region in Ghana (GSS, 2021). The Region is also a cosmopolitan area that is ideal to undertake research. The Northern region was chosen from the Northern Development Authority area. The region is the most populated in the Northern Development Authority area with a percentage of 7.5 out of the total population in the country (GSS, 2021). Selected regions and their corresponding Development Authority areas have been illustrated in Figure 5.3.

The second stage of sampling was the selection of a metropolitan area and a district in each of the three regions. The city of Accra the metropolitan area was purposively selected, and Ga West municipal district was randomly selected from the Greater Accra Region. From the Ashanti Region, Kumasi metropolis was purposively selected and the Ejisu municipal district was randomly selected. Tamale metropolis which is the third largest city in Ghana and the populous in the Northern region was purposively selected. The population mainly consist of the Mole-Dagbani people who are found in all the regions in the northern part of Ghana. Sagnarigu municipal district was randomly selected in the Northern region.

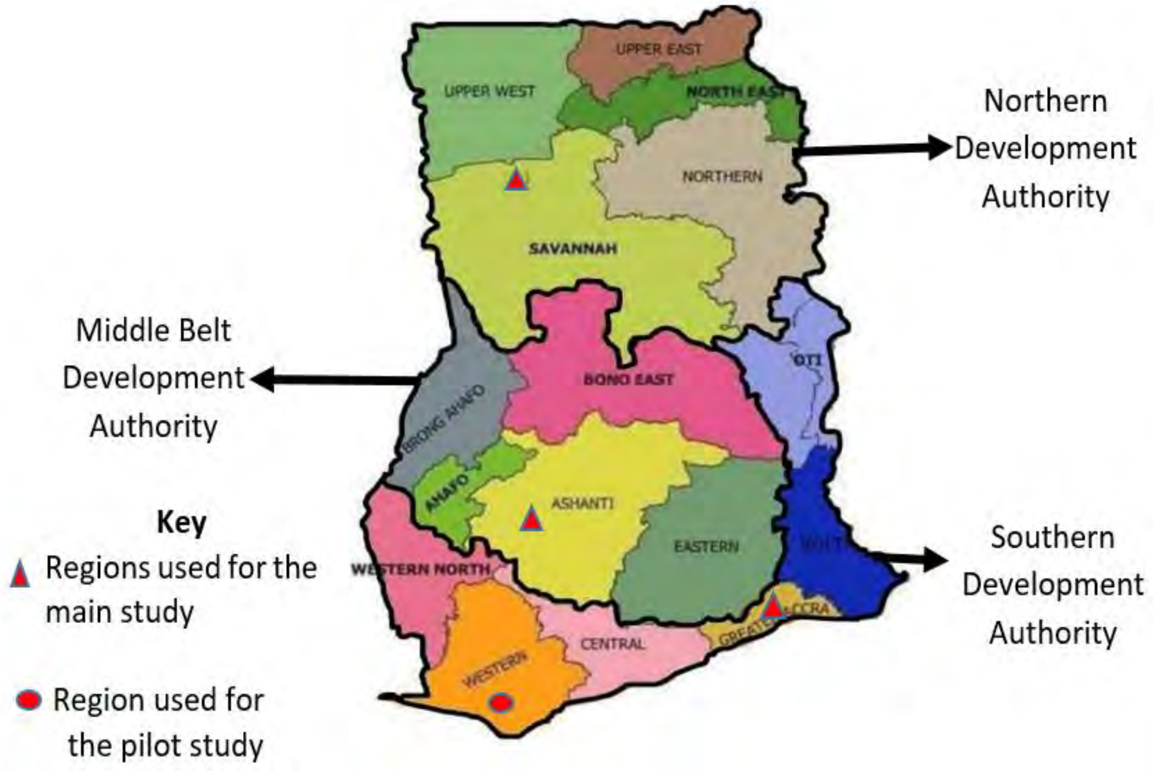


Figure 5.3: Ghana map indicating areas used for data collection

Four schools were randomly selected in each region. Two schools from each metropolitan area and two from each municipal district. In each area the two selected schools consisted of one public and a private school. This was to ensure that a representative sample of Ghanaian children were selected for this study as empirical evidence by Fiawoo (1979) indicated that Ghanaian females aged ten in privately owned schools were six centimetres taller than females of the same age in state owned schools. Also, the females in state owned schools in the Greater Accra were two centimetres taller than females in rural areas in Southern Ghana. This sampling approach is in line with the study by Bilhassan et al. (2018) where samples were selected from both public and privately own schools in the city of Benghazi.

The voluntary sampling method was used to select the participants upon receipt of both consent and assent forms from parents and participants respectively. This is the selection of potential participants who willingly agreed and qualified to be part of the survey (Murairwa, 2015). Participants then indicated their wish to be part of a sample and this method is also termed as self-selection sampling (Saunders, Lewis and Thornhill, 2019).

Murairwa (2015) added that the success or failure of this sampling method is contingent on promotion and pilot sampling. Elder (2009) advocated that precise findings can be generated from volunteer sampling method on the premise that high number of the population willingly return the data collection instruments. Additionally, in selection of sample, the principle of sampling that states that the method used in drawing the sample must ensure all individuals have equal chance of being part was not breeched. A call to participate was made in all selected schools for parents and participants to willingly be part of the study (Wallin, 1949).

The flow diagram in Figure 5.4 gives a simpler representation of the process of sampling used for this study. According to Huyssteen (2006) the procedure to select sample to survey must be detailed to enable interpretation of the data as well as to compare with other survey results. Additionally, several researchers have stressed the need for a representative sample during surveys (Henry, 1990; Bartlett et al., 2001; Ary et al., 2002). Taylor (1990) noted that there are local physical traits to be considered in the conduct of anthropometric survey that necessitate the spread of samples across a country. The study also focused on validity of the data by ensuring that participants used in the anthropometric survey corresponded with the target population (Kouchi, 2014).

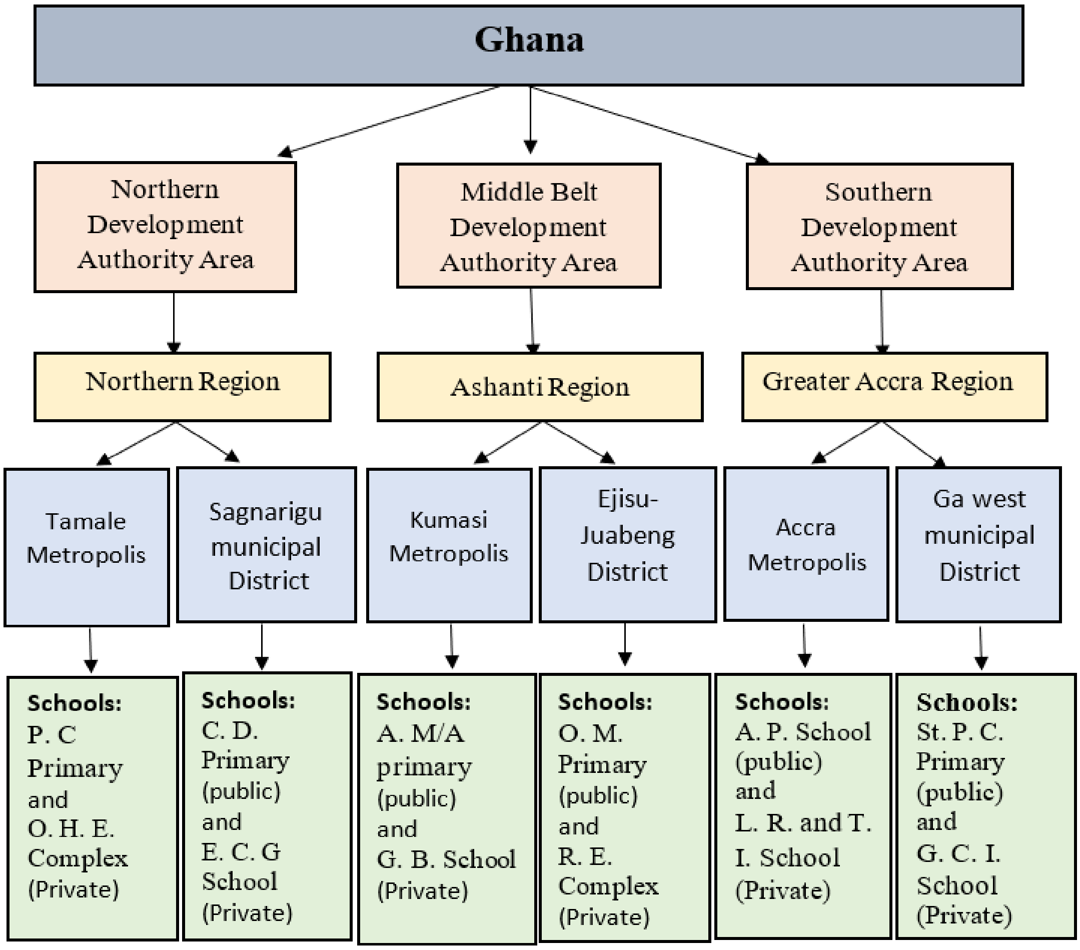


Figure 5.4: Flow chart of the processes of sampling for the main study

5.5.5 Data collection instruments

This section covers all the documents designed in connection with this study. These documents include the manual body measurement guidebook, participant information sheet (for parent/legal guardians), age-appropriate participant information sheets for ages 6-8 and 9-11, incident reporting form, withdrawal form**,** consent and assent forms for parents/legal guardians and participants respectively. The body measurements sheet (BMS) and fit assessment sheet were also developed for data collection. Demonstration videos in English and Twi (most popular Ghanaian language) were produced. Also, letters to the gate keeper and the schools were developed under this section.

Apart from the demonstration videos, all instruments used were paper-based. All though data was collected in a Covid era where the use of web-based instruments would have been ideal, this was not a convenient option. Considering the target audience, their geographical location, and the nature of the survey, using paper-based instruments were applicable as majority of the target populations may not be responsive to web surveys. Also, in terms of accessibility some the target population may not have access to a computer or an internet connection that is reliable at home. Paper records were used in this research in order not to cut off qualified and willing participants especially those from areas where internet penetration may be low since at the time of data collection in 2021, internet penetration in Ghana was about 50% (Kemp, 2021).

5.5.5.1 Manual body measurement guidebook

The manual body measurement guidebook (Appendix 2) consisted of text and colourful images of the manual body measurement processes. The text described the area of the body to be measured. The measurement guidebook was very handy, precise, and concise and served as the source of reference in matters relating to body landmarking and overall manual measurement process. This was to help guide parents and legal guardians to take accurate body measurements of their children for this study.

5.5.5.2 Manual body measurement demonstration videos

The demonstration videos were produced to illustrate to the parents/legal guardians the processes of measuring their children. The posture the child should be in and how to appropriately handle the tape measure to take the body measurements and record the measurements on the data sheet were all illustrated. This was to ensure that parents/legal guardians and participants are certain on the areas and how to accurately measure the participants. Videos easily attracts most individuals due to its blend of speech, images, and text. Usually, it is much easier to get to the point much quicker. The use of demonstration videos helped to create a personalized learning experience. Parents/legal guardians and the participants could go through the video at their own pace. Also, the instructional videos can be watched repeatedly as required in order to grasp the procedure effectively. The demonstration videos were hosted on MMUtube and the link distributed to participating schools. Copies were also shared to schools that requested to have copies via WhatsApp and other platforms.

5.5.5.3 Participant information sheets (PIS)

All potential participants were given enough information through the participant information sheets. This sheet described the research to enable participants to decide whether or not to take part in the study. Three separate PIS were developed. Firstly, the PIS was developed for the parents/ legal guardians (Appendix 10) to enable them to understand the nature of the research, what is required of them if they agree to participate, how the information they provide will be used and assurance of their anonymity if they agree to participate. The remaining two participant information sheets were developed based on the ages of the participants and their level of comprehension. PIS was developed for children ages 6-8 (Appendix 8) and ages 9-11 (Appendix 9). Both PIS were written in plain English suitable for the age ranges of the participants. This was important to ensure the children fully understood what the research was about and what was required of them if they decide to participate.

5.5.5.4 Consent and assent forms

Consent form (Appendix 6) was developed for the parents/legal guardians who willingly agreed to participate in the study to append their signature to show that they have agreed to be part of the study and that they understood what the study was about. The children on the other hand were given the assent form (Appendix 7) to circle 'Yes' or 'No' to simple questions to show their willingness to be part of the study. If the child answers yes to all the questions, it indicates his or her willingness to be part of the study. The child after completing the form, must write his or her name to authenticate the information provided.

5.5.5.5 Incident reporting form

Although, the study did not foresee any adverse risk to the participants, nonetheless an incident reporting form (Appendix 13) was designed, and copies deposited at the schools so that if any incident is reported it could be logged in. Copies were also in the possession of the researcher on her visit to the schools so as to log in any incident if reported. There was however no reported incident during the data collection process.

5.5.5.6 Withdrawal form

Participation in this study was voluntary and based on the premise of full understanding of the participant's involvement. It was the right of any participant and parent/legal guardian who had already consented to participate in this research to withdraw at any time with or without any reason. This means that any participant and his or her parent/legal guardian could withdraw consent via any means favourable to them including telephone communication to the school authorities or the researcher if they no longer wished to take part. Copy of the withdrawal form can be seen at Appendix 11. In the process of data collection for this study, none of the participants withdrew consent.

5.5.5.7 Body measurement sheets (BMS) and measurements collected in the study

This is the document that was used to record demographic and anthropometric data from the participants. It was developed based on an extensive review of related literature and the recommendations by Croney (1980) to design recording sheets ahead of time. It was reviewed by the supervisory team for the sequencing of the measurement processes. The BMS (Appendix 1) consisted of three sections. The first section consisted of demographic information such as age of participant, type of school, ethnicity among others. The second section consisted of the body measurements collected in this anthropometric research. The final section consisted of one Likert scale question that sought to find out from parents/legal guardians their confidence level in measuring their wards for the study. The body measurement sheet was included in the pack given to parents who willingly accepted to be part of the study.

The number of body measurements collected in an anthropometric survey varies from one researcher to the other based on the purpose of the anthropometric study. This is also based on the importance and purpose to which the design product will be used (Murteira, 1993 cited in de Campos et al., 2019). It was added that the norm was to select the height and girth dimensions that can be located easily on the body and covering the torso and extremities. Several researchers (Otieno, 1999; Bari et al., 2015; Zakaria, 2016; Widyanti et al., 2017**;** Bilhassan et al., 2018) in anthropometric studies on children have worked with different number of body dimensions. Zakaria (2016) in her study collected 50 body measurements from each participant to develop clothing sizing system for children in Malaysia. Bilhassan et al. (2018) collected 26 body dimensions from each participant in their study. Bari et al. (2015) measured 40 body dimensions from each participant. In Otieno's (1999) study on Kayan children, 32 body dimensions were collected from participants whose ages ranged between three and six.

For the purpose of this study, 35 body measurements were collected including weight and height. Height and weight measurements were added as they were both important in creating anthropometric data on children. Each selected measurement had significance for the production of apparel patterns. ISO 8559 (1979); BS EN 13402 (2001) and BS ISO 8559-1 (2017) standards were consulted in the selection of suitable measurements. These standards, have a number of body measurements suggested as essential in the production of certain apparel consisting of the primary control measurements along with the secondary control measurements. All the body dimensions of the participants were obtained manually, using anthropometric tools and equipment such as Sacca 213 portable stadiometer, calibrated flexible measuring tape among others. The measurements collected in this study can be used to produce different types of apparel such as school uniforms, dresses, blouses, skirts, shirts, trousers, pyjamas, among others. Table 5.2 shows the list of measurements that were collected in this study. Description and illustrations of all the 35 body measurements collected in this study can be seen in the guidebook at Appendix 2.

Table 5.2: Body measurements collected in the study

1.Height 2. Weight		
Girths Measurement	**Horizontal and depth measurements**	**Vertical measurement**
3. Head girth 4. Neck girth 5. Chest/Bust girth 6. Waist girth 7. Hip girth 8. Armscye girth 9. Upper arm/ Biceps girth 10. Elbow girth 11. Wrist girth 12. Thigh girth 13. Knee girth 14. Ankle girth	15. Shoulder length 16. Back Shoulder width 17. Scye depth length 18. Across chest 19. Bust point width 20. Across back 21. Shoulder to Elbow (bent) 22. Outer arm length (bent) 23. Crotch length 24. Body rise	25. Nape to waist 26. Nape to floor (contoured) 27. Base of throat to waist 28. Front neck point to waist 29. Torso height 30. Waist to hip 31. Waist to knee 32. Waist to ankle 33. Waist to floor 34. Knee to floor 35. Inside leg length/ Crotch to floor

According to Gupta (2014) some measurement that are problematic to measure by linear measures such as shoulder slope, neckline depth and width and armhole curve were approximated during the pattern construction process.

5.5.5.8 Fit evaluation sheets

The fit evaluation sheets (Appendices 29 and 30) were developed based on fit criteria espoused by Betzina (2003) and Amaden-Crawford (2012). This was used to evaluate the fit of toiles constructed from the developed size chart to validate the sizes. Fit evaluation sheets were designed separately for males and females.

5.5.6 Procedure for data collection

This study was undertaken during the Covid-19 pandemic and the use of 3D scanners would have been appropriate as the technology would have eliminated contact between measures and participants during the process of measuring. Also, 3D scanners are faster, more precise, and effective (Bougourd, et al., 2000; Istook and Hwang, 2001, Istook and Hwang, 2001; Xu and Huang, 2003; Bretschneider, et al., 2009; Connell et al., 2006; Makhanya et al., 2014). Although the 3D scanner would have been invaluable equipment in this anthropometric survey, its availability was beyond the reach of the researcher as is the case in most studies.

Also, the use of trained persons to collect manual anthropometric data is the norm when collecting data for clothing purposes, however, the collection of manual anthropometric data for this study using trained research assistants was not practicable due to the corona virus pandemic. Manual body measurement procedure involves close body contact between measurers and individuals to be measured. A successfully piloted remote data collection method was adapted. The remote approach to collect anthropometric data has been used in the field of science (Yoong et al., 2013; Chai et al., 2019; Ghosh-Dastidar et al., 2020) for several studies but new in the area of apparel design. Chai et al. (2019) conducted a study in Australia with the aim to ascertain the level of accuracy when parents are made to measure and report on height and weight, as well as body mass index. Their study found out that the anthropometric data collected by the parents were fairly accurate in reporting child height and weight between the ages of 4 and 11 years. Most of the collected data when used to calculate weight category were compared with objectively measured data and both data were similar. Their study thus concluded that obtaining child data from parent is a valid method of collecting child anthropometric data. A study by Ghosh-Dastidar et al. (2020) compared a remote method to collect anthropometric data from a sample using videoconference-assisted measurements procedure and measurements collected by a trained person. The findings of the study revealed that there was no significant difference between remotely collected data and data collected in person by trained personnel. Additionally, a study conducted by Haddad et al. (2022) during the Covid-19 pandemic revealed that remote anthropometric data on persons aged 3-18 could be beneficial due to the general resemblance with data collected by experts in person.

The study therefore used parents/legal guardians in the collection of anthropometric data on their children. Parents/legal guardians very often measure their children or send them to dressmakers and tailors to measure and construct apparel for them, making most Ghanaian parents/legal guardians privy to the process of manual measuring. Ghana is a country that depends mainly on manual measurement process to produce apparel, making the procedure the most common method used in Ghana for the collection of body dimensions for the purpose of clothing construction. Made-to-measure apparel making approach is a common means of acquiring apparel in Ghana and this according to Guerlain and Durand (2006) entails the use of accurate body measurements appropriate for the manufacturing process.

Additionally, parent/legal guardians were used in this study to assist in data collection as parents are the most significant individuals in the lives of children (Centre for Disease Control and Prevention, 2021). This was affirmed by the empirical research by Morrow (2004) where she ascertained that parent especially mothers, were very important to children in her study. Also, to Lewis et al. (1995) cited in Zakaria (2016) children and tweens with ages ranging between 9-12 are influence in terms of what to wear and how it is to be worn principally by their parents. These children rely on their parents for ideas regarding fashion selections (Lewis et al., 1995 cited in Zakaria, 2016). Tongue et al. (2010) in their study stated that in the consumption of clothing, parents/carers and their children act as joint consumers. Also, body landmarks are easily identifiable on this category of children and positions to be measured were clarified by the developed body measurement guidebook and demonstration videos making it simple for parents/legal guardians to accurately locate landmarks on the body. According to Beazley (1997a) the manual anthropometric method of collecting anthropometric data is viewed as the most appropriate for children's wear. Inferring from the empirical studies cited it was conclusive that parents/legal guardians in Ghana were in a good position to assist with the collection of accurate anthropometric data this research.

Data for the fitting trail was obtained from parents and experts. Thus, for the fitting trail, aside using parents who voluntarily agreed to be part of the fitting trail, experts were also sampled for an objective assessment of the fit of the toiles. Expert sampling involves the compilation of a sample of individuals with recognised or demonstrable experience and expertise in a field (Anaekwe, 2002). In this study, 3 experts were sampled. These experts have master's degrees in Home Economics with Clothing and Textiles option and with over 14 years teaching experience in Fashion design (pattern and garment construction). The sampled experts all possess at least 10 years of industrial experience in apparel manufacturing. The three experts were contacted on phone by the researcher, briefed on the study and their assistance sort. All three experts willingly agreed to be part of the fit evaluation process.

This survey was therefore conducted using manual anthropometric equipment and procedure to collect the primary data. The study was undertaken in conformity with reliable international standards such as the British Standards Institution (BSI) (2017) BS ISO 8559-1:2017, BSI (2001) BS EN 13402-1: 2001, BSI (2002) BS EN 13402-2: 2002, and BSI (2003) BS EN 13402-3: 2003 to ensure reliability and validity of the results in conformity with the statement by Saunders et al. (2019) that validity and reliability of research are vital for the quality of research.

Data collection was done through the participants' schools. Permissions sought from the Ghana Education Service (GES) and heads of participating schools were granted. The schools then liaised between the researcher and participants and their parents/legal guardians regarding the data collection process.

To aid the successful collection of data, packs were put together by the researcher and distributed to participating schools for onward distribution to parent/legal guardians who have indicated consent to be part of the study. The pack illustrated in Figure 5.5 contains the manual body measurement guidebook (Appendix 2), BMS (Appendix 1), calibrated tape measure, pencil, pen, eraser and a 100cm chord.

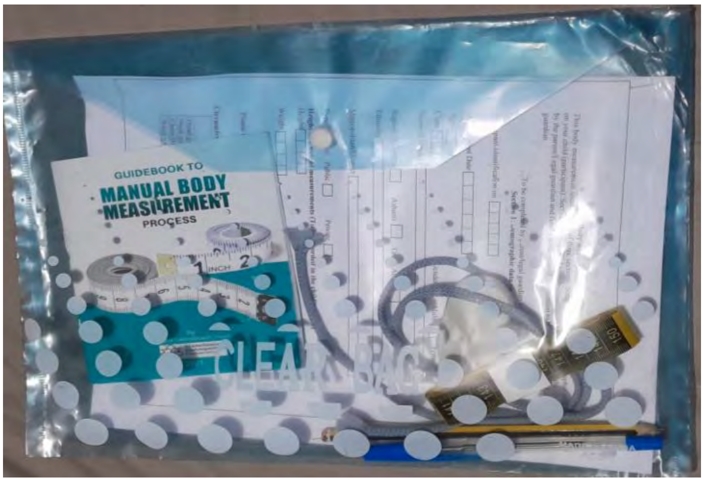


Figure 5.5 Pack given to parents/legal guardians for data collection

All items except for the manual body measurement guidebook and BMS were procured on wholesale basis by the researcher in Ghana. The tape measures were calibrated by the researcher using a standard steel ruler. The chords were also bought in bundles and cut into 100cm lengths. Images related to the items in the packs can be seen at Appendix 12.

5.5.6.1 Training of parents/legal guardians and selected staff of participating schools

According to Roebuck (1995) traditional body measurements procedure requires knowledge of the human anatomy focusing on names, landmarks and bone shapes or muscles in addition to handling and interpretation of reading on measuring equipment. The publication suggested that individuals that assist in the collection of anthropometric data must be trained and tested in measurements techniques. This is to ensure that they all adhere to the prescribed procedures; since a lot of factors such as posture of the participants, landmarks identification, handling of equipment among others all hinges on the measurement of participants which is error-prone (Ashdown, 2002; Muenier and Yin, 2000; Kouchi, 2014). de Onis et al. (2004) agreed by stating that the main aim of engaging in standardised training is to empower the measurers to measure precisely and without bias. This is confirmed by Chuan et al. (2010) stating that the accuracy and reliability in collecting human body measurements is attained with practice preceding to the data collection process. Huyssteen (2006) adds that an anthropometric survey can only be successfully structured and completed if it is conducted with accuracy, consistency, and reliability as cornerstones. Daanen and Byvoet (2011) stated that taking body dimensions at home is time consuming. Adding that the measurements are susceptible to errors if the measurer at home does not have specific measuring equipment and precise instructions on the measurement process. Parents and some staff of selected schools were trained to minimalize the intra and inter-observer error (Kouchi et al., 1996). This is affirmed by Mislihah (2005) cited in Widyanti et al. (2015) that training of persons to assist in anthropometric data collection possibly will eliminate intra and inter- observer errors.

To undertake manual anthropometric study on children in a developing country in a safe and consistent manner (in a Covid-19 era), parents/legal guardians and some staff of the participating schools were guided with a step-by-step manual body measurement guidebook and demonstration videos to enable them to accurately measure their participants at home for the study. Parents/legal guardians are the persons with the responsibility of planning the purchase of clothing for children between the ages of 6 and 11. These parents know the characteristics of growing children in terms of experiencing rapid growth. Smith (2013) reiterated that children within this age range are mainly influenced and directed by their parents. Also, a good knowledge of the dimensions of a child’s body is vital to aid in the selection of a size that accurately fit a child (Stamper et al.,1991). Many publications focused on anthropometric data collection process admit that the measurer taking the measurements must possess a good knowledge and skill of the human body in addition to possessing the skill to create a respectable rapport with the participants by making them feel at ease during the measurement process (O'Brian and Sheldon 1941; Kemsley 1957; Croney, 1980; Lohman, 1988; Beazley 1996). The process of collecting anthropometric data on children in Ghana using parents is even made easier with strong bond or relationship between parents (mothers) and their children. The bond between Ghanaian mothers and their children is very strong because they always keep their children very close whilst the children emulate them through observation (Rodriguez, 2014).

The parents/legal guardians and participants after given consent, were trained with a manual body measurement guidebook (Appendix 2) and guided with two demonstration videos in two languages for easy understanding of the measurement process. This colourful measurement guidebook (Appendix 2) has pictures to help parents/legal guardians understand the landmarks, location of the landmarks, posture, and the measuring process. Links to the two demonstration videos uploaded on MMutube and on the researcher’s google drive were distributed to the schools for onward distribution to parents/legal guardians of participants. The videos were also distributed via WhatsApp. These served as additional training process to ensure that parents/legal guardians accurately and effectively measure their children for the study. The content of the demonstration videos explicitly showed parents/legal guardians the process of measuring. It showed how to appropriately handle the tape measure to measure smoothly along the contours of the child's body and how to read and record them on the data sheet. Additionally, they were shown the appropriate posture and encouraged to check the posture of the participant as they take the body measurements. This is because the accuracy of manual body measurement is affected greatly by shifts in posture by the participant being measured (Ashdown, 2002; Kouchi, 2014). For instance, Kouchi (2014) noted that the orientation of the head of participants being measured has effect on the accuracy of measurements such as height and neck girth. The body structure is distorted with poor posture during measurement process. This may in turn affect vital body parts such as shoulders and buttocks to be misaligned (Rasband and Liechty, 2006) thereby, parents/legal guardians were trained on ensuring the child always maintained the right posture during the measurement process.

Simmons and Istook (2003) and Kouchi (2014) reiterated that observer error is the most common error with the collection of body measurement, and these includes inaccuracy to locate landmark, posture, and use of measuring instrument. This study thus ensured that parents/legal guardians and participants were certain on the areas to measure and how to accurately measure the human body. Parents/legal guardians and the participants had the opportunity to watch the video at their own pace and repeatedly as required in order to grasp the procedures effectively. The video can be paused whenever required and continued from where one left off. With the instructional video, the measurement procedure can be rehearsed cognitively. It can be stopped, and the concept thought through. In addition, the measurement guidebook and the videos illustrated the posture suitable for the measurement process.

This manual anthropometric study ensured that standardisation is adhered to. According to de Onis et al., (2004) this can be achieved through comprehensive training, continuous standardisation, and constant monitoring of the measurement procedures during data collection in the quest to reducing random error and bias in measurement on the part of the measurers. Adequate resources were designed and used to train parents. Regarding the monitoring of the measurements process, this was not possible as all the measurements except height and weight were collected at the participant's homes. The BMS therefore had one Likert scale question at the end that sought to ascertain from the parents/legal guardians their level of confidence in measuring their wards for the study. This was to show the researcher the level of certainty in measuring their children.

5.5.6.2 Landmarking and measurement of the participants

With the body measurement guidebook (Appendix 2) and demonstration videos, parents were directed on how to landmark the body of their children for this study. Taylor's (1990) recommendation of using one well-trained and experienced person to identify and label the landmarks in manual anthropometry for the purpose of consistency was not feasible in this study however, researchers in the area of anthropometry have stated that adequate training helps to minimize the level of errors in anthropometric data landmarking and subsequent data collection. Identification of landmarks is a crucial element in anthropometric data collection process since it is vital to recognise the position in relation to the alignment of the tape measure (Kohlschütter, 2012). Kemsley (1957); Tamburrino (1992a); Beazley (1997); Bougourd et al. (2000); Honey and Olds (2007) and Brownbridge (2012) all opined that standardisation of methods used to collect body measurements is important. For instance, measurement of the waist girth can differ based on proximity of the measurement landmark to the hip or the ribs. This may in turn affect another dimension such as waist to hip or waist to knee (Brownbridge, 2012). The ISO 8559 (1989) describes the waist girth as the circumferential measurement of the natural waistline upper section of the hip bones and the lower section of the ribs. Studies have used various approaches to measure the natural waistline. In the study by Chung et al. (2007) they used the navel as a guide in measuring the natural waistline. This study however, adopted the method of tying a string snugly around the waist to define the natural waistline and at the same time serve as a guide in the measurement process. Other measurements taken from the waist level became simpler since measurements started from the tied chord. The parents/legal guardian in this case the measurers were required to measure the participant in minimal clothing. This was vital so that the measurer could excellently evaluate the positions on the surface of the skin to place the tape measure (BS EN ISO 20685, 2010). Wren (2017) in her study noted that body measurements collected over clothes will not result in body surface dimensions needed for the construction of close-fitting blocks.

With the exception of height and weight that were collected from the participants' schools all the body measurements were collected by parents/legal guardians of participants. Anthropometric body measurements were taken snugly on the body but not tightly (Clayton, 1994) and were measured on the right side of the participants' body since the population of right handedness far outnumber that of left handedness. Also, the right hand is slightly bigger than the left side if that is the participants dominant hand (Bari et al., 2015; Bilhassan et al., 2018). Unlike the study of Cheng et al. (2018) that collected anthropometric data from the participants' dominant hands and legs, they first determined the dominant hands based on their hand preference in writing, using cutlery among others and dominant legs on the other hand was on based their leg preferences used in kicking balls. Collecting the measurements from one side of the participant's body help minimize the interaction between the measurer and the participant and hastens the measurement process. Reading and recording of measurements were done twice and the average of the two readings were calculated and used as the anthropometric measurements for each participant.

5.5.7. Tools and equipment used for the anthropometric data collection

Very simple and basic tools were issued to parents/legal guardians for the collection of data.

1. Calibrated tape measures were given and used to take all circumferential and length measurements. The accuracy of the measuring tapes were checked to ensure all tapes used had an accuracy level of 0.1 mm (Wang et al., 2002) before adding to the pack (image at Figure 5.5) that was given to each of the parents/legal guardians.
2. A sacca 213 portable stadiometer (image at Appendix 12) was used to measure the height of the participants in their schools. The stadiometer was used to measure height as it is a perfect instrument for measuring height (Centres for Disease Control and Prevention, 2007). The stadiometer was calibrated with an accuracy level of 0.1 mm (Wang et al., 2002).
3. A sacca digital weighing scale (Appendix 12) was used to measure the weight of each participant in their schools. The digital weighing scale was calibrated with an accuracy level of 0.01kg (Wang et al., 2002).
4. A chord cut 100cm long was also added to the pack that was given to the parents/legal guardians. This was used to tie around the waist girth to locate measuring positions for the waist level.

5.6 Data analysis techniques

This is an important aspect of the sizing development process. Watkins (2006) and Brownbridge (2012) reiterated that a sizing survey may not automatically produce well sized apparel. The data collected during the survey needs to be analysed cautiously. Kelly (2005) concurred by stating that, the raw anthropometric data does not make much meaning unless it is analysed statistically to make it purposeful. Also, the efficacy of anthropometric survey is centred on the transformation of the collected data through statistical analysis into adaptable data that is used to resolve challenges in design (Kemsley,1957). In this study, critical review of literature was conducted in partial fulfilment of all the study's objectives. Objective one is a literature related aim that was further satisfied through completion of the pilot study. This objective evaluated standardised measuring procedures applicable in this study. These include:

a. Identification of procedures for measuring children between the ages of 6-11 in a pandemic situation.

b. The selection and development of standardised measuring instruments for manual remote anthropometry.

c. The development of standard procedures and proper guidelines for measuring and data capturing.

Objective two focused on the development of anthropometric database of body measurements of Ghanaian children from six to eleven years. It was guided by BS ISO 8559-3 (2017). The data was computed using IBM Statistical Package for Social Sciences (SPSS). First, the data was edited and screened for outliers (Winks, 1997; Kline 2005) and normality of data confirmed before analysis, using the Shapiro-Wilk's test (Garson, 2012). Descriptive statistics were used to describe and encapsulate the characteristics of the study sample (Hinton, McMurray and Brownlow, 2014). Under descriptive statistics, frequencies and percentages were used to describe demographic characteristics of the participants. Means and standard deviations were computed for all the body measurements. Minimum and maximum values were also calculated to generate body measurement tables to fulfil objective three. In terms of average value, mean according to

Beazley (1998); Otieno (1999, 2008); Vronti (2005) and Kuma- Kpobee (2009) is the most frequently used for creating size steps.

Additionally, some inferential statistics were computed. Pearson correlation coefficient was computed to ascertain the interrelationship between the body dimensions. T-test and one away analysis of variance (ANOVA) were used to analyse the research questions. This was necessary to comprehensively understand the data set before probing further to develop the sizing system and size charts.

To fulfil objective four, the development of standardised sizing system, the principal component analysis (PCA), the cluster analysis and the empirical rule were applied. PCA is the statistical analysis that was used to select the key dimensions in the study. PCA is a frequently used technique to ascertain the most critical variables (Jackson, 2003) and their relationships in order to resolve more intricate design problems (Gupta, 2014). PCA, a method of factor analysis was used to reduce all variables into significant components. The PCA has been used successfully by a lot of researchers (Salusso et al., 1985; Gupta and Gangadhar, 2004; Guan et al., 2012; Xia, 2013; Zakaria, 2016) in clothing anthropometry for the selection of key variables. Guan et al. (2012) in their truck driver anthropometric study made use of PCA to reduce 12 dimensions into three principal components (PCs) separately for both males and females with 88% and 87% accounting for the total variance for males and females respectively. Azouz et al. (2006) acknowledged that PCA has been used in body shape analysis. These researchers made use of principal component analysis to determine a limited number of components that can adequately represent the variation of modes of the human body. Covariance-based structural equation modelling (CB-SEM) software of IBM AMOS version 20.0 was used to validate the extracted factors. This helped in the assessment of the model fit indices, convergent validity, and discriminant validity (Kline, 2005; Byrne, 2016; Hair et al., 2016).

Cluster analysis, a data mining technique that permit objects that possess similar features to be put together to aid additional processing was used. This analytical technique is effective for creating significant subgrouping of participants with the aim to categorise a sample into smaller groups based on resemblances (Hair et al., 2019). The study by Hsu and Wang (2005) used data mining technique to create sizing system and stated that the data mining has been used extensively in other fields but not very popular in the area of sizing. About seventeen years down the line, this technique has been used extensively by many researchers (Abdali et al., 2004; Hyussteen, 2006; Paquet and Viktor, 2007; Hsu, 2009; Xia, 2013; Zakaria, 2016) in clothing sizing. According to Hsu and Wang (2005) the data mining technique for sizing creation yields an extensive coverage of body shapes encountered in the population with minimal number of sizes, consistent patterns and rules for sizing creation and gives reference points to aid production.
The K-means algorithm according to many researchers (Pham, Dimov and Nguyen, 2004; Hsu, 2009; Morissette and Chartier, 2013; Zakaria, 2016) is a common data-clustering algorithm which is simple and gives best results when used studies. Cluster analysis or taxonomy analysis was used to group the participants into homogenous groups with similar body sizes. This multivariate technique was performed using K-means cluster analysis. This popular data clustering technique involves the pre-determination of the number of clusters. Morissette and Chartier (2013) and Larose and Larose (2014) added that it split up the dataset into non-overlapping groups with the aim to produce clusters with high resemblance within each cluster and low degree of resemblance between clusters. This was used to group participant bodies into clusters that are alike with one another and different to participants in other clusters (Kaufman and Roussoouw, 1990; Han and Kamber, 2001; Paquet and Viktor, 2007; Dubey et al., 2018 cited in Ahmar et al.,

2018). In K- means cluster analysis, variables move around clusters with the aim of increasing the between-cluster variance while reducing the within-cluster variance (Huysteen, 2006; Hsu, 2009). The empirical principle was further used to generate the sizes based on the clusters. Developed sizes were labelled and validated through size rolls and accommodation rate. Outliers were also determined.

To fulfil objective five, size charts were developed based on the established sizes in the sizing system. Percentile values guided the size chart development process. After the creation of the size charts, the sizes were validated through fit trials. Basic block patterns were produced following Aldrich's (2009) pattern cutting book entitled 'Metric pattern cutting for children's wear and babywear: from birth to 14 years. The functional ease used in her book was also adapted. Aldrich's pattern cutting book was used as it is a popular pattern cutting book used in Ghana.

Base sizes in reference to critical review of pattern construction books and suitable method for pattern production adopted and used. Fit testing was carried out on live fit models (selected participants) and assessed by experts in the industry and academia as well as parents/legal guardians together with their children who in this case were the of live fit models.

5.7 Pilot study

A pilot study is very important in a study that seeks to develop a standardised sizing system for children. Also, using a novel approach to data collection in the field of Fashion design required the conduct of a pilot study to test the procedure before embarking on the main study. According to the Collins English Dictionary (2014) a pilot study is an experiment, or a set of observation carried out on a small scale to determine when and how to embark on a full-scale project. A pilot study is directly linked to a larger study and is conducted to pave the way for the main study (Lancaster, Dodd and Williamson,2004; Eldridge et al., 2016). A pilot study was conducted to test the instruments for data collection, timings and establishing the sequence of data collection process (Oppenheim, 1992; Moser and Kalton, 1993; Kelly et al., 2003; Sarantakos, 2005). According to Hassan et al. (2006) it is unsafe to skip pilot study regardless of how painstaking a study has been strategically planned as there is the possibility of unanticipated or unexpected challenges. Fraser et al., (2018) added that pilot study encompasses a plan for alleviating risk in other to decrease the likelihood of failure in a larger study. Thus, the pilot study was conducted on a small scale to test the feasibility of the proposed research methodology, research techniques and equipment in preparation for the larger study (Stewart, n.d. as cited by Hassan et al., 2006; Zakaria and Gupta, 2014). Additionally, the pilot sampling was conducted to ascertain the level of enthusiasm of potential participant in taking part in this research (Murairwa, 2015).

The pilot study was conducted in Sekondi-Takoradi in the Western region of Ghana. An estimated sample size of 80 participants representing 10% of the actual proposed sample size for the main study was projected to be measured (Oppenheim, 1992) however, on the field a sample size of 118 participants were used since parents and participants upon reading the participant information sheet volunteered to be part of the pilot study. The researcher worked with the new figure for the pilot study because in surveys the larger the number of samples the more representative the results of the study will be. Samples were selected from three different schools. N-W basic primary, a public school was randomly selected from the Sekondi-Takoradi metropolitan area and K. A. M. A., a private school was also selected from the same metropolitan area. The A/A D/A ‘C’ primary school in Aboadzi/Abuesi, a town in the Shama district was also randomly selected.

Participant information sheets were dispatched to parents and participants through the schools' authorities. Consent and assent forms were also lodge with the schools for interested parents/legal guardians and participants to pick a copy and endorse to indicate their intention to be part of the study. As at the end of March 2021, a total of 121 parents and participants had endorsed and returned the consent and assent forms to the various schools. The data collection pack containing manual body measurement guidebook, BMS, calibrated tape measure, pencil, pen, eraser, and a chord measuring 100cm long was picked up by parents or given to participants to send to parents to carry out the measurement process.

5.7.1 Findings of the pilot study

It was ascertained from the pilot study that the schools do not have current height and weight data of the participants in the schools. This was because schools were closed during the Covid period, and some schools also do not keep such data on the pupils. All participating schools agreed to assist in the collection of current height and weight data on their pupils from the schools during physical education session times using calibrated instruments provided by the researcher. Height and weight measurements do not involve very close contact between measurers and participant compared to the other body dimensions collected in the study. Height and weight measurement were recorded on the data sheet of each participant with full consent before the packs were issued out for the remaining anthropometric data to be completed by parents/legal guardians.

The data collected was analysed to have a fair idea of the descriptive statistics and to check the internal consistency in the item measurements using reliability analysis. The pilot study had 118 participants from the three schools in the Western Region, out of which 66 (55.9%) were females and 52 (44.1%) were males. Details are presented in Table 5.3.

Table 5.3: Background Information (Pilot study)

Variables	Frequency (n)	Percentage (%)
Gender		
Male	52	44.1
Female	66	55.9
Total	**118**	**100.0**
Age group		
6 years	7	5.9
7 years	3	2.5
8 years	9	7.6
9 years	29	24.6
10 years	30	25.4
11 years	40	34
Total	**118**	**100.0**
Class		
1	8	6.8
2	20	16.9
3	17	14.4
4	30	25.4
5	29	24.6
6	14	11.9
Total	**118**	**100**
Name of School		
A/A D/A.C primary sch	44	37.3
K. A. M. A.	42	35.6
N-W basic sch	32	27.1
Total	**118**	**100**
Location of school		
Sekondi Takoradi	74	62.7
Shama	44	37.3
Total	**118**	**100**
Ethnicity		
Akan	109	92.4
Ewe	2	1.7
Ga	6	5.1
Dagomba	1	0.8
Total	118	100

5.7.2 Descriptive statistics (pilot study)

Descriptive statistics on the anthropometric measurements of the 6-11year old pupils in Western Region are presented in Table 5.4 for all participants. The shortest participant had a height of 106.5 cm and the tallest had a height of 160 cm. The mean height of all the participants was 136.3 cm with a standard deviation of 10.3 cm showing a big variation in the heights of the participants. The average weight of the participants was 30.2 Kg with a standard deviation of 5.1 Kg. The details of the other body measurements are shown in Table 5.4.

Table 5.4: Descriptive statistics (pilot study)

Variables	N Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std. Deviation Statistic	Skewness Statistic	Skewness Std. Error	Kurtosis Statistic	Kurtosis Std. Error
Height	118	106.5	160.0	136.352	10.2755	-.014	.223	.062	.442
Weight	118	20.2	44.0	30.216	5.1056	.397	.223	.428	.442
Head girth (cm)-1	118	48.0	56.0	52.381	1.8324	-.006	.223	-.276	.442
Neckgirth_1	118	24.0	35.0	28.865	2.7782	.286	.223	-.874	.442
Chestgirth_1	118	55.0	79.0	64.449	5.4531	.892	.223	.506	.442
Waistgirth_1	118	47.0	67.0	59.771	3.8733	-.318	.223	.233	.442
Hipgirth_1	118	54.0	93.0	73.381	8.7676	.511	.223	-.327	.442
Armseyegirth_1	118	21.0	40.0	31.051	4.0738	.155	.223	.009	.442
Upparmgirth_1	118	16.0	29.0	21.081	2.5787	.876	.223	1.166	.442
Elbowgirth_1	118	16.0	24.0	20.097	1.9748	.159	.223	-.695	.442
Wristgirth_1	118	11.0	17.0	13.856	1.2711	.215	.223	-.113	.442
Thighgirth_1	118	28.0	57.0	42.097	5.7943	.450	.223	-.064	.442
Kneegirth_1	118	22.0	36.0	29.942	2.9193	.123	.223	-.116	.442
Anklegirth_1	118	16.0	24.0	20.110	2.0456	.184	.223	-.819	.442
Shouldlength_1	118	9.0	15.0	11.659	1.2582	.097	.223	.035	.442
Backshwidth_1	118	27.0	38.0	32.758	2.5036	.061	.223	-1.015	.442
Scyedepth_1	118	11.0	18.0	14.523	1.3635	.551	.223	.640	.442
Acrosschest_1	118	22.0	37.0	28.455	3.6795	.447	.223	-.804	.442
Bustpoint_1	118	10.0	17.0	13.302	1.8495	.451	.223	-.697	.442
Acrossback_1	118	24.0	35.0	30.336	2.6496	-.090	.223	-.696	.442
ShoulderElb_1	118	20.0	31.0	25.052	2.8778	.085	.223	-.970	.442
Outerarm_1	118	36.0	59.0	47.171	5.5759	.086	.223	-.829	.442
Crotch_1	118	38.0	63.0	51.755	5.3426	-.062	.223	-.296	.442
Bodyrise_1	118	16.0	21.5	18.556	1.3524	-.028	.223	-.796	.442

Napewaist_1	118	21.0	34.0	26.364	2.6720	.357	.223	-.040	.442
Napefloor_1	118	91.0	139.0	114.026	10.7963	-.027	.223	-.491	.442
Basethroat_1	118	20.5	34.0	26.165	2.9958	.688	.223	.032	.442
Frontneck_1	118	21.0	39.0	30.919	2.9978	-.006	.223	.779	.442
Torsoheight_1	118	47.0	74.0	59.140	5.0914	-.006	.223	.394	.442
Waisthip_1	118	12.0	19.0	17.026	1.3286	-.680	.223	1.113	.442
Waistknee_1	118	34.5	54.0	45.144	4.3403	.153	.223	-.752	.442
Waistankle_1	118	60.0	94.0	77.788	6.1822	.038	.223	.063	.442
Waistfloor_1	118	66.5	99.0	83.682	7.0782	-.018	.223	-.488	.442
Kneefloor_1	118	31.0	49.0	40.436	3.1586	-.207	.223	.671	.442
Insideleg_1	118	52.0	80.0	64.318	6.3031	.105	.223	-.622	.442
Valid N (listwise)	118								

5.7.3 Reliability analysis

Reliability has to do with the consistency of measurement when it is repeated. Reliability analysis was performed using Cronbach's alpha, the highly applied measure of reliability (Tavakol and Dennick, 2011) for the 35 anthropometric measurements. The purpose was to assess the internal consistency in the item measurements. The results presented in Tables 5.5 (Cronbach's alpha) and Table 5.6 (item-to-total statistics) show a very high reliability of the item measurements because the Cronbach's alpha was 0.946 which is higher than 0.70 (Nunnally, 1978; George and Mallery, 2003; Hair et al., 2010; Kwapong, 2022).

Table 5.5: Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
.946	.960	35

Furthermore, Table 5.6 shows that all the items had very high item-to-total correlations. That is all the item-to-total correlations were above 0.30 (Nurosis, 1994; Hair et al., 1998). Additionally, the Cronbach's alpha obtained if any of the 35 items is deleted was above 0.90 indicating that, the scale used for the pilot study possess high internal consistencies and reliability. Therefore, the BMS is appropriate for use in gathering anthropometric measurements data for the main study.

Table 5.6: Item-total statistics

Variables	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Height	1345.875	7730.303	.891	.919	.942
Weight	1452.010	8769.670	.680	.649	.943
Head girth (cm)-1	1429.845	9243.064	.566	.538	.945
Neckgirth_1	1453.361	9083.852	.669	.793	.944
Chestgirth_1	1417.777	8623.473	.783	.743	.942
Waistgirth_1	1422.455	9036.468	.535	.464	.944
Hipgirth_1	1408.845	8153.716	.767	.854	.943
Armseyegirth_1	1451.175	8911.935	.672	.746	.943
Upparmgirth_1	1461.146	9087.670	.715	.772	.944
Elbowgirth_1	1462.130	9208.724	.615	.790	.945
Wristgirth_1	1468.370	9289.303	.632	.777	.945
Thighgirth_1	1440.129	8670.020	.688	.785	.943
Kneegirth_1	1452.285	9075.880	.650	.657	.944
Anklegirth_1	1462.116	9240.937	.510	.740	.945
Shouldlength_1	1470.567	9311.616	.546	.648	.945
Backshwidth_1	1449.468	9261.197	.370	.649	.945
Scyedepth_1	1467.703	9282.593	.614	.656	.945
Acrosschest_1	1453.771	9184.175	.352	.897	.946
Bustpoint_1	1468.925	9320.877	.340	.841	.946
Acrossback_1	1451.891	9163.854	.542	.802	.945
ShoulderElb_1	1457.175	9032.345	.741	.830	.944
Outerarm_1	1435.055	8562.924	.825	.838	.942
Crotch_1	1430.471	8728.715	.690	.692	.943
Bodyrise_1	1463.670	9315.563	.492	.656	.945
Napewaist_1	1455.862	9161.189	.542	.664	.945
Napefloor_1	1368.200	8032.087	.670	.848	.947
Basethroat_1	1456.061	9190.789	.428	.686	.945
Frontneck_1	1451.307	9113.931	.564	.677	.944
Torsoheight_1	1423.086	8839.319	.606	.652	.944
Waisthip_1	1465.200	9265.381	.698	.637	.945
Waistknee_1	1437.082	8867.406	.684	.798	.943
Waistankle_1	1404.438	8520.863	.777	.906	.942
Waistfloor_1	1398.544	8328.624	.826	.932	.941
Kneefloor_1	1441.790	9050.109	.642	.772	.944
Insideleg_1	1417.908	8820.599	.494	.508	.945

5.7.4 Degree of self-confidence of parents/legal guardians in measuring their children (Pilot study)

Parents/legal guardians were required to rate their level self-confidence in measuring their children for the study. This result from the pilot study was analysed and presented in Table 5.7. This process was vital as it confirms to the researcher the credibility of measurements collected by the parents/legal guardians. Out of the total sampled, 89.8% of the parents/legal guardians declared they were either confident (41.5%) or very confident (48.3%) in measuring their children for the study with 10.2 % selecting neutral which impliedly means they were unsure of their confidence level in the measurement process. None of the parents/legal guardians indicated that they were not confident.

Table 5.7: Degree of self-confidence of parents/legal guardians in measuring their children (Pilot study)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not strongly confident	0	0	0	0
	Not confident	0	0	0	0
	Neutral	12	10.2	10.2	10.2
	Confident	49	41.5	41.5	51.7
	Strongly Confident	57	48.3	48.3	100.0
	Total	118	100	100.0	
Total		118	100.0		

5.8 Ethical issues and considerations

This study adhered to established ethical protocols. According to Neuman (2014) and Apeagyei et al. (2007), ethical issues and considerations border on expertise, conscientiousness, fairness, and integrity. Neuman (2014) added that a study is ethical when the anonymity, privacy, confidentiality, and informed consent are adhered to. This research was approved by the

Research Ethics and Governance Committee of Manchester Metropolitan University after series of scrutinies and several amendments requested by the committee due to considerable changes in the level of risk to both the researcher and the participants with the advent of the Covid-19 pandemic. As rightly noted by Mcleod (2015) it is the moral obligation of all undertaking research to ensure that research participants are safe. The study's methodology which originally was to train research assistants to assist with data collection was thus modified to minimize excessive contact with the researcher, any intended research assistants, and the participants. The application of the MMU Covid-19 ethics guidelines was also instrumental in this approval.

All the appropriate governmental and institutional regulations and protocols concerning the use of human participants with regards to ethics were followed during this research. No data was collected for this study until receipt of ethical clearance certificate.

In accordance with ethical principles in this study, contact to the study population was first done through gatekeepers. Gatekeepers according to Ogletree and Kawulich (2012) are individuals or institutions that could grant permission to researchers to enable them access establishment or communities to carry out a study. Written permission was sent to the GES, the gatekeeper of all basic and second cycle education in Ghana. Upon receipt of approval from the GES (Appendix 5) copies of the permission letters were first sent to the GES regional offices in the three selected regions in Ghana for the main study and the western region for the pilot study. This was a directive from the GES head office to officially make GES officers in each selected region aware of the presence of the researcher in the regions. Copies of the approval letter from GES was attached to a letter (Appendix 4) that was sent to the selected schools to fully inform them of the nature of the study and request for their support. Upon confirmation of participation, the principal researcher comprehensively briefed school authorities about the research. This briefing indicated the procedures for data collection, anonymity and confidentiality of participants, instruments for data collection, health and safety concerns and the right of participants to participate or decline and to withdraw at any point.

Three separate PIS developed by the study were used to educate parents/ legal guardians and participants of the procedure for data collection and what was required of each person if they agree to participate. The PIS for the parents/ legal guardians (Appendix 10), clearly stated the purpose of the research, anonymity and confidentiality of participants, the right of participants to withdraw at any point in the process. Age-appropriate PIS for the participants aged 6-8 (Appendix 8) and 9-11(Appendix 9) were also used. This was designed to ensure the children fully understood the study and what was required of them. Consent and assent forms were issued to parents/legal guardians and the participants respectively. This was fully completed and endorsed before the measurement packs were handed to the participants and their parents. An incident reporting form was added to the pack that was deposited at the schools for reporting incidents.

CHAPTER SIX

PRESENTATION OF RESULTS

6.1 Introduction

The data collected from the field were analysed and presented in this chapter. A sample of seven hundred and seventy-six (776) participants from twelve (12) schools across three metropolitan areas and three municipal districts in three regions of Ghana were used for the analysis. Results presented in this chapter include initial data preparation, background information of participants, t-test comparisons, ANOVA, exploratory factor analysis (EFA) to select key dimensions, confirmatory factor analysis and cluster analysis to categorise the participants into homogenous groups. The processes for the development of sizing system and size charts are also presented. A fit evaluation was conducted to validate the developed sizes through the production of patterns and subsequent construction of toiles for fit trials. After validation of the fit of the developed sizes, patterns were graded. These processes resulted in the development of sizing system and size charts for ready-to-wear clothing for Ghanaian children aged 6-11.

6.2 Initial data preparation

A total of nine hundred and sixty (960) body measurement packs containing the data collection sheets were administered in all the twelve (12) selected schools, out of which eight hundred and six (806) data sheets were received. Before inputting the information on the data sheets into IBM SPSS version 26, each data sheet was checked physically by the researcher. This was to ensure that all the data sheets were accurately filled out. This was also done to ensure that inconsistencies and errors on data sheets were rectified or discarded. During the process of screening, some inconsistencies were identified on the data sheets. It was observed that some of the data sheets were not completed fully. On a few of the body measurement sheets, only two thirds ($^2/_3$) of the measurements had been completed. Also, during screening of the data sheets, there were errors on some of the recorded measurements. For instance, on a few of the body measurements sheets, some of the measurements such as across chest, across back and scye depth were very large when compared with that of their peers. In addition, during the manual screening process the validity and reliability were checked based on the four scenarios of weight reading espoused by Dawson (2017). Each body dimension was measured and recorded twice. The two recorded measurements were cross checked before keying into IBM-SPSS. In inputting the data into IBM-SPSS, averages of the two dimensions collected were used. All data sheets that did not meet the reliability and validity criteria used for the manual inspection were rejected. Therefore, out of the eight hundred and six (806) body measurements sheets received, thirty (30) were rejected due to inconsistent body measurements and incompletely filled sheets.

6.3 Data cleaning

In total seven hundred and seventy-six (776) usable data sheets of pupils across the twelve (12) schools in the three regions surveyed were used. The usable data sheets were carefully coded into the IBM SPSS version 26 software for data analysis. After the data entry, the entire data was checked for outliers as emphasized by Winks (1997) and Kline (2005) for the creation of a reliable sizing system. Thus, this approach facilitated the development of a valid system that caters for majority of the sampled population. A normality test was carried out graphically and numerically. A graphical representation using box plots was performed, which showed no significant outliers in the dataset as shown in Figure 6.1. Next, the item scores were converted into standardised values (z-scores). The descriptive statistics showing minimum and maximum z-score values were all within the range -3 and +3, showing absence of significant outliers.

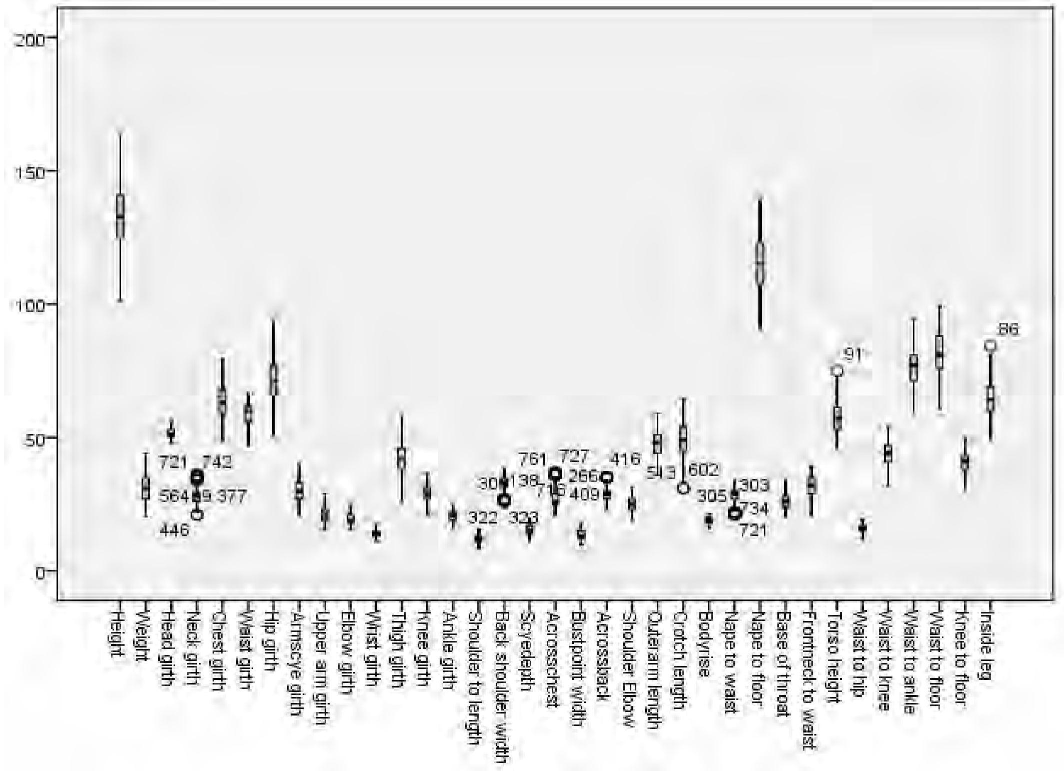


Figure 6.1: Assessing outliers using box plots

Finally, skewness and kurtosis were performed for each item in line with recommendations by Blanca et al. (2013), Zakaria (2016) and Watkins (2018). This was used to explain the structure of a variable's distribution (Dawson, 2017)**.** According to Watkins (2018) skewness and kurtosis have effect on EFA results and they need to be checked under descriptive statistics. Byrne (2016) and Hair et al. (2010) stated that data is said to be normal if skewness and Kurtosis values range between -2 to +2 and -7 to +7 respectively. From Table 6.1, all the skewness values for the 35 body measurement items were between -1.5 and +1.6 thus showing absence of outliers; all the kurtosis values range between -2.0 and +2.0 which is acceptable to show absence of outliers. Outliers according to Antonius (2013) are values that are remarkably large or remarkably small in a distribution.

Table 6.1: Assessing outliers and normality test

Items	Min	Max	Mean	SD	Skewness	Kurtosis
Height	101.20	163.50	132.94	11.84	0.03	-0.32
Weight	20.50	44.00	31.11	5.23	0.37	-0.36
Head girth	48.00	56.00	51.59	1.73	0.23	-0.17
Neck girth	21.00	36.00	27.96	2.30	0.36	0.31
Chest girth	49.00	79.50	63.56	6.33	0.29	-0.34
Waist girth	47.00	67.00	59.02	4.27	-0.35	-0.52
Hip girth	51.00	93.00	71.64	8.89	0.36	-0.30
Armscye girth	21.00	40.00	30.19	3.83	0.22	-0.44
Upper arm girth	15.50	29.00	21.13	2.81	0.68	0.26
Elbow girth	15.50	24.50	19.45	1.85	0.29	-0.36
Wrist girth	11.00	17.50	13.83	1.35	0.37	-0.19
Thigh girth	26.00	58.00	42.12	6.13	0.22	-0.20
Knee girth	21.00	36.50	29.20	3.07	-0.11	-0.02
Ankle girth	16.00	24.50	20.46	1.80	-0.02	-0.38
Shoulder to length	8.50	15.50	11.98	1.37	0.16	-0.13
Back shoulder width	26.00	38.00	33.26	2.57	-0.16	-0.30
Scye depth	11.00	19.50	15.49	1.99	0.04	-0.94
Across chest	21.00	37.00	27.09	3.21	0.68	0.09
Bust point width	10.00	17.50	13.44	1.67	0.50	-0.55
Across back	23.00	35.00	28.71	2.62	0.10	-0.28
Shoulder Elbow	19.00	31.00	25.33	2.77	0.03	-0.34
Outer arm length	36.00	59.00	47.57	4.88	0.06	-0.41
Crotch length	31.00	64.00	49.42	6.31	0.02	-0.46
Body rise	16.00	21.50	18.71	1.34	-0.24	-0.72
Nape to waist	21.00	34.00	28.60	2.68	0.04	-0.40
Nape to floor	91.00	139.0	115.2	10.49	0.09	-0.67
Base of throat	20.50	34.00	26.18	2.88	0.67	0.00
Front neck to waist	21.00	39.00	31.90	3.54	0.15	-0.62
Torso height	46.00	75.00	57.47	5.70	0.33	-0.55
Waist to hip	12.00	19.00	15.95	1.58	-0.04	-0.62
Waist to knee	32.00	54.00	43.77	4.81	-0.01	-0.22
Waist to ankle	59.00	94.50	76.60	7.81	0.04	-0.31
Waist to floor	61.00	99.50	81.87	7.84	0.11	-0.45
Knee to floor	31.00	49.50	40.65	3.67	0.05	-0.31
Inside leg	49.50	84.50	64.50	6.71	0.11	-0.55

(All the measurement values are in centimetres except for weight which is kilograms)

The absence of significant outliers coupled with the very low skewness and kurtosis values suggest that the data follow approximate normal distribution (Blanca et al., 2013; Byrne, 2016; Hair et al., 2016). All the measurement values were calculated in centimetres (cm) except for weight which is in kilograms. The standard deviation values were rounded to two decimal places.

6.4 Demographic information

Table 6.2 gives the breakdown of the demographic information such as gender, age, type of school, ethnicity among others. Table 6.2 indicates that half of the participants were males (n=391/ 50.4%) whereas the other half were females (n=385/ 49.6%). The survey attained the targeted percentages in terms of gender, based on the population of pupils in the primary level. The minimum age was six whereas the maximum age was 11; the average age of the participants was eight with a standard deviation of one year. Age seven recorded the least number of participants (n=99/ 12.8%) whilst age eight had the highest number of participants (n=153/ 19.7%).

More than half (n=426/ 54.9%) of the participants were in lower primary (classes 1 to 3), whilst the rest were in upper primary (classes 4 to 6) (n=350/ 45.1%). Primary three recorded slightly higher no of participants (n=157/ 20.2%) whereas primary six recorded fewer number of participants (n=72/ 9.3%). The significantly smaller number of participants recorded for class six was not an expected outcome however class six ends primary education in Ghana from which the children move to Junior Secondary School. The drop in the number of participants in class six can be attributed to the fact that most of the children in class six in the schools used may have attained ages above the maximum age limit of the study. It is obvious from Table 6.2 that a lot of the participants were age 11 (n-150\ 19.3%) which is supposed to be the normal age for children in class six therefore the drop may be that children aged 11 were measured from other classes other than class six. This drop in representation of participants in class six did not have effect on the representation of the ages as each age was adequately represented.

Table 6.2 indicates the proportion of participants that took part in each region. These include the Northern region (n=277, 35.7%), Ashanti region (n=239, 30.8%) and Greater Accra region (n=260, 33.5%). The result shows nearly equal distribution of sample across the three regions. The results obtained from the regions does not represent the actual population in each region in the country as Greater Accra region has the highest population followed by Ashanti region and then the Northern region. The representation of regions was not based on proportions, but equal number of participants were selected from each region on participant's willingness to participate in the study.

Half of the participants were in public primary schools (n=388, 50%) and the other half were in private primary schools (n=388, 50%). The survey got the targeted percentage of participants in terms of the type of school. This result is not also the reality on the ground as the population of public primary school children in Ghana is almost three times that of private primary schools as shown in Table 5.1 in the methodology section. In terms of ethnicity, the participants were dominated by Akans (n=391, 50.4%). Akans are the largest ethnic group in Ghana. Constituting about 50% of the Ghanaian population. It must be noted that the Akan group is a consolidation of around twenty different ethnic groups (Langer and Ukiwo, 2007; GSS, 2021) consisting of Ashanti, Fanti, Akwapem, Akyem, Nzema people among others. Dagomba (n-129, 16.6%) is the second largest ethnicity in Table 6.2 however, Dagomba (n-129, 16.6%), Mamprusi (n-42, 5.4%) and Gonja people (n-7, 0.9%) all captured in Table 6.2 fall under the Mole-Dagbani ethnic group. Adding their numbers, makes them the second largest ethnic group sampled for the study. The Ewe (n- 85, 11%) ethnic group is the third largest ethnic group sampled in the study as shown in Table 6.2.

Table 6.2: Background Information

Variables	Frequency (n)	Percentage (%)
Gender		
Male	391	50.4
Female	385	49.6
Total	**776**	**100.0**
Age group		
6 years	100	12.9
7 years	99	12.8
8 years	153	19.7
9 years	125	16.1
10 years	149	19.2
11 years	150	19.3
Total	**776**	**100.0**
Class		
1	128	16.5
2	141	18.2
3	157	20.2
4	143	18.4
5	135	17.4
6	72	9.3
Total	**776**	**100**
Region		
Northern	277	35.7
Ashanti	239	30.8
Greater Accra	260	33.5
Total	**776**	**100**
Type of School		
Public	388	50
Private	388	50
Total	**776**	**100**
Name of School		
A. P. School	64	8.2
A. M/A P. School	52	6.7
C D. Primary	70	9

E. C. G School	88	11.3
G. C. I. School	52	6.7
G. B. School	71	9.1
L. R. T I. School	68	8.8
O. H. E. Complex	50	6.4
O. M. P. School	55	7.1
R. E. Complex	59	7.6
St P. C. Primary	71	9.1
St S. C. Primary	76	9.8
District		
Accra Metro	132	17
Ejisu	114	14.7
Ga-West	128	16.5
Kumasi Metro	123	15.9
Sagnarigu District	158	20.4
Tamale Metro	121	15.5
Ethnicity		
Akan	337	43.4
Ga	41	5.3
Ewe	85	11
Dagomba	129	16.6
Frafra	27	3.5
Kasena	18	2.3
Mamprusi	42	5.4
Dagaati/Dagaaba	39	5
Hausa	9	1.2
Gonja	7	0.9
Others	42	5.4
Total	776	100

6.5 Descriptive statistics

The descriptive statistics from the anthropometric survey of the 6-11-year pupils are presented in Table 6.3 for all participants together and separately for males and females. The descriptive data of the entire sample was analysed to provides profile of the body sizes in the population sampled and generate table of body measurements. This according to Beazley (1998) helps in the determination of size ranges for key dimensions as they are arrived at through computation of the extremes, mean, and standard deviation for the study sample. The mean values generated from the descriptive statistics are commonly used by several researchers (Beazley, 1998; Otieno, 1999, 2008; Gupta and Gangadhar, 2004; Kuma- Kpobee, 2009; Adu-Boakye, 2011) for developing sizes. The descriptive statistics in Table 6.3 also indicates the range of body measurements for the study sample. Zakaria (2016) concurred that knowledge of the different body measurements aid in the development of clothing sizes with a good fit.

From Table 6.3, height distribution of the entire sample is 101.20-163.50cm with a mean of 132.94cm and a standard deviation of 11.84cm showing a big variation in the heights of the participants. The weight from the same sample ranges from 20.50- 44.00kg with a mean of 31.11kg and a standard deviation of 5.23kg. Again, the chest girth measurement for the entire sample ranges between 49.00-79.50cm with a mean of 63.56cm and a standard deviation of 6.33cm. The waist girth ranges from 47.00-69.00cm with a mean of 59.02cm and a standard deviation of 4.27cm. The hip girth distribution of the total sample also ranges from 51.00-93.00cm with a mean of 71.64cm and a standard deviation of 8.89cm.

From Table 6.3 the height distribution for the males (n- 391) ranges from 105.00-158.60cm with a mean height of 132.84cm and a standard deviation of 11.29cm. Weight distribution for the same sample group ranges from 20.50-44.00kg with a mean of 31.10kg and a standard deviation of 5.40kg. Their chest girth ranges from 49.00-79.50cm with a mean and standard deviation of 63.65cm and 6.10cm respectively. Waist girth distribution ranges from 47.00-67.00cm with a mean of 58.94cm and a standard deviation of 4.21cm. The hip girth distribution of the same sample span from 52.00-91.00cm with a mean of 70.47cm and a standard deviation of 8.46cm.

From the same Table 6.3, the height distribution of the female sample (n- 385) is 101.20-163.50cm. This indicate that both the shortest (101.20 cm) and tallest (163.50 cm) participants were females. The standard deviation of the heights was even wider among the females (12.39cm) than the males (11.29cm). The weight of the females ranges from 21.00-44.00kg with a mean of 31.12kg and a standard deviation of 5.06kg. Looking at the results, the average weight of all participants is 31.11Kg which does not differ significantly along gender lines (males average=31.10kg, female average=31.12kg). Chest girth of female sample ranges from 49.00-79.00cm with a mean and standard deviation of 63.46cm and 6.56cm respectively. The average chest girth of the participants is 63.56cm which does not differ significantly along gender lines (males average=63.65cm, female average=63.46cm). The waist girth of the females range from 48.10-67.00cm with a mean of 59.11cm and a standard deviation of 4.32cm. Deducing from the results on gender lines, it was clear that males have wider spread of between 47.00cm and 67.00cm whilst the females showed a not too wide a spread of between 48.10 and 67.00cm with females starting a bit higher than the males. The hip girth distribution of the female sample ranges from 51.00- 93.00cm with a mean of 72.82cm and a standard deviation of 9.18cm. The details of the other body dimensions are shown in Table 6.3.

Table 6.3: Anthropometric measurements of 6 –11-year-old Ghanaian children

	All participants				Males (n=391)				Females (n=385)					
Body Dimension	Min	Max.	Mean	SD	Min	Max.	Mean	SD	Min	Max.	Mean	SD	t	p
Height	101.20	163.50	132.94	11.84	105.00	158.60	132.84	11.29	101.20	163.50	133.04	12.39	-0.24	0.81
Weight	20.50	44.00	31.11	5.23	20.50	44.00	31.10	5.40	21.00	44.00	31.12	5.06	-0.04	0.97
Head girth	48.00	56.00	51.59	1.73	48.00	56.00	51.77	1.70	48.00	56.00	51.40	1.75	3.03	0.00**
Neck girth	21.00	36.00	27.96	2.30	22.00	36.00	27.94	2.24	21.00	35.00	27.97	2.37	-0.15	0.88
Chest girth	49.00	79.50	63.56	6.33	49.00	79.50	63.65	6.10	49.00	79.00	63.46	6.56	0.43	0.67
Waist girth	47.00	67.00	59.02	4.27	47.00	67.00	58.94	4.21	48.10	67.00	59.11	4.32	-0.53	0.60
Hip girth	51.00	93.00	71.64	8.89	52.00	91.00	70.47	8.46	51.00	93.00	72.82	9.18	-3.72	0.00**
Armscye girth	21.00	40.00	30.19	3.83	21.00	40.00	30.12	3.91	21.00	40.00	30.26	3.76	-0.51	0.61
Upper arm girth	15.50	29.00	21.13	2.81	15.50	29.00	20.90	2.66	15.50	29.00	21.37	2.95	-2.37	0.02*
Elbow girth	15.50	24.50	19.45	1.85	15.50	24.00	19.36	1.73	16.00	24.50	19.54	1.96	-1.34	0.18
Wrist girth	11.00	17.50	13.83	1.35	11.00	17.00	13.83	1.31	11.00	17.50	13.84	1.39	-0.08	0.93
Thigh girth	26.00	58.00	42.12	6.13	26.00	58.00	41.10	5.90	27.00	58.00	43.15	6.20	-4.73	0.00**
Knee girth	21.00	36.50	29.20	3.07	21.00	36.50	29.14	3.03	21.00	36.00	29.25	3.12	-0.49	0.62
Ankle girth	16.00	24.50	20.46	1.80	16.00	24.50	20.59	1.70	16.00	24.50	20.32	1.89	2.08	0.04*
Shoulder to length	8.50	15.50	11.98	1.37	9.00	15.50	12.10	1.38	8.50	15.00	11.86	1.34	2.41	0.02*
Back shoulder width	26.00	38.00	33.26	2.57	27.00	38.00	33.56	2.40	26.00	38.00	32.94	2.69	3.38	0.00**
Scye depth	11.00	19.50	15.49	1.99	11.00	19.50	15.55	1.95	11.00	19.50	15.43	2.03	0.88	0.38
Across chest	21.00	37.00	27.09	3.21	21.00	37.00	27.23	3.20	21.00	37.00	26.95	3.22	1.22	0.23
Bust point width	10.00	17.50	13.44	1.67	10.00	17.00	13.43	1.70	10.00	17.50	13.45	1.65	-0.13	0.90

Across back	23.00	35.00	28.71	2.62	23.00	35.00	28.85	2.61	23.00	35.00	28.58	2.62	1.46	0.14
Shoulder Elbow	19.00	31.00	25.33	2.77	19.00	31.00	25.21	2.78	19.00	31.00	25.45	2.75	-1.22	0.22
Outer arm length	36.00	59.00	47.57	4.88	36.00	59.00	47.24	4.94	36.00	58.00	47.91	4.79	-1.91	0.06
Crotch length	31.00	64.00	49.42	6.31	31.00	63.00	48.49	6.12	31.00	64.00	50.37	6.36	-4.19	0.00**
Body rise	16.00	21.50	18.71	1.34	16.00	21.00	18.63	1.32	16.00	21.50	18.79	1.35	-1.71	0.09
Nape to waist	21.00	34.00	28.60	2.68	22.00	34.00	28.75	2.58	21.00	34.00	28.45	2.77	1.55	0.12
Nape to floor	91.00	139.00	115.21	10.49	91.00	138.00	114.62	10.34	93.00	139.00	115.81	10.62	-1.58	0.12
Base of throat	20.50	34.00	26.18	2.88	21.00	34.00	26.34	2.84	20.50	34.00	26.01	2.91	1.59	0.11
Front neck to waist	21.00	39.00	31.90	3.54	21.00	39.00	32.12	3.40	21.00	39.00	31.67	3.66	1.77	0.08
Torso height	46.00	75.00	57.47	5.70	46.00	73.00	57.60	5.64	46.00	75.00	57.34	5.77	0.64	0.53
Waist to hip	12.00	19.00	15.95	1.58	12.00	19.00	15.97	1.53	12.00	19.00	15.94	1.63	0.25	0.81
Waist to knee	32.00	54.00	43.77	4.81	32.00	54.00	43.08	4.67	32.00	54.00	44.46	4.86	-4.04	0.00**
Waist to ankle	59.00	94.50	76.60	7.81	59.00	94.00	75.69	7.41	59.00	94.50	77.52	8.11	-3.29	0.00**
Waist to floor	61.00	99.50	81.87	7.84	61.00	99.50	80.92	7.84	62.00	99.50	82.83	7.72	-3.42	0.00**
Knee to floor	31.00	49.50	40.65	3.67	31.00	49.00	40.38	3.78	32.00	49.50	40.92	3.54	-2.05	0.04*
Inside leg	49.50	84.50	64.50	6.71	49.50	80.00	63.74	6.54	50.00	84.50	65.28	6.81	-3.22	0.00**

Note: **p<0.01; *p<0.05; +p<0.10

6.6 Distribution of key body dimensions using histograms

In this section, histograms are used to analyse key body dimensions. Histogram helps to understand the distribution of values for some key measurements to be able to recognise the pattern of body sizes for the chosen sample population (Zakaria, 2016). These graphs help to show if the data values are normally distributed, skewed, or bimodal (Cooke, 2015) and aids in the visualisation of the distribution of data (Zakaria, 2016). In this study, key anthropometric measurements, namely height, weight, chest girth, waist girth and hip girth are presented in Figure 6.2 - 6.11 using histograms to shows the distribution of data.

6.6.1 Height

Among all the participants, the average height obtained was 132.94 cm, with a standard deviation of 11.84 cm. The average height of female participants (133.04 cm) was marginally higher than that of males (132.84 cm). The positioning of the normal curve is indicative of the approximate normal distribution of the height data for all participants (Figure 6.2) and separately for male and female participants in Figure 6.3.

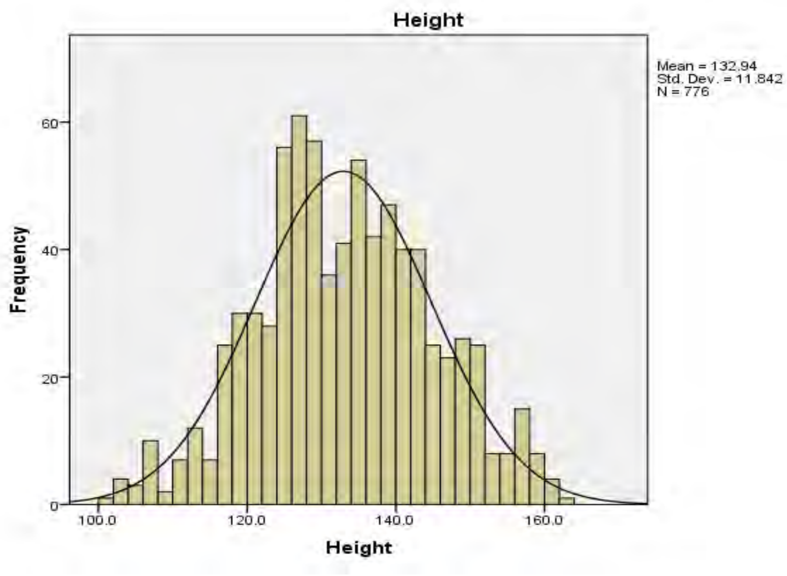


Figure 6.2: Height-histogram distribution for males and females

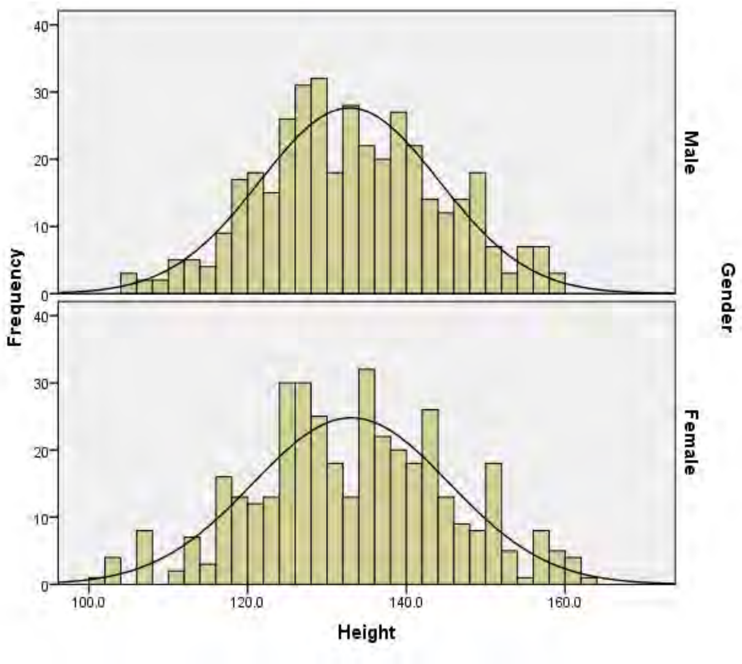


Figure 6.3: Height-histogram distribution separately for males and females

6.6.2 Weight

Among all the participants, the average weight obtained was 31.11 kg, with a standard deviation of 5.23kg. The average weight of the participants did not differ significantly along gender lines (males average=31.10kg, female average=31.12kg). The positioning of the normal curve is indicative of approximate normal distribution of the weight data for all participants (Figure 6.4) and separately for male and female participants (Figure 6.5).

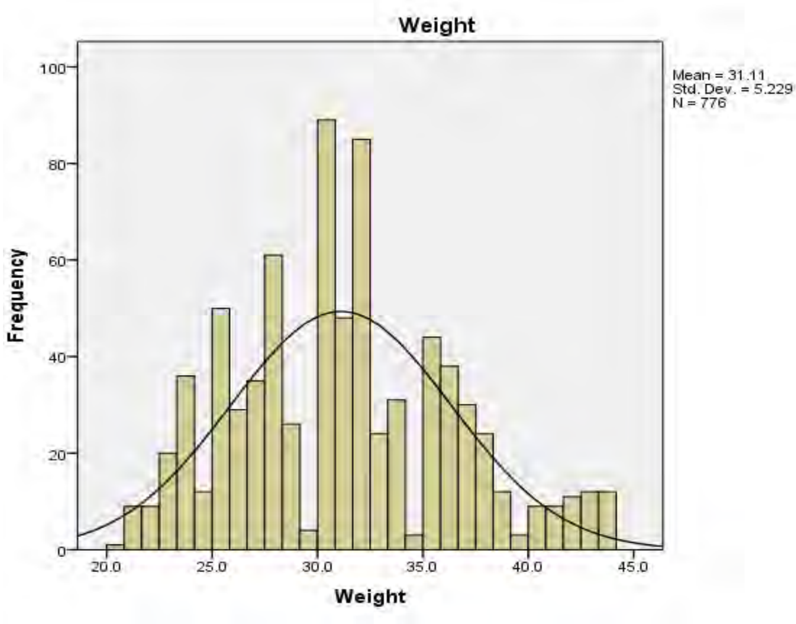


Figure 6.4: Weight- histogram distribution for males and females

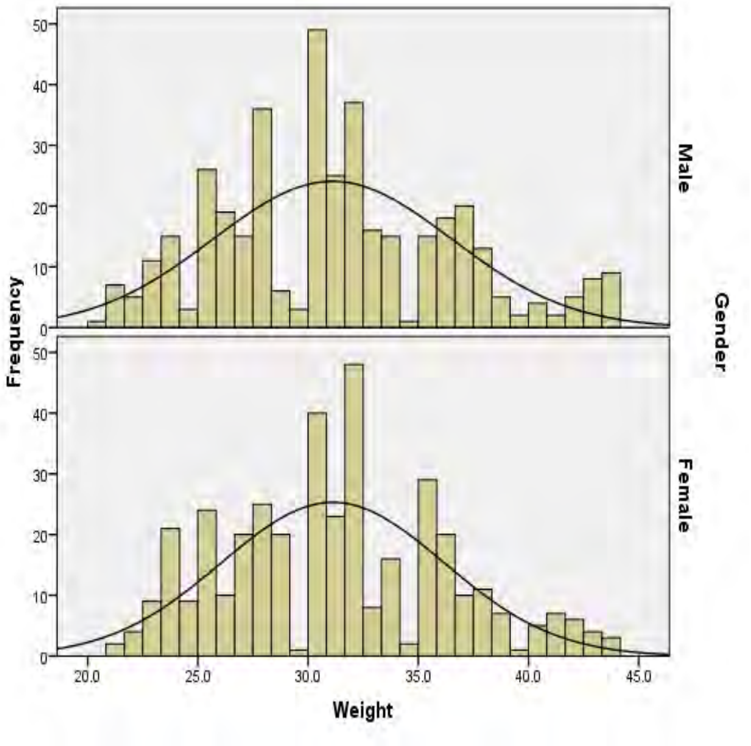


Figure 6.5: Weight- histogram distribution separately for males and females

6.6.3 Chest girth

The average chest girth for all the participants is 63.56 cm, with a standard deviation of 6.33 cm. The average chest girth of the participants did not differ significantly along gender lines (males average=63.65 cm, female average=63.46 cm). The positioning of the normal curve is indicative of left skewed distribution of the chest girth data for all participants (Figure 6.6) and separately for male and female participants (Figure 6.7).

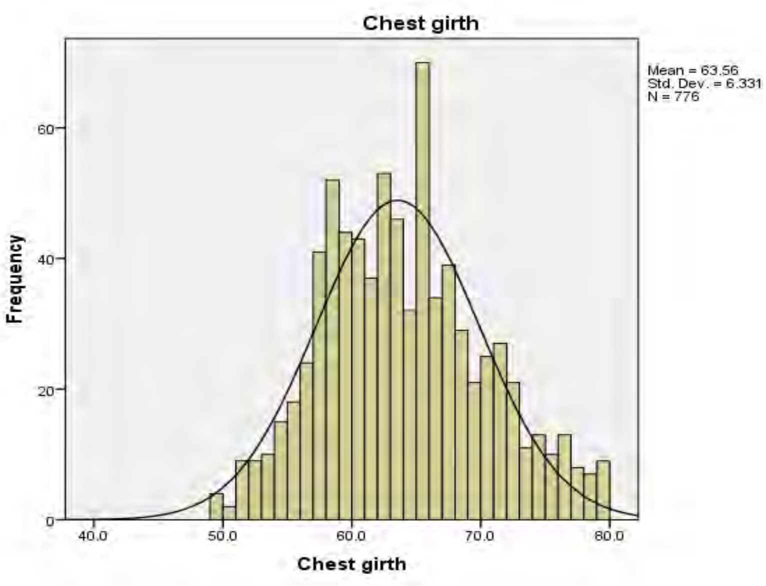


Figure 6.6: Chest girth- histogram distribution for males and females

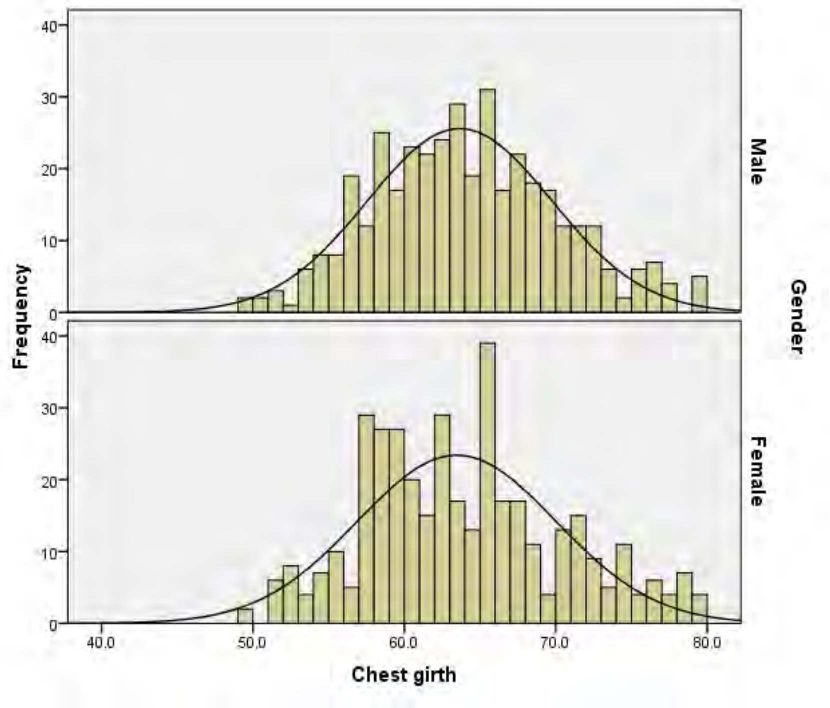


Figure 6.7: Chest girth- histogram distribution separately for males and females

6.6.4 Waist girth

For all the participants, the average waist girth obtained was 59.02 cm, with a standard deviation of 4.27 cm. The average waist girth of the female participants was marginally larger than male participants (female average=59.11 cm, males average=58.94 cm). The positioning of the normal curve is indicative of left skewed distribution of the waist girth data for all participants (Figure 6.8) and separately for male and female participants (Figure 6.9).

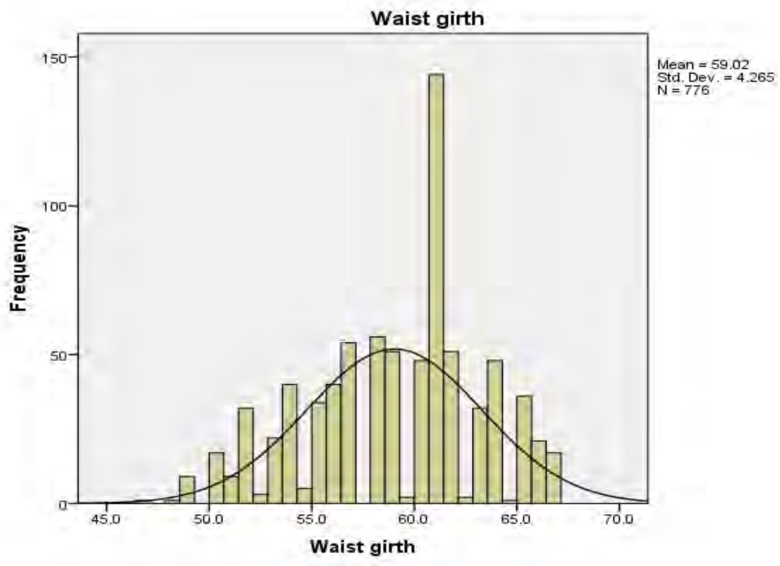


Figure 6.8: Waist girth- histogram distribution for males and females

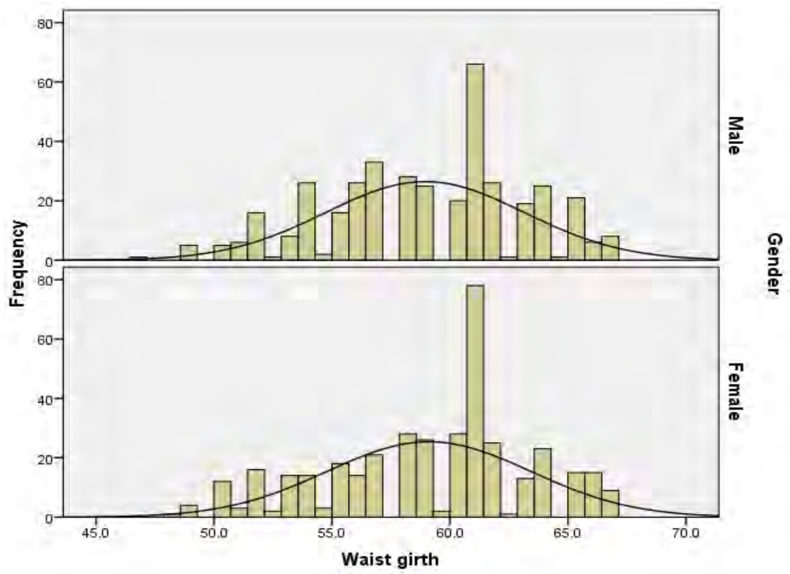


Figure 6.9: Waist girth- histogram distribution separately for males and females

6.6.5 Hip girth

Among all the participants, the average hip girth obtained was 71.64 cm, with a standard deviation of 8.89 cm. The average hip girth of the female participants (72.82 cm) was significantly larger than male participants (70.47 cm). The position of the normal curve is indicative of approximate normal distribution of the hip girth data for all participants (Figure 6.10) and separately for male and female participants (Figure 6.11).

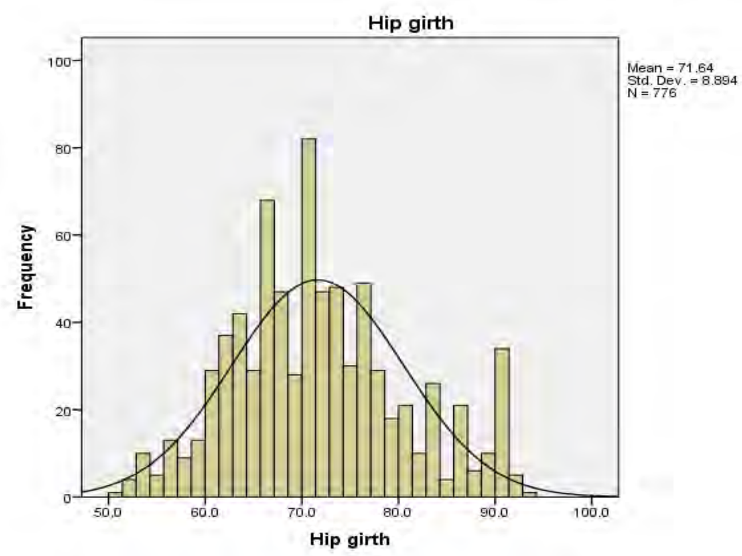


Figure 6.10: Hip girth- histogram distribution for males and females

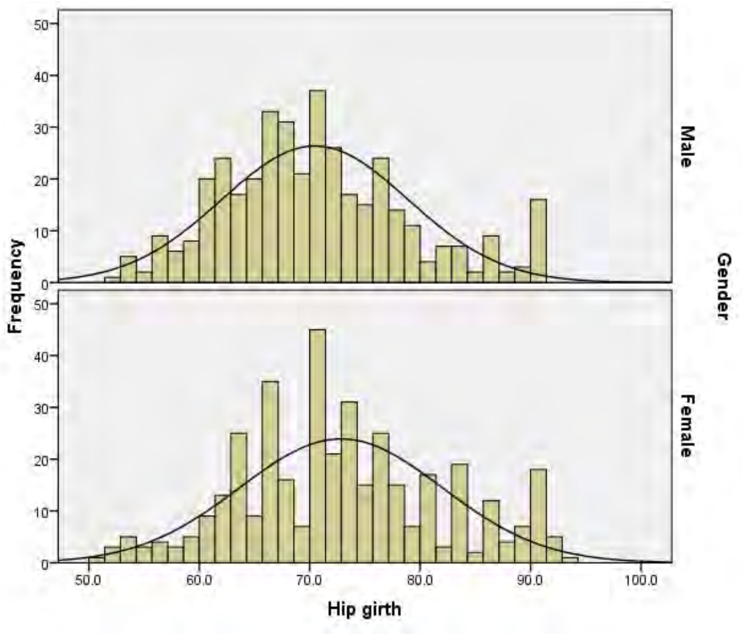


Figure 6.11: Hip girth- histogram distribution separately for males and females

6.7 Height distribution across ages of all participants

The height distribution of participants across the ages of the participants surveyed is further illustrated in Figure 6.12. The raw height of each participant was plotted against their ages. From

Figure 6.12 it is evident that height tends to increase with age for some of the participants, which is an expected pattern of growth, however, this trend cannot be generalized to the entire sample. From the same Figure 6.12 height does not increase with age in some situations. Some children are between the ages of 6-8 but have height dimensions that are comparable to children around the ages of 9-11. Other children aged 8-11 are far shorter than children aged 6-7. The graph in Figure 6.12 clearly depicts that age is not a suitable size code to use for children's clothing. This affirms findings from other researchers (Brown and Rice, 2014; Oteino and Fairhurst, 2000; Huyssteen, 2006; Carr and Laing, 2012; Zakaria and Gupta, 2014; Zakaria, 2016) in clothing anthropometrics that age alone is not an appropriate size code for children's clothing.

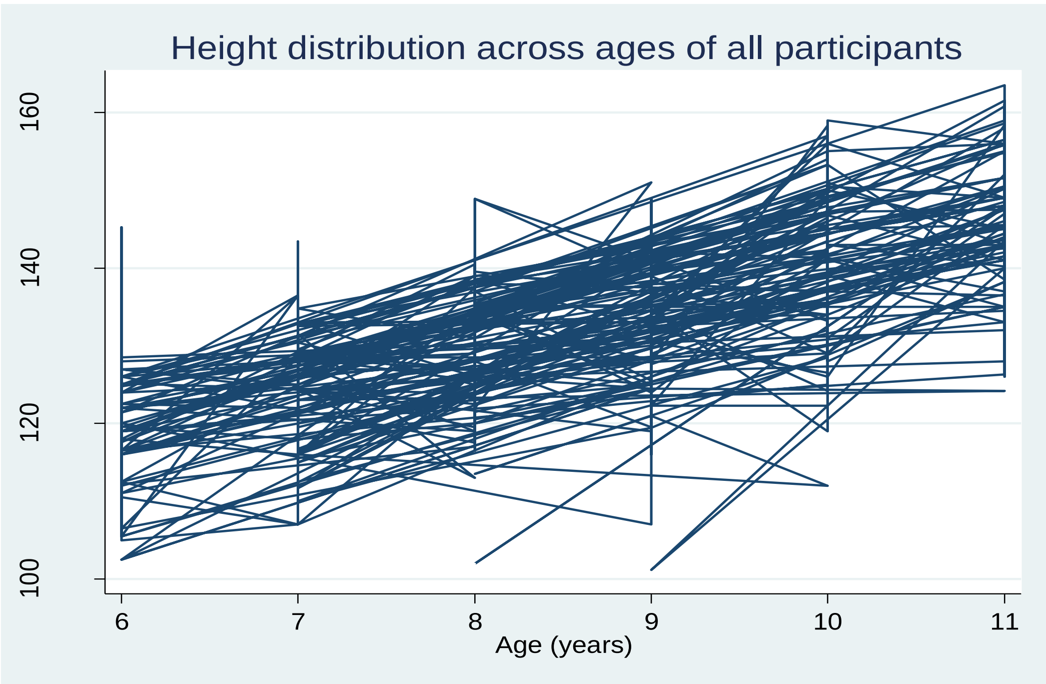


Figure 6.12: Height distribution across ages of all participants

6.8 Growth trend

In the development of standard sizing system for children, growth patterns of the participants are very vital. The growth trend provides a confirmation of the rate of growth for males and females sampled portraying similarities and differences at each age level. The growth trends show mean values for critical body dimensions such as heigh, weight, chest girth, waist girth and hip girth as illustrated in Figures 6.13-6.15. Analysing the trend of growth for all participants from Figure 6.13, it can be observed that both height and hip girth significantly increased with increasing age of participants. Weight also increased with increasing age, however, the weight of participants aged 10 and 11 were almost similar. Chest girth also increased with increasing age, but the chest girth of 10- and 11-year-olds were almost similar. For waist girth, there was a marginal increase between participants who were 6 and 7 years; a significant increase in waist occurred between 7 and 8 years. However, the waist of 8 to 11-year-olds is similar.

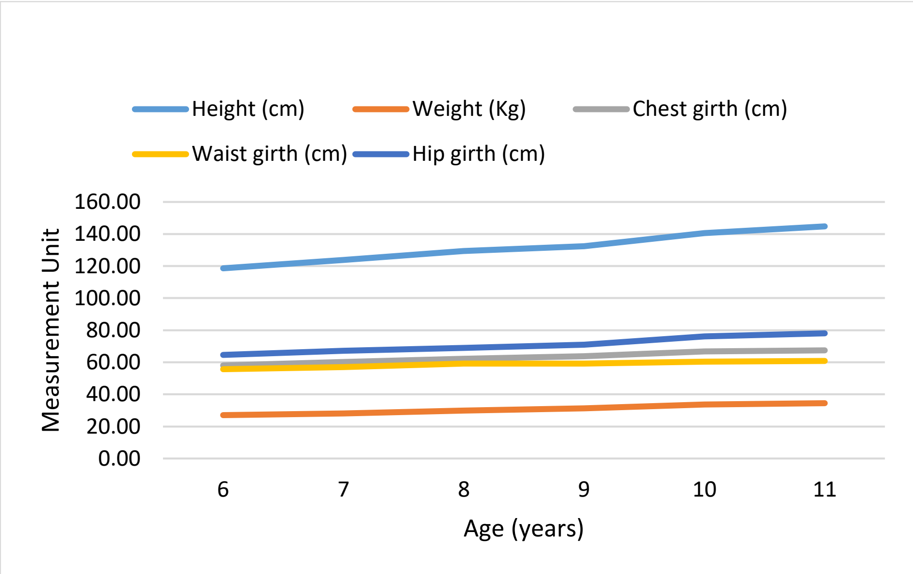


Figure 6.13: Growth trend for key body dimensions-All participants

6.8.1 Male growth trend

From Figure 6.14, it can be observed that both height and hip girth significantly increased with increasing age of male participants. Weight also increased with increasing age, however, the weight of participants 10 and 11-year-olds were almost similar. Chest girth also increased with increasing age, however, the chest girth of 10 and 11-year-olds were similar. Waist girth also increased with increasing age but plateaued between 9 to 11-year-olds.

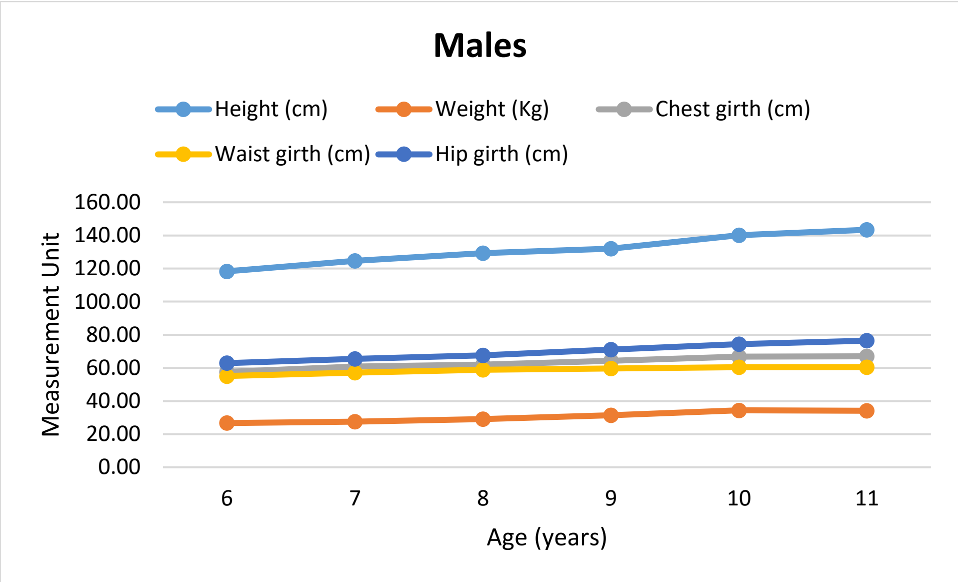


Figure 6.14: Growth trend for key body dimensions-male participants

6.8.2 Female growth trend

From Figure 6.15, it can be observed that height significantly increased with increasing age of female participants. Weight also increased with increasing age. Chest girth also increased with increasing age, with a big gap between 9 and 10-year-olds. For waist girth, it was similar between participants aged 6 and 7; a significant increase in waist occurred between 7 and 8-year-olds. However, the waist girth of 8 to 11-years-olds were similar. For hip girth, there was an increase in hip girth per age between 6- and 8-year-olds, the hip girth on the other hand plateaued between 8 and 9-year-olds and then significantly increased for 9 to 10-year-olds.

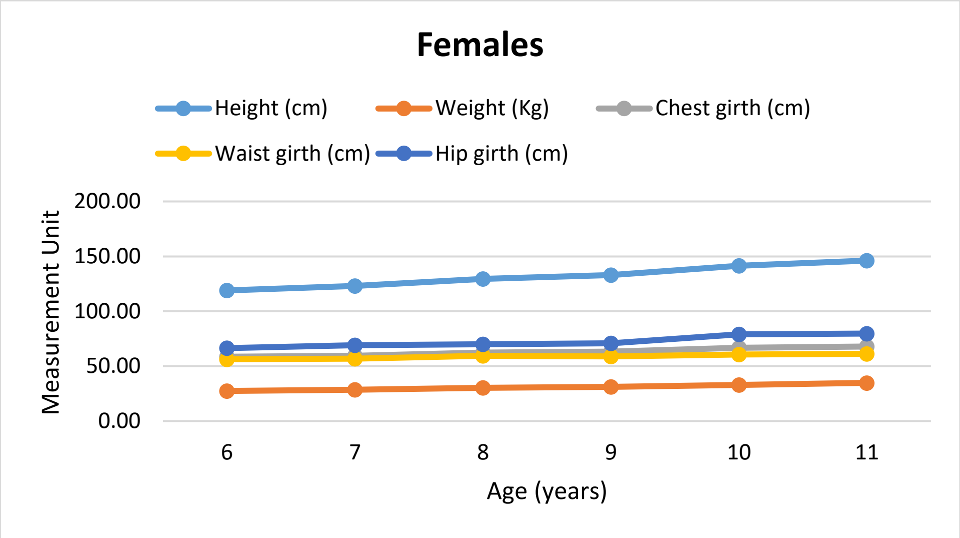


Figure 6.15: Growth trend for key body dimensions-female participants

6.9 Differences in body dimensions across gender (T- test)

From Table 6.3 it is evident that there are significant differences in the body measurements of females and males collected in this study. Out of the 35 body measurements collected, 13 of the measurements showed significant differences along gender lines. These measurements include hip girth ($p<0.01$), thigh girth ($p<0.01$), shoulder length ($p<0.01$), back shoulder width ($p<0.01$), crotch length ($p<0.00$) just to mention a few. These measurements are important in the construction of apparel with a good fit. The hip girth ($p<0.01$) which happens to be one of the body measurements used to designate a garment also showed significant difference, where females (mean=72.82) had significantly larger hip girths than males (mean=70.47).

6.10 Differences of key body dimensions across the three regions (ANOVA results)

ANOVA test was run to ascertain if there were significant differences in the body measurements across the three regions sampled. In the development of a sizing system for a population that is heterogenous like Ghana, it is best to determine whether there are differences in the data collected from the different areas sampled in the country. Height, weight, chest girth, waist girth, and hip girth measurements of children across the three regions (Northern, Ashanti, and Greater Accra) were compared using one way ANOVA. One way ANOVA results are presented in Table 6.4 and Fishers LSD multiple comparison test presented in Table 6.5. The main dependent (target) variables were height, weight, chest girth, waist girth, and hip girth, whereas the independent (grouping) variables were the regions (Northern/Ashanti/Greater Accra). There were significant differences between the regions regarding height ($p<0.01$) and weight ($p<0.001$) measurements of pupils across the three regions sampled. Specifically, drawing from the mean value results in Table 6.4 and multiple comparison in Table 6.5, the average height was highest in Greater Accra region, followed by Ashanti and Northern regions respectively. Also, average weight was heaviest in Ashanti region, followed by Greater Accra and Northern regions respectively. Significant differences were obtained for chest girth ($p<0.001$) and hip girth ($p<0.001$) but there was no significant difference for waist girth ($p=0.14 >0.05$) across the three regions of Ghana. Drawing from the mean value results in Table 6.4 and multiple comparison in Table 6.5, the average chest girth was larger in Ashanti region, followed by Greater Accra and Northern regions respectively. Also, average hip girth was larger in Ashanti region, followed by Greater Accra and Northern regions respectively.

Table 6.4: Test of differences in body measurements among regions- One-way ANOVA

Items	Region (Mean)			F	P
	Northern (n=277)	Ashanti (n=239)	Greater Accra (n=260)		
Height (cm)	131.0	133.3	134.6	6.39	0.002**
Weight (Kg)	30.1	32.3	31.1	11.47	0.000***
Chest girth (cm)	62.4	64.8	63.7	9.54	0.000***
Waist girth (cm)	58.8	59.5	58.9	1.98	0.14
Hip girth (cm)	70.0	72.7	72.4	7.72	0.000***

***p<0.001; **p<0.01

Table 6.5: Fisher's LSD multiple comparisons-across regions

Dependent Variable	(I) Region	(J) Region	Mean Difference (I-J)	Std. Error	p.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Height	Northern	Ashanti	-2.2714*	1.0383	.029	-4.310	-.233
		Greater Accra	-3.5827*	1.0155	.000	-5.576	-1.589
	Ashanti	Northern	2.2714*	1.0383	.029	.233	4.310
		Greater Accra	-1.3113	1.0539	.214	-3.380	.758
	Greater Accra	Northern	3.5827*	1.0155	.000	1.589	5.576
		Ashanti	1.3113	1.0539	.214	-.758	3.380
Weight	Northern	Ashanti	-2.1818*	.4556	.000	-3.076	-1.288
		Greater Accra	-.9795*	.4456	.028	-1.854	-.105
	Ashanti	Northern	2.1818*	.4556	.000	1.288	3.076
		Greater Accra	1.2024*	.4624	.009	.295	2.110
	Greater Accra	Northern	.9795*	.4456	.028	.105	1.854
		Ashanti	-1.2024*	.4624	.009	-2.110	-.295
Chest girth	Northern	Ashanti	-2.4019*	.5528	.000	-3.487	-1.317
		Greater Accra	-1.3307*	.5407	.014	-2.392	-.269
	Ashanti	Northern	2.4019*	.5528	.000	1.317	3.487
		Greater Accra	1.0712	.5611	.057	-.030	2.173
	Greater Accra	Northern	1.3307*	.5407	.014	.269	2.392
		Ashanti	-1.0712	.5611	.057	-2.173	.030
Waist girth	Northern	Ashanti	-.7001	.3761	.063	-1.438	.038
		Greater Accra	-.0946	.3678	.797	-.817	.627
	Ashanti	Northern	.7001	.3761	.063	-.038	1.438
		Greater Accra	.6054	.3817	.113	-.144	1.355
	Greater Accra	Northern	.0946	.3678	.797	-.627	.817
		Ashanti	-.6054	.3817	.113	-1.355	.144
Hip girth	Northern	Ashanti	-2.7428*	.7785	.000	-4.271	-1.215
		Greater Accra	-2.4380*	.7615	.001	-3.933	-.943

	Ashanti	Northern	2.7428*	.7785	.000	1.215	4.271
		Greater Accra	.3049	.7902	.700	-1.246	1.856
	Greater Accra	Northern	2.4380*	.7615	.001	.943	3.933
		Ashanti	-.3049	.7902	.700	-1.856	1.246

*. The mean difference is significant at the 0.05 level.

A further tested was conducted to ascertain whether there were differences among the measurements of participant from the metropolitan areas and the municipal districts using one way ANOVA presented in Table 6.6 and Fishers LSD multiple comparison test presented at Appendix 14. The main dependent (target) variables were height, weight, chest girth, waist girth, and hip girth, whereas the independent (grouping) variables were the districts (Tamale metro/Sagnarigu/ Kumasi metro/ Ejisu/ Accra metro/ Ga west). There were significant differences between the districts regarding all the five measurements namely height (p<0.001), weight (p<0.001), chest girth (p<0.001), waist girth (p<0.001), and hip girth (p<0.001) across the six areas sampled. Specifically, drawing from the mean value results in Table 6.6 and multiple comparison at Appendix 14, the average height was highest in the Kumasi metro, followed by Accra metro, Ga West municipal district, Tamale metro, Sagnarigu district and Ejisu district respectively. Similarly, weight was heaviest in Kumasi metro, and chest girth, waist girth and hip were largest in the Kumasi metro.

Table 6.6: Test of differences in body measurements- metropolitan and district- one-way ANOVA

Items	Metropolitan and District (Mean)						F	P
	Tamale Metro	Sagnarigu District	Kumasi Metro	Ejisu District	Accra Metro	GA West Municipal		
Height (cm)	132.6	129.8	137.5	128.9	136.4	132.8	11.46	0.000***
Weight (Kg)	30.1	30.2	33.7	30.7	31.3	30.8	8.74	0.000***
Chest girth (cm)	63.4	61.7	67.3	62.0	64.2	63.2	14.24	0.000***
Waist girth (cm)	58.9	58.7	61.1	57.7	59.0	58.7	8.84	0.000***
Hip girth (cm)	70.8	69.3	76.0	69.2	73.7	71.1	7.72	0.000***

***p<0.001

6.11 Exploratory Factor Analysis (EFA)

This section performs data reduction analysis using exploratory factor analysis procedure of Principal Component Analysis (PCA). This multivariate statistical method analyses the inter-relationships among the 35 variables and extracts the fundamental factors vital for body shape interpretation (Chung et al., 2007). This is done by reducing the number of variables into a smaller set of variables termed as factors (Williams, Onsman and Brown, 2010). This application regrouped the variables into restricted smaller groups based on shared variance (Yong and Pearce, 2013).

This is an important phase of the sizing process as it commences the selection of key dimensions used in the designation of clothing. The PCA was first performed on all participants together and separately for male and female participants. The use of all 35 anthropometric measurements to develop a sizing system is not practicable. Therefore, the PCA was used to extract the important variables. All the thirty-five (35) anthropometric measurement items were subjected to PCA with Varimax rotation (Yong and Pearce, 2013; Zakaria, 2016). Using extraction criteria of Eigen values greater than unity, four factors were extracted. This is evident by the fact that a sharp curve (change) occurred between factor 4 and factor 5 as shown in the scree plot in Figure 6.16.

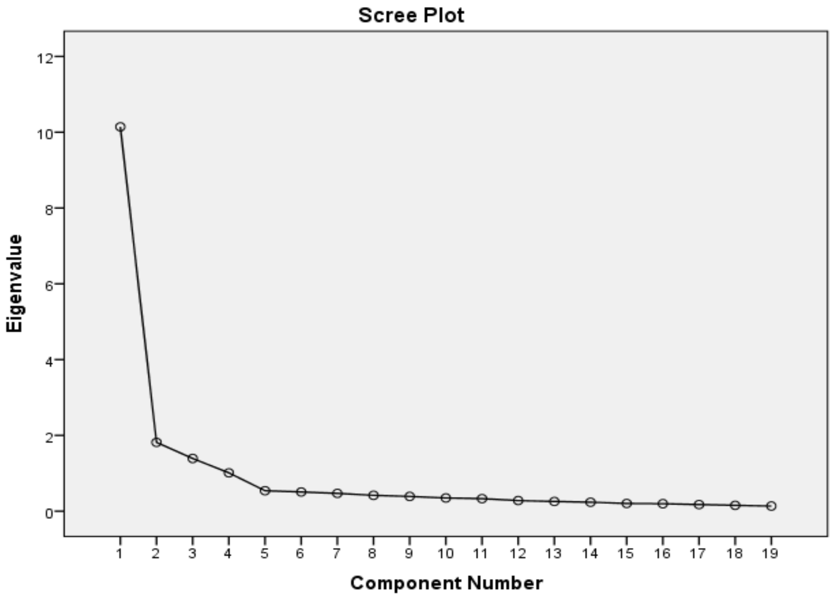


Figure 6.16: Scree plot showing extracted factors for-all participants

Only items with factor loadings ≥0.70 were retained in order to recognize the observable patterns in the anthropometric measurements of the pupils (Zakaria, 2011; Zakaria, 2016). The utilisation of eigen values greater than one alongside item loadings ≥0.70 resulted in a reduction of the original 35 anthropometric items to 19 items having four extracted factors accounting for about 75.58% of the total variance. The variables that featured in Factor 1 were vertical length-related variables and comprised of waist to ankle, inside leg length, waist to floor, nape to floor, outer arm length, height, shoulder to elbow and knee to floor. The variables that featured in Factor 2 were girths-related variables and encompassed thigh girth, upper arm girth, chest girth, waist girth, knee girth and elbow girth. The variables that featured in Factor 3 were also vertical length-related variables and comprised of front neck to waist, base of throat to waist and nape to waist.

Table 6.7: PCA-Extracting Eigen values greater than unity

	Factors/PCs			
Items	**1**	**2**	**3**	**4**
Waist to ankle	0.837			
Inside leg	0.81			
Waist to floor	0.802			
Nape to floor	0.789			
Outer arm length	0.76			
Height	0.741			
Shoulder Elbow	0.738			
Knee to floor	0.72			
Thigh girth		0.812		
Upper arm girth		0.75		
Chest girth		0.734		
Waist girth		0.731		
Knee girth		0.71		
Elbow girth		0.71		
Front neck to waist			0.868	
Base of throat			0.843	
Nape to waist			0.789	
Scye depth				0.795
Waist to hip				0.745
Eigenvalue	10.143	1.815	1.39	1.012
% of Variance	53.385	9.555	7.318	5.325
Cum. % of variance	53.385	62.939	70.258	75.583

A Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy as well as a Bartlett's Test of Sphericity of Chi-square were computed. To Williams et al. (2010) and Watkins (2018) the range for KMO is from 0.00 to 1.00 and several researchers concur that a desirable KMO should have a value ≥0.70 (Hair et al.,1995; Williams et al., 2010; Hoelzle and Meyer, 2013, and Lloret et al., 2017 cited in Watkins, 2018). Watkins (2018) added that KMO values ≥0.90 is spectacular. A KMO Measure of Sampling Adequacy value of 0.94 as well as a Bartlett's Test of Sphericity of Chi-square=12043.12, df=171, and $p<0.001$ were obtained, which show that sample is adequate for factor analysis and that the anthropometric measurement variables correlate well as shown in Table 6.7.

Reliability analysis of the four extracted factors were performed in the form of Cronbach's coefficient alpha as shown in Table 6.8. The first three factors were found to be reliable with Cronbach's alphas above the minimum threshold of 0.70 showing high internal consistencies (Byrne, 2016; Hair et al., 2017). The fourth factor, however, was eliminated from further analysis has it was found not to be reliable with Cronbach's alpha below the minimum threshold of 0.70 (Byrne, 2016; Hair et al., 2017). The first factor contained eight items all related to body length measurements hence, factor 1 was termed as "length" The second factor contains six items all related to girth measurements, factor 2 was termed as "girth". Factor three also relates to length measurements of the upper body and termed as "upper body length". This means that these measurements in each of the factors are good predictors of size.

Table 6.8: Reliability analysis

Parameter	Loading	Alpha	**Decision**
PC 1 (length)		0.921	Retain
Waist to ankle	0.837		
Inside leg	0.81		
Waist to floor	0.802		
Nape to floor	0.789		
Outer arm length	0.76		
Height	0.741		
Shoulder Elbow	0.738		
Knee to floor	0.72		
PC 2 (girth)		0.874	Retain
Thigh girth	0.812		
Upper arm girth	0.75		
Chest girth	0.734		
Waist girth	0.731		
Knee girth	0.71		
Elbow girth	0.71		
PC 3 (upper body length)		0.875	Retain
Front neck to waist	0.868		
Base of throat	0.843		
Nape to waist	0.789		
PC 4(scye and waist hip)		0.593	Eliminate
Scye depth	0.795		
Waist to hip	0.745		

6.11.1 Confirmatory Factor Analysis (CFA)

The three factors extracted from principal component analysis were further validated using covariance-based structural equation modelling (CB-SEM) software of IBM AMOS version 20.0 (Byrne, 2016). Confirmatory factor analysis involves the assessment of model fit indices, convergent validity, and discriminant validity (Kline, 2005; Byrne, 2016; Hair et al., 2016). During the measurement model analysis, the modification indices suggested the setting of the error covariance between some of the items free. The path diagram and item loadings following purification of the model is shown in Figure 6.17. This was done in accordance with findings by Otieno and Fairhurst (2000b) that methodology used in the development of a sizing system based on collected anthropometric data are very significant; and procedures should be carried out thoroughly and sequentially to circumvent error while increasing reliability and validity of the results.

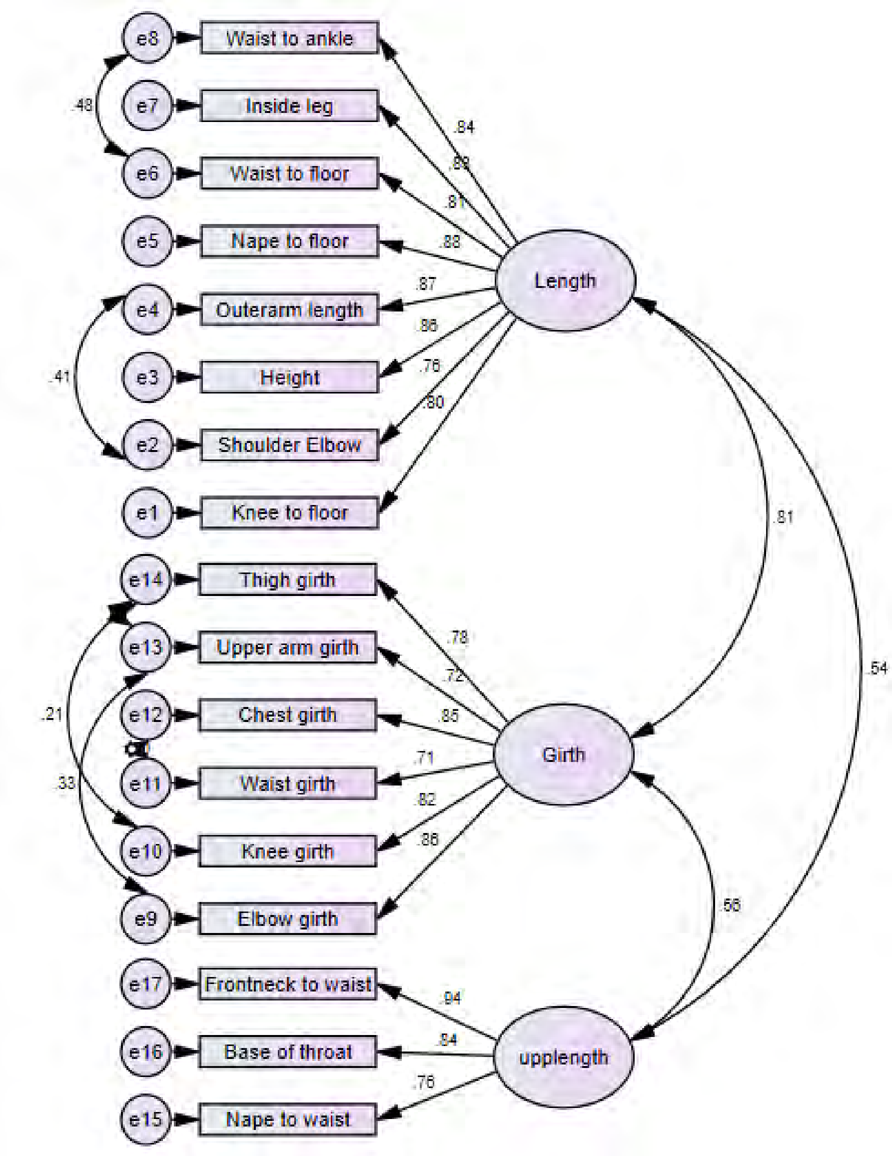


Figure 6.17: CFA Path diagram showing standardised coefficients and covariances

6.11.2 Fit indices

The model had acceptable fit indexes (χ^2= 448.8, df=110, χ^2/df=4.07, CFI = 0.97, RMSEA = 0.063, AGFI = 0.915) as shown in Table 6.9. The fit indexes are acceptable if the recommended thresholds are met including χ^2/df <5, RMSEA< 0.08, AGFI> 0.80 and CFI> 0.95 (Byrne, 2016).

6.11.3 Reliability and Convergent Validity

From Table 6.9, all the three components/factors Cronbach's alpha were above 0.70, composite reliabilities (C.Rs) were higher than 0.70 and average variance extracted estimates were also higher than 0.50, therefore the model demonstrates adequate reliability and convergent validity (Hair et al., 2017).

6.11.4 Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion (Fornell and Larcker 1981). The square root of the average variance extracted estimates were all higher than the inter-component correlations between them as shown in Table 6.10, therefore, all the three components extracted demonstrate discriminant validity and are unique (Byrne, 2016; Hair et al., 2017).

Table 6.9: Details of items measurement, validity and reliability assessment results

Construct	A	CR	AVE	T values	Loading	
Length	0.921	0.948	0.694			
Waist to ankle				27.007	0.840	
Inside leg				26.732	0.834	
Waist to floor				25.599	0.809	
Nape to floor				28.840	0.880	
Outer arm length				28.480	0.872	
Height				28.129	0.864	
Shoulder to Elbow				23.668	0.763	
Knee to floor				Fixed	0.797	
Girth	0.874	0.909	0.626			
Thigh girth				25.433	0.777	
Upper arm girth				27.373	0.721	
Chest girth				29.350	0.848	
Waist girth				22.137	0.708	
Knee girth				27.871	0.822	
Elbow girth					0.857	
Upper body length	0.875	0.884	0.719			
Front neck to waist				25.830	0.938	
Base of throat				24.273	0.839	
Nape to waist					0.757	
Fit Statistics	**Chi-square (df)**	**X2/df**	**RMSEA**	**AGFI**	**TLI**	**CFI**
Model Fit	448.18(110)	4.074	0.063	0.915	0.963	0.97

Notes: CR- composite reliability, Alpha (a) - Cronbach's Alpha, AVE -Average variance extracted, DF- Degree of freedom, RMSEA- Root mean square error of approximation, AGFI- Adjusted Goodness of Fit Index, CFI- Comparative fit index, TLI- Tucker-Lewis Index were reported.

Table 6.10: Discriminant Validity-Fornell-Larcker Criterion

Constructs	1	2	3
1 Length	**0.833**		
2 Girth	0.714***	**0.791**	
3 Upper body length	0.487***	0.495***	**0.845**

***p<0.001 (two-tail test); Square root of AVEs in diagonal-bold

6.12 Correlation Matrix

The Pearson correlation analysis of the 17 validated variables is presented in Table 6.11. All the inter-variable correlations were positive and significant ($p<0.01$). The implication is that an increase in one variable leads to an increase in the other variables. Table 6.12 presents the correlation analysis of five (5) key anthropometric measurements including height, weight, chest girth, waist girth, and hip girth. All the inter-variable correlations were positive and significant. For example, height is significant and positively related to weight ($p<0.01$), chest girth ($p<0.01$), waist girth ($p<0.01$) and hip girth ($p<0.01$).

Table 6.11: Correlation matrix- validated variables

Body Dimension	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Height	1.00																
Chest girth	0.67	1.00															
Waist girth	0.51	0.68	1.00														
Upper arm girth	0.47	0.61	0.54	1.00													
Elbow girth	0.63	0.72	0.61	0.74	1.00												
Thigh girth	0.56	0.69	0.55	0.65	0.67	1.00											
Knee girth	0.63	0.69	0.61	0.60	0.70	0.72	1.00										
Shoulder Elbow	0.68	0.56	0.43	0.43	0.53	0.46	0.52	1.00									
Outer arm length	0.76	0.64	0.46	0.52	0.65	0.54	0.63	0.80	1.00								
Nape to waist	0.38	0.38	0.36	0.36	0.42	0.30	0.37	0.40	0.45	1.00							
Nape to floor	0.77	0.61	0.47	0.47	0.64	0.52	0.58	0.64	0.75	0.43	1.00						
Base of throat	0.38	0.40	0.40	0.35	0.40	0.33	0.36	0.32	0.42	0.62	0.42	1.00					
Front neck to waist	0.42	0.44	0.40	0.39	0.46	0.34	0.41	0.42	0.48	0.71	0.45	0.79	1.00				
Waist to ankle	0.72	0.53	0.39	0.44	0.60	0.49	0.55	0.65	0.75	0.34	0.74	0.28	0.33	1.00			
Waist to floor	0.69	0.55	0.41	0.46	0.60	0.49	0.55	0.64	0.72	0.33	0.70	0.28	0.29	0.83	1.00		
Knee to floor	0.67	0.54	0.43	0.49	0.54	0.47	0.58	0.59	0.67	0.37	0.71	0.39	0.43	0.67	0.67	1.00	
Inside leg	0.70	0.53	0.39	0.41	0.54	0.44	0.52	0.65	0.72	0.37	0.76	0.38	0.42	0.73	0.67	0.69	1.00

Note: All correlations are positive and significant at $p<0.01$

Table 6.12: Correlation matrix- 5 key measurements

Body Dimension	1	2	3	4	5
1. Height	1.00				
2. Weight	0.60**	1.00			
3. Chest girth	0.67**	0.60**	1.00		
4. Waist girth	0.51**	0.55**	0.68**	1.00	
5. Hip girth	0.67**	0.54**	0.69**	0.56**	1.00

Note: ** p<0.01

6.13 PCA results per gender

PCA was performed separately for males and females. To ensure loadings of the key variables, the analysis extracted item Eigen values greater than unity and factor loadings greater than 0.60 (Hair et al., 2010). The results are presented as follows:

6.13.1 PCA for male participants

All the thirty-five (35) anthropometric measurement items were subjected to principal component analysis with varimax rotation (Yong and Pearce, 2013; Zakaria, 2011). Using extraction criteria of Eigen values greater than unity and loadings higher than 0.60, four factors were extracted (Hair et al., 2010). This is evident by the fact that a sharp curve (change) occurred between factor 4 and factor 5 as shown in the scree plot in Figure 6.18.

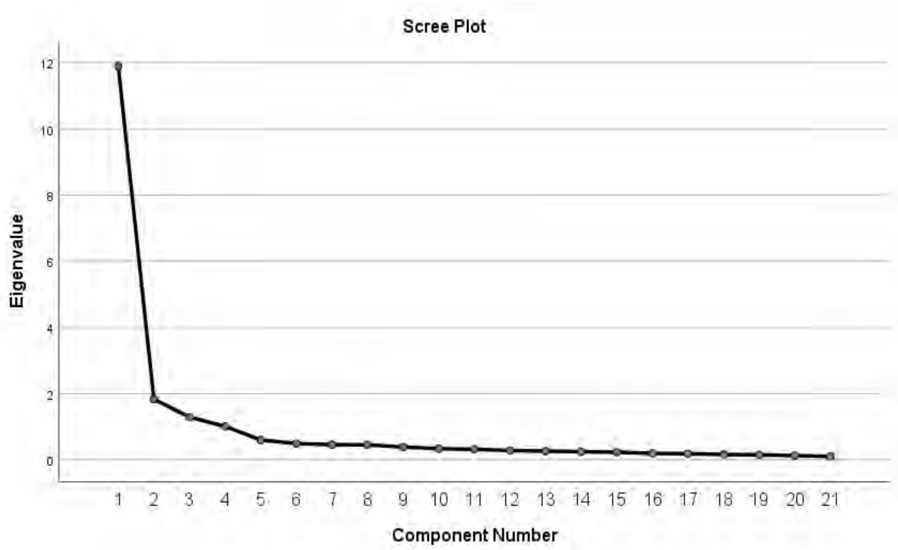


Figure 6.18: Scree plot showing extracted factors for males (6-11years)

The utilisation of eigen values greater than one and alongside item loadings ≥0.60 resulted in a reduction of the original 35 anthropometric items to 21 items having four extracted factors accounting for about 76% of the total variance. A Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy value of 0.95 as well as a Bartlett's Test of Sphericity of Chi-square=7469.4, df=210, and p<0.001 were obtained, which show that sample is adequate for factor analysis and that the anthropometric measurement variables correlate well as shown in Table 6.13.

Table 6.13: PCA-based loadings >0.60 for male participants

Items	Factors/PCs			
	1	2	3	4
Waist to ankle	0.839			
Waist to floor	0.79			
Nape to floor	0.779			
Inside leg	0.777			
Knee to floor	0.775			
Outer arm length	0.741			
Height	0.733			
Shoulder Elbow	0.731			
Thigh girth		0.813		
Chest girth		0.746		
Upper arm girth		0.718		
Waist girth		0.702		
Elbow girth		0.702		
Hip girth		0.672		
Knee girth		0.668		
Armscye girth		0.662		
Front neck to waist			0.867	
Base of throat			0.84	
Nape to waist			0.812	
Scye depth				0.793
Waist to hip				0.717
Eigenvalue	11.891	1.835	1.288	1.01
% of Variance	56.625	8.737	6.135	4.812
Cum. % of variance	56.625	65.362	71.498	76.31

KMO=0.947; Barletts Test Chi-square=7469.4, df=210, p=0.000; Total variance explained=76.3%

Just as the PCA for all participants, first factor contains eight items all related to body length measurements therefore, factor 1 was termed as “length” The second factor contains eight items all related to girth measurements, factor 2 was termed as “girth”. Factor three also relates to length measurements of upper body with three factors and termed as “upper body length”.

6.13.2 PCA for female participants

All the thirty-five (35) anthropometric measurement items were subjected to principal component analysis with varimax rotation for the female participants (Yong and Pearce, 2013; Zakaria, 2011). Using extraction criteria of Eigen values greater than unity and loadings higher ≥ 0.60, four factors were extracted. This is evident by the fact that a sharp curve (change) occurred between factor 4 and factor 5 as shown in the scree plot in Figure 6.19.

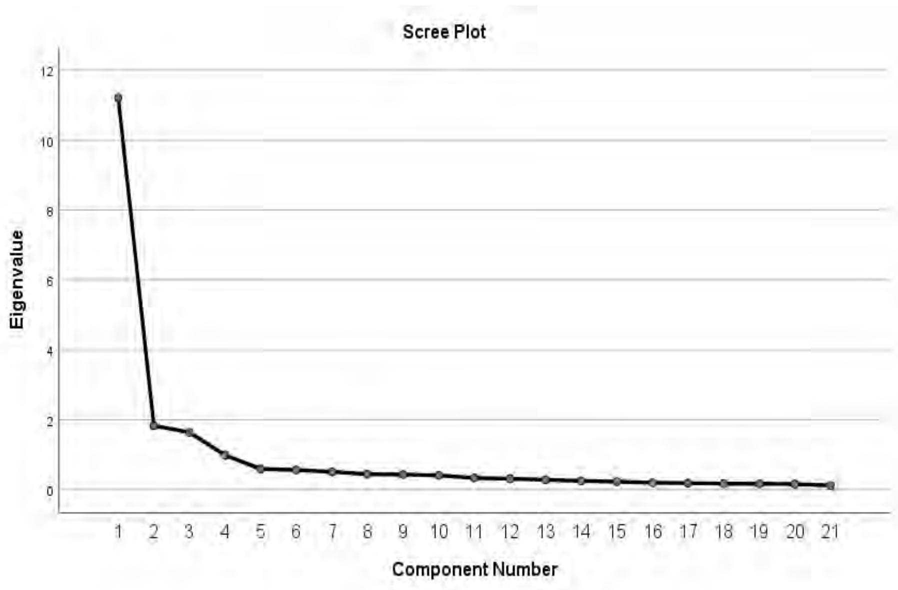


Figure 6.19: Scree plot showing extracted factors for females (6-11 years)

The utilisation of eigen values greater than one alongside item loadings ≥0.60 resulted in a reduction of the original 35 anthropometric items to 22 items having four extracted factors accounting for about 74% of the total variance. Unlike, the PCA for males, weight loaded significantly into the PCA for females. Also, "inside leg" has a higher loading than "waist to ankle" among females. A Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy value of 0.95 as well as a Bartlett's Test of Sphericity of Chi-square=14553.3, df=231, and $p<0.001$ were obtained, which confirm that the sample is adequate for factor analysis and that the anthropometric measurement variables correlate well as shown in Table 6.14. The first factor contains eight items all related to body length measurements and termed as “length” The second factor contains nine items all related to girth measurements, factor 2 was termed as “girth”. Factor three also relates to length measurements of the upper body with three factors and termed as “upper body length”.

Table 6.14: PCA-based loadings >0.60 for female participants

Items	Factors/PCs			
	1	2	3	4
Inside leg	0.828			
Waist to ankle	0.816			
Waist to floor	0.792			
Nape to floor	0.776			
Outer arm length	0.752			
Height	0.739			
Shoulder Elbow	0.719			
Knee to floor	0.65			
Thigh girth		0.846		
Upper arm girth		0.782		
Elbow girth		0.737		
Waist girth		0.737		
Chest girth		0.734		
Knee girth		0.727		
Weight		0.679		
Hip girth		0.646		
Armscye girth		0.63		
Front neck to waist			0.856	
Base of throat			0.833	
Nape to waist			0.759	
Scye depth				0.774
Waist to hip				0.742
Eigenvalue	11.955	1.817	1.483	1.077
% of Variance	54.341	8.258	6.74	4.897
Cum. % of variance	54.341	62.599	69.339	74.237

KMO=0.954; Barletts Test Chi-square=14553.3, df=231, p=0.000; Total variance explained=74.2%

6.14 Key dimensions and the selection of control dimensions

Key dimensions are important in the development of a sizing system. In this study, key dimensions were determined using PCA method founded on the 35 body dimensions collected from the study sample of Ghanaian children between the ages of 6 and11. From Table 6.13 and 6.14, PCA results show dimensions that are significant to use for the creation of sizing system. These dimensions are mostly collected in many anthropometric surveys. Key measurements according to Otieno and Fairhurst (2000a) should be fairly distributed between the upper and lower torsos. Twenty-one key measurements featured in the PCA for males whilst 22 key dimensions featured in that of the females.

Majority of the key measurements that featured are easy to measure and essential in pattern drafting and garment production. Key dimensions mostly used in clothing anthropometry for children were significant in this study. These include height, chest girth, waist girth, waist to ankle (outer leg length) and inside leg length. From Table 6.13 and 6.14, it is evident that the waist to ankle length (outer leg length) (0.837-males and 0.816-females) and inside leg length (0.828-females) have the strongest correlation to length factor for the study samples. Zakaria's (2016) study also obtained similar result with the inside leg length. Contrary to the study by Zakaria (2016) in which the upper arm girth was the strongest variable correlated to girth factor for male and female samples aged 7–12, the results in this study had the thigh girth having the highest factor loading correlated to girth in this study sample.

Based on the results of the PCA and the practicality of developing sizing system, height (factor loading of 0.733- males and 0.739- females) was selected as the primary control dimension for length in this study for both upper body and lower body designations of both males and females.

The chest girth dimension was selected as secondary control dimensions for upper body in addition to height the primary control dimension. The chest girth (factor loading of 0.746- males and 0.734- females) measurement was selected as it is relatively easy to measure (ISO 3635, 1977 and ISO 8559, 1989) and an important dimension in the development sizing system and upper body patterns for garments (Tamburino, 1992a). Waist girth was selected as secondary control dimensions for lower body in addition to height the primary control dimension. The waist girth has a high factor loading (factor loading of 0.702- males and 0.737- females), relatively simpler to measure (Hsu and Wang, 2005) and is among the frequently used body dimensions to designate lower body garments (Tamburino, 1992a; Mpampa et al., 2009). Selection of control dimensions is further elaborated in section 7.6.1 of chapter seven.

6.15 Cluster analysis

In this section, the researcher performed a multivariate technique using K-Means cluster analysis to extraction clusters to identify the body type of Ghanian children for the development of sizing system to produce ready-to-wear clothing. A cluster is normally composed of members with similar body characteristics that can be studied as a size category or a physique (Chung et al., 2007) and a sizing system is used to categorise a particular population into sub identical groups based on selected key body dimensions with individuals in each subgroup possessing similar body traits (Chung et al., 2007) making the use of this statistical process relevant to this study. Also, the range obtained in the descriptive statistics in Table 6.3 for most of the key dimensions were wide coupled with high values of standard deviations. For instance, height a key dimension used in the designation of children's sizes had a range of 53.6cm with a standard deviation of 11.29cm for males and a range of 62.3cm with a standard deviation of 12.39 for females. The chest girth has a range of 30.50cm with a standard deviation of 6.10cm for male participants and a range of

30.0cm with a standard deviation of 6.56cm was obtained for the females. These values indicate a widespread in the body dimensions of the population necessitating a statistical procedure to group sample into homogenous subgroups practical for the development of sizing system. Two control dimensions namely the height (primary control dimension) and chest girth (secondary control dimension) were used for upper body categorisation whereas height (primary control dimension) and waist girth (secondary control dimension) were applied for lower body categorisation for performing the cluster analysis. The k-means analysis indicated the number of participants in each cluster, the means for the control dimensions used for each cluster as well as the minimum and the maximum of each control dimension used for the clustering.

6.15.1 Upper body clusters- all participants

The K-means cluster analysis was performed using height and chest girth as control variables for upper body with the extraction of 3-clusters for all participants as shown in Table 6.15 and Figure 6.20. The cluster analysis was conducted using both male and female participants. From Table 6.15 cluster-1 participants (n=212) had a mean height of 147.4cm and standard deviation of 5.8cm, whereas the chest girth had a mean of 70.1cm and a standard deviation of 4.6cm. Cluster-2 participants (n=329) had a mean height of 133.1cm and standard deviation of 4.6cm. The chest girth had a mean of 63.4cm and a standard deviation of 4.7cm. For cluster 3, participants (n=235) had a mean height of 119.7cm and standard deviation of 6.1cm, whereas the chest girth had a mean of 57.8cm and a standard deviation of 3.5cm. Participants in cluster 1 may be termed as belonging to large body type, cluster 2 may be termed as consisting of participants in medium size category, and cluster 3 may be termed as having participants from small size category for the upper body. The overall cluster quality was high since the ratio of the largest to the smallest cluster is 1.5 which is less than 3 (Hair et al., 2010). Both height ($F=1455$, $p<0.001$) and chest girth

(F=449, p<0.0001) significantly influenced the cluster formation for the upper body for all the participants together.

Table 6.15: Clusters for upper body- all participants

Parameter	Custers			ANOVA	
	Cluster 1	Cluster 2	Cluster 3		
Height				1455.280	0.000***
N	212	329	235		
Mean height, cm	147.4	133.1	119.7		
SD height, cm	5.8	4.6	6.1		
Range height, cm	136.5-163.5	124.0-146.8	101.2-129.0		
Chest girth				449.288	0.000***
Mean chest girth, cm	70.10	63.40	57.80		
SD chest girth, cm	4.60	4.70	3.50		
Range chest girth, cm	59.0-79.5	49.0-76.0	49.0-71.0		
Body Type	Large	Medium	Small		

***p<0.001

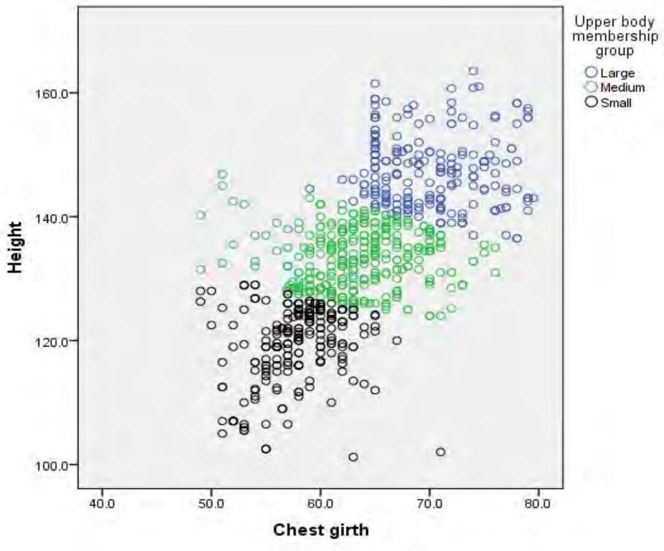


Figure 6.20: Upper body clusters using height and chest girth- all participants

6.15.2 Upper body clusters-male participants only

K-means cluster analysis for only male participants with the extraction of 3-clusters shows the results in Table 6.16 and Figure 6.21. Cluster 1 participants (n- 118) had a mean height of 146.2 cm and standard deviation of 5.6cm, whereas the chest girth had a mean of 69.8cm and a standard deviation of 4.5cm. Cluster 2 participants (n=171) had a mean height of 131.7cm and standard deviation of 4.3cm, whereas the chest girth had a mean of 63.0cm and a standard deviation of 4.1cm. Finally, Cluster 3 participants (n=102) had a mean height of 119.2cm and standard deviation of 5.3cm, whereas the chest girth had a mean of 57.7cm and a standard deviation of 3.5cm. Cluster 1 is termed as large type, cluster 2 as medium body type, and cluster 3 as small type for the male upper body. The overall cluster quality was very high since the ratio of the largest to the smallest cluster is 1.7 which is less than 3 (Hair et al., 2010). Both height ($F=814.6$, $p<0.001$) and chest girth ($F=246.7$, $p<0.001$) significantly influenced the cluster formation for the upper body of Ghanaian male children aged 6-11.

Table 6.16: Clusters for upper body- males only

Parameter	Clusters			ANOVA	
	Cluster 1	Cluster 2	Cluster 3		
Height				814.559	0.000***
N	118	171	102		
Mean height, cm	146.2	131.7	119.2		
SD height, cm	5.6	4.3	5.3		
Range height, cm	135.0-158.6	124.0-140.5	105.0-128.0		
Chest girth				246.720	0.000***
Mean chest girth, cm	69.8	63.0	57.7		
SD chest girth, cm	4.5	4.1	3.5		
Range chest girth, cm	51.0-79.5	53.0-73.0	49.0-67.0		
Body Type	Large	Medium	Small		

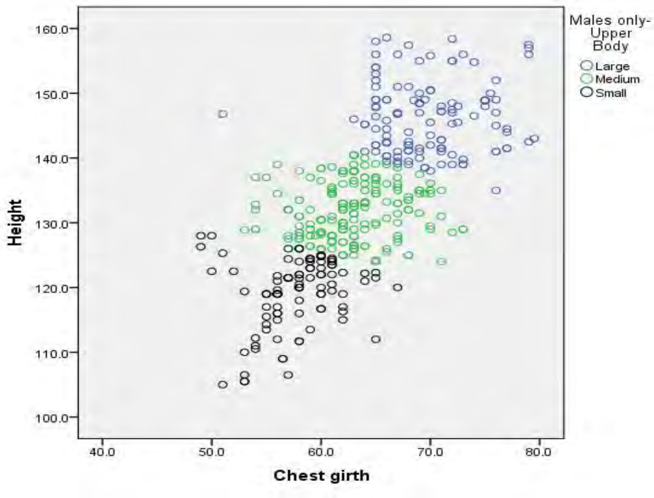


Figure 6.21: Upper body clusters using height and chest girth- male participants

Table 6.17: Ages of participants in each cluster group- male upper body

Ages	Cluster for male upper body according to height and chest girth						Total	
	Large (Cluster 1)	%	Medium (Cluster 2)	%	Small (Cluster 3)	%	Total	%
6	0	0.0	11	6.4	40*	39.2	51	13.0
7	1	0.8	23	13.5	26	25.5	50	12.8
8	3	2.5	45*	26.3	18	17.6	66	16.9
9	15	12.7	32	18.7	13	12.7	60	15.3
10	46	39.0	41	24.0	3	2.9	90	23.0
11	53*	44.9	19	11.1	2	2.0	74	18.9
Total	118	100	171	100	102	100	391	100.0

The ages of the participants within the clusters were analysed. Table 6.17 indicates the distribution of ages within the cluster groups for male upper body. Apart from the large body type (cluster 1) that did not have any of the participant with age six, all remaining ages can be found in each cluster. For large body type (cluster 1) in Table 6.17 majority of the participants belong to age 11 (n-53). The Medium body type (cluster 2) has participants spread across all ages, with majority of the participants belonging to age eight (n-45). This is closely followed by age 10 (n-41). Small body type (cluster 3) has most of the participants in age 6 (n-40). Based on the result in Table 6.17, it is evident that the lowest age (6 years) of the sample is predominantly within the small body type classification. The highest age of the sample (11 years) is mostly in the large body type.

6.15.3 Upper body clusters- female participants only

The result of the K-means cluster analysis for female participants with the extraction of 3-clusters are shown in Table 6.18 and Figure 6.22. Cluster 1 participants (n=106) had a mean height of 147.9cm and standard deviation of 6.2cm, whereas the chest girth had a mean of 70.0cm and a standard deviation of 4.9cm. Cluster 2 participants (n=161) had a mean height of 133.4cm and standard deviation of 4.8cm, whereas the chest girth had a mean of 63.4cm and a standard deviation of 5.2cm. Finally, Cluster 3 participants (n=118) had a mean height of 119.2cm and standard deviation of 6.6cm, whereas the chest girth had a mean of 57.7cm and a standard deviation of 3.3cm. Cluster 1 in this study is termed as large body type, cluster 2 termed as medium body type, and cluster 3 termed as small body type for female upper body. The overall cluster quality was very high since the ratio of the largest to the smallest cluster is 1.5 which is less than 3 (Hair et al., 2010). Both height ($F=684.6$, $p<0.001$) and chest girth ($F=194.7$, $p<0.001$) significantly influenced the cluster formation for the upper body of Ghanaian female children aged 6-11.

Table 6.18: Clusters for upper body - females only

Parameter	**Custers**			ANOVA	
	Cluster 1	Cluster 2	Cluster 3		
Height				684.630	0.000***
N	106	161	118		
Mean height, cm	147.9	133.4	119.2		
SD height, cm	6.2	4.8	6.6		
Range height, cm	136.5.0-163.5	124.0-145.0	101.2-129.0		
Chest girth				194.724	0.000***
Mean chest girth, cm	70.0	63.4	57.7		

SD chest girth, cm	4.90	5.20	3.30
Range chest girth, cm	59.0-79.0	49.0-76.0	51.0-71.0
Body Type	Large	Medium	Small

***p<0.001

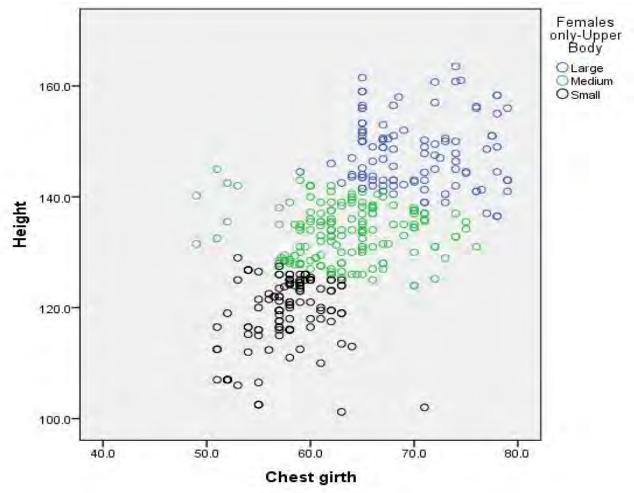


Figure 6.22: Upper body clusters using height and chest girth- female participants

Table 6.19 Ages of participants in each cluster group- female upper body

Ages	Clusters for female upper body according to height and chest girth						Total	
	Large (Cluster 1)	%	Medium (Cluster 2)	%	Small (Cluster 3)	%	Total	%
6	1	0.9	8	5.0	40*	33.9	49	12.7
7	2	1.9	16	9.9	31	26.3	49	12.7
8	3	2.8	55*	34.2	29	24.6	87	22.6
9	11	10.4	42	26.1	12	10.2	65	16.9
10	35	33.0	19	11.8	5	4.2	59	15.3
11	54*	50.9	21	13.0	1	0.8	76	19.7
Total	106	100.0	161	100.0	118	100.0	385	100.0

Table 6.19 gives the breakdown of the ages of the sample within the cluster groups for female upper body. All ages can be found in each cluster. Large body type (cluster 1) has greater of the participants in age 11 (n-54). The Medium body type (cluster 2) has majority of the participants in age eight (n-55) Small body type (cluster 3) has majority of the participants in age six (n-40).

Based on the result, it is evident that the lowest age (6 years) of the sample is predominantly within the small body type classification whereas the highest age of the sample (11 years) is mainly in the large body type.

6.15.4 Lower body clusters- all participants

The k-means cluster analysis was performed on all participants together using height and waist girth as two key variables for lower body with the extraction of 3-clusters as shown in Table 6.20 and Figures 6.23. Cluster 1 participants (n=231) had a mean height of 147.0cm and standard deviation of 5.7cm, whereas the waist girth had a mean of 61.9cm and a standard deviation of 2.6cm. Cluster 2 participants (n=363) had a mean height of 131.6cm and standard deviation of 4.5cm, whilst the waist girth had a mean of 58.9cm and a standard deviation of 3.9cm. Finally, Cluster 3 participants (n=182) had a mean height of 117.9cm and standard deviation of 5.7cm, whereas the waist girth had a mean of 55.7cm and a standard deviation of 4.1cm. Cluster 1 is termed as large body type, cluster 2 is termed as medium size body type, and cluster 3 is termed as small body type for the lower body. The overall cluster quality was high since the ratio of the largest to the smallest cluster is 1.99 which is less than 3 (Hair et al., 2010). Both height ($F=1634$, $p<0.001$) and waist girth ($F=152$, $p<0.0001$) significantly influenced the cluster formation for the lower body.

Table 6.20: Clusters for lower body- all participants

Parameter	Clusters			ANOVA	
	Cluster 1	Cluster 2	Cluster 3		
Height				1634.099	0.000***
N	231	363	182		
Mean height, cm	147.0	131.6	117.9		
SD height, cm	5.7	4.5	5.7		
Range height, cm	138.2-163.5	124.0-140.2	101.2-126.3		
Waist girth				151.872	0.000***

Mean waist girth, cm	61.90	58.90	55.70
SD waist girth, cm	2.60	3.90	4.10
Range waist girth, cm	54.0-67.0	50.0-67.0	47.0-67.0
Body Type	Large	Medium	Small

***p<0.001

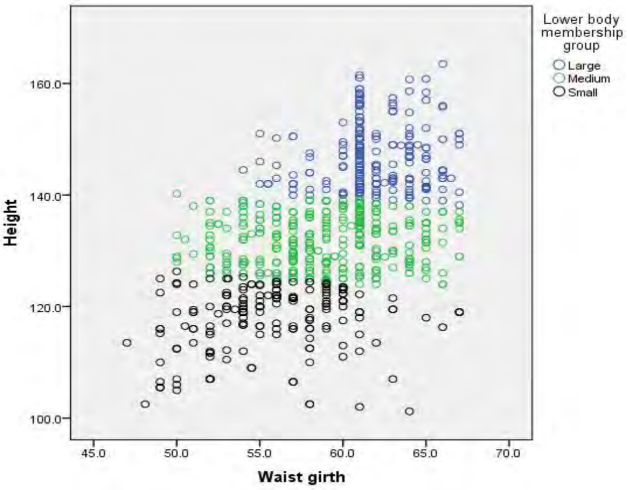


Figure 6.23: Lower body clusters using height and waist girth- all participants

6.15.5 Lower body clusters-male participants only

K-means cluster analysis for male participants with the extraction of 3-clusters shows the results in Table 6.21 and Figure 6.24. Cluster 1 participants (n=118) had a mean height of 146.3cm and standard deviation of 5.5cm, whereas the waist girth had a mean of 62.2cm and a standard deviation of 2.4cm. Cluster 2 participants (n=181) had a mean height of 131.3cm and standard deviation of 4.3cm, whereas the waist girth had a mean of 58.6cm and a standard deviation of 3.7cm. Cluster 3 participants (n=92) had a mean height of 118.5cm and standard deviation of 5.1cm, whereas the waist girth had a mean of 55.4cm and a standard deviation of 3.8cm. Cluster 1 is labelled as large body type, cluster 2 labelled as medium body type, and cluster 3 labelled as small body type for the lower body. The overall cluster quality was high since the ratio of the largest to the smallest cluster is 1.97 which is less than 3 (Hair et al., 2010). Both height (F=865.6, p<0.001) and chest girth (F=105.1, p<0.001) significantly influenced the cluster formation for the lower body of Ghanaian male participants.

Table 6.21: Clusters for lower body-males only

Parameter	Clusters			ANOVA	
	Cluster 1	Cluster 2	Cluster 3		
Height				865.588	0.000***
N	118	181	92		
Mean height, cm	146.3	131.3	118.5		
SD height, cm	5.5	4.3	5.1		
Range height, cm	138.5-158.6	124.0-139.1	105.0-126.3		
Waist girth				105.091	0.000***
Mean waist girth, cm	62.2	58.6	55.4		
SD waist girth, cm	2.4	3.7	3.8		
Range waist girth, cm	55.0-67.0	50.0-67.0	47.0-67.0		
Body Type	Large	Medium	Small		

***p<0.001

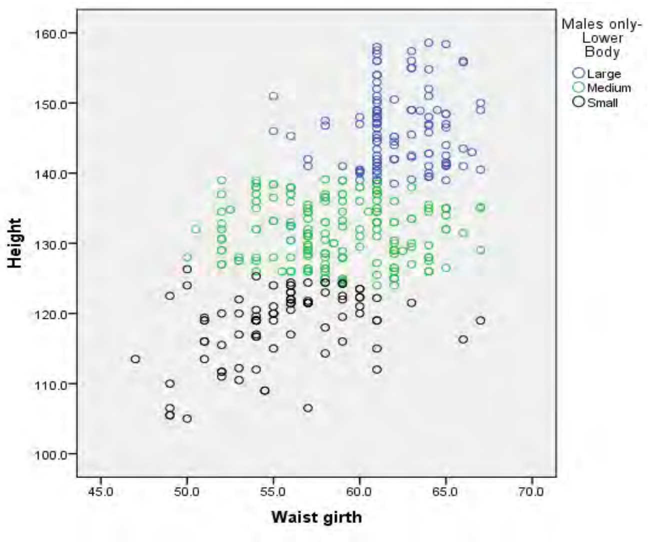


Figure 6.24: Lower body clusters using height and waist girth- male participants

Table 6.22 Ages of participants in each cluster group- male lower body

Ages	Cluster for male lower body according to height and chest girth						Total	
	Large (Cluster 1)	%	Medium (Cluster 2)	%	Small (Cluster 3)	%	Total	%
6	0	0.0	15	8.3	36*	39.1	51	13.0
7	1	0.8	24	13.3	25	27.2	50	12.8
8	3	2.5	47*	26.0	16	17.3	66	16.9
9	14	11.9	35	19.3	11	12.0	60	15.3
10	48	40.7	40	22.1	2	2.2	90	23.0
11	52*	44.1	20	11.0	2	2.2	74	18.9
Total	118	100.0	181	100.0	92	100.0	391	100.0

Table 6.22 shows the results of the ages of the participants within the clusters for male lower body. All ages can be found in each cluster except age six which did not feature in the large body type (cluster 1). Majority of the participants in the large body type (cluster 1) belong to age 11 (n-52). The medium body type (cluster 2) has participants spread across all ages, with a slight majority belonging to age 8 (n-47). The small body type (cluster 3) has most of the participants in age six (n-36). Based on the result in Table 6.22 it is evident that the lowest ages (6 and 7) of the sample are mainly in the small body type classification. The highest ages of the sample (10 and 11 years) are mostly in the large body type.

6.15.6 Lower body clusters-female participants only

K-means cluster analysis for female participants with the extraction of 3-clusters is presented in Table 6.23 and Figure 6.25. In cluster 1, participants (n=115) had a mean height of 147.6cm and standard deviation of 6.0cm, whereas the waist girth had a mean of 61.6cm and a standard deviation of 2.6cm. Cluster 2 participants (n=179) had a mean height of 131.7cm and standard deviation of 4.7cm, however the waist girth had a mean of 59.1cm and a standard deviation of 4.1cm. Finally, cluster 3 participants (n=91) had a mean height of 117.2cm and standard deviation of 6.2cm, whereas the waist girth had a mean of 56.0cm and a standard deviation of 4.3cm.

Cluster 1 is termed as large body type, cluster 2 as medium body type, and cluster 3 as small body type for female lower body. The overall cluster quality was high since the ratio of the largest to the smallest cluster is 1.97 which is less than 3 (Hair et al., 2010). Both height ($F=783.4$, $p<0.001$) and waist girth ($F=55.1$, $p<0.001$) significantly influenced the cluster formation for the lower body of females.

Table 6.23: Clusters for lower body-females only

Parameter	Clusters			ANOVA	
	Cluster 1	Cluster 2	Cluster 3		
Height				783.373	0.000***
N	115	179	91		
Mean height, cm	147.6	131.7	117.2		
SD height, cm	6.0	4.7	6.2		
Range height, cm	139.0-163.5	124.0-140.2	101.2-125.0		
Waist girth				55.052	0.000***
Mean waist girth, cm	61.6	59.1	56.0		
SD waist girth, cm	2.60	4.10	4.30		
Range waist girth, cm	54.0-67.0	50.0-67.0	48.1-67.0		
Body Type	Large	Medium	Small		

***p<0.001

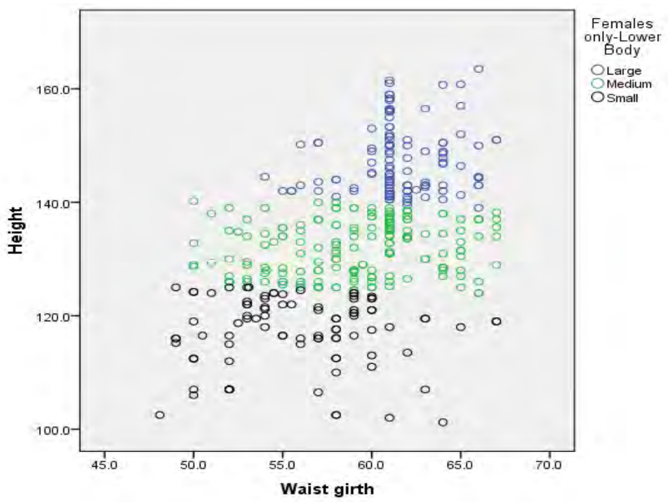


Figure 6.25: Lower body clusters using height and waist girth- female participants

Table 6.24: Ages of participants in each cluster group for female lower body

Ages	Cluster for female upper body according to height and chest girth						Total	
	Large (Cluster 3)	%	Medium (Cluster 2)	%	Small (Cluster 1)	%	Total	%
6	1	0.9	11	6.1	37*	40.7	49	12.7
7	0	0.0	25	14.0	24	26.4	49	12.7
8	3	2.6	65*	36.3	19	20.9	87	22.6
9	16	13.9	42	23.5	7	7.7	65	16.9
10	36	31.3	19	10.6	4	4.4	59	15.3
11	59*	51.3	17	9.5	0	0.0	76	19.7
Total	115	100.0	179	100.0	91	100.0	385	100.0

Table 6.24 shows the results of the ages of the participants within the clusters for female lower body. All ages featured in each cluster except ages six and 11 that did not obtain any participant in the small body type (cluster 3) and large body type (cluster 1) respectively. Majority of the participants in the large body type (cluster 1) belong to age 11 (n-59). The medium body type (cluster 2) has most of the participants in age eight (n-65). The small body type (cluster 3) has most of the participants in age six (n-37). The result in Table 6.24 shows that the lowest ages (6 and 7) of the sample are mainly in the small body type classification whilst the highest ages of the sample (10 and 11) are mainly in the large body type.

Clustering the participants together indicated that majority of the participant are in the medium body type (cluster 2). The mean values in all clusters labelled medium body types (clusters 2) correspond closely to the arithmetic mean in the descriptive statistics in Table 6.3. This goes to show why most sizing systems are based on the mean values obtained in the descriptive statistics of the analysed data. However, a critical observation of the cluster Tables (6.15-6.16, 6.18, 6.20-6.21 and 6.23) all indicate that sizeable number of participants are covered by large body type and small body type (cluster 1 and 3) showing the need to factor body types in the creation of a sizing system that is representative of a target population.

Additionally, ANOVA was run in each generated set of clusters to ascertain any significant differences among each set of clusters. The results indicate significant differences among the cluster groupings (Tables 6.15-6.16, 6.18, 6.20- 6.21 and 6.23). Thus, members in one cluster are different from members in bordering cluster groups. For example, in the cluster for lower body for females (Table 6.23) significant differences were obtained for height ($p<0.000$) and waist girth ($p<0.000$).

6.16 Development of the sizing system

The sizing system was developed using results from the cluster analysis. Specifically, the mean and the standard deviation values from each cluster. The aim of a sizing system is to group the population into subgroups that are homogeneous with similar characteristics in terms of body size and shape, making each member of the subgroup fit flawlessly into the same apparel size. This was applicable to use in the development of the sizing system as members in each cluster are homogenous and different from members in bordering cluster groups based on the ANOVA results for the clusters analysis (Tables 6.15-6.17, 6.20- 6.21 and 6.23) which indicate significant differences among the three cluster groups, namely large body type (cluster 1), medium body type (cluster 2) and small body type (cluster 3). This necessitated the creation of separate sizes for each body type categorised in the cluster analysis.

At this stage, the empirical rule was applied in the creation of size steps. That is, in a normal distribution, plus or minus one standard deviation of the mean will cover approximately two thirds of the population (68%). Plus, or minus two standard deviations of the mean will cover approximately 95% of the population. Finally, Plus or minus three standard deviations of the mean will cover approximately 99.7% of the population. The mean and standard deviation in each cluster were used in the creation of the sizing system for the selected control dimensions (height and chest girth for upper body and height and waist girth for lower body). The size steps were established by the addition and subtraction of the approximated value of the standard deviation from the mean in the clusters in order to achieve different values. A five-step categorisation of body sizes was used for each of the body type identified in the cluster. This was done by the addition of one standard deviation (+1SD) and two standard deviations (+2SD) to the mean value to obtain values greater than the mean value. Likewise, to obtain values lower than the mean, one standard deviation (-1SD) and two standard deviations (-2SD) were subtracted from the mean. The addition of one standard deviation (+1SD) and two standard deviations (+2SD) to the mean and the subtraction of one standard deviation (-1SD) and two standard deviations (-2SD) from the mean were considered appropriate for the sample under study as it gives an accommodation rate of 95% for the sample in each cluster. Also, this was applicable as a production accommodation rate of a sizing system ranges between 65% and 85% (Petrova, 2007) and the use of five standard deviation divisions statistically accommodate a given sample (Cramer, 1998).

In total, twelve tables were generated for both males and females aged 6-11. Table 6.25a-c caters for male upper body while Table 6.26a-c covers female upper body. Table 6.27a-c covers male lower body and female lower body is covered in Table 6.28a-c. From Table 6.25a to 6.28c the mean and standard deviation values used for the computation are bolded in parentheses beside the original values obtained in the cluster analysis. To make the computation of figures straightforward, the values for the mean and the standard deviation were all rounded up to the nearest whole number. Some values from 0.5 cm and above were approximated to 1.0 cm whilst values below 0.5 were excluded. Further, to obtain consistent size steps some values that when approximated will result in and odd number that will not render a consistent interval to the sizes were either dropped down a little or raised slightly. For instance, the standard deviation for height in Table 6.25(a) had a standard deviation of 5.3cm. If this standard deviation value is approximated, 5cm must be used however, for the purpose of consistency and practicality, 6cm was used. Also, in Table 6.26(a) the original standard deviation was 6.6 which if rounded will be 7cm was also adjusted to 6cm. These minor adjustments were done to obtain size interval values that are practical and consistent and in line with sizing standards. The size intervals used in this study are 4cm and 6cm for height and 2cm and 4cm for the girth dimensions.

Table 6.25a was used to generate small sizes for male children aged 6-11. A mean height of 119cm was used as against a mean chest girth of 58cm. Standard deviations (SD) of 6cm and 4cm were used in the calculation of size steps for height and chest girth respectively. Four size steps were generated. At Mean +1 SD the range for height (primary dimension) was covered. The chest girth was not fully covered with Mean +1 SD but since height (primary dimension) was fully covered, four size step was retained for small body type. For the medium sizes for the same age range, Table 6.25b was used. A mean height of 132cm was used as against a mean chest girth of 63cm. A standard deviation (SD) of 4cm was used in the calculation of size steps for both height and chest girth. Five size steps were generated which accurately accommodate the ranges in the cluster group. Table 6.25c was used to generate large sizes for male children aged 6-11. A mean height of 146cm was used as against a mean chest girth of 70cm. Standard deviations (SD) of 6cm and 4cm were used in the calculation of size steps for height and chest girth respectively. Five size steps were generated which perfectly covers the entire size ranges for height and chest girth in the cluster group.

The female sizing system for upper body was generated using Tables 26a-c. The small sizes were covered by Table 6.26a whereas the medium and large sizes were covered by Table 6.26b and 6.26c respectively. For the small sizing system for females aged 6-11 upper body, a mean height of 119cm was used as against a mean chest girth of 58cm. Standard deviations (SD) of 6cm and 4cm were used in the calculation of size steps for height and chest girth respectively. Four size steps were generated. Like Table 6.25a for male upper body, at mean +1 SD the range for height (primary dimension) was covered. The chest girth was not fully covered with mean +1 SD but since height (primary dimension) was fully covered, four size step was retained for small body type. In generating medium sizes for female upper body, Table 6.26b was used. A mean height of 133cm was used as against a mean chest girth of 63cm. A standard deviation (SD) of 4cm was used in the calculation of size steps for both height and chest girth resulting in five-size-roll which accurately accommodate the ranges in this cluster group. Table 6.26c was used to generate large sizes for Ghanaian female children aged 6-11. A mean height of 148cm was used as against a mean chest girth of 70cm with standard deviations (SD) of 6cm and 4cm for height and chest girth respectively.

Table 6.25a: Development of small sizes- male upper body

Small body type (Cluster 3) Height range cm -105.0-128.0 Chest girth range cm- 49.0-67.0		Mean Height cm-119.2 **(119)** Mean chest girth, cm - 57.7 **(58)**		SD height, cm - 5.3 **(6)** SD chest girth cm- 3.5**(4)**
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**
Height	107	113	119	125
chest girth	50	54	58	62

No +2SD values since the maximum height range is covered by +1SD)

Table 6.25b: Development of medium sizes- male upper body

Medium body type (Cluster 2) Range height cm - 124.0-140.5 Mean Height cm-131.7**(132)** SD height, cm -4.3**(4)** Range chest girth cm- 53.0-73.0 Mean chest girth, cm -63.0 **(63)** SD chest girth cm-4.1**(4)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean +2 SD**
Height	124	128	132	136	140
chest girth	55	59	63	67	71

Table 6.25c: Development of large sizes- male upper body

Large body type (Cluster 1) Range height cm -135.0-158.6 Mean Height cm-146.2 **(146)** SD height, cm -5.6 **(6)** Range chest girth cm- 51.0-79.5 Mean chest girth, cm -69.8 **(70)** SD chest girth cm- 4.5 **(4)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean +2 SD**
Height	134	140	146	152	158
chest girth	62	66	70	74	78

Table 6.26a: Development of small sizes- female upper body

Small body type (Cluster 3) Range height cm – 101.2-129.0 Mean Height cm- 119.2 **(119)** SD height, cm -6.6 **(6)** Range chest girth cm-51.0-71.0 Mean chest girth cm - 57.7 **(58)** SD chest girth cm- 3.3**(4)**				
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**
Height	107	113	119	125
chest girth	50	54	58	62

No +2SD values since the maximum height range is covered by +1SD)

Table 6.26b: Development of medium sizes- female upper body

Medium body type (Cluster 2) Range height cm – 124.0-145.0 Mean Height cm-133.4 **(133)** SD height, cm - 4.8 **(4)** Range chest girth cm-49.0-76.0 Mean chest girth cm -63.4 **(63)** SD chest girth cm- 5.2 **(4)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean +2 SD**
Height	125	129	133	137	141
Chest girth	55	59	63	67	71

Table 6.26c: Development of Large sizes- female upper body

Large body type (Cluster 1) Range height cm -136.5-163.5 Mean Height cm-147.9 **(148)** SD height, cm - 6.2 **(6)** Range chest girth cm-59.0-79.0 Mean chest girth, cm – 70.0 **(70)** SD chest girth cm- 4.9 **(4)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean+2 SD**
Height	136	142	148	154	160
Chest girth	62	66	70	74	78

The process of developing lower body sizes for Ghanaian male children aged 6-11 is shown in Tables 6.27a-c. Table 6.27a was used to generate small sizes for male children aged 6-11. A mean height of 119cm was used as against a mean waist girth of 55cm. Standard deviations of 6cm and 4cm were used to generate four size steps. Like Table 6.25a and 6.26a for male upper body and female upper body, mean +1 SD covered the range for height (primary dimension) thereby the use of four size step for small body type. Medium size for this same gender and age group is shown in Table 6.27b. A mean height of 131cm, a mean waist girth of 59cm and a standard deviation of 4cm were used to generate five sizes for both height and waist girth. Table 6.27c was used to generate large size for lower body garments for male children aged 6-11. A mean height of 146cm and a mean waist girth of 62cm with a standard deviation (SD) of 6cm and 2cm for height and waist girth respectively.

Table 6.27a: Development of small sizes- male lower body

Small body type (Cluster 3) Range height cm - 105.0-126.3 Mean Height cm-118.5 **(119)** SD height, cm -5.1**(6)** Range waist girth cm- 47.0-67.0 Mean waist girth cm -55.4 **(55)** SD waist girth cm- 3.8 **(4)**				
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**
Height	107	113	119	125
waist girth	47	51	55	59

No +2SD values since the maximum height range is covered by +1SD)

Table 6.27b: Development of medium sizes- male lower body

Medium (Cluster 2) Range height cm –124.0-139.1 Mean Height cm-131.3 **(131)** SD height, cm – 4.3 **(4)** Range waist girth cm -50.0-67.0 Mean waist girth, cm -58.6 **(59)** SD waist girth cm- 3.7 **(4)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean +2 SD**
Height	123	127	131	135	139
waist girth	51	55	59	63	67

Table 6.27c: Development of large sizes- male lower body

Large body type (Cluster 1) Range height cm – 138.5-158.6 Mean Height cm-146.3 **(146)** SD height, cm -5.5 **(6)** Range waist girth cm- 55.0-67.0 Mean waist girth cm -62.2 **(62)** SD waist girth cm-2.4 **(2)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean +2 SD**
Height	134	140	146	152	158
waist girth	58	60	62	64	66

Lower body sizes for Ghanaian female children aged 6-11 are shown in Tables 6.28a-c. Table 6.28a shows small sizes for female children aged 6-11. A mean height of 117cm and a mean waist girth of 56cm with a standard deviation of 6cm and 4cm for height and waist girth respectively were used for the computation to generate four sizes. Like Table 6.25a and 6.26a for male upper body and female upper body respectively, mean +1 SD covered the range for height (primary dimension) thereby the use of four size step for small body type. A mean height of 132cm, a mean waist girth of 59cm and a standard deviation 4cm were used to generate five sizes for both height and waist girth for medium sizes for lower body as shown in Table 6.28b. Table 6.28c was used to generate large sizes for lower body garments for Ghanaian female children aged 6-11. A mean height of 148cm and a mean waist girth of 62cm with a standard deviation (SD) of 6cm for height and 2cm waist girth were used to create the size steps. Table 6.26(a) to 6.27(c) is the developed sizing system for lower body garments for males and females (6-11 years) based on the height and waist girth ranges.

Table 6.28a: Development of small sizes- females lower body

Small body type (Cluster 3) Range height cm -101.2 - 125.0 Mean Height cm-117.2 **(117)** SD height, cm -6.2 **(6)** Range waist girth cm -48.1- 67.0 Mean waist girth cm -56.0 **(56)** SD waist girth cm-4.3 **(4)**				
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**
Height	105	111	117	123
waist girth	48	52	56	60

No +2SD values since the maximum height range is covered by +1SD)

Table 6.28b: Development of medium sizes- females lower body

Medium (Cluster 2) Range height cm – 124.0 -140.2 Mean Height cm- 131.7 **(132)** SD height, cm – 4.7 **(4)** Range waist girth cm -50.0 - 67.0 Mean waist girth cm -59.1 **(59)** SD waist girth cm-4.1**(4)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean +2SD**
Height	124	128	132	136	140
chest girth	51	55	59	63	67

Table 6.28c Development of Large sizes- females lower body

Large body type (Cluster 1) Range height cm- 139.0 - 163.5 Mean Height cm- 147.6 **(148)** SD height, cm - 6.0 **(6)** Range waist girth cm- 54.0 - 67.0 Mean waist girth cm- 61.6 **(62)** SD waist girth cm-2.6 **(2)**					
	Mean -2SD	**Mean -1 SD**	**Mean**	**Mean +1 SD**	**Mean+2 SD**
Height	136	142	148	154	160
chest girth	58	60	62	64	66

The use of standard deviation as the size interval has been used by many researchers in the development of clothing sizes in clothing anthropometry. Gupta and Gangadhar (2004) made use of standard deviation as the size interval for height for the creation of clothing sizes. The study by Moon and Nam (2003) used the control dimension and the size range to create garment sizing system for lower body garments. Aldrich (1999) used an interval of 6cm for height measurement based on the centilong system. The study by Chung et al. (2007) used size interval of 8cm for stature and 4cm for other dimensions. Different standards propose different size intervals. In ISO/TR 10652 (1991) the developed sizing system for upper garment for males and females (6-11 years) is based on the height (primary dimension) and chest girth (secondary dimension) ranges as size criteria.

6.16.1 Determination of upper and lower boundaries of developed sizes

Table 6.29(a) to 6.30(c) consist of the proposed sizes and the upper and lower boundaries for upper body sizes. Tables for proposed sizes and the upper and lower boundaries for lower body sizes can be found at Appendix 16. Within each body type, four or five size rolls were developed. According to Beazley, (1998); Otieno, (1999); Otieno and Fairhurst (2000); Mlauli (2003); Kuma-Kpobee (2009); Adu- Boakye et al. (2011) to ascertain the degree of coverage for the inter- size range, upper and lower boundaries of each body dimension needed to be identified. As presented in the Table 6.29a to 6.30c and Appendix 16, half of every size step is evaluated and added to or subtracted from each body dimension to get the upper and lower boundaries. For example, a mean value of 107cm with 6cm size interval will have a size-step of 3cm (6cm/2). The lower boundary will then be the mean value minus 3cm (107cm – 3cm) which is 104cm whilst the upper boundary will be the mean plus 3cm (107cm+3cm) which is 110cm. However, to avoid overlapping at the upper boundaries, a value of 0.01 is deducted from the upper figure (110cm – 0.01) resulting in an upper boundary figure of 109.9cm.

Table 6.29a: Proposed small sizes with upper and lower boundaries- male upper body

Size codes	Small sizes			
	S107-50	**S113-54**	**S119-58**	**S125-62**
Height ranges	104.0 **107.0** 109.9	110.0 **113.0** 115.9	116.0 **119.0** 121.9	122.0 **125.0** 128.0
Chest girth ranges	48.0 **50.0** 51.9	52.0 **54.0** 55.9	56.0 **58.0** 59.9	60.0 **62.0** 63.9

Table 6.29b: Proposed medium sizes with upper and lower boundaries- male upper body

Size codes	Medium sizes				
	M124-55	**M128-59**	**M132-63**	**M136-67**	**M140-71**
Height ranges	122.0 **124.0** 125.9	126.0 **128.0** 129.9	130.0 **132.0** 133.9	134.0 **136.0** 137.9	138.0 **140.0** 142.0
Chest girth ranges	53.0 **55.0** 56.9	57.0 **59.0** 59.9	61.0 **63.0** 64.9	65.0 **67.0** 68.9	69.0 **71.0** 73.0

Table 6.29c: Proposed large sizes with upper and lower boundaries- male upper body

Size codes	Large sizes				
	L134-62	**L140-66**	**L146-70**	**L152-74**	**L158-78**
Height ranges	131.0 **134.0** 136.9.	137.0 **140.0** 142.9	143.0 **146.0** 148.9	149.0 **152.0** 154.9	155.0 **158.0** 161.0
Chest girth ranges	60.0 **62.0** 63.9	64.0 **66.0** 67.9	68.0 **70.0** 71.9	72.0 **74.0** 75.9	76.0 **78.0** 80.0

Table 6.30a: Proposed small sizes with upper and lower boundaries- female upper body

Size codes	Small sizes			
	S107-50	**S113-54**	**S119-58**	**S125-62**
Height ranges	104.0 **107.0** 109.9	110.0 **113.0** 115.9	116.0 **119.0** 121.9	122.0 **125.0** 128.0
Chest girth ranges	48.0 **50.0** 51.9	52.0 **54.0** 55.9	56.0 **58.0** 59.9	60.0 **62.0** 63.9

Table 6.30b: Proposed medium sizes with upper and lower boundaries- female upper body

Size codes	Medium sizes				
	M125-55	**M129-59**	**M133-63**	**M137-67**	**M141-71**
Height ranges	123.0 **125.0** 126.9	127.0 **129.0** 130.9	131.0 **133.0** 134.9	135.0 **137.0** 138.9	139.0 **141.0** 143.0
Chest girth ranges	53.0 **55.0** 56.9	57.0 **59.0** 60.9	61.0 **63.0** 64.9	65.0 **67.0** 68.9	69.0 **71.0** 73.0

Table 6.30c: Proposed large sizes with upper and lower boundaries - female upper body

Size codes	Large sizes				
	L136-62	**L142-66**	**L148-70**	**L154-74**	**L160-78**
Height ranges	133.0 **136.0** 138.9	139.0 **142.0** 144.9	145.0 **148.0** 150.9	151.0 **154.0** 156.9	157.0 **160.0** 163.0
Chest girth ranges	60.0 **62.0** 63.9	64.0 **66.0** 67.9	68.0 **70.0** 71.9	72.0 **74.0** 75.9	76.0 **78.0** 80.0

6.16.2 Determination of outliers in the developed sizes

Outliers are values beyond the designated size range. Relating to this study, outliers are the values outside the developed size steps identified. Thus, any value further than the -2 and +2 standard deviation is regarded as an outlier. The total number of outliers with corresponding percentages were calculated based on the range of the developed sizes in relation to the range of the body type categorisation (the clusters). For each of the developed sizes, the total outliers were determined based on the values of the size ranges. Values below the minimum and above the maximum size step are classified as outliers.

Table 6.31: Determination of outliers within the range of each developed sizing system versus the cluster ranges for male upper body and lower body

Male upper body (6-11 years)				
Body type/ clusters	**Height /chest ranges within clusters**	**Height /chest ranges within developed sizing system**	**Outliers height /chest**	**%**
Large (Cluster 1)	135.0-158.6/ 51.0-79.5	131.0-161.0/60.0-80.0	0/ 1	0.0/ 0.0
Medium (Cluster2)	124.0-140.5/ 53.0-73.0	122.0-142.0/53.0-73.0	0/ 0	0.0/ 0.0
Small (Cluster 3)	105.0-128.0/ 49.0-67.0	104.0-128.0/48.0-64.0	0/ 6	0.0/ 5.9
Male lower body (6-11 years)				
Body type/ clusters	**Height /waist ranges within clusters**	**Height /waist ranges within developed sizing system**	**Outliers-height /waist**	**%**
Large (Cluster 1)	138.5-158.6/ 55.0-67.0	131.0-161.0/57.0-67.0	0/ 3	0.0/ 2.5
Medium (Cluster 2)	124.0-139.1/ 50.0-67.0	121.0-141.0/48.0-69.0	0/ 0	0.0/ 0.0
Small (Cluster 3)	105.0-126.3/47.0-67.0	104.0-128.0/45.0/61.0	0/ 6	0.0/ 5.9

Table 6.31 shows the outliers for male upper body and lower body. Working with four size steps for small body type and five size steps for medium and large body types, resulted in fewer outliers. In fact, in terms of height the primary dimension for both male upper body and lower body, did not record any outlier. Thus, the four or five-size steps completely exhausted the heights of the study sample. The chest girth (upper body) and the waist girth (lower body) both recorded a few outliers.

Table 6.32: Determination of outliers within the range of each developed sizing system versus the cluster ranges for female upper body and lower body

Female upper body (6-11 years)				
Body type/ clusters	**Height /chest ranges within clusters**	**Height /chest ranges within developed sizing system**	**Outliers height /chest**	**%**
Large (Cluster 1)	136.5- 163.5/ 59.0- 79.0	133.0- 163.0/ 60.0- 80.0	0/ 1	0.0/ 0.9
Medium (Cluster 2)	124.0- 145.0/ 49.0- 76.0	123.0- 143.0/49.0- 73.0	1/ 12	0.6/ 7.5
Small (Cluster 3)	101.2- 129.0/ 51.0- 71.0	104.0- 128.0/ 48.0- 64.0	6/ 1	5.9/ 0.8
Female lower body (6-11 years)				
Body type/ clusters	**Height /waist ranges within clusters**	**Height /waist ranges within developed sizing system**	**Outliers- height /waist**	**%**
Large (Cluster 1)	139.0- 163.5/ 54.0- 67.0	133.0- 163.0/ 57.0- 67.0	0/ 6	0.9/ 5.2
Medium (Cluster 2)	124.0- 140.2/ 50.0- 67.0	122.0- 142.0/ 49.0- 69.0	0/ 0	0.0/ 2.2
Small (Cluster 3)	101.2- 125.0/ 48.1- 67.0	102.0-126.0/ 46.0- 62.0	5/ 6	4.3/ 5.2

Table 6.32 shows the outliers for female upper body and lower body. Working with four and five size steps resulted in fewer outliers. In the case of height, the primary dimension for upper body, the medium body type recorded one (0.6%) outlier whereas the small body type recorded six (5.8%) outliers. Height the primary dimension for lower body, recorded five (5.5%) outliers for the small body type. The chest girth (upper body) recorded one (0.9%) outlier for large body type, 12(7.5%) outliers for medium body type and one (0.9%) outlier for small body type. The waist girth (lower body) recorded six (5.2%) outliers for large body type and six (5.2) outliers for small body type.

6.16.3 Determination of the rate of coverage

For each number of participant(s) assigned a size label, the corresponding percentage accommodation was also calculated. In calculating the accommodation rate, a value of 0.01 was subtracted from the upper limit. This was applicable to prevent overlapping of the upper limit and the next adjacent lower limit value (Beazley, 1998; Vronti, 2005; Otieno, 2009, 1999; Kuma-Kpobee, 2009; Adu-Boakye et al., 2012). The accommodation rate was calculated for each size categorisation namely, small, medium, and large. The components presented in Table 6.33 and 6.34 are the size rolls, control dimensions and accommodation rates. These are based primarily on height as a primary control dimension and chest or waist girth as a secondary dimension in validating the sizes.

6.16.4 The rate of coverage of developed sizes

Tables 6.33, 6.34, 6.35 and 6.36 were used to check the accommodation rate of the developed sizes and to validate the sizes. The tables consist of nine columns. The first column, consist of the size roll which is the n number of sizes generated. The second column indicated the body type classifications. The third column is the size labels which is prefix with the first letter of the body type classifications, followed by a value indicating the primary control measurement (height) and next to it is the value for the secondary control measurement. The fourth column contains the size ranges for the primary control dimension (height). The fifth column indicate the number of participants whose body measurement falls within each height range. The sixth column indicates the percentage of participants within the specified size range. The seventh column indicates the ranges of the secondary control dimensions, thus chest girth and waist girth for upper body and lower body respectively. The next two columns represent the number of participants covered within the size ranges of the secondary control dimensions (chest and waist girth).

Table 6.33 shows the size roll and accommodation rate for upper body garments for Ghanaian males aged 6-11. From Table 6.33, it is evident that the samples are distributed across the different size categories. Both the primary and secondary dimensions accommodated appreciable number of the sample except for the large sizes that has one size (L134-62) accommodating less than 2% of the sample for both the primary and the secondary control dimensions. This size is marked with an asterisk in Table 6.33 and was not included in the final sizes there by bring the total size roll to 13 sizes for male upper body.

Table 6.33: Distribution of sizes of Ghanaian males (6-11 years) upper body

Size roll	Body type	Size Labels	Ranges and frequencies of control dimensions (cm)					
			Height (primary)	N	%	Chest girth (secondary)	N	%
1		S107- 50	104.0- 109.9	7	6.9	48.0- 51.9	6	5.6
2	Small	S113- 54	110.0- 115.9	14	13.7	52.0- 55.9	16	15.7
3		S119- 58	116.0- 121.9	44	43.1	56.0- 59.9	49	48.0
4		S125- 62	122.0- 128.0	37	36.3	60.0- 64.0	25	24.5
5		M124- 55	122.0- 125.9	11	6.4	53.0- 56.9	9	5.3
6		M128- 59	126.0- 129.9	56	32.7	57.0- 60.9	22	12.9
7	Medium	M132- 63	130.0- 133.9	46	26.9	61.0- 64.9	86	50.3
8		M136- 67	134.0- 137.9	41	24.0	65.0- 68.9	37	21.6
9		M140- 71	138.0- 142.0	17	9.9	69.0- 73.0	17	9.9
10		L134- 62	131.0- 136.9	1	0.8*	60.0- 63.9	1	0.8*
11		L140- 66	137.0- 142.9	43	36.4	64.0- 67.9	39	33.1
12	Large	L146- 70	143.0- 148.9	41	34.7	68.0- 71.9	38	32.2
13		L152- 74	149.0- 154.9	19	16.1	72.0- 75.9	34	28.8
14		L158- 78	155.0- 161.0	14	11.9	76.0- 80.0	5	4.2

All dimensions used are in centimetres (cm)

Kwon et al. (2009) stated that sizes with 2% coverage indicate low accommodation rate. In Zakaria's (2016) study she worked with an accommodation rate of 2% and above. Other studies are of the opinion that coverage less than 1% is viewed as not densely populated (ISO/TR 10652, 1991; Hsu et al, 2007). This study regards coverage of less than 2% of the primary control dimension (height) as not densely accommodated. Sizes that therefore obtained less than 2% coverage for the primary control dimension (height) were eliminated. However, coverage for the secondary dimensions were not the focal point for the elimination of sizes.

Table 6.34 shows the size roll and accommodation rate for upper body garments for Ghanaian females aged 6-11. Height, the primary dimension densely accommodated the sample. However, the secondary control dimension (chest girth) for medium sizes (M 125- 55) and large sizes (L136-62) accommodated less than 2% of the sample. Contrary to large size (L134-62) for male upper body in Table 6.33 that had the primary control dimension (height) in addition to the secondary control dimension (chest girth) both covering less than 2% of the sample resulting in the elimination of that size, with the female upper body, the medium size (M 125- 55) and large size (L136-62) accommodated more than 2% of the primary control dimension (height) leading them being retained. This resulted in the generation of 14 sizes for upper body garment for Ghanaian females aged 6-11.

Table 6.34: Distribution of sizes for Ghanaian females (6-11 years) upper body

Size roll	Body type	Size Labels	Ranges and frequencies of control dimensions (cm)					
			Height (primary)	N	%	Chest girth (secondary)	N	%
1		S107- 50	104.0- 109.9	8	6.8	48.0- 51.9	4	3.4
2	Small	S113- 54	110.0- 115.9	12	10.2	52.0- 55.9	26	22.0
3		S119- 58	116.0- 121.9	41	34.7	56.0- 59.9	59	50.0
4		S125- 62	122.0- 128.0	51	43.2.	60.0- 64.0	27	22.9
5		M125- 55	123.0- 126.9	14	8.7	53.0- 56.9	1	0.6*
6		M129- 59	127.0- 130.9	38	23.6	57.0- 60.9	40	24. 8
7	Medium	M133- 63	131.0- 134.9	40	24.8	61.0- 64.9	49	30.4
8		M137- 67	135.0- 138.9	46	28.6	65.0- 68.9	36	22.4
9		M141- 71	139.0- 143.0	22	13.7	69.0- 73.0	23	14.3
10		L136-62	133.0- 138.9	3	2.8	60.0- 63.9	2	1.9*
11		L142-66	139.0- 144.9	40	37.7	64.0- 67.9	42	39.6
12	Large	L148-70	145.0- 150.9	33	31.1	68.0- 71.9	21	19.8
13		L154-74	151.0- 156.9	19	17.9	72.0- 75.9	20	18.9
14		L160-78	157.0- 163.0	11	10.4	76.0- 80.0	20	18.9

All dimensions used are in centimetres (cm)

Table 6.35 indicates the size roll and the accommodation rate for lower body garments for Ghanaian males aged 6-11. Apart from large size that did not record any participant for size L134-58 in terms of the height the primary control dimension, all other sizes have sample adequately covered by the primary control dimension (height). The size L134-58 was eliminated although the waist girth which is a secondary control dimension recorded a few participants. Since functional ease is mainly added to girth dimensions, it is anticipated that participants in the eliminated size will be covered in bordering sizes. The final size roll was therefore reduced by one, bringing the total validated size roll to 13.

Table 6.35: Distribution of sizes for Ghanaian males (6-11 years)- lower body

Size roll	**Body type**	**Size Labels**	**Ranges and frequencies of control dimensions (cm)**					
			Height (primary)	**N**	**%**	**Waist girth (secondary)**	**N**	**%**
1	Small	S107- 47	104.0- 109.9	7	7.6	45.0- 48.9	1	1.1*
2		S113- 51	110.0- 115.9	14	15.2	49.0- 52.9	19	20.7
3		S119- 55	116.0- 121.9	44	47.8	53.0- 56.9	40	43.5
4		S125- 59	122.0- 128.0	27	29.3	57.0- 61.0	24	26.1
5	Medium	M123- 51	121.0- 124.9	6	3.3	49.0- 52.9	14	7.7
6		M127- 55	125.0- 128.9	56	30.9	53.0- 56.9	35	19.3
7		M131- 59	129.0- 132.9	47	26.0	57.0- 60.9	88	48.6
8		M135- 63	133.0- 136.9	45	24.9	61.0- 64.9	33	18.2
9		M139- 67	137.0- 141.0	27	14.9	65.0- 69.0	11	6.1
10	Large	L134- 58	131.0- 136.9	0	0.0*	57.0- 58.9	4	3.4
11		L140- 60	137.0- 142.9	44	37.3	59.0- 60.9	8	6.8
12		L146- 62	143.0- 148.9	41	34.7	61.0- 62.9	52	44.1
13		L152- 64	149.0- 154.9	19	16.1	63.0- 64.9	29	24.6
14		L158- 66	155.0- 161.0	14	11.9	65.0- 67.0	22	18.6

All dimensions used are in centimetres (cm)

Table 6.36 shows the size roll and the coverage for lower body garments for Ghanaian females aged 6-11. Aside large size L136-58 that did not record any participant for the primary control dimension, all other sizes have sample adequately covered. The size L136-58 was eliminated although the waist girth which is a secondary control dimension recorded a few participants. The final size roll was therefore reduced by one, bringing the total validated size to 13.

Table 6.36: Distribution of sizes for Ghanaian females (6-11 years)- lower body

Size roll	Body type	Size Labels	Ranges and frequencies of control dimensions (cm)					
			Height (primary)	N	%	Waist girth (secondary)	N	%
1		S105-48	102.0- 107.9	12	13.2	46.0- 49.9	14	15.4
2		S111-52	108.0- 113.9	9	9.9	50.0- 53.9	17	18.7
3	Small	S117-56	114.0- 119.9	32	35.2	54.0- 57.9	22	24.2
4		S123-60	120.0- 126.0	37	40.7	58.0- 61.9	30	33.0
5		M124-51	122.0- 125.9	18	10.1	49.0- 52.9	15	8.4
6		M128-55	126.0- 129.9	55	30.7	53.0- 56.9	33	18.4
7	Medium	M132-59	130.0- 133.9	31	17.3	57.0- 60.9	56	31.3
8		M136-63	134.0- 137.9	54	30.2	61.0- 64.9	54	30.2
9		M140-67	138.0- 142.0	21	11.7	65.0- 69.0	21	11.7
10		L136-58	133.0- 138.9	0	0.0*	57.0- 58.9	7	6.1
11		L142-60	139.0- 144.9	51	44.3	59.0- 60.9	8	7.0
12	Large	L148-62	145.0- 150.9	34	29.6	61.0- 62.9	60	52.2
13		L154-64	151.0- 156.9	19	16.5	63.0- 64.9	19	16.5
14		L160-66	157.0- 163.0	10	8.7	65.0- 67.0	15	13.0

All dimensions used are in centimetres (cm)

6.16.5 Size labelling

Size label is a vital user interface in the selection of apparel with a good fit. Like the study of McCulloch et al. (1998) and Zakaria (2016) the size label developed in this study is in line with recommendation by ISO 3636 and ISO 3637. Size labelling marks the final step in the sizing system development process. This study used the pictogram labelling system to designate the developed sizes. Pictogram figuratively portray the human silhouette with indications of measuring positions used for the designation of sizes. These illustrate the sizes that show the body measurements the apparel is produced to fit (Zakaria, 2016). In addition to the pictogram is a numbered size designation that indicate the label and the range for the control dimensions used.

Height and chest girth used in the creation of the sizing system was the as the criteria for the size designation for upper body whereas height and waist girth were used as the criteria for the size designation for lower body.

Sizes were labelled according to the body type categorisation namely small, medium, and large. The dimensions of the control variables namely height and chest girth for upper body and height and waist girth for lower body were used. These were prefixed with the first letter of the body type categorisation namely small, medium, and large. Hence, small sizes developed for small body type were prefixed with the letter 'S'. Medium sizes for medium body type were prefixed with the letter 'M' whilst large sizes for large body type were prefixed with the letter 'L'. In all developed size labels, the prefix for the body type is first written followed by the average value of the primary control dimension (height), a hyphen and then the secondary control dimension (chest girth for upper body garments and waist girth for lower body garments). After developing labels to identify the sizes, the study used unique pictogram developed by the researcher to designate the developed sizes. These developed pictograms symbolically portray the human silhouette of a male and a female child. These unique pictograms were created and use to make it simple for both parents and children to relate and select garments. The pictograms illustrate the location of the control dimensions and the average values used for the sizes. In addition to the developed pictogram is a numbered size labelling that shows the size label and the range for the control dimension. Figure 6.26 indicates a small size designation for upper body for Ghanaian male children aged 6-11. A medium size designation for upper body for Ghanaian male children for the same age group is shown in Figure 6.27. Figure 6.28 indicates large size designation for lower body for Ghanaian male children aged 6-11.

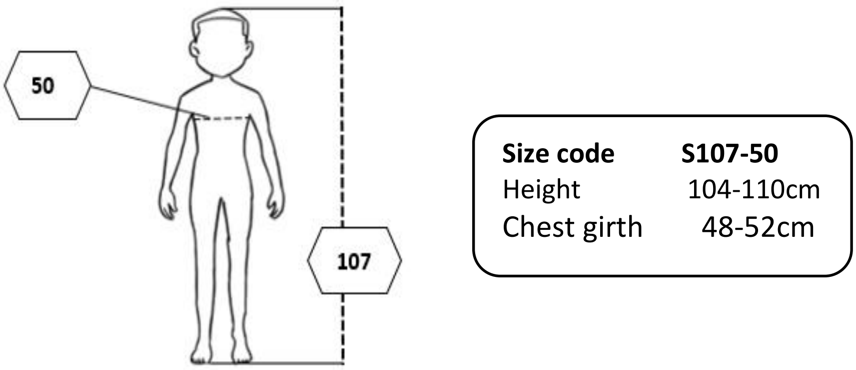


Figure 6.26: Mondoform small size (S) labelling for males- upper body

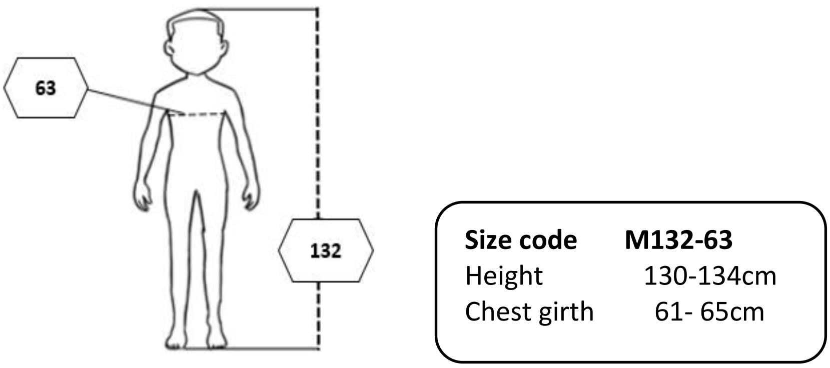


Figure 6.27: Mondoform medium size (M) labelling for males- upper body

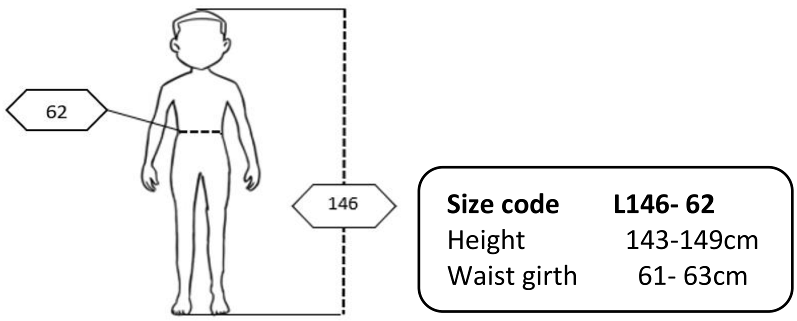


Figure 6.28: Mondoform large size (L) labelling for males- lower body

A designation in Figure 6.26 with size code S107-50 for upper body for Ghanaian males aged 6-11 suggests that the size is appropriate for the small male figure type aged 6-11 within the height range of 104-110cm and a chest girth of 48-52cm. Likewise, a designation of L146- 62 for

Ghanaian males aged 6-11 lower body implies that the size is appropriate for the large figure type within the height range of 143-149cm and a waist girth range of 61- 63cm.

Samples of size designation for Ghanaian female children aged 6-11 are illustrated in Figure 6.30 and Figure 6.31. Figure 6.30 illustrate a size code of S119-58 for a small size designation for upper body for Ghanaian female children aged 6-11. The designation suggests that the size is suitable for a female children aged 6-11 with small body type within the height range of 116-122cm and a chest girth of 56- 60. Figure 6.31 with a designation of L148-62 indicates the size is suitable for large size figure with height dimension of 148-152cm and a chest/bust girth of 62-64cm.

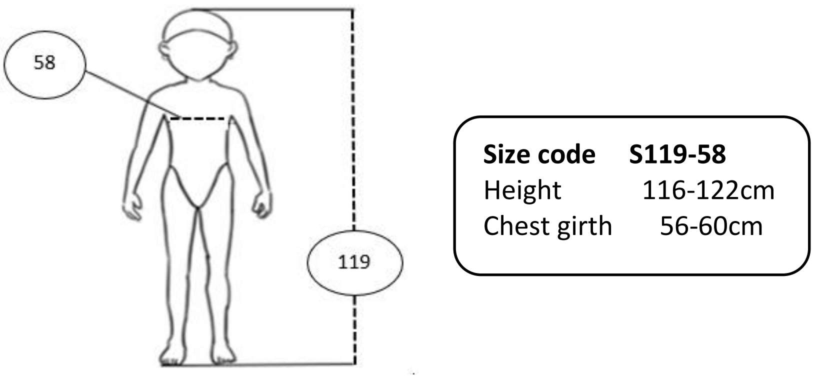


Figure 6.29: Mondoform small size (S) labelling for females- upper body

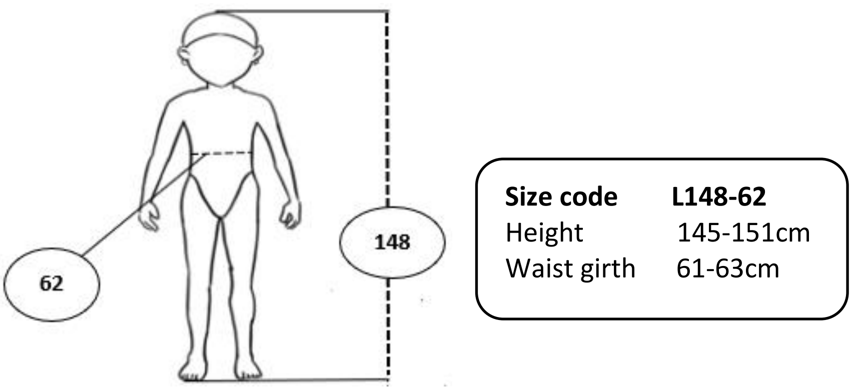


Figure 6.30: Mondoform large size (L) labelling for females- lower body

6.17 Development of size charts

This study, after developing the sizing system goes further to develop size charts to produce patterns to test the fit of the developed sizes. As explained by Otieno and Fairhurst (2000), size charts indicate garment measurements that has basic ease allowance incorporated. Size charts were developed and used to produce sample garments and as a reference point at some point in fitting trials. In the creation of the size charts different percentiles were used. Percentile for all variables were computed for all participants (Appendix 14) and separately for males (Table 6.37) and females (Table 6.38). Values obtained for the generated percentiles were cross checked with the mean values obtained in the three clusters groups used for the sizing system. It was observed that value for the 50th percentile or the median for height corresponded with the mean height for the medium body type in the cluster for both males and females. Bland (2006) stated that in a symmetrical distribution, the sample mean, and the median are just about the same. The small body type in the cluster also closely corresponded with the 10^{th} percentile and the large size was the same to the 90^{th} percentile. The 10^{th} percentile values were used as the base size to generate body dimensions for the small sizes. The 50^{th} and 90^{th} percentiles were also used as the base sizes to generate body dimensions for the medium sizes and large sizes respectively.

Researchers (Otieno and Fairhurst, 2000; Adu-Boakye, 2011) recommend the use of the 50th percentile for clothing purposes to accommodate majority of the population however, empirical evidence from this study show that using only the 50^{th} percentile will cover some of the populace but at the same time a sizable number will also not be adequately covered. Working with only the 50^{th} percentile (median) of the entire data set for children will not accommodate a good majority of the populace.

Table 6.37: Percentiles- males only

Variables	Percentiles							
	5	10	25	50	60	75	90	95
Height	115.0	119.0	125.0	132.0	135.5	141.0	148.5	152.0
Weight	23.0	24.1	27.0	30.5	32.0	35.0	38.0	42.0
Head girth	49.0	50.0	51.0	52.0	52.0	53.0	54.0	55.0
Neck girth	24.6	25.1	26.0	28.0	28.0	29.0	31.0	32.0
Chest girth	54.0	56.0	59.0	63.0	65.0	68.0	72.0	75.0
Waist girth	52.0	53.0	56.0	59.0	61.0	62.0	64.0	65.0
Hip girth	58.0	61.0	65.0	69.0	71.6	76.0	82.8	88.4
Armscye girth	24.0	26.0	27.0	30.0	31.0	33.0	36.0	37.0
Upper arm girth	17.0	18.0	19.0	21.0	21.0	22.0	24.0	26.0
Elbow girth	17.0	17.0	18.0	19.0	20.0	20.5	22.0	22.0
Wrist girth	12.0	12.0	13.0	14.0	14.0	15.0	16.0	16.0
Thigh girth	32.0	34.0	38.0	41.0	42.0	45.0	50.0	51.0
Knee girth	24.0	25.0	27.0	29.0	30.0	31.0	33.0	34.0
Ankle girth	17.5	18.0	20.0	21.0	21.0	22.0	23.0	24.0
Shoulder to length	10.0	10.0	11.0	12.0	12.0	13.0	14.0	15.0
Back shoulder width	30.0	30.0	32.0	34.0	34.0	35.0	37.0	38.0
Scye depth	13.0	13.0	14.0	15.0	16.0	18.0	18.0	18.0
Across chest	23.0	24.0	25.0	27.0	28.0	29.0	32.0	34.0
Bust point width	11.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0
Across back	24.0	25.0	27.0	29.0	29.0	31.0	32.0	33.3
Shoulder elbow	21.0	22.0	23.0	25.0	26.0	27.0	29.0	30.4
Outer arm length	39.0	41.0	44.0	47.0	48.0	51.0	53.8	56.0
Crotch length	39.0	41.0	44.0	48.0	49.0	53.0	57.0	59.2
Body rise	16.0	17.0	18.0	19.0	19.0	20.0	20.0	21.0
Nape to waist	25.0	26.0	27.0	29.0	30.0	30.0	32.0	33.0
Nape to floor	99.0	101.0	107.0	114.0	118.0	123.0	128.0	132.0
Base of throat	23.0	23.0	24.0	26.0	26.0	28.0	31.0	32.0
Front neck to waist	27.0	28.0	29.0	32.0	33.0	35.0	37.0	38.0
Torso height	49.0	51.0	53.0	57.0	59.0	62.0	66.0	68.0
Waist to hip	14.0	14.0	15.0	16.0	16.0	17.0	18.0	18.0
Waist to knee	35.0	37.0	40.0	43.0	44.0	46.0	49.0	52.0
Waist to ankle	64.0	65.0	71.0	76.0	77.0	80.0	86.0	89.0
Waist to floor	69.0	71.0	75.0	80.0	83.0	87.0	91.8	95.0
Knee to floor	34.0	36.0	38.0	40.0	41.0	43.0	46.0	47.0
Inside leg	53.0	55.0	59.0	64.0	66.0	68.0	72.8	74.4

Table 6.38: Percentiles- females only

Variables	Percentiles							
	5	10	25	50	60	75	90	95
Height	112.5	117.1	125.0	133.0	136.5	142.0	150.0	154.5
Weight	24.0	24.5	27.0	31.0	32.0	35.0	38.0	41.0
Head girth	49.0	49.0	50.0	51.0	52.0	52.5	54.0	54.5
Neck girth	24.0	25.0	26.0	28.0	28.0	29.8	31.0	32.0
Chest girth	53.0	56.0	58.5	63.0	65.0	67.0	73.0	76.0
Waist girth	51.0	52.8	56.0	60.0	61.0	62.0	65.0	66.0
Hip girth	58.3	62.0	66.0	72.0	74.0	78.0	86.4	90.0
Armscye girth	24.0	25.0	27.5	30.0	31.0	33.0	35.7	37.0
Upper arm girth	17.0	18.0	19.0	21.0	22.0	23.0	25.0	27.0
Elbow girth	16.5	17.0	18.0	19.0	20.0	21.0	22.0	23.0
Wrist girth	12.0	12.0	13.0	14.0	14.0	15.0	16.0	16.5
Thigh girth	33.0	35.0	38.0	43.0	45.0	47.0	52.0	54.0
Knee girth	24.0	25.0	27.0	30.0	30.0	31.0	33.0	34.0
Ankle girth	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0
Shoulder to length	10.0	10.0	11.0	12.0	12.0	13.0	13.5	14.0
Back shoulder width	28.0	29.0	31.0	33.0	34.0	35.0	36.0	37.0
Scye depth	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0
Across chest	23.0	23.0	25.0	26.0	27.0	29.0	31.0	33.0
Bust point width	11.0	12.0	12.0	13.0	13.5	15.0	16.0	16.5
Across back	24.0	25.0	27.0	29.0	29.0	30.0	32.0	33.0
Shoulder elbow	20.0	22.0	24.0	26.0	26.0	27.0	29.0	30.0
Outer arm length	40.0	41.0	45.0	48.0	49.0	51.0	55.0	56.0
Crotch length	39.3	42.0	46.0	50.0	52.0	55.0	58.0	61.0
Body rise	16.0	17.0	18.0	19.0	19.0	20.0	20.0	21.0
Nape to waist	24.0	24.8	26.0	28.0	29.0	30.0	32.5	34.0
Nape to floor	99.2	100.1	108.0	116.0	119.0	124.0	130.0	134.0
Base of throat	22.0	23.0	24.0	26.0	26.0	28.0	30.0	32.0
Front neck to waist	26.2	27.0	29.0	31.0	33.0	35.0	37.0	38.0
Torso height	50.0	50.0	52.0	57.0	59.0	61.0	66.0	67.7
Waist to hip	13.0	14.0	15.0	16.0	16.0	17.0	18.0	18.0
Waist to knee	35.0	38.3	41.0	45.0	45.0	48.0	51.0	53.0
Waist to ankle	63.0	66.0	72.0	77.0	80.0	83.0	88.4	92.0
Waist to floor	71.0	73.6	78.0	82.0	84.0	89.0	94.0	96.9
Knee to floor	34.0	36.0	38.8	41.0	41.3	43.3	45.0	47.0
Inside leg	54.0	56.6	60.0	65.0	67.0	70.0	75.0	77.0

The percentile values and the standards deviations were used to generate the body dimensions used in the development of the size charts. Body measurements according to Otieno and Fairhurst (2000) are based on actual body dimensions without ease and are used in the development of clothing size charts. Table 6.39 consist of anthropometric body measurement for medium sizes for Ghanaian males aged 6-11 with Table 6.40 consisting of anthropometric body measurements for medium sizes for Ghanaian females aged 6-11. Body measurement for the small and large sizes for both Ghanaian males and females can be found at Appendix 17 to20.

Table 6.39: Body measurements for medium sizes for Ghanaian males aged 6-11

Body measurements of Ghanaian males (Medium sizes) Upper Body (UB) Lower Body (LB) **Age range 6-11 years**					
Size labels	**M124-55 (UB)** **M123-51 (LB)**	**M128-59 (UB)** **M127-55 (LB)**	**M132-63(UB)** **M131-59 (LB)**	**M136-67 (UB)** **M135-63 (LB)**	**M140-71 (UB)** **M139-67 (LB)**
Height	124	128	132	136	140
Weight	26.5	28.5	30.5	32.5	34.5
Head girth	50	51	52	53	54
Neck girth	24	26	28	30	32
Chest girth	55	59	63	67	71
Waist girth	51	55	59	63	67
Hip girth	61	65	69	73	77
Armscye girth	26	28	30	32	34
Upper arm girth	19	20	21	22	24
Elbow girth	17	18	19	20	21
Wrist	12	13	14	15	16
Thigh girth	33	37	41	45	49
Knee girth	25	27	29	31	33
Ankle girth	19	20	21	22	23
Shoulder length	10	11	12	13	13
Back shoulder width	32	33	34	35	36
Across chest	23	25	27	29	31
Across back	25	27	29	31	33
Scye depth	13	14	15	16	17
Shoulder to elbow	23	24	25	26	27
Outer arm length	41	44	47	50	53
Crotch length	40	44	48	52	56
Body rise	17	18	19	20	21
Front neck to waist	26	28	32	34	34
Torso height	53	55	57	59	61
Nape to waist	25	27	29	31	33
Nape to floor	106	110	114	118	122
Waist to hip	14	15	16	17	18
Waist to knee	37	40	43	46	49
Waist to ankle	68	72	76	80	84
Waist to floor	72	76	80	84	88

Knee to floor Inside leg length	36 56	38 60	40 64	42 68	44 72

Table 6.40: Body measurements for medium sizes for Ghanaian females aged 6-11.

Body measurements of Ghanaian females (Medium sizes) Upper Body (UB) lower Body (LB) **Age range 6-11 years**					
Size designations	**M121- 55(UB) M124- 51(LB)**	**M127- 59(UB) M128- 55(LB)**	**M133- 63(UB) M132- 59(LB)**	**M137- 67(UB) M136- 63(LB)**	**M141-71 (UB) M140- 68 (LB)**
Body Dimensions					
Height	121	127	133	139	141
Weight	26	28	31	33	35
Head girth	49	50	51	52	53
Neck girth	24	26	28	30	32
Chest girth	55	59	63	67	71
Waist girth	52	56	60	64	68
Hip girth	64	68	72	76	80
Arm scye girth	26	28	30	32	32
Upper arm girth	17	19	21	23	25
Elbow girth	17	18	19	20	21
Wrist girth	12	13	14	15	16
Thigh girth	35	39	43	47	51
Knee girth	26	28	30	32	34
Ankle girth	18	19	20	21	22
Shoulder length	11	11	12	13	13
Back shoulder width	29	31	33	35	37
Across chest	22	24	26	28	30
Bust point width	11	12	13	14	15
Across back	24	27	29	31	33
Scye depth	13	14	15	17	18
Shoulder to elbow	24	25	26	27	28
Outer arm length	40	44	48	52	56
Crotch length	44	47	50	53	56
Body rise	17	18	19	20	21
Front neck to waist	25	28	31	34	36
Base of throat to waist	22	24	26	28	30
Torso height	53	55	57	59	61
Nape to waist	24	26	28	30	32
Nape to floor	104	110	116	122	126
Waist to hip	14	15	16	17	18
Waist to knee	37	41	45	49	53
Waist to ankle	69	73	77	81	85
Waist to floor	72	78	82	86	90
Inside leg length	57	61	65	69	73

Size charts were developed bearing in mind its purpose and final use and the ultimate consumer. The size charts were developed by using the percentile values guided by the mean values and the standard deviations. Three separate size charts were developed for each gender and age range of 6-11. Within each size chart, four or five sizes were created. Using the percentile values in comparison with the mean values and the standard deviations, size steps were created. These developed size charts have ease added to the body measurements to create garment measurements. Within the size charts in Table 6.41-6.42, garment measurements are bolded and in parentheses. These are the measurements that are required to construct basic pattern blocks. The sizes were designated with both pictograms and numbered sizes. The chart also covers vital body dimensions required for the construction of patterns. Refer to Appendices 21-28 for the rest of the size charts.

Table 6.41: Medium size chart for Ghanaian females aged 6-11- upper body

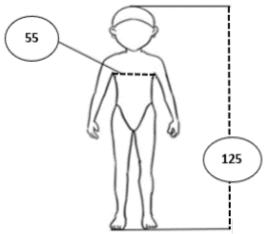
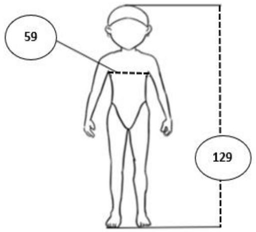
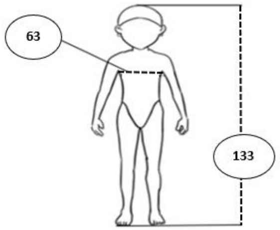
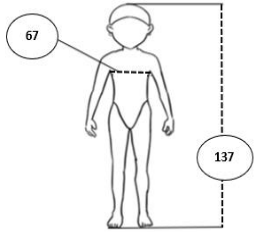
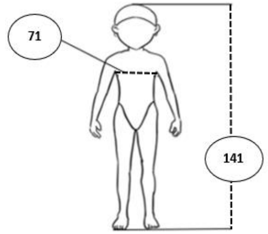
Females Size chart (Medium sizes) **Upper body garments (Bodice)**						
Size Designations	 **Size code M125-55** Height 123-127cm Chest girth 53-57cm	 **Size code M129-59** Height 127-131cm Chest girth 57-63cm	 **Size code M133-63** Height 131-135cm Chest girth 61-65cm	 **Size code M137-67** Height 135-139cm Chest girth 65-69cm	 **Size code M141-71** Height 139-143cm Chest girth 69-73cm	**Ease allowance**
Body Dimensions						
Chest	55 **(65)**	59 **(69)**	63 **(73)**	67 **(77)**	71 **(81)**	+10
Waist	52 **(58)**	56 **(62)**	60 **(66)**	64 **(70)**	68 **(74)**	+6
Neck girth	24 **(26)**	26 **(28)**	28 **(30)**	30 **(32)**	32 **(34)**	+2
Shoulder length	11 **(11)**	11 **(11)**	12 **(12)**	13 **(13)**	13 **(13)**	0
Across chest	22 **(23)**	24 **(25)**	26 **(27)**	28 **(29)**	30 **(31)**	+1
Across back	25 **(27)**	27 **(29)**	29 **(31)**	31 **(33)**	33 **(35)**	+2
Scye depth	13 **(15)**	14 **(16)**	15 **(17)**	17 **(19)**	18 **(20)**	+2
Front neck to waist	25 **(25)**	28 **(28)**	31 **(31)**	34 **(34)**	36 **(36)**	0
Base of throat to waist	22 **(22)**	24 **(24)**	26 **(26)**	28 **(28)**	30 **(30)**	0
Nape to waist	24 **(24)**	26 **(26)**	28 **(28)**	30 **(30)**	32 **(32)**	0
Upper arm girth	17 **(23)**	19 **(25)**	21 **(27)**	23 **(29)**	25 **(31)**	+6
Elbow girth	17 **(23)**	18 **(24)**	**19 (25)**	20 **(26)**	21 **(27)**	+6
Wrist girth	12 **(15)**	13 **(16)**	14 **(17)**	15 **(18)**	15 **(18)**	+3
Outer arm length	40 **(40)**	44 **(44)**	48 **(48)**	52 **(52)**	52 **(52)**	0

Table 6.42: Medium size chart for Ghanaian females aged 6-11- lower body

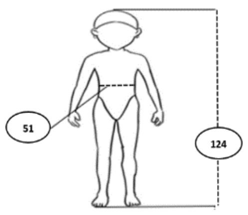
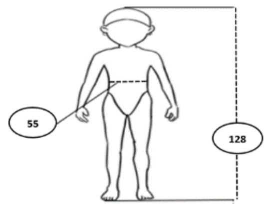
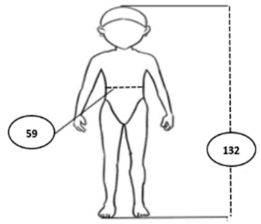
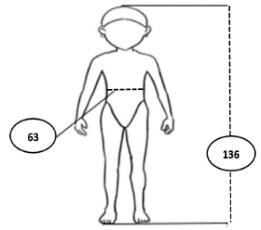
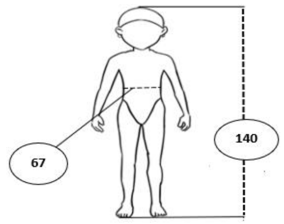
Size Chart for Ghanaian Females (Medium sizes) **Lower Body (Skirt/trousers)**						
Size Designations	 **Size code M124-51** Height 122-126cm waist girth 49-53cm	 **Size code M128-55** Height 126-130cm waist girth 53-57cm	 **Size code M132-59** Height 130-134 cm waist girth 57-61cm	 **Size code M136-63** Height 134-138cm waist girth 61-65cm	 **Size code M140-67** Height 138-142cm waist girth 65-69cm	**Ease Allowance**
Body Dimensions						
Waist girth	52 **(58)**	56 **(62)**	60 **(66)**	64 **(70)**	68 **(74)**	+6
Hip girth	64 **(70)**	68 **(74)**	72 **(78)**	76 **(82)**	80 **(86)**	+6
Thigh girth	35 **(41)**	39 **(45)**	43 **(49)**	47 **(53)**	51 **(57)**	+6
Knee girth	26 **(32)**	28 **(28)**	30 **(36)**	32 **(38)**	34 **(40)**	+6
Ankle girth	18 **(21)**	19 **(22)**	20 **(23)**	21 **(24)**	22 **(25)**	+3
Crotch length	44 **(47)**	47 **(50)**	50 **(53)**	53 **(56)**	53 **(56)**	+3
Body rise	17 **(17)**	18 **(18)**	19 **(19)**	20 **(20)**	21 **(21)**	0
Waist to hip	14 **(14)**	15 **(15)**	16 **(16)**	17 **(17)**	17 **(17)**	0
Waist to knee	37 **(37)**	41 **(41)**	45 **(45)**	49 **(49)**	53 **(53)**	0
Waist to ankle	69 **(69)**	73 **(73)**	77 **(77)**	81 **(81)**	85 **(85)**	0
Inside leg length	57 **(57)**	61 **(61)**	65 **(65)**	69 **(69)**	73 **(73)**	0

Table 6.43: Medium size chart for Ghanaian males aged 6-11- upper body

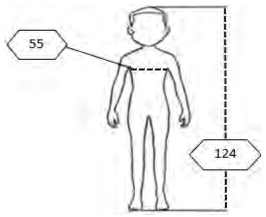
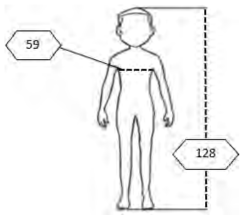
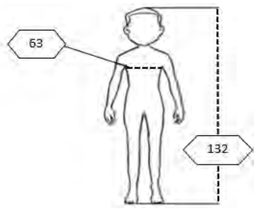
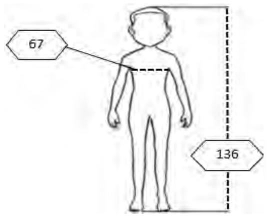
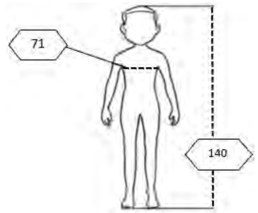
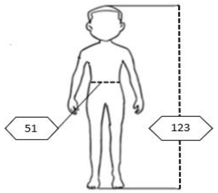
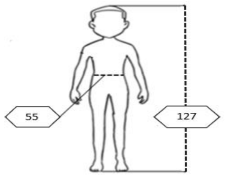
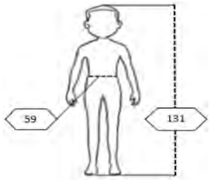
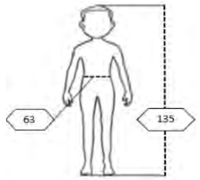
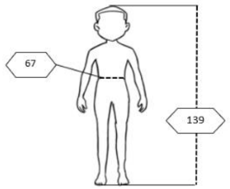
Males Size Chart (Medium Sizes) Upper Body Garments (Shirts)						
Size Designation	 **Size code 124-55** Height 122-126cm Chest girth 53-57cm	 **Size code 128-59** Height 126-130cm Chest girth 57-61cm	 **Size code 132- 63** Height 130-134cm Chest girth 61-65cm	 **Size code 136-67** Height 134- 138cm Chest girth 65-69cm	 **Size code 140-71** Height 138-142cm Chest girth 69-73cm	**Ease allowance**
Body Dimensions						
Chest girth	55 **(65)**	59 **(69)**	63 **(73)**	67 **(77)**	71 **(81)**	+10
Waist girth	51 **(57)**	55 **(61)**	59 **(65)**	63 **(69)**	67 **(73)**	+6
Neck girth	24 **(26)**	26 **(28)**	28 **(30)**	30 **(32)**	32 **(34)**	+2
Shoulder length	10 **(10)**	11 **(11)**	12 **(12)**	13 **(13)**	13 **(13)**	0
Back shoulder width	32 **(32)**	33 **(33)**	34 **(34)**	35 **(35)**	36 **(36)**	0
Across chest	23 **(24)**	25 **(26)**	27 **(28)**	29 **(30)**	31 **(32)**	+1
Across back	25 **(27)**	27 **(29)**	29 **(31)**	31 **(33)**	33 **(35)**	+2
Scye depth	13 **(15)**	14 **(16)**	15 **(17)**	16 **(18)**	17 **(19)**	+2
Front neck to waist	26 **(26)**	28 **(28)**	32 **(32)**	34 **(34)**	36 **(36)**	0
Waist to hip	14 **(14)**	15 **(15)**	16 **(16)**	17 **(17)**	17 **(17)**	0
Upper arm girth	19 **(25)**	20 **(26)**	21 **(27)**	22 **(28)**	23 **(29)**	6
Elbow girth	17 **(23)**	18 **(24)**	19 **(25)**	20 **(26)**	21 **(27)**	+6
Wrist girth	12 **(15)**	13 **(16)**	14 **(17)**	15 **(18)**	15 **(18)**	+3
Outer arm length	41 **(41)**	44 **(44)**	47 **(47)**	50 **(50)**	54 **(54)**	0

Table 6.44: Medium size chart for Ghanaian males aged 6-11- lower body

Males Size Chart (Medium sizes) **Lower Body Garments (Shorts/trousers)**						
Size Designation	 **Size code M 123-51** Height 121-125cm waist girth 49-53cm	 **Size code M127- 55** Height 125-129cm waist girth 53-57cm	 **Size code M131-59** Height 129-133cm waist girth 57-61cm	 **Size code M135-63** Height 133-137cm waist girth 61-65cm	 **Size code M139-67** Height 137- 141cm waist girth 65-69cm	**Ease Allowance**
Waist girth	51 **(56)**	55 **(61)**	59 **(65)**	63 **(69)**	67 **(73)**	+6
Hip girth	61 **(67)**	65 **(71)**	69 **(75)**	73 **(79)**	77 **(83)**	+6
Thigh girth	33 **(39)**	37 **(43)**	41 **(47)**	45 **(51)**	49 **(55)**	+6
Knee girth	25 **(31)**	27 **(33)**	29 **(35)**	31 **(37)**	33 **(39)**	+6
Ankle girth	19 **(22)**	20 **(23)**	21 **(24)**	22 **(25)**	23 **(26)**	+3
Crotch length	40 **(43)**	44 **(47)**	48 **(51)**	52 **(55)**	56 **(59)**	+3
Body rise	17 **(17)**	18 **(18)**	19 **(19)**	20 **(20)**	20 **(20)**	0
Waist to hip	14 **(14)**	15 **(15)**	16 **(16)**	17 **(17)**	17 **(17)**	0
Waist to knee	37 **(37)**	40 **(40)**	43 **(43)**	46 **(46)**	49 **(49)**	0
Waist to ankle	72 **(72)**	74 **(74)**	76 **(76)**	78 **(78)**	80 **(80)**	0
Inside leg length	60 **(56)**	62 **(62)**	64 **(64)**	66 **(68)**	68 **(68)**	0

6.18 Pattern drafting and configuration

It is very important to verify the developed size chart. Garment measurements were developed for the construction of basic patterns and used to produce trial garments to verify the developed size charts. Ease allowance was added to body measurements that require them on the developed size chart. The method of pattern drafting outlined in Aldrich's (2009) book, The metric pattern cutting for children's wear: from 2-14 years was used to manually draft the basic pattern blocks in this study**.** The mid-size in each of the developed size charts which happens to be the mean of each size category based on the clusters were used as a base size in the pattern construction process. Base size is described as the mid-size in the range of sizes that is used to produce the first basic block that is decreased and increased for smaller and larger sizes (Domjanić and Ujević, 2018).

The basic bodice, skirt, and sleeve blocks were constructed for the females whereas the basic trouser, shirt and sleeve blocks were produced for the males. Before the production of basic block patterns, the type of fabric to be used must be factored. In Ghana, woven fabrics are commonly used for apparel production. According to Lo (2011) block for woven fabrics must have specified amount of tolerance. This is usually one or two centimetres added to the exact body dimensions to give room for movement, comfort and fit. On the other hand, Lo (2011) added that blocks for stretch fabrics are sometimes smaller than the exact body dimension.

The manually constructed block patterns were digitised through pattern configuration process. This is the process of translating manual blocks into 2-D digitised patterns. The digitisation was done at Manchester Metropolitan University using the System Management of the Gerber Technology version 15. This process made it easy to convert the manually drafted patterns to 2D digitised patterns that were quicker to crosscheck and validate the accuracy of the patterns. Additionally, the digitised images allowed the pattern pieces to be superimposed on top of each corresponding pattern to check the shape of the original and altered patterns. Figure 6.31 to6.32 shows the digitize base patterns for medium sizes. The front bodice patterns for the females and the back shirt pattern for the males were mirrored to produce a full front bodice and a full shirt back pattern respectively.

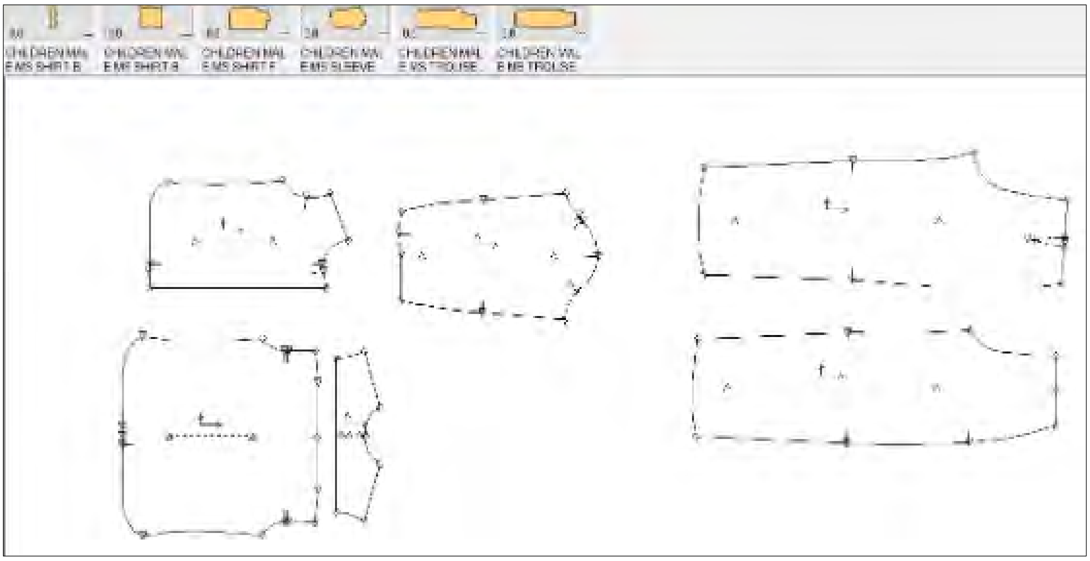


Figure 6.31: Digitised base size patterns for medium size-male upper and lower body

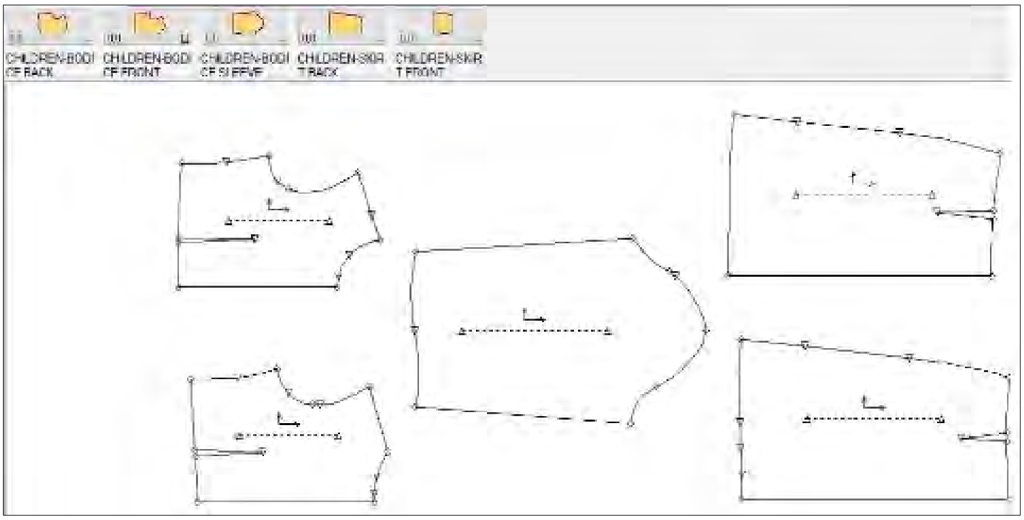


Figure 6.32: Digitised base size pattern for medium size-female upper and lower body

A 1cm seam allowance was added on to the shoulders and a 2cm sides seam was also added. A 2cm seam allowance was added to the centre back edges of the bodice and skirt patterns to allow for zip. A 1cm seam allowance was added all round to the sleeve pattern for the females. For the males, however, 1cm seam allowance was allowed all-round the shirt, trouser and sleeve patterns. Base size of all patterns with turnings were printed and used to cut the toiles for fitting trials. Figure 6.33 illustrate an image of a base size pattern with turnings.

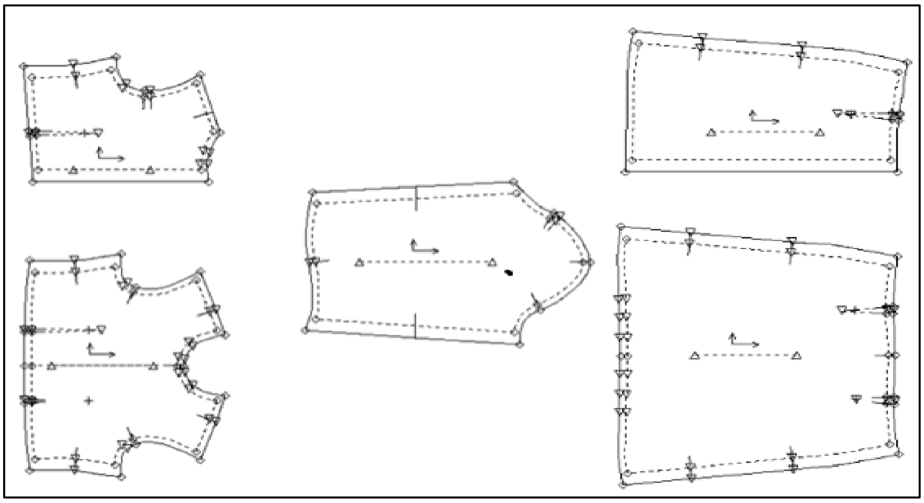


Figure 6.33 Sample of female base size pattern with turnings.

6.19 Production of toiles and fitting trial

According to Beazley and Bond (2003) when block patterns are first constructed, it must be verified by converting them into garment. This garment, termed as toile is fitted by potential consumers whose body dimension are in accordance with the measurements of the toiles. To validate the developed size charts in this study, toiles for the patterns were produced and tested for fit. Patterns for each size was cut out in calico that had been pre-shrunk and pressed. The cut-outs were stitched together by the researcher, and an open-ended zip of a matching colour fixed at the centre back of the bodice. The open-ended zips were placed on the centre back with the centre back meeting perfectly to conceal the teeth of the zip. This was to avoid detraction during the fit assessment process. Final pressing of the constructed toiles was done before packaging and sending off to the schools. The entire validation process was guided by the observation by Ashdown and O'Connell (2006) that state that apparel fit issues are as a result of choice of fit models, pattern production, pattern grading, and distortion of the grain line which are all linked to inadequate product development. All toiles were carefully constructed by the researcher to ensure consistency.

Thirty (30) participants who participated in the main survey and indicated willingness to undertake the fitting trial were carefully chosen based on key dimensions (height and chest girth and height and waist girth for upper body garments and lower body garment respectively). School heads of selected participants and parents were contacted on phone to confirm if they are still willing to participate. Bodice with sleeve and skirts blocks were produced for females' upper body and lower body respectively for all developed sizes. Shirt and trousers were produced for male upper body and lower body respectively for the base sizes. In all, five toiles were produced for each size group namely, small, medium, and large. Five sample garments were produced for each size category to fit children (live models) whose body measurements are in accordance with the developed sizes. This is in line with the recommendation by ASTM to work with a range of 3-5 participants during fitting trials. A total of thirty (30) prototypes garments were assembled for the fitting trials.

Participants whose sizes were within the designated sizes and had given consent were used as fit models. Selected participants were contacted to verify if they were still interested in being part of the fitting trial. Packs consisting of toiles of bodice and skirts together with the assessment tool for the parents/legal guardians of the participants were sent to the schools for selected female participants. For male participants, packs containing toiles of shirts and trousers together with the assessment tools for the parents/legal guardians were also sent to the schools. Assessment sheets for experts were sent directly to them. The schools assisted the researcher by liaising with the parents/legal guardians on the date for the fit assessment trials. Agreed dates were communicated to experts and they accepted. Fit evaluation was carried out in the selected participants' schools. On the day of fitting, parents were encouraged to assist participants wear the toiles for a period not less than 30 minutes before carrying out the evaluation process with the judges.

The study used parents and the three subject experts to evaluate the fit of the toiles produced from the basic pattern blocks as the issue of fit is subjective based on individual preference. In the evaluation of fit of apparel, models used must represent the target population. As stated by Vinué et al. (2014) the function of the human fit model is the most vital compared with the other fit models such as dress forms used for fit assessment. Additionally, the study used three subject experts in addition to the parents/legal guardians of the participants to balance the subjectiveness of fit preferences. The fit trials were conducted by the participants and their parents together with experts from academia and industry at the participants schools. Participants were required to wear their lingerie underneath the toiles.

6.19.1 Results of the fitting trial

Validation of size charts through fitting trials is important to ascertain the fit of the sizes based on the proposed dimensions (Roebuck 1995; Pheasant, 1986). Fitting trial evaluation was conducted separately for males and females. The females fitted the bodice and skirt whereas the males tried on the shirt and trousers. Fifteen trial garments consisting of bodice with a sleeve and skirt were produced for the female participants and 15 garments, a shirt with sleeve and a pair of trousers were also produced for the male participants. The five elements of fit grain, balance, line, set, and ease used by Chen (2007) and Yu (2007) guided the fit assessment process. All sample garments were worn over basic undergarments and assessed by participants' parents and three experts. Tables 6.46 and 6.47 show the summary of the results for the fitting trials for females whereas Tables 6.49- 6.51 give the summary of the results for the male participants.

Table 6.45: Ages of females fit models

Variables	Frequency (n)	Percentage (%)
Age group		
6 years	2	13.3
7 years	2	13.3
8 years	5	33.3
9 years	3	20.0
10 years	2	13.3
11 years	1	6.7
Total	15	100

Table:6.46: Result of fit evaluation for female participants

Descriptions of garment areas		Good fit	Poor fit	Comments
Neck girth		56	4	Slightly wide in relation to neck
Chest girth		60	0	No fit challenges found
Waist girth		58	3	Waist girth too loose
Hip girth		57	3	Dropped hip due to posture
Shoulder seamline		57	3	Length shortened due to posture
Length- neckline to waistline		58	2	Too long due to posture
Length- waistline and hipline		48	12	Sleeve too long
Sleeve length		60	0	No fit challenges found
Length of skirt (females)		60	0	No fit challenges found
Side seams straight and perpendicular to the floor.		60	0	No fit challenges found
No unpleasant vertical wrinkles		60	0	No fit challenges found
No unpleasant horizontal wrinkles		60	0	No fit challenges found
Hemlines- even and parallel to the floor		60	0	No fit challenges found
Hang- smooth without pulling		60	0	No fit challenges found
Right amount of ease across the following areas	Chest level	60	0	No fit challenges found
	Waist level	60	0	No fit challenges found
	Hip level	60	0	No fit challenges found
	Biceps	56	4	Looseness due to amount of ease

Table 6.47: Fit rating of toiles as participants perform underlisted activities- females

Activities	Rating scale			
	Good fit	Percentage	Poor fit	Percentage
Standing	57	95.0	3	5.0
Sitting	53	88.3	7	11.7
Walking	54	90.0	6	10.0
Bending	55	91.7	5	8.3
Arms raised above head	52	86.7	8	13.3

Table 6.48: Overall fit rating of toiles- females

Overall fit rating					
Good	**%**	**Satisfactory**	**%**	**Poor fit**	**%**
53	88.3	4	11.7	0	0.0

Experts and parents/legal guardians rated the fit of the sample garment as the participant performs the activities stated in Table 6.47**.** On the assessment of the overall fit of the sample garments experts and parents/legal guardians were to rank the fit. Out of all 60 assessments sheets collected 53 indicated that the overall fit of the sample garments for females were good representing 88.3% of the total. Four indicated that the fit was satisfactory representing 11.7% and none indicated poor fit.

Table 6.49: Ages of male fit models

Variables	**Frequency (n)**	**Percentage (%)**
Age group		
6 years	2	13.3
7 years	3	20.0
8 years	4	26.7
9 years	4	26.7
10 years	3	13.3
11 years	0	0.0
Total	15	100

Table 6.50: Result of fit evaluation for male participants

Descriptions of garment areas		Good fit	Poor fit	Comments
Neckline		**60**	**0**	No fit challenges found
Chest girth		**60**	**0**	No fit challenges found
Waist girth		**60**	**3**	Waist girth too loose
Hip girth		**60**	**0**	No fit challenges found
Shoulder seamline		**60**	**0**	No fit challenges found
Shirt length		**60**	**0**	No fit challenges found
Length- waistline and hipline		**60**	**0**	No fit challenges found
Sleeve length		**54**	**6**	Length of sleeve too long
Length of trouser (males)		**56**	**4**	Length of trouser too long
Side seams straight and perpendicular to the floor		**60**	**0**	No fit challenges found
No unpleasant vertical wrinkles		**60**	**0**	No fit challenges found
No unpleasant horizontal wrinkles		**57**	**3**	Slight Wrinkles on sleeve due to length being too long
Hemlines- even and parallel to the floor Hang-smooth without pulling		**60**	**0**	No fit challenges found
Right amount of ease across the following areas	Chest level	**60**	**0**	No fit challenges found
	Waist level	**60**	**0**	No fit challenges found
	Hip level	**60**	**0**	No fit challenges found
	Biceps	**60**	**0**	No fit challenges found
	Thigh girth	**60**	**0**	No fit challenges found
	Knee girth	**60**	**0**	No fit challenges found
	Ankle girth	**60**	**0**	No fit challenges found
	Crotch	**56**	**4**	Crotch too long

Table 6.51: Fit rating of toiles as participants perform underlisted activities- males

Activities	Rating scale			
	Good Fit	Percentage	Poor Fit	Percentage
Standing	54	90.0	6	10
Sitting	56	93.3	4	6.7
Walking	57	95.0	3	10
Bending	56	93.3	4	6.7
Arms raised above the Head	57	95.0	3	5.0

Table 6.52: Overall fit rating of toiles - males

Overall fit rating					
Good	%	Satisfactory	%	Poor fit	%
55	91.6	5	8.3%	0	0.0

On the assessment of the overall fit of the sample garments experts together with parents ranked the fit. Out of all 60 assessments sheets collected 55 indicated that the fit of the sample garments for males aged 6-11 were good representing 91.6% of the total. Five indicated that the fit was satisfactory representing 8.3% and non-indicated poor fit. Results from Table 6.52 shows that the toiles were constructed well and based on the principles of fit espoused Betzina (2001) and Amaden-Crawford, (2012). The toiles displayed appropriate line in terms of seam positions, darts, hems, and grain. Balance and set were on point with sufficient amount of ease. The adverse comments were mostly related to the sleeve length. This could be attributed to the type of garment. The basic blocks produced for the females were closer to the body compared with that of their male counterpart making fit issues easily noticeable. Also, since fitting trial was conducted using the base size, some of the fitting issues raised could easily be covered by the participant opting for an adjacent size. From the result of the fitting trial, it can be concluded that the total assessment of fit of the base sizes were good.

6.20 Grading increments

Grading is the act of expanding and reducing the size of a pattern using prescribed increments to create a range of sizes (Carufel and Bye, 2020). Grading rules were applied after validating the pattern (Beazley and Bond, 2003). The patterns were graded to obtain the size steps below and above the base sizes. The grade rules are the formulae used for generating various sizes founded on a specific base size generated (Gribbin, 2014). After successful fit evaluation process, the base sizes were graded to generate the other sizes.

Table 6.53: Grading increments- medium sizes of Ghanaian males aged 6-11

Grading Increments for Ghanaian Males (Medium sizes/ Aged 6-11)				
Size Designation	**M124-55 (UB) to M128-59 (UB) and M123-51 (LB) to M 127-55(LB)**	**M128-59 (UB) to M132-63 (UB) and M 127-55(LB) to M131-59 (LB)**	**M132-63 (UB) to M136-67 (UB) and M131-59 (LB) to M135-63 (LB)**	**M136-67 (UB) to M140-71 (UB) and M135-63 (LB) to M139-67 (LB)**
Body Dimensions				
Height	4	4	4	4
Weight	2	2	2	2
Head girth	1	1	1	1
Neck girth	2	2	2	2
Chest girth	4	4	4	4
Waist girth	4	4	4	4
Hip girth	4	4	4	4
Armscye girth	2	2	2	2
Upper arm girth	2	2	2	2
Elbow girth	1	1	1	1
Wrist girth	1	1	1	1
Thigh girth	4	4	4	4
Knee girth	2	2	2	2
Ankle girth	1	1	1	1
Shoulder length	1	1	1	1
Back shoulder width	1	1	1	1
Across chest	2	2	2	2
Across back	2	2	2	2
Scye depth	1	1	1	1
Shoulder to elbow	1	1	1	1
Outer arm length	3	3	3	3
Crotch length	4	4	4	4
Body rise	1	1	1	1
Front neck to waist	2	2	2	2
Torso height	2	2	2	2
Nape to waist	2	2	2	2
Nape to floor	4	4	4	4
Waist to hip	1	1	1	1
Waist to knee	3	3	3	3
Waist to ankle	4	4	4	4
Waist to floor	4	4	4	4
Knee to floor	2	2	2	2
Inside leg length	4	4	4	4

Table 6.54: Grading increments- medium sizes for Ghanaian females aged 6-11

Grading Increments for Ghanaian Females (Medium sizes/ Aged 6-11)				
Size Designations	**M124-55(UBG) to M128-59 (UBG) and M124-51 (LBG) to M128-55 (LBG)**	**M128-59 (UBG) to M133-63 (UBG) and M128-55 (LBG) to M132-59(LBG)**	**M133-63 (UBG) to M137-67 (UBG) and M132-59(LBG) to M136-67(UBG)**	**M137-67(UBG) to M141-71(UBG) and M136-63 (LBG) to M140-67(LBG)**
Body Dimensions				
Height	4	4	4	4
Weight	2	2	2	2
Head girth	1	1	1	1
Neck girth	2	2	2	2
Chest girth	4	4	4	4
Waist girth	4	4	4	4
Hip girth	4	4	4	4
Arm scye girth	2	2	2	2
Upper arm girth	2	2	2	2
Elbow girth	1	1	1	1
Wrist girth	1	1	1	1
Thigh girth	4	4	4	4
Knee girth	2	2	2	2
Ankle girth	1	1	1	1
Shoulder length	1	1	1	1
Back shoulder width	2	2	2	2
Across chest	2	2	2	2
Bust point width	1	1	1	1
Across back	2	2	2	2
Scye depth	1	1	1	1
Shoulder to elbow	1	1	1	2
Outer arm length	4	4	4	4
Crotch length	3	3	3	3
Body rise	1	1	1	1
Front neck to waist	3	3	3	3
Base of throat to waist	2	2	2	2
Torso height	2	2	2	2
Nape to waist	2	2	2	2
Nape to floor	6	6	6	6
Waist to hip	1	1	1	1
Waist to knee	4	4	4	4
Waist to ankle	4	4	4	4
Waist to floor	4	4	4	4
Inside leg length	4	4	4	4

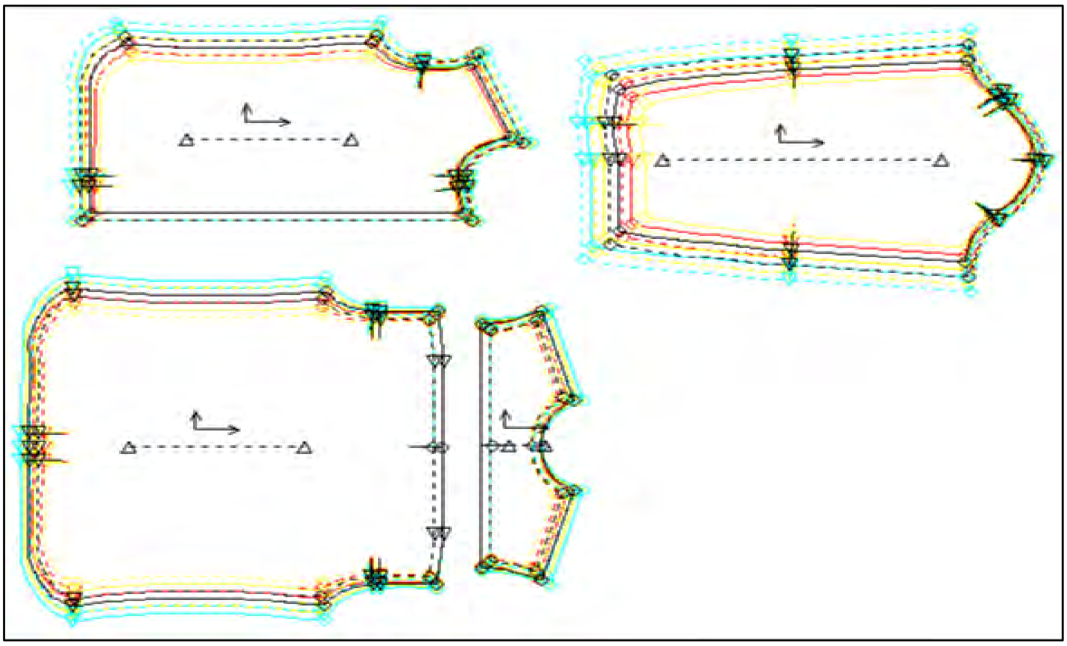


Figure 6.34: Graded patterns for medium size- male upper body

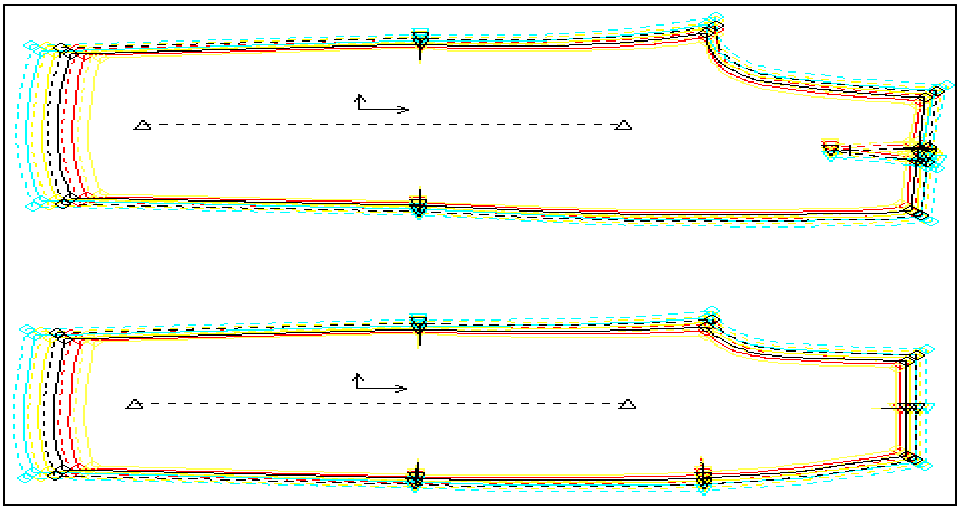


Figure 6.35: Graded patterns for medium size- male lower body

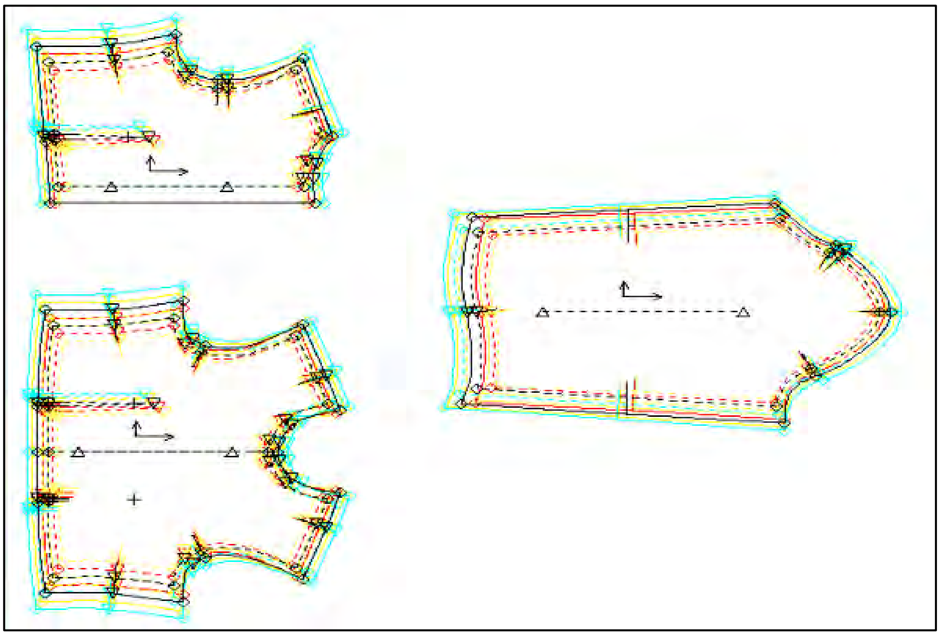


Figure 6.36: Graded patterns for medium size- female upper body

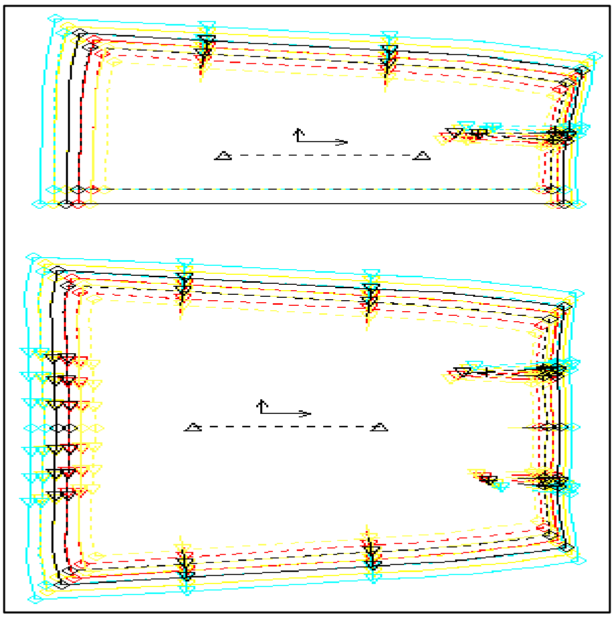


Figure 6.37: Graded patterns for medium size female lower body

6.21 Degree of self-confidence of parent/legal guardians in measuring their children

Additionally, based on the procedure for data collection, the final section of the body measurement sheet consisted of a Likert scale question that sought to ascertain from parents/legal guardians their level of confidence in measuring their wards for the study. The result of this was analysed and presented in Figure 6. 38 and Table 6.55. This goes to confirm to the researcher the credibility of measurements done by the parents/legal guardians. Almost all (98.2%) of the parents/legal guardians claimed they were either confident (53%) or very confident (45%) in measuring their children for the study as shown in Figure 6.38 and Table 6.55.

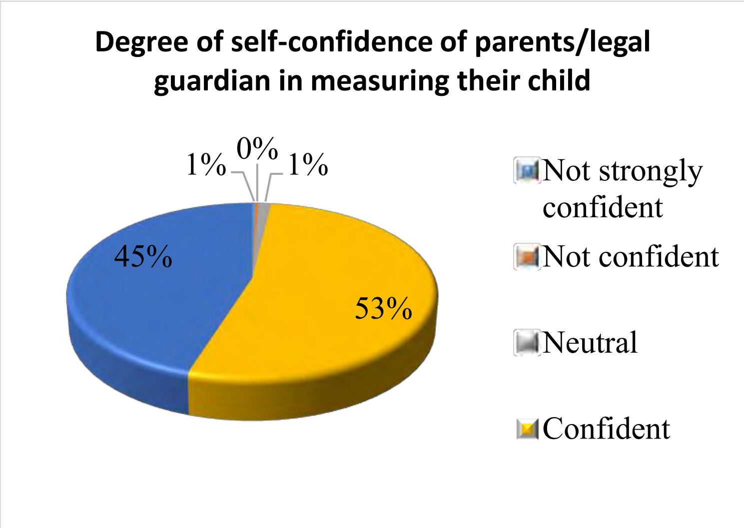


Figure 6.38: Graphical representation of the degree of self-confidence of parent/legal guardians in measuring their children.

Table 6.55: level of self-confidence of parent/legal guardians in measuring their children

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not strongly confident	2	.3	.3	.3
	Not confident	2	.3	.3	.5
	Neutral	10	1.3	1.3	1.8
	Confident	408	52.6	53.1	54.9
	Strongly Confident	347	44.7	45.1	100.0
	Total	769	99.1	100.0	
Missing	System	7	.9		
Total		776	100.0		

CHAPTER SEVEN

DISCUSSION OF FINDINGS

7.1 Introduction

This chapter discusses the overall findings of the empirical study. This is based on the anthropometric body measurements of Ghanaian children between the ages of six and 11. The discussion is focused on the aim of the research which is to develop standardised sizing systems and size charts for Ghanaian children for the production of ready to wear apparel in Ghana. The discussions of findings are presented under the processes undertaken to develop an effective clothing sizing system and charts for Ghanaian children aged 6-11. To develop a sizing system and size charts for a population requires the conduct of anthropometric survey on the population to collect current and accurate anthropometric data.

7.2 Development of standardised measuring procedures for measuring children remotely

The study determined through objective (1) standardised measuring procedures applicable for measuring children remotely. The study reviewed literature on previous manual anthropometric surveys. It also indicated the measurements collected by different researchers. However, since the remote method of anthropometric data collection is novel in the field of Fashion, literature was further gathered from the field of science, that has been making use of remote anthropometric data collection method and adapted the procedure for this study. Different materials were developed to aid the successful collection of manual anthropometric data remotely. These included colourful body measurement guidebook and demonstration videos that vividly described the measurement procedures. Parents of participants were trained to collect the body measurements for this study. The process was successfully piloted in three schools and the procedure was effective and generated credible results.

7.3 Establishment of anthropometric database of Ghanaian children

After the conduct of the anthropometric survey, data collected on the population was organised into an anthropometric database. An anthropometric database is a collection of demographic and anthropometric information gathered from a population and stored in a electronically in a computer. Collected data was keyed into IBM SPSS version 26. This database for the purpose of this study was in IBM SPSS however, it can also be converted into other forms based on the needs of the user of this database. This created database is valuable as it can be assessed and used for varied purposes.

After establishment of the database on Ghanaian children aged 6-11, descriptive analysis was conducted on both the demographic and anthropometric data. Descriptive analysis of the anthropometric data gave a synopsis of the body measurements and provided the profile of the body sizes encountered within the study sample as whole and separately for males and females. Kemsley (1957) acknowledged that the efficacy of anthropometric survey is dependent on the degree to which the collected data are statistically transformed into summaries used to resolve design challenges. The values obtained in the anthropometric data from the survey indicate that the data is normally distributed. Maximum and minimum values, mean along with the standard deviation for each of the body measurement collected were computed. This was done to establish the range of each of the body dimensions.

The descriptive statistics show that the size ranges for most of the key dimensions are wide. For example, the size range for height of male participants is 105.00-158.60cm therefore the difference in the range is 53.60cm. That of the female participants is even wider with size range of 101.00-163.50cm, resulting in a difference of 62.30cm. The findings from this study echo previous findings in the study by Zakaria (2011) that used other populations. From Zakaria's study, focusing on females aged 7-12, she recorded that the minimum height was 102.6cm whereas the maximum height was 162.9cm resulting in a difference of 60.3cm. From the descriptive statistics in Table 6.3 the mean height for the females aged 6-11 is 133.0cm with a standard deviation of 12.4cm, however, Zakaria's (2011) study obtained a mean of 131.5cm with a standard deviation of 12.7cm for females aged 7-12. Similarly, the study by Wadyanti et al. (2017) on Indonesian children between the ages of 6 and 10 indicated a mean height of 126.8 and a standard deviation of 10.7 for males and a mean height of 126.5 and a standard deviation of 11.6 for females. These large values obtained in the standard deviations indicate wide variations in the measurements of children. Additionally, studies have revealed that children aged 6-11 exhibit a significant increase in height (Eun Gyung Chun, 1991; Jeong-Ah Jang, 1999 cited in Kang et al., 2001; Zakaria, 2016). Children's apparel has a wide range of sizes linked to height and girth dimensions (Chan Mi Park's, 1999 cited in Kang et al., 2001). Laios and Giannatsis (2010) added that even children of the same age have wide variance in their anthropometric data.

Also, from the descriptive statistics results in Table 6.3 in chapter six, the hip range along gender lines is different. Although the range for both males and females start from 52.00cm the maximum for the females is larger than that of the males (male= 52.00-91.00cm and females= 52.00-93.00cm). This could be attributed to the early onset of growth process in females. According to Chung et al. (2007) and Smith (2013) females begin to grow between the ages of 8 and 12 reaching puberty about two years earlier than males. This period is also associated with physical changes which includes the widening of hips of females. This finding is also consistent with the study by Zakaria (2016) that focused on children aged 7-12. This is also consistent with the assertion by Blaak (2001) that the female body possesses higher proportion of body fat compared to males. Higher percentage of this fat is stored in the hip and thigh area (gluteal-femoral region) for females while the male body accumulate more fat in the abdominal (visceral) region.

7.4 Gender morphological differences of Ghanaian children aged 6-11

The t-test result in Table 6.3 (chapter six) was conducted to aid in the fulfilment of research question one which sought to ascertain any differences in the body measurements of males and females aged 6-11 in Ghana. The t-test result indicates significant differences in some of the body measurements collected in this study along gender lines. These include head girth (0.00), hip girth (0.00), upper arm girth (0.02), thigh girth (0.00), back shoulder width (0.00) just to mention a few. This is in accordance with the study of Bilhassan et al. (2018) where they run t-test on the body dimensions across gender and found that thirteen of the anthropometric measurements were significantly different across gender lines. The study by Wadiyanti et al. (2017) on the other hand recorded significant difference ($p < 0.01$) in all body dimensions between male and female participates apart from neck girth. Their study ascertained that male participants have larger and longer body dimensions compared to their female counterparts. Many researchers based on empirical evidence have concluded that gender is a factor that affect growth of the human body and in turn affect clothing sizes (Anbahan Ariadurai et al., 2009; Zakaria, 2016; Wadiyanti et al., 2017; Bilhassan et al., 2018). These researchers recommend separate analysis based on gender due to differences in body measurements between male and female data set and the outcome of this study concur with their findings.

Additionally, observing the growth pattern of the study sample in Figure 6.14 and 6.15, it is obvious that both male and female participants exhibit growth in both vertical and horizontal dimensions. Thus, as height a vertical dimension increases chest girth, waist girth and hip girth all horizontal dimensions also increase steadily. From the growth trend in Figure 6.14 for males and Figure 6.15 for females, the mean values for the key dimensions tested are comparatively linear. These suggest a steady growth in all the variables examine for both males and females. This generally indicate that gender dimorphism is less in children aged 6-11. This affirms the statement by Chung et al. (2007) that both male and female participants aged 6 to 12 show rapid variation in both vertical and horizontal dimensions necessitating the need to develop a sizing system using both vertical and horizontal dimensions as the control dimensions. As espoused by Kang et al. (2001) an appropriately styled and sized garment factors the growth of children as well as enable free movement. These findings informed the selection of control dimensions for this study.

7.5 Differences in body measurements of Ghanaian children between regions and districts

Due to the ethnically heterogenous nature of the Ghanaian population, in the conduct of an anthropometric survey data was collected strategically from the population. A comparison of selected measurements (height, weight, chest girth, waist girth, and hip girth) of participants from the three regions sampled was conducted using one-way ANOVA. This procedure was to answer research question two. From the one-way ANOVA results in Table 6.4, all key measurements tested indicated significant differences among the three regions surveyed except for waist girth that did not show significant difference. These results obtained contradict an old undocumented perception regarding height of Ghanaians. There is the perception that people from the northern part of Ghana are generally taller as compared to mainly people from the middle and southern parts of Ghana. However, based on the empirical data from this study, it is obvious that this old perception is not valid as children in Greater Accra region were taller followed by children in the Ashanti region and then the Northen region. The analysis further indicates that participants from the middle belt (Ashanti region) are bigger and weighed more than those in the northern and southern belt. This may be due to the low cost of living in the Ashanti region and the middle belt as a whole. This goes to prove the perception in Ghana that food is cheaper in the middle belt than the other parts of Ghana including the southern and the northern belts.

To answer research question three, a further comparison between selected measurements (height, weight, chest girth, waist girth, and hip girth) of participants from the metropolitan areas and municipal districts was conducted using one-way ANOVA as shown in Table 6.6 and Fishers LSD multiple comparison test presented at Appendix 14. This also revealed significant differences in all the measurement tested. These differences in anthropometric data across the three regions, metropolitan areas and municipal districts were expected based on literature. Gioello and Berke (1979) maintain that variability in body sizes and shape are mostly due to biological and social differences amongst groups. Also, empirical evidence by researchers such as Gioello and Berke, (1979), Iseri and Arslan (2009), Otieno and Fairhurst (2000), Igbo (2005) and Widyanti et al. (2015) all state that factors such as geographical region, ethnic composition, age, nutrition, and social status are probable factors that affect the distribution of anthropometric variables. Otieno and Fairhurst (2000) added that variability exist in terms of size, shape, and proportions of human figure even among people of the same age group and ethnicity. Igbo (2005) concurred, stressing that the height and weight of a child is influenced adequately by nutrition. The Centre for Ergonomics of Developing Countries (CEDC) in Sweden conducted a comparative study of variations in body sizes where the outcome showed differences in nearly every single part of the body measured between the distinct nations (Le Pechoux and Ghosh, 2002). The results obtained from the ANOVA test in Table 6.4 go to affirm the statement by Ashdown (1998) that sizing system should be developed for every country and even region within countries. Also, as Ashdown (2002) stated anthropometric measurements are very necessary in nations where differences are due to the population comprising of a range of ethnic groups. The study by Widyanti et al. (2015) on Indonesian population ascertained significant differences in the anthropometric data among three large ethnic groups thereby concluding that ethnicity needs to be considered in the conduct of anthropometric research.

7.6 Establishment of sizing system

It has been ascertained from literature that there are different statistical procedures use in the development of a sizing system. This ranges from simple to more rigorous statistical procedures. The procedure to use mostly depends on the variability in the data set. It is worth mentioning that regardless of the procedure used, the basic component of a sizing system is the same. This research through objective [4] developed comprehensive sizing system of Ghanaian children aged 6-11. Discussion on the development of sizing system is done systematically focusing on the selection of control dimensions, categorisation of participant into homogenous subgroups, determination of size range and intervals to establish the sizing system and labelling of sizes for effective selection of appropriate sizes. After developing the sizing system, it was first validated through the calculation of size roll and the accommodation rate.

7.6.1 Control dimensions used

After exploration of the data through descriptive and some inferential statistics such as t-test and ANOVA to understand the distribution, a multivariate statistical analysis was conducted to ascertain the inter-relationship among the 35 variables and extracts the fundamental factors important for body size analysis. The PCA was used to extract the important variables out the 35 body dimensions from which the key dimensions were selected. Otieno and Fairhurst (2000) alluded that the determination of key dimension is an essential phase in the development of body-measurement tables and subsequent developed into size charts. PCA has been successfully used by several researchers (Hyussteen, 2006; Hsu 2009; Guan et al., 2012; Zakaria, 2016; Widyanti et al. 2017) in the selection of key dimensions. Several studies have worked with different loadings in the extraction of significant variables. The study by Hsu (2009) worked with anthropometric variables that showed factor loadings greater or equal to 0.5(≥ 0.5). Zakaria's (2016) study used factor loading greater or equal to 0.75 (≥ 0.75). Widyanti et al. (2017) on the other hand worked with dimensions with factor loading greater than 0.7 (≥ 0.7). This study on the other hand worked with factor loadings greater than or equal to 0.6 (≥ 0.6). In PCA small eigenvalue of principal components may be as significant as those with a large variance (Jolliffe, 1982; Xia and Istook, 2017). In the selection of control variables from the PCs, practical situations must be factored.

Height was selected as the control dimension for length in this study. Looking at the results of principal components in Tables 6.13 and 6.14 other variables had higher eigenvalues than height but height was selected as the control dimension for length based on its practicality in sizing system development (Winks, 1997). Height according to some researchers is an inevitable dimension in the creation of a sizing system (Yeosun, Hei-Sun, and Woel-Hee, 2001; Joint Clothing

Council Limited and Great Britain Board of Trade, 1957). Also, several researchers based on empirical evidence noted that height is a good estimator of size of children (Aldrich, 2009; Otieno and Fairhurst, 2000; Kang et al., 2001; Hyussteen, 2006; Chung et al., 2007; Zakaria, 2016). The British Standards, BS 3728 (1982) recommends the designation of children clothing using height dimension. Height due to its ease in measuring, particularly for children is recommended by Jones and Stone (1984); Otieno and Fairhurst (2000); Hyussteen (2006) and Zakaria, (2016) as a key dimension for children's clothing sizing system. Tanner (2021) in the field of science, emphasised that height in most instances is the best sole indicator of growth as it is controlled by a single tissue, thus the skeleton. Chung et al. (2007) reiterated that in designating apparel for growing children, height should be used as the primary variable. Also, height is one measurement that most parents are conversant with. It is evident that height is an appropriate dimension to use as a primary control dimension to group the sample into different clusters.

The girth dimension selected as control dimensions for upper body is the chest girth. This was used as a secondary dimension in conjunction with height the primary control dimensions. The chest measurement was selected as it is an important dimension in the development of sizing system or patterns for upper body (Tamburino, 1992a). According to the international standards on definition and body measurement procedures (ISO 3635:1977 and ISO 8559: 1989), it is easy measuring the chest girth as the tape measure is placed around the bust on the level of the nipple of the participant (Otieno, 2000). Therefore, for upper body, height and chest girth dimensions were used as these are commonly used by sizing system developers (Otieno, 1999; Zakaria, 2016). Height and chest girth from Tables 6.13 and 6.14 have high factor loading for length and girth respectively. Additionally, the chest girth measurement was selected in addition to the height as it was relatively easy to measure and a good predictor of size.

For lower body, height (primary control dimension) and waist girth (secondary control dimension) were used in this study contrary to height and hip girth by other researchers (Otieno, 1999; Zakaria, 2016). The hip girth in this study did not obtain an appreciable factor loading in the PCA however, the waist girth did. The waist girth is among the frequently used body dimensions to designate lower body garments (Tamburino, 1992a; Mpampa et al., 2009). The waist girth was used in the study of Hsu and Wang (2005) as the primary dimension to denote the girth factor as the waist circumference was simpler to measure. Based on the ease of measuring, the use of waist girth as a secondary dimension in addition to height the primary dimension was appropriate for designating lower body garments for children. Otieno's (1999) study classified children according to height as a primary dimension for both upper body garments and lower body garments in addition to bust as a secondary dimension for upper body garments and hip for lower body garments. This study is of the opinion that the waist measurement is easy to measure compared to hip girth. Huyssteen (2006) on the other hand added age for practical reasons to height as a size indicator. Based on the finding in this study in Figure 6.12, age is not a good indicator of size even when used in add to a primary dimension such as height as children of the same age may have varying height measurements. This study used therefore used height a vertical dimension as the primary control dimension and horizontal dimensions chest girth and waist girth as secondary control dimensions for upper and lower body respectively. This is in accordance with the statement by Chung et al. (2007) that both vertical and horizontal dimensions should be used as control dimensions in the establishment of sizing system for both males and females under the age of 13.

Otieno and Fairhurst (2000) admit that regardless of the purpose of clothes, one of the essential issues of concern with regards to clothes, has to do with the assessment of the size and proportion of the human form to be able to designate the appropriate apparel size. Although Kunick (1984) and Huyssteen (2006) are of the opinion that age should not be disregarded in the creation of a sizing system as it serves as a valuable code number and a possible first clue in the selection of the right size. Nonetheless, this study used only vertical and girth dimension as control variables as they offer more reliable prediction of size. This is affirmed by Winks (1997) who stated that for accurate prediction of all the body measurements both vertical and girth dimension must be applied. The usage of height as primary dimension in addition to chest girth as a secondary dimension to designate upper body garments in this research is in line with the recommendation of the BS ISO 8559 (2017) standards. Additionally, the BS ISO 8559 (2017) standards endorses the use of height as a primary dimension supplemented with waist girth as a secondary dimension.

7.6.2 Categorisation of participants into homogenous subgroups

Based on the results of the descriptive statistics in Table 6.3 in chapter six, it was realised that the standard deviations of most of the key dimensions such as height were high. However, the higher the standard deviation value, the wider the spread of the data point from the arithmetic mean (Steyn, Smit, and Strasheim, 1994). Kuma-Kpobee (2009) acknowledged that majority of individuals possess varied body proportions that is subject to certain fit needs. Thus, establishing ready-to-wear apparel sizes on basically the average size, may not accommodate the wide size variability in the population. McConville (1979) in his research document advocated for the concept of segmenting the population into subgroups of people with similar body dimensions and analysing the anthropometric data for the groups as this helps to accommodate the variability of sizes in each group. The cluster analysis was therefore run to group the participants into similar body types. This process was necessary as there is variability in the body measurements of children. Also, growth rate of children varies, and children of the same age may not necessarily possess similar body dimensions. Zakaria (2016) in her study stressed that the rate of growth of children is very rapid and uncertain as such it is prudent to segment children based on sizes. The K-means cluster algorithm was used to segment the sample as it is simple and in term of outcomes, it has been used in several studies and the results were excellent as it provided clear distinction between groups (Hair et al., 1997; Moon and Nam, 2003; Abdali et al., 2004; Chung et al., 2007; Hsu, 2009; Zakaria, 2016). The pros and cons of the K-means cluster algorithm was evaluated. Pham et al. (2004) noted that one weakness of the K-means cluster is its prerequisite for the specification of the number of clusters “K”, before the algorithm is used. To overcome this challenge, this study experimented with several cluster groupings before deciding on the 3-group cluster for two reasons: first it obtained the best cluster quality (Hair et al., 2010), and secondly, three-group clusters are considered practical for size clustering of school age children, due to the familiarity of three basic sizes (small, medium and large) in most local industries in Ghana and this is in line with the study by Zakaria (2016).

The k-means cluster analysis method has been used in the classification of body types in the development of sizing system (Moon and Nam, 2003; Huyssteen, 2006; Hsu, 2009; Zakaria, 2016). Moon and Nam (2003) used k-means cluster analysis method in their study to successfully categorise the lower body shapes of elderly women into few figure forms. Huyssteen’s study made use of k-means cluster analysis by grouping the participants into 13 clusters based on the ages of the participants. Zakaria’s (2016) study also effectively extracted three clusters from each age range studied using k-means cluster method. This study extracted three clusters as it was appropriate for the study, and it clearly indicated the body types encountered in the population.

Additionally, ANOVA was run for each generated set of clusters to ascertain any significant difference among each set of clusters. The results indicated significant differences among the cluster groupings (Tables 6.15 to 6.19). Thus, members in one cluster are different from members in bordering cluster groups. For example, in the cluster for lower body for females (Table 6.19) significant differences were obtained for height ($p<0.000$) and waist girth ($p<0.000$). Like the study by Hsu (2009) that ascertained significant differences according to the ANOVA results for the five clusters generated, this study equally demonstrated notable differences among the three cluster groups generated.

Categorising the body dimensions of the participants into clusters further reduced the standard deviation values to levels practical for the creation of sizing system. This is attributed to the lower within cluster variance. From Table 6.3 in the descriptive statistics section, the standard deviation for height for males and females are 11.29cm and 12.39cm respectively. However, the standard deviation for male upper body cluster (Table 6.16) according to body types; small, medium and large are 5.3cm, 4.3cm and 5.6cm respectively. Likewise, the cluster for female upper body, small body type has a standard deviation of 6.6cm for height. Standard deviation for medium cluster is 4.8cm and large is 6.6cm for height. These standard deviation values obtained in the clusters are feasible to use as size intervals to develop the sizing system.

Comparable to the result of the study by Huyssteen (2006) in terms of extensive overlaps of the height measurements between the different age groups for both males and females; this current study also realised slight overlap in the different cluster groups. This means that children who are not well accommodated in one cluster will be catered for in a bordering cluster groups. Thus, the k-means algorithm aided in the categorisation of the participants and the identification of body sizes encountered in the Ghanaian children population.

7.6.3 The size range and intervals used in the sizing system

The creation of an effective sizing is dependent on the size range and the size interval (Zakaria, 2016). Different size intervals have been used for the creation of sizing system based on the size range of the control variable. Also, the size range may affect the size interval that will be chosen, and this will in turn affect the size roll. According to Kunick (1984) there are differences in size intervals ranging from 3cm to 8cm. Kunick, however, endorses an interval of 6cm. Aldrich (1999) likewise advocates for a size interval of 6cm for height. Hsu (2009) adds that an interval of 4-6cm for girth is generally accepted by most countries. Chung et al. (2007) support an interval of 5-10cm for height. The size interval used in this study ranges between 4-6cm for the height dimension (primary dimension) and 2 and 4cm for the girth dimension. These are within practical values stated in literature and applicable intervals to use for developing children's clothing sizes as there are a lot variability in children's body dimensions.

It must be noted that regardless of the population, the inter size interval used in the creation of clothing sizing system must be within prescribed values. Taylor (1990) recommends sizes to be close together in the development of sizing system. The value of the size interval will determine how close sizes would be. Thus, the wider the size interval the farther the sizes would be. The size interval of 4cm and 6cm for the height the primary dimension and an interval of 2cm and 4cm for the girth dimensions were therefore practicable and produced sizes that are efficient for wholesale production and meet the needs of apparel consumers. The use of these generated size intervals may mean the creation of a few more sizes. However, this will afford apparel manufacturers the flexibility to select sizes from the varied size categories that will be more suitable for their consumer base.

Emanuel et al. (1959) stressed that aside from the body size variability that is considered in the determination of size interval, other factors as the fabric to be used, the type of fit desired, among others ought to be considered. The size intervals used was applicable as they are neither to wide nor tool and appropriate compared to the rate of growth of children. The number of sizes produced based on the size interval within each range were critically considered bearing in mind the recommendation by Beazley (1999c) for sizes developed to be useful for both wholesale manufacturing purposes as well as meet the requirements of the final consumer.

After obtaining the control dimensions and the size intervals, all was set to develop the sizing system. A sizing system consists of a set of sizes established based on statistical methods and basic assumptions (Ashdown, 2002). This study developed sizing system separately for males and females based on body sizes encountered in the Ghanaian children population. Like Moon and Nam's (2003) study that used the control dimension and the size range to create garment sizing system for lower body garments, this study also used control dimensions, means, standard deviations and size ranges within each cluster group to create the sizing system. The development process of the sizing system in this study was guided by the description by Sindicich and Black (2011) where they describe a sizing system as the categorisation of sizes formulated with increasing dimensions with the aim to increase the number of persons accommodated and at the same time restricting the number of sizes developed. The sizing system developed in this study was additionally founded on the third configuration advocated by Taylor (1990) based on height (primary control dimension) and girth dimensions (secondary control dimension). With this process, an increase in height corresponds to an increase in the girth dimension. This was applicable in this study as this is a reasonable application to use when developing sizes for children as they have growing bodies. However, this procedure may not be appropriate for adult populations (Taylor, 1990).

Developing a sizing system for a population that is ethnically heterogenous, the diverse nature of the population must be factored. A sizing system must accommodate majority of the population factoring the diverse body sizes. Otieno and Fairhurst (2000) added that a developed sizing system must cater for individuals of different sizes for the manufacturing of mass-produced clothing as well as aid apparel consumers in the selection of apparel with a good fit. In this study, five sizes were developed for each size category based on the three distinct clusters (small, medium and large). Overall, 30 sizes were developed to cater for both male and female upper body and lower body, however in the validation process using accommodation rate (section 6.16.3, Determination of the rate of coverage), four size were omitted in total bringing the overall sizes to twenty-six. This developed sizing system gives a lot of flexibility to apparel manufacturers as the number of sizes are moderate and the different figure types identified are well catered for. Children with small body types as well as those with large body types are adequately contained and the medium body type which happen to be more conventional is also well covered. It is important to note that there are more variations in the figure types for children than adults (Chung et al., 2007) thereby necessitating more sizes when it comes to the development of sizing system. According to Lee (2013) the apparel industry is faced with the problem of reducing the number of sizes developed whereas boosting the rate of coverage to attain efficient sizes. This developed sizing system ascertains the best number of size groups that satisfactorily describes the many shapes and sizes encountered in the population. This is in line with the study by McCulloch et al. (1998) where they observed differences in the subgroups and stated that members of the other subgroups are different and would need different sized apparel. Zakaria (2016) also using cluster analysis and classifying rules of decision tree analysis also observed that members in a subgroup are different and therefore develop a sizing system for the different subgroups.

Several researchers have proposed different methods of body classification systems using varying methods. Different methods of size designations also exist. Researchers have admitted that the variations in human body shapes is the cause of poor fitting apparel (Pisut and Connell, 2007; Schofield et al., 2006; Simmons et al.,2004a). This sizing system was therefore developed by relating the body types and measurements, as this helps to offer good fit (Ashdown, 1998). Consequently, this study on the other hand considering the variability in the Ghanaian children population aged 6-11 developed a sizing system that factors the variability within the studied population. Based on the result of the cluster analysis, it realised that within the population studied there were different body types. Some of the children are short with small girth dimensions, others have average height with medium to large girth dimensions and some are medium to tall with large girth dimensions. To adequately cater for the diverse body-shapes encountered in the population and to satisfy the clothing needs of an ethnically heterogenous country like Ghana, the sizing system was developed for each body type. This adequately caters for the small through medium to large body sizes.

Several researchers have observed that the ready-to-wear companies offer limited number of sizes particularly for the plus- size consumers and a good sizing system aims to aid apparel manufacturers to produce ready-to-wear clothing that accurately fit the target population as well as enable them make gains (Petrova, 2007; Giovis, 2007; Bickle et al., 1995). Thus, developed sizes must not be too few nor too many making this developed sizing system effective as the number of sizes are neither too many nor too few.

7.6.4 Labelling of sizes for effective selection of appropriate sizes

Size designation is the means through which apparel consumers are guided in the selection of apparel that appropriately fit their body (Chun-Yoon and Jasper, 1996). Various researchers (Tamburino, 1992a; Chun-Yoon and Jasper, 1996; McCulloch et al. 1998; Otieno, 2000; Workman and Lentz, 2000; Anderson et al., 2001; Istook and Hwang, 2001; Faust et al., 2006; Faust and Carrier, 2010; Adu-Boakye, 2011) have identified the inability of apparel consumers to select suitable garment size based on the garment label as a frustration encountered by most consumers. Apparel consumers find it difficult to choose garments that fit their bodies well and Laitala, Klepp, and Hauge (2011) also attribute this to size inaccurate designations. Additionally, from Adu-Boakye's (2011) study, she ascertained that Ghanaian apparel producers designate garments by alpha or numeric sizing labels or both. It is obvious that these size designations are ineffective for apparel consumers as they do not offer enough information about body dimensions importantly the control dimensions such as height, chest, waist, and hip used to designate the sizes. Chun-Yoon and Jasper (1996) have advocated a size designation system that correctly describes the body dimensions used to designate the garment. This study therefore used numeric sizing in addition to pictogram to designate the developed sizes. These pictograms indicated the body measurements used for the size designations. These labels are understandable and portray vital measurements required to accurately fit an apparel on the human form (Chun-Yoon and Jasper, 1995). The International standards ISO 8998(1989) have recommended the use of pictogram to label garment sizes.

Size labels that are simple and understandable helps consumers to effectively select suitable apparel. This can as well provide clues for purchases made in in the future provided, they live through the life span of the garment (Mason et al., 2008). This wordless pictogram labelling together with the numeric labelling are appropriate to use to designate sizes for Ghanaian children since Ghana import some of its ready-to-wear clothing for children. Designating sizes developed for Ghanaian children with wordless pictogram in addition to numeric labelling is very valuable for international trade, as it is simple to comprehend and addresses the issue of language barriers (Mason et al., 2008). Chun-Yoon and Jasper (1995) added that pictogram labelling is preferred by most apparel consumers. The way size labels are presented to consumers is key in apparel selection process (Mason et al., 2008). They added that the success of a size label is dependent on consumers ability to comfortably and effectively pick apparel that fit their bodies based on the label (Mason et al., 2008). Many researchers (Chun-Yoon and Jasper, 1995; Brown and Rice, 2014) explicitly state that size labelling should be self-explanatory, informative and shows body type and related body measurements used in the designation as it is beneficial to consumers and adds to consumer satisfaction.

After the development of the sizing system, the sizes were validated in line with the assertion by Petrova (2007) by calculating the accommodation rate. Petrova (2007) asserts that accommodation rate should range from 65% to 85%. Winks (1997) added that a sizing system can be projected to accommodate from the 10th to the 90th percentiles, covering 80% of the population (Winks,1997). The accommodation rate is the percentage of the populace covered by the proposed sizing system (Petrova, 2007). This is aimed to ascertain the number of persons that fit accurately into the developed sizes. In this validation process, sizes for upper body garments were evaluated using height (primary) and chest girth (secondary) dimensions as the criteria measurements. Thus, the number of participants whose height fell within the assigned size label and participants whose chest girth were also within the assigned size label. Same was done for lower body garments. These validations were done separately for males and females.

Kwon et al. (2009) are for accommodation rate above 2% and Zakaria's (2016) advocates for coverage rate equal or above 2%. This study considered coverage less than 2% as not densely accommodated. Except for a few sizes that were not densely populated most of the developed sizes were densely populated. The total coverage for the sizing system developed for males' and females' upper body is 99.7% and 98.1% respectively based on height only. From literature it is evident that a sizing system cannot accommodate the entire population. However, if participants are grouped according to body types it increases the rate of coverage.

This study from Table 6.28 and 6.29 indicated very few outliers, with the percentage of outliers ranging between 0.8 and 5.5. Also, even if sizes that obtained less than 2% accommodation rate in the primary dimension (height) are eliminated, the numbers of outliers will not be equal to 10%. Many researchers admit that the use of anthropometric data to generate size charts normally comes with outliers as the extremes of the population are not covered (Kuma-Kpobee, 2009; Zakaria, 2016). Not all participants could fit accurately into a developed sizing system. There are some participants within a size category who cannot fit flawlessly into the sizes due to extremes in body dimensions or unusual body proportions (Emanuel et al., 1959). Many researchers (Emanuel et al., 1959; Zakaria, 2016) have alluded to the fact that an efficient sizing system must accommodate larger percentage of the population whereas the number of individuals that are not accommodated are brought to the barest minimum.

7.7 Establishment of the size charts and validation

A collection of essential body measurements is required to produce apparel, and this is attained through the development of size chart. According to Beazley (2007) a size chart is developed when a set of measurements are artificially divided. Size charts developed for this study is based on the size designations established in the sizing system. Percentiles were used in the development of the size charts. Percentiles have been used by researchers to establish body measurement tables and size charts (DOB,1994; BSI, 1990; Otieno, 1999; Le Pechoux and Ghosh, 2002). As espoused by Otieno and Fairhurst (2000), Le Pechoux and Ghosh (2002) and Yadav and Chanana (2020) selection of any of the major percentiles may come with merits and demerits. The 5^{th} - 25^{th} percentile will accommodate persons with small body dimensions well, however, it will not be appropriate for individuals with large body dimensions. Likewise, the 75^{th} - 95^{th} percentile may accommodate persons with larger body dimension but fail to accommodate smaller body sizes. They added that the use of 50^{th} percentile may cover the average person but may not adequately accommodate the variability in the population. As stated by Ashdown (1998) size groups are selected in a manner that ensures that limited number of sizes will offer apparel that fit well and accommodate majority of the population. Researchers have advocated for size charts that are precise, with regular size intervals, easy to read and economical in terms of size roll (Kunick 1984;). Apparel manufacturers and retailers prefer size charts that are economical in the size roll, succinct, easy to read and have regular size intervals (Kunick, 1984; Beazley 1997).

The fit of an apparel is an important attribute to the quality of an apparel, and it also helps to boost the self-confidence of the wearer. Additionally, the wearer of an apparel attains comfort when the garment has good fit. Fit of an apparel is complicated to assess because it is based on individualised perceptions making fit preferences a subjective process (Watkins, 2006; Otieno, 2008). This study used selected participants whose body dimensions fit into the designated sizes. The fitting trial was carried out using five participants for each size group as the ASTM proposes the use of between three and five participants in the execution of fitting trials. Participants together with their parents/legal guardians were used with experts to evaluate the fit of the sample garment on the children. Ashdown (2002) indicated the need for wearer responses in assessing the fit of toiles to validate a developed sizing system. This study, however, had parents/legal guardians and children assess the toiles for fit. The assessment of fit was further buttressed with evaluation from experts in the field. Parents/legal guardians were used as they mostly purchase clothing for children between the age range of 6 and 11 and understand their children better. Nevertheless, to obtain objective results that are valid and consistent, three professional persons joined in the evaluation of fit (Ashdown et al., 2004).

The use of fit trials to validate the fit of the developed size is in line with the aim of anthropometry as indicated by Pheasant (1984) and Le Pechoux and Ghosh (2002) that products developed must fit the end user. Beazley and Bond (2003) asserted that fitting toiles offer the opportunity to revise patterns where necessary as dependence on measurements solely may not replicate the overall body shape. Additionally, Bye and LaBat (2005) stated that in the product development process, evaluation of apparel through fitting trial is an important phase. This process was very essential in the development of sizes for children as it helps to ascertain the aptness of the sizes produced as well as reveal the variability, suitability of fit and offer practical experiences in terms of preferences (Pheasant, 1986).

It must be noted that there are other means to statistically assess the fit of developed sizing system and size charts through the calculation of the aggregate loss of fit and this was used by McCulloch et al. (1998), Gupta and Gangadhar (2004) and Zakaria (2016). However, like the study by Wren (2017), this study obtained feedback from the participants together with their parents/legal guardian on the sensory feedback on the fit of toiles. Wren and Gill (2010) stated that it is a common practice in industry to use only feedback from the observer in a garment fit session. Thus, obtaining both subjective (participants and their parents/legal guardian) and objective (experts) feedback on fit assessment adds to knowledge regarding fit procedure.

7.8 Summary

The study used a novel remote anthropometric procedure to collect anthropometric data from Ghanaian children. This led to the development of unique approach and tools to aid in the successful collection of manual anthropometric data. Collected data was manually screen and keyed into IBM SPSS analytic software to generate a database. Descriptive analysis was conducted to generate a synopsis of the body measurements and provide profile of the body sizes within the study sample. T-test was conducted which indicated significant differences among male and female participants. Differences were also observed in the body measurements of the study sample on geographical grounds.

Based on the high standard deviation values obtained which indicated variability in the body measurements and the significant differences realised when body measurements of the study sample were compared based on geographical locations of the study sample informed the rigorous statistical procedures applied in the generation of the sizes. Sizes were generated separately for males and females' upper body and lower body. Height and chest girth were used as the primary control dimension and secondary control dimension respectively for upper body garments while height and waist girth were used as the primary control dimension and secondary control dimension respectively for lower body garments.

Sizes were generated in relation to the body type of the participants. Sizes for both male and female children in this study were categorised into three homogenous subgroups namely small, medium, and large. In all, thirteen sizes were generated after validation through accommodation rate separately for male upper body and lower body. Out of the 13 generated sizes, four sizes were for the small body type, five sizes for the medium body type and four sizes for the large body type. For female upper body and lower body 14 sizes and 13 sizes were respectively confirmed after the validation through accommodation rate. Out of the 14 sizes for female upper body, four sizes were for the small body type five sizes for medium body type and five sizes also for the large body type. For the female lower body sizes, four sizes were developed for the small body type, five sizes for the medium body type and four sizes for the large body type.

The established sizes offer a lot of flexibility to apparel manufacturers and consumers as the number of sizes are moderate and the different figure types identified are well catered for. Thus, children with small body types as well as those with large body types are adequately contained and the medium body type which happen to be more conventional is also well covered. The developed sizing system enhances the apparel fit for consumers as well as boost the clothing industry. This will further help in the selection of garments that fit well for children, as the size designations in the system are based on vertical and girth dimensions applicable to them. Thus, with the correct sizes, it becomes easy and quick to select the right garments to meet children's needs.

CHAPTER EIGHT

THEORETICAL AND EMPIRICAL CONTRIBUTIONS OF THE STUDY

8.1 Introduction

This chapter presents theoretical and empirical contributions of the research to the body of knowledge in anthropometrics. The study fulfilled of all its five objectives stated in chapter one. The research sought to develop an anthropometric data collection procedure (objective 1). This was enhanced by its developed universal guidebook and videos that enabled the capability of remote and safe measuring practices for children. The study developed a database and body measurement table for 6-11-year-olds (objective 2 and 3) that may be applied extensively by industry and academia. This study through extensive statistical analysis developed a comprehensive sizing system and size chart for children aged 6-11 (objective 4 and 5).

8.2 Anthropometric update of children 6-11 years

Ghana has hitherto no official anthropometric survey conducted on its general population for clothing purposes. This study determined that size charts in circulation are based on the British and American system; hence a localised update is overdue. Ghana the then Gold Coast had its first stint and some semblance of an anthropometric survey during the second world war when 65,000 Ghanaians were conscripted into the Royal West African Frontier Force under the command of British officers. Some anthropometric information was gathered from the soldiers about their height, head circumference, weight, among others to produce uniforms that fit. This information has been gathered over the years to date for the security agencies in Ghana. Some Ghanaian academic researchers in academia have also conducted some anthropometric surveys on the female population as discussed in chapter one. However there has been no nationwide study recorded on Ghanaian children for clothing purposes.

Historic and current records indicate that there have been some anthropometric surveys conducted on some segments of the Ghanaian population such as the security agencies and women, but nothing has been done on the pre-teen population. This research has therefore updated the Ghanaian anthropometric survey space by conducting the first national anthropometric survey on Ghanaian children between the ages of 6 and 11.

8.3 Manual remote anthropometric data collection

The onset of Covid-19 pandemic and its associated restrictions such as social distancing highlighted awareness in exercising care with practices that dealt with physical contact. In response to addressing this issue sufficiently for research and ethical practice in anthropometric procedures, this study developed a guide for promoting safety and convenience when capturing and recording body measurements for children. This new method of taking anthropometric data remotely generated a complete training package for parents/legal guardians of children whose body measurements needed to be taken. For this study, the parents/legal guardians were trained through printed manual body measurements guidebook and demonstration videos in taking precise body measurements of their wards. This successful procedure validated the instrumentation used for wider implementation.

This data collection technique developed by this study is the first of its kind, where manual anthropometric survey for clothing purposes has been conducted remotely using parents/legal guardians and nominated adults to assist with the collection of anthropometric data of participants instead of the researcher and a trained research team carrying out field work and its associated set-up. This method presents a considerable minimised reduction of related costs sustained during fieldwork for anthropometric surveys. The collection of manual anthropometric data involves close physical contact between measurers and participants being measured. The newly developed approach used in this study which sought to minimise contact, promotes convenience, safety and ethical practice in anthropometric procedures for children.

8.4 Manual body measurement guidebook and demonstration videos

This study based on its novel method of data collection, developed manual body measurements guidebook and demonstration videos to train parents/ legal guardians and nominated staff of schools to assist with data collection. The developed manual body measurement guidebook (Appendix 2) is made up of all the instructions with corresponding colourful images on how to take body measurements of participants to help parents/legal guardians take accurate measurements. Additionally, the study produced two demonstration videos in English and Twi (local dialect) on how to take and record accurate body measurements to guide the parents/legal guardians. With this, the study demonstrated the appropriate posture of participants when being measured. This promotes good levels of reliability. The correct handling of measuring instruments to take body measurements and the recording of these measurements on a data sheet. A personalised learning experience is attained with these videos as scenes in the video can be repeated for emphasis. These developed instruments add to knowledge and serve as a source of reference for manual anthropometric surveys in both academic and practitioner spaces. This empirical study has developed several documents including age-appropriate participant information sheets for ages six to eight and ages nine to eleven to educate the participants on the research (refer to Appendices 8 and 9).

8.5 Implication of developed packs to industry and future researchers

For the purpose of accuracy and consistency, this study went the extra mile to put together a pack consisting of basic items required to manually collect body measurements of participants, in addition to the data collection documents. These developed packs described in chapter five, had all the item assembled in an A4 colourful plastic envelope file bag. The use of pack contributes to knowledge as it an innovation that can be used by industry and researchers in the collection of data from a population. For instance, in the phase of a pandemic where there is the need to conduct research which requires the transportation of data collection materials, that require limited handling of individual items, organising these materials in a pack for onward collection by the participants is economical and safe. Industry players and researchers can replicate this approach henceforth to collect data remotely by sending same or similar packs to respondents for easy collection of data.

8.6 Anthropometric database for Ghanaian children aged 6-11

The collection of anthropometric data on any social group becomes extremely necessary in populations that are ethnically diverse such as Ghana. This research contributes to on-going debates and theories on anthropometric sizing. In the study's comprehensive search for literature, it was apparent that populations do differ in terms of body size and shape and several researchers (Roebuck, 1995; Beazley, 1997; Ashdown, 2002; Ashdown, 2007; Apeagyei 2008; Otieno, 2009; Apeagyei 2010; Chun, 2011; Watkins, 2011; Zakaria, 2016) advocate for the development of sizing systems based on population measurements. Although the efficiency of any sizing system hangs on population measurements, this research cautions that these must be accurate, current and representative for the target population that the sizing system will be developed for.

With fulfilment of all its objectives, this study creates a current and verifiable anthropometric database on Ghanaian children between the ages of 6 and 11. There has been no existing database on this segment of the Ghanaian population prior to this study. Subsequently, the one developed by this study may be used to determine the changing nature of the relevant population by tracking growth patterns within this population in the future. This database may be accessed and analysed when new information is gathered on this segment of the population in the future.

8.7 Procedure for developing sizing system and the established sizing system

Findings from the extensive literature reviewed in this study presents evidence that different researchers in the area of clothing anthropometrics have used varied procedures in developing sizing systems. These range from simple to complex statistical procedures, all with the sole aim of improving the fit of garments. This study adds to the body of knowledge by reviewing and sequentially presenting key procedures involved in the development of an empirical anthropometric based research for the creation of sizing system. The systematic procedures demonstrated in this study is applicable to develop sizing system for an ethnically diverse population by blending the procedures for developing sizing system outlined in past and current literature to develop a comprehensive sizing system with fewer sizes that accurately fit majority of the population based on body types.

Thorough explanation was provided for each of the procedures utilised in this study from screening of anthropometric data to validation of the sizes through accommodation rate and designation of the sizes. Figure 8.1 presents a pictorial path of key statistical procedures in the creation of an appropriate sizing system for clothing production. These procedural steps have been established by this study and for the first time in Ghana, data of this kind on children was methodically standardised and recorded in a format that makes it possible for comparative and successive research to be carried out with maximum level of accuracy and ease.

The established sizing system offers a lot of flexibility to apparel manufacturers and consumers as the number of sizes are moderate and the different figure types identified within the population are well catered for. Thus, children with small body types as well as those with large body types are adequately contained and the medium body type which happen to be more conventional is also well covered. The developed sizing system will enhance the apparel fit for consumers as well as boost the clothing industry. This will further help in the selection of garments that fit well for children, as the sizes in the system are based on vertical and girth dimensions and body type applicable to the population. Thus, with the correct sizes, it becomes easy and quick to select the right garments to meet children's needs.

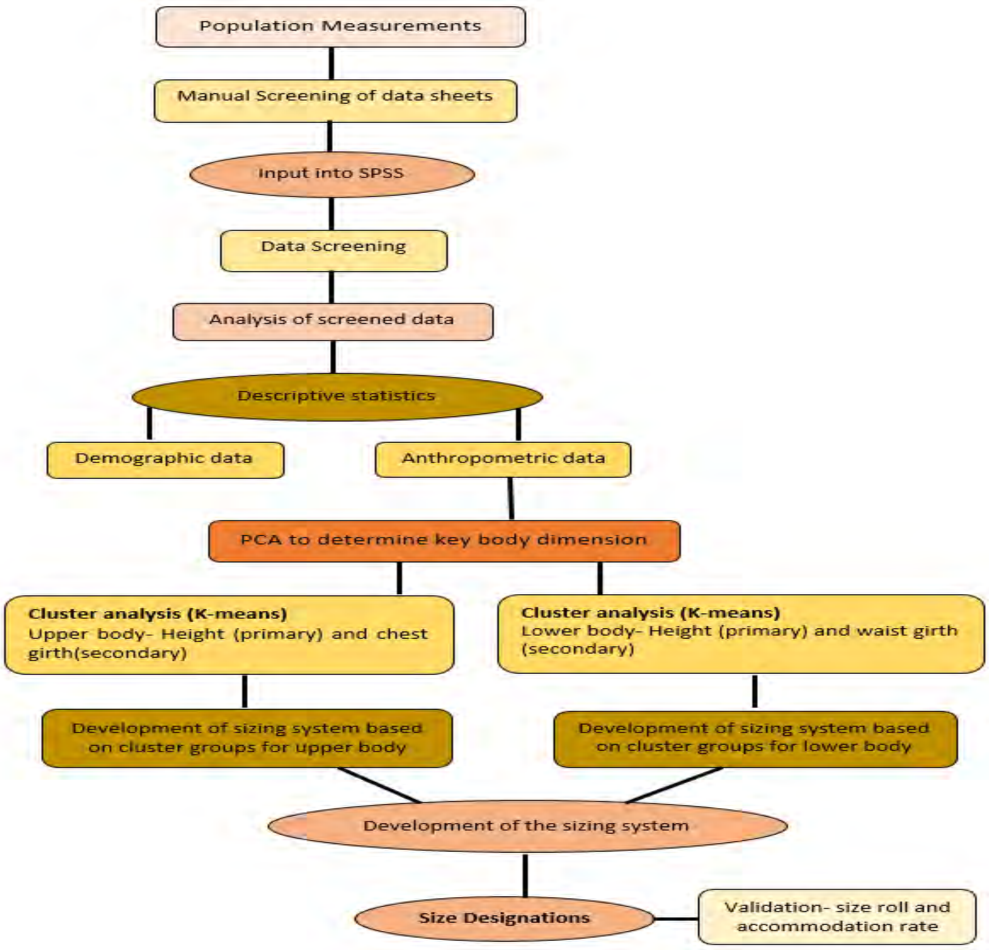


Figure 8.1: Flow chart of the procedures for the establishment of a sizing system

8.8 Establishment of size chart for Ghanaian children

Size charts currently used in Ghana are usually based on colonial British sizes. Results found in this research from literature highlight that as body proportions and stature vary with ethnicity; the need to develop localised sizing for clothes is important. Subsequently, this study has established verified size charts for children aged 6-11 developed from its anthropometric database and sizing system.

The creation of this new size chart for Ghanaian children is very useful for stakeholders in the clothing industry in Ghana. Using this created size chart, apparel manufacturers will produce ready-to-wear garments that appropriately fit the different body types in Ghanaian children's population. The developed size chart is particularly useful for school uniform manufactures in Ghana as it was developed based on a strategically selected sample of the Ghanaian children population to ensure that the different body types within this segment of the population is captured to aid in the production of school uniforms with a good fit. The size charts stand to serve as a source of reference for teaching in schools, as well as the conduct of farther research that contributes to knowledge in anthropometric practices and the provision of fit for children's clothing.

8.10 Implications of developed sizes for apparel industries in Ghana

This developed sizing system and size chart are of immense benefit to the apparel industry in Ghana. The created database can be used or adjusted by apparel industry to conform with their needs. This database can be managed to fit within industry specific context. The collected data was analysed into three clusters based on body type using height as a primary control dimension and chest or waist girth as secondary control dimension for upper and lower body respectively. This resulted in the development of sizing system with size designations based on height (primary control dimension) and chest girth (secondary control dimension) for upper body garments. Height (primary control dimension) and waist girth (secondary control dimension) were also used as designations for lower body garments. Also, based on the wide-ranging sampling procedure used in this study, it is applicable for industry to extract specific sectors of the population that is of interest to them. Aside the categorisation of the sizes according to body type, the minimum and maximum values will afford the industry the opportunity to develop garments to fit children along the growth path with explicit size designations.

Also, based on the comprehensive sizes developed, consisting of four small sizes, five medium sizes and four or five large sizes separately for males and females, each industry that decides to implement the newly developed sizes will have the option to select which sizes to produce that will be suitable for their consumer base. Thus, an industry considering the sizes of their consumer base may opt to produce two sizes out of the four developed sizes for the small body type, two or three sizes out of the five developed sizes for medium body type and two or three sizes out of the four or five developed sizes for large body type. Further, in an ideal situation where an industry is to produce apparel such as school uniforms for Ghanaian children within the study's age range across the country, the use of all developed sizes in this study will be best as it will adequately cover the variations of sizes within the entire population.

8.11 Implications of developed sizes for computer aided design and pattern grading systems

The advancement in technology has propelled the garment industry to use computers for the process of designing garments leading to more efficient ways of producing patterns. With the size charts developed in this study, body measurements established in the charts can be used to construct patterns for Ghanaian children which can be used for mass production of garments. Additionally, this study established grading increment for the developed sizes making it simple to increasing or decreasing the size of a garment pattern in line with a given size chart.

8.12 Implications of developed sizes for the production of mannequin

The comprehensive body measurements collected in this study coupled with the extensive statistical analysis conducted to generate body measurements tables and sizes serve as a great basis for the creation of mannequins and dummies. This will aid in mannequins and dummies development within the range of maximum and minimum values of all dimensions. Also, sizes developed in this study combined vertical and horizontal measurements in addition to body type which is excellent in the creation of unique mannequins and dummies as the posture, body type and full body measurements are clearly specified for the mannequins and dummies developer.

8.11 The uniqueness of the study in relation to the accessibility and inclusivity of participant.

In research, accessibility to qualified and willing participants is very crucial in the representativeness and credibility of the resultant data that will be collected. The design of a system to enhance access and making it convenient to all participants is known as accessibility. This research made this possible with the use of paper documents for data collection and the use of instructional videos in two languages.

With participants located in all parts of the country (both rural and urban) and with 50% internet penetration rate, it was unlikely that all qualified and willing participants sampled for this research will be reached using technology (internet) hence the use of paper document for data collection. Here, all participants sampled were reached through paper document in a set of a pack of measuring tools sent to parents to take the body measurements of their wards through selected schools involved in the research. Paper documents included the manual measurement guidebook, data recording sheets among others.

In order to reach all parents of sampled participants for clear understanding of the measuring instructions, instructional videos in English and Twi (the most popular Ghanaian language) were sent to them. This made it possible for all willing parents to clearly understand the process of data collection hence avoiding the exclusion of qualified and willing participants.

The study was very inclusive because equal access and opportunities were given to any person who qualifies to participate in the research. This was done by getting participants from all parts of Ghana including metropolitan and district areas as well as public and private schools. Thus, qualified children from both metropolitan and districts areas who qualified and were willing to participate in the research took part in the collection of data. These areas further represented both the urban and rural areas of the country. Also, to uphold the principle of inclusivity in this study, pupils from both the public and private schools were included in the study. This application of accessibility and inclusivity of participant regarding the selection of sample adds to knowledge in representative sample selection in the conduct of survey.

CHAPTER NINE

CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The main purpose of this research was to develop a comprehensive and accurate sizing system and size chart based on anthropometric data of Ghanaian children aged 6-11 for the production of ready-to-wear garments for the apparel market in Ghana. Undertaking this study has immensely added to knowledge and skill in anthropometric surveys.

Children's clothes that are tailored to their anthropometric measurements tends to fit well and is an important aspect to their physical health and well-being. A national children's sizing system and size charts for the Ghanaian population is of great benefit to the apparel manufacturing industry, importers of children's clothing, retailers, and consumers. Collected primary data keyed into IBM SPSS is a database generated from this study. This is of special benefit to the apparel industry in Ghana, the government that monitors national growth; relevant educational institutions for similar interest; and health departments that may seek insights into children's physical growth and development.

Comprehensive and critical reviews of literature from wide sources enabled the study to meet objective one, which developed standardised measuring procedure that was appropriate for measuring children between the ages of 6-11 remotely. The occurrence of the pandemic and restrictions in social contact motivated the study's approach to establish a non-contact method of collecting anthropometric data. This did not only ensure adherence to ethical considerations, but it also generated a standardised and useful approach to sustainable practice in relatable countries.

In fulfilling objective two, which sought to develop an anthropometric database on Ghanaian children from 6-11 years, anthropometric data of the target population was collected from the field and critically keyed into IBM SPSS version 26 statistical software. This provided a comprehensive and up-to-date record of relevant anthropometric data that can be converted into other forms for wide professional, commercial and academic use.

In the fulfilment of objective three, the study established tables of body measurements for Ghanaian children aged 6-11. For this aspect, the study had to further categorise the body measurements it had collated, classifying them in ranges using the mean. Minimum and maximum measurements values were further used to ensure accountability of the body measurements of the sample within the given population.

The study met objective four by further applying advanced statistical methods to the anthropometric body measurements to develop a comprehensive sizing system for Ghanaian children aged 6-11. The sizing system created used the principal component analysis to select key measurements and K- means cluster analysis method to categorise the data set into three homogenous subgroups which were distinct from each other. This verifies established systems for generating children's sizing system; and considers the significance of height and girth measurements in creating the sizing system.

Objective five sought to establish size charts for clothing pattern production for Ghanaian children aged 6-11. In fulfilling this objective, percentile values obtained from the data and the empirical principle were applied to develop adequate size for each size category and developed dependable size charts. These were validated through fit testing to establish reliable size charts.

The primary data collected from the target population applied a remote anthropometric data collection method which is novel in the field of fashion. Data collected was analysed into a database for Ghanaian children aged 6-11 and further processed to develop comprehensive sizing system and size charts. The novel method of collecting anthropometric data remotely applied in this study has added to knowledge. The use of this remote method of collecting anthropometric data is useful for academic training, practitioners, and consumers especially in the conduct of surveys at critical times such as during pandemics as this study adhered to procedures that are safe and convenient when capturing and recording body measurements of children. The study provided criteria for systematic procedures in capturing anthropometric measurements as well as widely applicable guidelines for academic and industrial practice and reduce the cost and duration of anthropometric surveys for children.

As observed in clothing anthropometric literature and the empirical evidence from this study, it is obvious that the use of age as the control dimension may not be a good size indicator. This study therefore firmly concludes that the use of age as the only control dimension to designate children's clothing is not appropriate. Children between the ages of 6 and 11 significantly possess different body dimensions regardless of age; and this is based on a comparison of ages and raw height dimensions of the study sample. Importantly, there was not much correlation between age and other body measurements. This new sizing system developed for Ghanaian children, used height (a vertical dimension) and chest girth (a horizontal dimension) as the control dimensions for upper body for both males and females. Height and waist girth were used as the control dimensions for lower body garments for both genders. The study concludes that height has a strong correlation with most of the body dimensions and applying this measurement as a primary control dimension in addition to a girth measurement (chest and waist) as a secondary dimension for children's sizing will afford apparel retailers and consumers the opportunity to select apparel with a good fit.

Based on the empirical evidence from this study which corroborates with findings from literature, it is essential for countries to develop sizing system based on their local populations as variation in sizes are prevalent.

9.2 Recommendations for further studies

Founded upon the outcome of this study, it is viable to propose recommendations for further studies. The established aims and results obtained through this research could be expanded and applied in consecutive research. Some areas of further research have been outlined.

Based on the scope, timing and financial implications, this study concentrated on Ghanaian children aged 6-11. The study therefore recommends further conduct of anthropometric research to cover children under and above this age range in Ghana. As the country does not have a national sizing system, full anthropometric survey record of children of all ages will help generate a more comprehensive database. This will be very useful for the purpose of creating clothing sizes for children in Ghana which will boost the children's wear market not just practically but also through online business.

Beyond the work conducted in this research, it is recommended that a national anthropometric survey be conducted on the adult male population to generate a database and size charts for clothing sizing. This would complement studies conducted on Ghanaian female adult population by Ashong (2004), Kuma-Kpobee (2009) and Adu-Boakye (2011), and this current study on children. To aid productivity in manufacturing as well as improve the growth of the apparel market, local and current anthropometric data that truly reflect the body shape and sizes within populations must be used. Establishing a sizing system based on body shapes would also provide insights into silhouettes, and proportions of different ethnic groups, countries and continents to improve the fit of garments and trade in the fashion industry.

With current advances in technology, this study recommends the use of automated technology such as the 3D body scanning technology to generate comprehensive databases on the sizes and shapes of children for clothing purposes. However, it must be noted that such technologies require expert training and are expensive, which may not be practical for all communities especially in developing countries. Common practices in certain communities where provision of garments are based on customised sizing rely on trained individuals to measure and record of anthropometric measurements. This highlights the value of this study in generating a suitable manual-based framework for replication in the conduct of anthropometric studies.

Also, since differences were obtained based on geographical locations sampled, further analysis can be performed on the database to identify key dimensions prevalent in the three main geographical areas sampled. Differences in growth trends, body shape and body mass distribution can be computed based on data on the three areas. This analysis can also be computed based on ethnicity of the sample.

This study recommends the development of appropriate size charts for regions based on reginal population. This study segmented Ghana into three namely the Northern, Middle and the Southern belts where one region was selected within each belt for data collection. Data collected and analysed indicated significant differences among the body measurements of participants of these regions. Data for each region can be extracted to develop appropriate size chart for children in each of the regions or belts to produce garments that fit well. It is also intuitive to note that intra-regional size charts could also be developed as there were significant differences among participants from municipal/district and metropolitan areas within each region studied.

Critical inferences can be established concerning the selection of key body dimensions as indicators of body size as well as control dimensions for specific parts of the body. As a result of this information, successive research may only concentrate on the key body dimensions used for the sizing system and charts. This will reduce the duration spent in measuring participant as well as the cost of the study.

Additionally, since the created sizes were according to body shape and measurements and designated using pictograms in addition to numerical size labelling, communication of the size information to all stakeholders in the apparel sectors in Ghana to explain the sizes is vital. The outcome of this study needs to be explained to various stakeholders such as manufacturers, retailers, fashion students among others. This will further advance the communication on sizing between industry players and individuals of diverse knowledge backgrounds. The outcome of this thesis is an invaluable tool for learners and professionals as its analysed current anthropometric data on Ghanaian children in the generation of apparel sizes.

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Appendices

Appendix 1

Body measurement sheet (BMS)

Body measurement sheet

This body measurement sheet consists of three sections. Section one consists of demographic data on your child (participant). Section two consist of body measurements to be measured on the child by the parent/Legal guardian and finally section three is a question to be answered by parent/Legal guardian.

To be completed by parent/legal guardian of participant

Section 1: Demographic data on participant

Participant identification no. ☐☐☐☐☐

Measurement Date ☐☐☐☐☐☐

Age: ☐☐

Class: ☐☐ Gender: Male ☐ Female ☐

Name of School ______

Region: Northern ☐ Ashanti ☐ Grater Accra ☐

Ethnicity ______

Metropolitan/District ______

Type of school: Public ☐ Private ☐

Height and weight measurements (To be recorded in the child's school)

Height ☐☐☐☐

Weight ☐☐☐☐

Section 2

Body measurements (To be measured in centimeters [cm])

Please take all measurements twice and record accordingly. All measurements are to be taken using the tape measure provided by the researcher since it has been calibrated.

Circumferential measurements **Body Measurements in cm**

	1st set of body measurements						2nd set of body measurements				
Head girth											
Neck girth											
Chest/Bust girth											
Waist girth											

Hip girth											
Armscye girth											
Upper- arm/ Biceps girth											
Elbow girth											
Wrist girth											
Thigh girth											
Knee girth											
Ankle girth											

Horizontal and depth measurements

Shoulder length											
Back Shoulder width											
Scye depth length											
Across chest											
Bust point width											
Across back											
Shoulder to Elbow (bent)											
Outer arm length (bent)											
Crotch length											
Body rise											

Vertical measurements

Nape to waist											
Nape to floor (contoured)											
Base of throat to waist											
Front neck point to waist											
Torso height											
Waist to hip											
Waist to knee											
Waist to ankle											
Waist to floor											
Knee to floor											
Inside leg length/ Crotch to floor											

Section 3

Please circle the appropriate option

1. Please rank your level of confidence in measuring your child

   a. Not strongly confident
   b. Not confident
   c. Neutral
   d. Confident
   e. Strongly confident

Thank you

Appendix 2

Manual body measurement guidebook

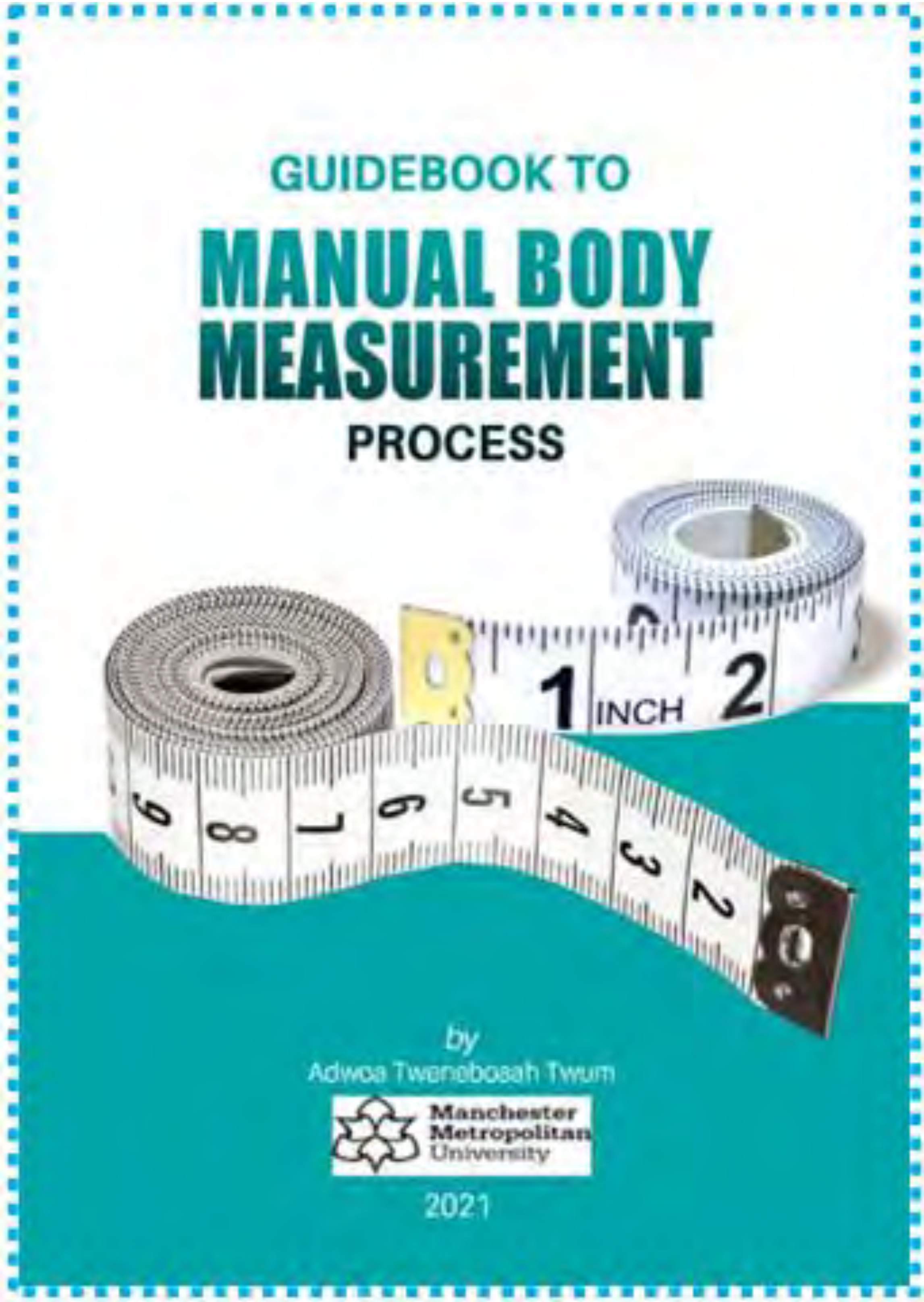


Table of Contents

List of Tables

List of Figures

1.0 Introduction

This body measurement guidebook is prepared by Adwoa Tweneboaah Twum, a PhD researcher at Manchester Metropolitan University. It is intended to be used for the purpose of guiding parents/legal guardians in the collection of body measurements on their children between the ages of 6-11. The purpose of this study is to develop standardised measuring procedures and techniques pertinent to the development of accurate body measurement tables as a basis for the development of sizing systems and basic block patterns to produce outer garments for children in the apparel market in Ghana.

This guidebook was prepared taking into consideration the Ethics and Governance Policy of Manchester Metropolitan University which ensures that research activities reduce risk to participants, researchers, third parties and the university.

The guidebook is to be a reference for providing detailed information on body measurement process. Every participant in this project plays an important role in the total success of the research. The people who will participate in this survey are the principal researcher, management, and teachers from selected schools as well as parents and children from the schools. All the children from whom data will be collected through this research will be referred to as participants.

The guidebook is very handy, precise, and concise and shall serve as the source of reference in matters relating to body land marking and manual measurement process. It will be used in conjunction with the participant information sheet to educate all members involved in the field project.

1.2 Sections in this Guidebook

This guidebook covers the following list of items:

- The child (participant) and parents/legal guardians in this project.
- Landmarks on skeleton and body.
- Preparation of children for manual measuring procedures.
- Descriptions and illustrations of how to measure children.

1.3 The Child (participant)

According to this study, all the children from whom data will be collected will be referred to as participants. The study will use children between the ages 6 and 11 as participants. In other for a child to participate in the study, he or she must be a pupil of one of the selected schools. For children to participate in the study, they must have consent form dully signed by their parent/legal guardian and an assent form completed by the child indicating his/her willingness to have his/her body measurements taken and recorded by his or her parents/legal guardian.

1.4 Parents/Legal Guardians

Parental participation in this study is very necessary since without their involvement data cannot be collected. For a parent to qualify to grant permission and assist in data collection, he or she must be a parent of the child registered in one of the participating schools. An individual can only grant permission if he or she is the parents/legal guardians of the child. The parent or legal guardian of participants must possess basic skill in reading and writing to be able to effectively help with the collection of data.

2.0 Tools and Equipment

Very simple, everyday equipment will be used for data collection. After both the parents/legal guardians and the participants have agreed to take part in the study, a data collection pack consisting of a calibrated tape measure, 2mm diameter elastic tape, a body measurement sheet, body measurement guidebook for reference purposes and a link to demonstrational videos on MMUtube and other social media platforms will be delivered to parents/legal guardians of participants through the school.

Table 1: Equipment and materials, uses and corresponding image

Equipment	Use	Image
Tape measure	This should be used to measure the child. During use of the tape measure, always ensure that reasonable tension is applied, and the body not restricted.	
Cosmetic pencil	A wax-based cosmetic pencil can be used to mark body landmarks as a guide during measuring process	
Digital weighing Scale	This is used to measure the weight of the participant.	
Stadiometer	This device is used to measure human height. It consists of vertical ruler with a sliding horizontal head piece which is adjusted to rest on the top of the head of the person being measured.	
Chord (0.5cm diameter)	This will be tied around the child's waist with reasonable tension to indicate the true waist level.	

3.1 Posture and preparation of the child for the measurement process

3.2 Posture of child (participants)
This refers to the position of the child's body in a standing or sitting mode. Posture is an important factor to consider in measuring children. The posture of the child has effect on the accuracy of the measurements to be collected.

3.3.1 Dos in terms of posture

- The child must stand upright with feet together or shoulder width apart.
- The head must be positioned in the Frankfurt plane (Figure 1) unless otherwise stated.
- The child arms must be relaxed, vertical, fingers straight unless otherwise directed.
- The child's body weight must be distributed equally on both legs.
- For measurement taken of seated participants, the surfaces of the seat and the foot must be smooth and non-compressible with thighs and feet set horizontally and the legs in a vertical position.
- The body measurements **preferably** should be taken in the early hours of the day as the height of the human body tends to decrease during the day (Montagu and Broek, 1960).

3.3.2 Don'ts in terms of posture

- The child must never look at the direction of the measuring position or the measurer.
- The child must not look up or even lift his or her chin during measurement taking.
- The child must never tag the tummy in during measuring.
- The child must never stand with a hollow back.

3.3 Preparation of the child for measurement process

- Before beginning to measure the child, ensure that the child is in a light body fitted clothing such as swim wear.
- Ensure that the child is barefooted.
- Sitting and standing surfaces must be leveled and incapable of being compressed.

4.1 Landmarks and positions for measurement

Landmarks are prominent point of the human skeleton underneath the skin and are easily detected by visual inspection or touching with one's fingers (palpation).

4.2 Frankfurt plane

This is an anatomical terminology that has to do with the position of the human head. The skull is set based on hypothetical lines. To set the skull based on a plane passing through the inferior margin of the left orbit and the upper margin of each ear canal which is most parallel to the surface of the earth, and close to the position the head is normally carried in the living participant (Quick Medical, 2012).

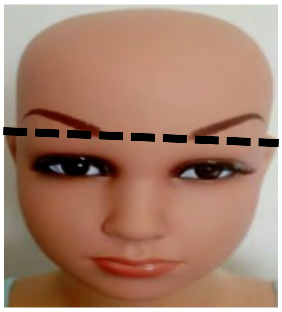
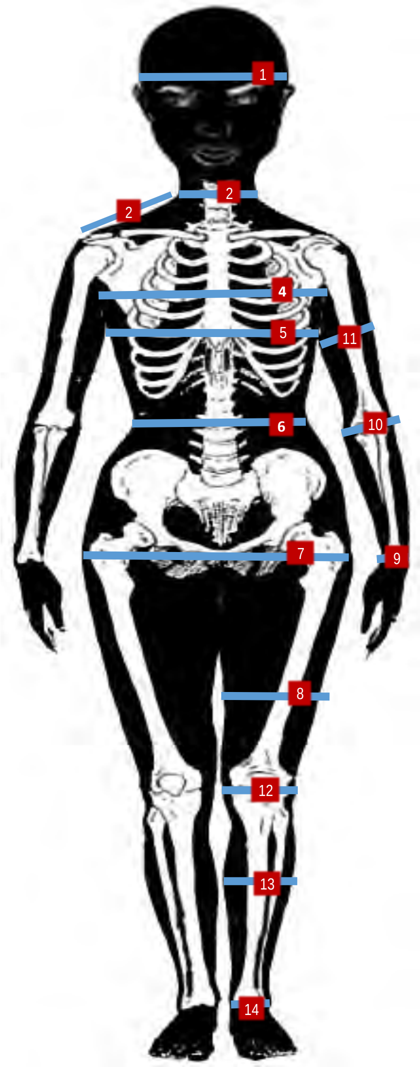


Figure 1: Frankfurt plane

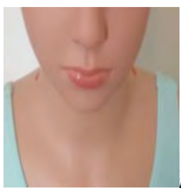
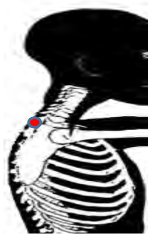


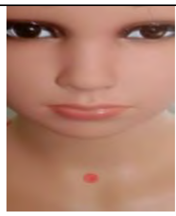
1- Head girth
2 - Neck girth
3- Shoulder length
4- Across chest
5 - Chest/bust girth
6 - Waist girth
7 - Hip girth
8 - Thigh girth
9 - Wrist girth
10- Elbow girth
11 - Upper arm girth
12 - Knee girth
13 - Calf girth
14 - Ankle girth

Figure 2: Landmarks and positions for measurement

Source: Kunick (1984)

Table 2: landmarks, description and corresponding images

Landmark	Description	Image
Neck point:	This landmark is located at the base of the neck at the upper point of the shoulder in line with the long shoulder landmark.	 
Nape (Cervical)	This is the 7th Cervical. This is the prominent bone at the base of the back of the neck. It is easily identified by lowering of the child's head.	 

Front neck point or Base of throat	This landmark is located at the base of the neck in the hollow made by the suprasternal notch bone.	 
Shoulder Point	This landmark is located at the end of the shoulder bone. Both shoulder points must be labelled.	 

5.1 Body measurements to be collected in this research

In all, Thirty- five (35) body measurements will be collected from each child. Table 3 gives a list of all the measurements that will be collected during this survey. All girth measurements must be taken close to the contour of the body. Take all girth measurements snugly and never put two fingers in the tape measure as this will add to the measurement. Hold the extension loop attached to the tape measure to make measuring and reading of measurements easy.

Table 3: List of body measurements to be collected in the survey

*Weight *Height		
Girth measurements	**Horizontal and depth measurements**	**Vertical measurements**
Head girth Neck girth Chest/Bust girth Waist girth Hip girth Armscye girth Upper arm/ Biceps girth Elbow girth Wrist girth Thigh girth Knee girth Ankle girth	Shoulder length Back shoulder width Scye depth length Bust point width Across chest Across back Shoulder to elbow (bent) Outer arm length (bent) Crotch length Body rise	Nape to waist Nape to floor (contoured) Base of throat to waist Front neck point to waist Torso height Waist to hip Waist to knee Waist to ankle Waist to floor Knee to floor Inside leg length/ Crotch to floor

6.1 Girth measurements

6.1.1 Head girth

This measurement must be taken with head in the Frankfurt plane with the child either sitting or standing using the tape measure. Take this measurement snugly around the centre point of the brow ridge or the frontal bones directly above the eyebrows, around to the broadest part of the back of the head with the tape above each ear. Ensure that hair style or hair ornament does not interfere with the measurement. Measurement must be recorded to the nearest 0.1 cm.

Figure 3: Measurement of Head girth

6.1.2 Neck girth

This measurement must be taken with head in the Frankfurt plane with the child either sitting or standing. Take this measurement at a point 2cm below the thyroid cartilage with measurement taken perpendicular to the longitudinal axis of the neck.

Figure 4: Neck girth

6.1.3 Chest/bust girth

To take this measurement, the child must stand erect with arms hanging freely downward. Using the tape measure, take this measurement snugly around the fullest part of the chest.

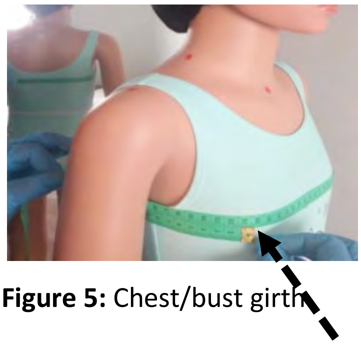


Figure 5: Chest/bust girth

6.1.4 Waist girth

Take this measurement with child standing erect with arms hanging freely downward and abdomen relaxed. Take this measurement snugly around the circumference of the natural waist using the elastic tied around the waist as a guide.

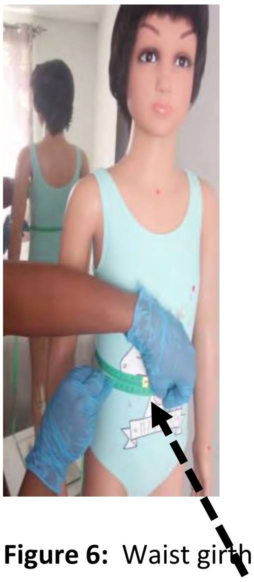


Figure 6: Waist girth

6.1.5 Hip girth

In taking this measurement, the participant must stand erect with legs together, arms hanging freely downward and abdomen relaxed**.** From the right side of the participant, take this measurement at the widest part of the lower hip at maximum circumference of the buttocks ensuring that the tape is level in front and back.

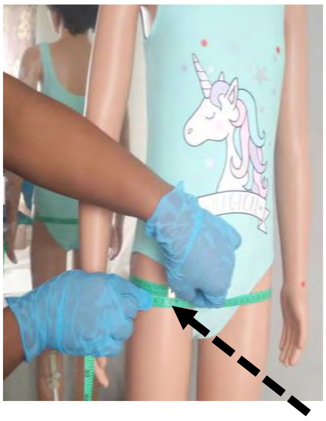


Figure 7: Hip girth

6.1.6 Armscye girth

In taking this measurement, the child must stand erect with arms hanging freely downward and the measurement taken from behind on the right side of the participant. With the aid of the tape, pass it through the under- arm midpoint and vertically over the shoulder ensuring minimal pressure so that the skin is not compressed.

Figure 8: Armscye girth

6.1.7 Upper-arm/ Bicep girth

In taking this measurement the child must stand erect with arms hanging at 20°angle to the side of the body. Take this measurement on the right side of the participant. Using the midway between the shoulder and elbow point (olecranon) as the landmark, pass the tape snugly round the arm horizontally.

Figure 9: Upper arm/ Bicep girth

6.1.8 Elbow girth

In taking this measurement, the child must stand erect with arms hanging freely downward. Pass the tape round the elbow where the landmark is placed.

Figure 10: Elbow girth

6.1.9 Wrist girth

Forearm of participant is held horizontal, hand stretched with fingers extended and palm facing down. Take this measurement with the measurer in front of the child. Placed the tape measure on outer end of the wrist and measure snugly round the wrist.

Figure 11: Wrist girth

6.1.10 Thigh girth

In taking this measurement, the child must stand erect with legs shoulder width apart. Take this measurement at the maximum horizontal circumference of the thigh just below the gluteal fold using a tape measure.

Figure 12: Thigh girth

6.1.11 Knee girth (straight)

The child must stand erect with legs shoulder width apart. Measurer must squat in front of the child while measuring the circumference of the knee over the centre point of kneecap in a horizontal plane.

Figure 13: Knee girth (straight)

6.1.12 Ankle girth

The child must stand erect with arms hanging freely downward and legs shoulder width apart. Using the tape measure, pass it round the outer ankle point.

Figure 14: Ankle girth

7.1 Horizontal and depth measurements

7.1.1 Shoulder length

Take this measurement with child standing erect, arms hanging freely downward with shoulders relaxed. With the aid of a tape measure take the measurement from the neck point over the right shoulder to the shoulder point.

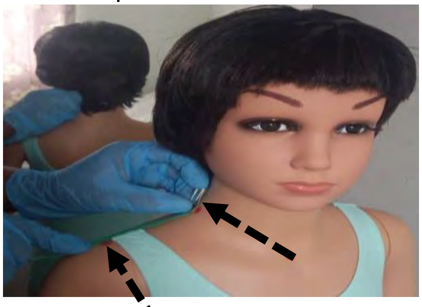


Figure 15: Shoulder length

7.1.2 Back Shoulder width

Take this measurement with child standing erect, arms hanging freely downward with shoulders relaxed**.** Take this measurement from the right shoulder points and left shoulder points over the contour of the body.

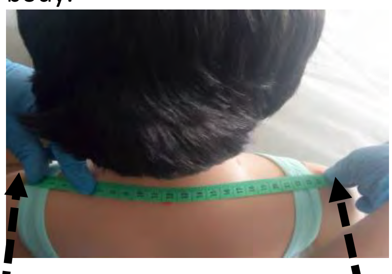


Figure 16: Back Shoulder width

7.1.3 Scye depth length

The child must stand upright, arms hanging freely down the body with the head in the Frankfurt plane. Using a tape measure and the measurer position behind the participant, take this measurement vertically by placing the zero on the tape measure on the back-neck point (nape) and measure down the centre back onto the horizontal level with armpit.

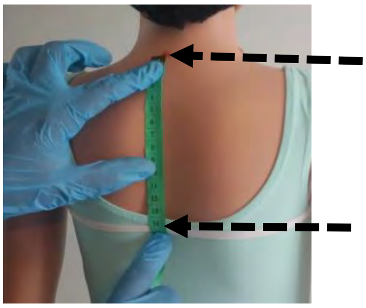


Figure 17: Scye depth length

7.1.4 Across chest

Take this measurement with child standing erect with arms hanging freely downward and shoulders relaxed. This measurement must be taken halfway between the shoulder point (acromion) and the front armpit fold point. This measurement must be taken with the measurer standing in front of the child. With the aid of a tape measure take this measurement from the right front scye line across to the left front scye line.

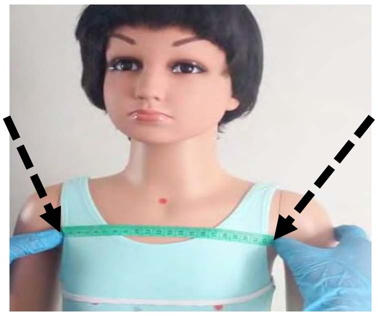


Figure18: Across chest

7.1.5 Bust point width

This is the distance between the nipples. Take this measurement with the child standing erect with arms hanging freely downward and shoulders relaxed. This measurement must be taken with the measurer standing in front of the participant. With the aid of a tape measure, take this measurement from one nipple landmark to the other nipple landmark as shown in Figure 19.

Figure 19: Bust point width/Nipple to nipple

7.1.6 Across back

Take this measurement with the child standing erect with arms hanging freely downward and shoulders relaxed. This measurement must be taken halfway between the shoulder point and the back armpit fold point. This measurement must be taken with the measurer standing behind the child. With the aid of a tape measure, take this measurement from the left back scye line across to the right back scye line without measuring on the contour of the body.

Figure 20: Across back

7.1.7 Shoulder to elbow (bent)

The child must stand upright, shoulders relaxed, and the right fist positioned on the hip bone with the thumb towards the front. Take this measurement using a tape measure with the measurer position on the right side of the participant a little towards the posterior. Measure from the shoulder point to the elbow point.

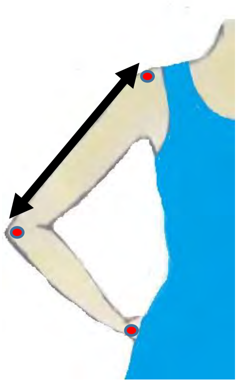


Figure 21: Shoulder to elbow (bent)

7.1.8 Outer arm length (bent)

Let the child stand upright, shoulders relaxed, and the right fist positioned on the hip bone with the thumb towards the front**.** Take this measurement using a tape measure with the measurer position on the right side of the child a little towards the posterior. Measure from shoulder point over the elbow point to the wrist.

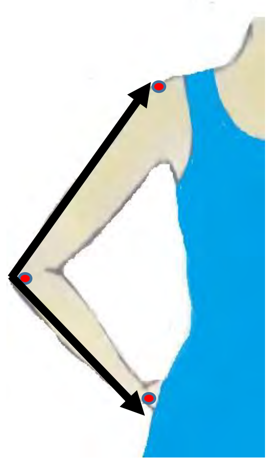


Figure 22: Outer arm length (bent)

7.1.9 Crotch length

Take this measurement with participant standing erect with legs shoulder width apart. Take this measurement gently on the contour of the body from the back-waist level landmarks through the crotch to the Centre front waist level landmark.

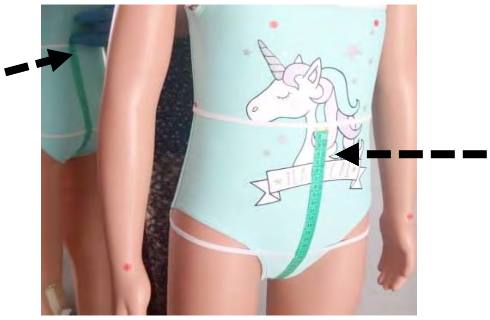


Figure 23: Crotch length

7.1.10 Body rise

Take this measurement with the child seated on a smooth, firm and leveled chair or stool with the torso in erect position. Take this measurement on the right side of the child using a tape measure with the measurer squatting. Measure from the waist level landmark down the body perpendicular to the seat level.

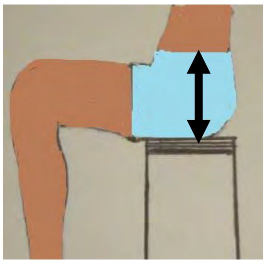


Figure 24: Body rise

8.1 Vertical measurements

8.1.1 Nape to waist

Measurement must be taken with child's standing erect, shoulders relaxed and head in the Frankfurt plane. Take this measurement with the measurer behind the child. Following the contour of the body, measure from back neck point (nape) to waist level landmark using a tape measure.

Figure 25: Back neck point to waist /Nape to waist

8.1.2 Back neck point to floor /Nape to floor (contoured)

Measurement must be taken with child standing erect, shoulders relaxed and head in the Frankfurt plane. Take this measurement with the measurer behind the participant. Following the contour of the body, measure from back neck point (nape) along the contour of the spinal column through the waist level to the hip level then vertically to the ground using a tape measure.

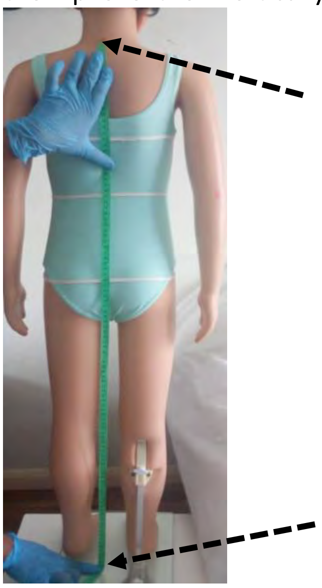


Figure 26: Back neck point to floor /Nape to floor (contoured)

8.1.3 Base of throat to waist

Take this measurement with the child standing erect with arms hanging freely downward and shoulders relaxed. Take this measurement with the measurer facing the child. With the suprasternal notch or simply the base of throat and waist landmark on the centre front, take this measurement from midpoint of the suprasternal notch or base of throat landmark to the centre front waist landmark following contour of the body.

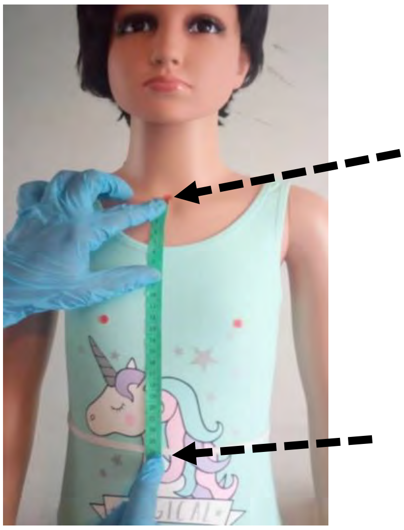


Figure 27: Base of throat to waist

8.1.4 Front neck point to waist/ Front shoulder to waist
Measurement must be taken with child standing erect, shoulders relaxed and head in the Frankfurt plane. Take this measurement with the measurer standing in front of the child. Take the measurement on the right side of the child over the contour of the body vertically from the front neck point to waist level.

Figure 28: Front neck point to waist/ Front shoulder to waist

8.1.5 Torso height
Measurement must be taken with child standing erect, shoulders relaxed and head in the Frankfurt plane. Take this measurement with the measurer behind the child. Following the contour of the body, measure from back neck point (nape) along the contour of the spinal column through the waist level then vertically to the inside leg level.

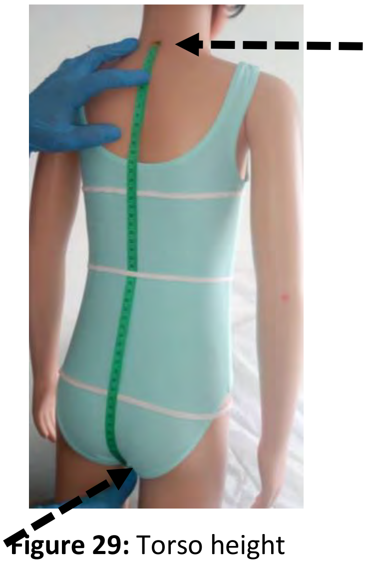


Figure 29: Torso height

8.1.6 Waist to hip

Measurement must be taken with child standing erect, abdomen relaxed and hand hanging down slightly away from the trunk. Take this measurement with the measurer standing on the right side of the participant. Measure from the right side of the child from the waist level over the contour of the body vertically to the hip level.

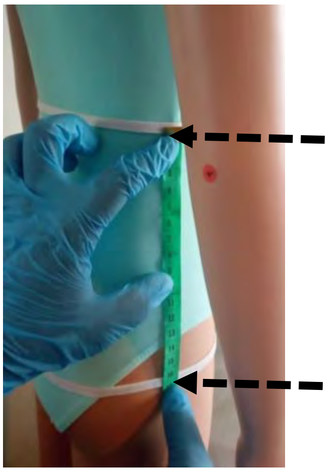


Figure 30: Waist to hip

8.1.7 Waist to knee

Measurement must be taken with child standing erect, abdomen relaxed and hand hanging down slightly away from the trunk. Take this measurement with the measurer standing on the right side of the participant. Measure from the right side of the child's waist level landmark over the contour of the body vertically to the knee level landmark.

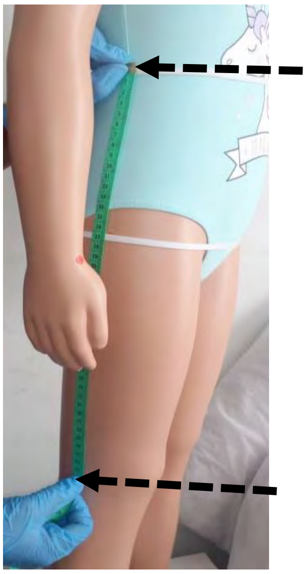


Figure 31: Waist to knee

8.1.8 Waist to ankle

The child must stand upright, legs together with arms relaxed downward and slightly away from the trunk. Take this measurement with the measurer standing on the right side of the child. Measure from the right side of the participant using a tape measure from the waist level landmark over the contour of the body vertically to the hip level and end on the ankle landmark.

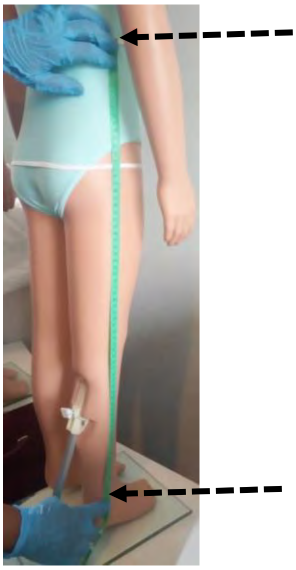


Figure 32: Waist to ankle

8.1.9 Waist to floor

The child must stand upright, legs together with arms relaxed downward and slightly away from the trunk. Take this measurement with the measurer standing on the right side of the child. Measure from the right side of the child using a tape measure from the waist level landmark over the contour of the body vertically to the hip level and continue to the ground.

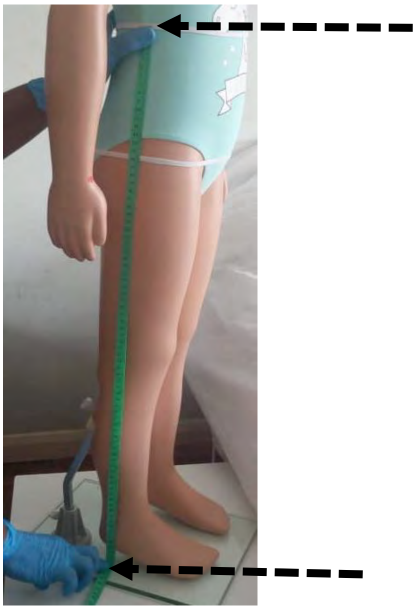


Figure 33: Waist to floor

8.1.10 Knee to floor

The child must stand upright, legs together with arms relaxed downward and slightly away from the trunk. Take this measurement with the measurer standing on the right side of the child. Measure from the right side of the child's knee level using a tape measure to the ground.

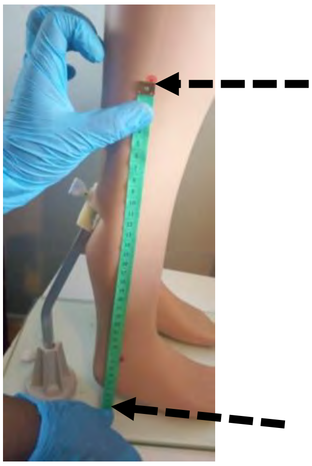


Figure 34: Knee to floor

8.1.11 Inside leg length/ Crotch to floor

The child must stand upright with feet shoulder width apart and arm relaxed downward. Take this measurement using a tape measure with the measurer standing on the right side behind the child. Measure from the inside leg level along the contour of the leg to the ground.

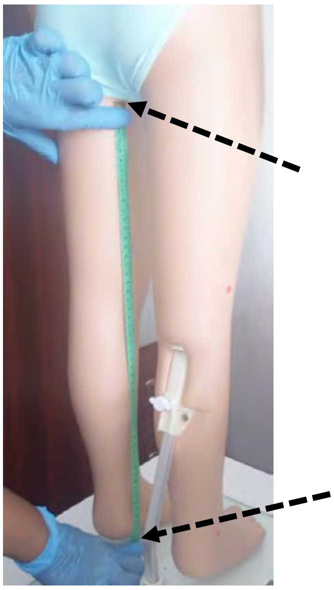


Figure 35: Inside leg length/ Crotch to floor

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Appendix 3

Letter to the Ghana Education Service

Manchester Metropolitan University
Faculty of Art and Humanities
School of Fashion
M14 6HR
Manchester

The Director General
Ghana Education Service
Ministries –Accra, Ghana

Dear Sir,

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SCHOOLS

My name is Adwoa Tweneboaah Twum, a PhD research student at the Manchester Metropolitan University in UK and conducting research into body sizing system for Ghanaian children. The purpose of my study is to 'Develop a standard sizing system and basic block patterns for Ghanaian children aged 6-11'.

I am writing to seek permission to involve pupils in primary schools and their parents/legal guardians to take part in my study through their school authorities.

I am seeking consent to approach some schools in three regions in Ghana, namely Greater Accra, Ashanti, and Northern regions to provide participants for the main research study and schools in Western region for the pilot study. Parents/legal guardians will take body measurements of their wards at home.

Parents/legal guardians and participants will be given information about the study and their consent sought. Parents/legal guardians and participants with endorsed consent and assent forms will be provided with a step-by-step body measurement guidebook, demonstration video on how to measure a child on MMUtube and other social media platforms, a tape measure and body measurement sheet to take and record 35 body measurements of their ward(s).

In all, body measurements will be collected from 800 participants across the country with the sole aim to develop a standard sizing system and basic block patterns for Ghanaian children. A pilot study of 80 participants will be used to test the study's methodology in the Western Region in March 2021. The main study will be conducted between April and June 2021.

Your outfit stands to benefit from the outcome of this study since it will provide a reliable size charts and basic block patterns for Ghanaian children that will be used for mass production of outer garment especially school uniforms for primary school pupils. It will also serve as a basis for further studies in anthropometry in Ghana. Parents/legal guardians and participants who participate in the study will gain knowledge in body measurement process.

If you require any further information, please do not hesitate to contact me.
I therefore count on your favourable cooperation.

Thank you.

Yours faithfully

Adwoa Tweneboaah Twum

In case of general concerns or complaints about the project, kindly contact the following:

Adwoa Tweneboaah Twum, Principal researcher, Mobile no. (UK) 0044(0)771135609 and (Gh) +233(0)244990874, e-mail address adwoa.t.twum@stu.mmu.ac.uk

Dr Phoebe Apeagyei (Director of Studies), Manchester Metropolitan University, Faculty of Arts and Humanities, School of Fashion, All Saints Campus, Cavendish North, M15 6BG, Tel: (UK) 0044(0)1612472779, e-mail address: P.Apeagyei@mmu.ac.uk

University Research Ethics and Governance Manager, ethics@mmu.ac.uk
Manchester Metropolitan University, Cavendish Street, Cavendish North Building, Room 1.25, Manchester M15 6BG

Appendix 4

Letter to selected schools

Manchester Metropolitan University
Faculty of Art and Humanities
School of Fashion
M14 6HR
Manchester

The principal/head teacher
…………………………….
…………………………….
…………………………….

Dear Sir /Madam

PERMISSION TO CONDUCT RESEARCH STUDY IN YOUR SCHOOL

I am writing to request permission to conduct a research study at the primary level of your school. I am a PhD researcher with Manchester Metropolitan University, UK. As part of my studies, I have identified a need for research in the area of sizing system and basic block patterns for Ghanaian children aged 6-11. I am writing to seek permission for your school to assist in the research by liaising between the researcher and primary school pupils and their parents/legal guardians who will be interested in taking part in my study.

I intend to recruit around 80 males and females between the ages of 6 and 11 from your school. Parents/legal guardians along with their wards will be guided to complete a two-page body measurement sheet (copy enclosed). Interested pupils and their parents/legal guardians will be given assent and consent forms respectively to indicate their willingness to participate in the by endorsing the forms (copies enclosed). If approval is granted, parents/legal guardians and participants would receive participant information sheets for their perusal. After receipt of consent from parents/legal guardians and participants the body measurement sheets, a step-by-step body measurement guidebook, link to video, pencil and a tape measure will be delivered to parents/legal guardians through the school. Height and weight measurements of participants will be collected from current data in the school.

The survey results will be analysed collectively. Individual results of this study will remain anonymous. Should this study be published, only pooled results will be documented. This study does not come with any cost to your school or the participants.

Your school stands to benefit from the outcome of this research since it will provide a size charts and basic block patterns for Ghanaian children that will be used for mass production of outer garment especially school uniform for primary school pupils. It will serve as a basis for further

studies in the area of anthropometry in Ghana. It will further educate parents on body measurement process.

Your endorsement to conduct this study will be greatly appreciated. I will follow up with a telephone call in the coming week and would be happy to answer any questions or concerns that you may have regarding the study. I hope my request will be given the due consideration.
Attached is the approval letter from the Ministry of Education.

Yours sincerely,

Adwoa Tweneboaah Twum

In case of general concerns or complaints about the project, kindly contact the following:

Adwoa Tweneboaah Twum, Principal researcher, Mobile no. (UK) 0044(0)771135609, Mobile no. (GH) +233(0)244990874, e-mail address adwoa.t.twum@stu.mmu.ac.uk

Dr Phoebe Apeagyei (Director of Studies), Manchester Metropolitan University, Faculty of Arts and Humanities, School of Fashion, All Saints Campus, Cavendish North, M15 6BG, Tel: (UK) 0044(0)1612472779, e-mail address: P.Apeagyei@mmu.ac.uk

University Research Ethics and Governance Manager, ethics@mmu.ac.uk
Manchester Metropolitan University, Cavendish Street, Cavendish North Building, Room 1.25, Manchester M15 6BG

Appendix 5

Permission letter from Ghana Education Service

GHANA EDUCATION SERVICE

In case of reply the number and date of this letter should be quoted

Republic of Ghana

HEADQUARTERS
Ministry Branch Post Office
P. O. Box M.45

My Ref. GES/HQTS/PA/21/006
Accra

22nd March, 2021.

Regional Directors Concerned

APPROVAL TO CONDUCT A REASEACH

This is to confirm that approval has been granted to Ms Adwoa Tweneboaah Twum, a PhD research student at the Manchester Metropolitan University in UK conducting a research into body sizing system for Ghanaian children. The purpose of the study is to **'Develop a standard sizing system and basic block patterns for Ghanaian children aged 6-11'.**

This consent is provided on the assurance that the researchers fully comply with requirements and the protection of the rights of pupils/students who will be selected for the study and ensure that agreed procedures are followed accordingly.

The Researcher will contact you for further directives on selection of Districts, Schools and the agreed strategies including strict adherence to COVID-19 protocols.

A copy of her request letter is attached for ease of reference.

Thank you,

BIRIKORANG FREDERICK
DIRECTOR, PARTNERSHIPS & AFFILIATIONS
***FOR*: DIRECTOR-GENERAL**

Cc: Director-General, GES, Acca
The Deputy Director-General, (MS), GES, Accra
The Deputy Director-General, (Q&A), GES, Accra
Director, Schools and Instructions, GES, Accra
Regional Director of Education, GES, Ashanti
Regional Director of Education, GES, Greater Accra
Regional Director of Education, GES, Northern
Regional Director of Education, GES, Western
Ms Adwoa Tweneboaah Twum, Manchester Metropolitan University

Appendix 6

Consent form for parents/legal guardians

EthOS ID: 20470

CONSENT FORM

Title of Project: Development of Standardized Sizing System and Basic Block Patterns for Ghanaian Children Aged 6-11

Name of Researcher: Adwoa Tweneboaah Twum

Participant Identification number for this project: ☐☐☐☐☐

Please initial box

1. I confirm that I have read and understood the information sheet dated ………….. for the above project and have had the opportunity to ask questions about the study procedure. ☐

2. I understand that my child's participation is voluntary and that I am free to withdraw at any time without giving any reason to the named researcher. ☐

3. I understand and agree to personally measure my child in a light tight fitting clothing for this research project. ☐

4. I agree to take part in the above research project. ☐

5. I agree to take part in the manual fit testing of sample garment. ☐

6. I understand and agree for the outcome of the research to be dissemination through Open Access repository. ☐

____
Name of participant

______________________	______________	______________
Name of parent/guardian	Date	Signature
______________________	______________	______________
Name of person taking consent	Date	Signature

To be signed and dated in presence of the parent/guardian

Once this has been signed, you will receive a copy of your signed and dated consent form, body measurement sheet, tape measure and other information sheet through the school.

Appendix 7

Assent form for children aged 6-11

Manchester Metropolitan University

Assent Form

EthOS ID: 20470

Participant Identification Number [ ][ ][ ][ ][ ]

Form to be completed by the child

Project Title: Development of Size Chart and Basic Block Patterns for Ghanaian Children Aged 6-11

Please circle **YES** or **NO** to all that you agree with.

1. Do you know what this project is about? Yes/No
2. Have you asked all the questions you want? Yes/No
3. Have all your questions been answered well? Yes/No
4. Are you happy to take part in the project? Yes/No
5. Are you happy to try on the sample garment? Yes/No

- If you answered 'No' or you don't want to take part, don't write your name.
- If you want to take part, you can write your name below

Name of Participant	Date	
Name of Person taking Consent	Date	Signature

Appendix 8

Participant information sheet for children aged 6-8

Study on the development of clothing sizes for Ghanaian children aged 6-11

Manchester Metropolitan University

Child information sheet (6-8 years)

What is a study?

A study is what you do when you want to find out about something or learn and make something new.

Why have I been invited?

You have been invited to take part in my study to help make clothing sizes.

Do I have to say yes?

You can say **yes** if you want to take part or **no** if you don't want to take part.

What will I be asked to do?

You will be measured by your mummy or daddy (or carer) with a tape measure at home, barefooted and in your tight clothing.

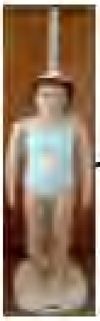
Tape measures

Using tape measure

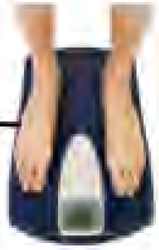
Version: 1.3.2 Date: June 2019

Ethical approval number (EthOS): 20470

Page 1 / 3



Your height and weight measurement will be written from your school's physical education (PE) records



Are there any risks if I take part?

There are no dangers if you take part in this study.

Will it help if I take part in the study?

Taking part in the study will help to make clothing sizes for Ghanaian children. This will make it easy for your parent (or carer) to buy clothes that will fit you well.

What will happen with my measurements?

Your measurements and that of other children will help to make clothing sizes.

You name will not be mentioned.

I will let you know through your mummy or daddy (or carer) what happens to the study.

Version: 1.3.2 Date: June 2019
Ethical approval number (EthOS): 20470

Manchester Metropolitan University

What will happen to all the measurements and sizes of the study?

The measurements and sizes of the study will be given to;

- Your school to help them with school uniform sizes.
- Dressmakers and tailors in Ghana
- Your mummy or daddy (or carer).

Who can I ask if I have questions?

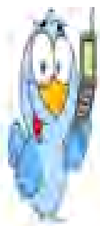
If you have any questions about the study, ask mummy or daddy to contact me at any time through;
Adwoa T. Twum at adwoa.t.twum@stu.mmu.ac.uk or call 0044(0)771135609 (UK), or 00233(0)244990874(Ghana).

OR

Dr Phoebe Apeagyei, Manchester Metropolitan University, Faculty of Arts and Humanities, School of Fashion, All Saints Campus, Cavendish North, M15 6BG, Tel: (UK) 0044(0)1612472779, e-mail address: P.Apeagyei@mmu.ac.uk

OR

University Research Ethics and Governance Manager, ethics@mmu.ac.uk Manchester Metropolitan University, Cavendish Street, Cavendish North Building, Room 1.25, Manchester M15 6BG



THANK YOU

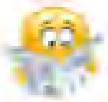
Appendix 9

Participant information sheet for children aged 9-11

Manchester Metropolitan University

STUDY ON THE DEVELOPMENT OF CLOTHING SIZES FOR GHANAIAN CHILDREN AGED 6-11

Child information sheet (9-11 years)



What is a study?
A study is what you do when you want to find out about something or learn and make something new.

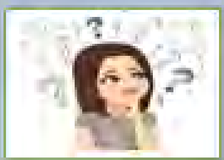
My name is Adwoa Tweneboaah Twum. I am doing a study on the development of clothing sizes for Ghanaian children. I would like to invite you to take part in my study.

Why have I been invited?

You have been invited to take part in my study to develop clothing sizes for Ghanaian children.

Do I have to take part?

No, not at all. It is up to you to think about it.



You can say **yes** if you want to take part or **no** if you don't want to take part.

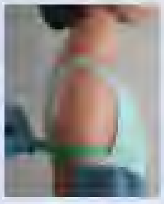
Page 1 / 3

Version: 1.3.2 Date: June 2019
Ethical approval number (EthOS): 20470

Manchester Metropolitan University

What will I be asked to do?

Your mum or dad (or carer) will be guided to measure and write down your measurements at home using a tape measure. Your height and weight measurements will be written from your school's current physical education (PE) measurements.



Are there any risks if I take part?

No, there are no risks if you take part in this study.

What will happen with the information I provide?

The information you give will be studied together with that of your friends and used to make the clothing sizes and basic garment shapes.

Any information about you will not have your name in it.

I will inform you through your parents or carer about the result of the study

Will it help if I take part in the study?

Taking part in the study will help me to make clothing sizes for Ghanaian children. This will make it easy for your parent (or carer) to buy clothes that will fit you well.

Version: 1.3.2 Date: June 2019
Ethical approval number (EthOS): 20470

Manchester Metropolitan University

What will happen to the results of the study?

- The result of the study will be given to people who make clothes to help them with clothing sizes of Ghanaian children.
- The clothing sizes and basic clothing shapes will be given to your school. This will help with the making of school uniforms that will fit you well.
- The clothing sizes will be given to your mummy or daddy (or carer) through your school.

Who do I contact if I have questions?

If you have any question about the study, kindly contact me at any time.
Adwoa T. Twum at adwoa.t.twum@stu.mmu.ac.uk or call 0044(0)771135609 (UK), or 00233(0)244990874(Ghana).

OR

Dr Phoebe Apeagyei, Manchester Metropolitan University, Faculty of Arts and Humanities, School of Fashion, All Saints Campus, Cavendish North, M15 6BG, Tel: (UK) 0044(0)1612472779, e-mail address: P.Apeagyei@mmu.ac.uk

OR

If you have any concerns regarding the personal data collected from you, our Data Protection Officer can be contacted using the legal@mmu.ac.uk e-mail address, by calling 0044(0)161 247 3331 or in writing to: Data Protection Officer, Legal Services, All Saints Building, Manchester Metropolitan University, Manchester, M15 6BH. You also have a right to lodge a complaint in respect of the processing of your personal data with the Information Commissioner's Office as the supervisory authority. Please see: https://ico.org.uk/global/contact-us/

THANK YOU

Version: 1.3.2 Date: June 2019
Ethical approval number (EthOS): 20470

Appendix 10

Participant information sheet for the parents/legal guardians

Manchester Metropolitan University

Participant Information Sheet

[DEVELOPMENT OF STANDARDIZED SIZING SYSTEM AND BASIC BLOCK PATTERNS FOR GHANAIAN CHILDREN AGED 6-11] *

1. Invitation to research

I would like to invite you and your ward to take part in my research project. My name is Adwoa Tweneboaah Twum and I am a PhD researcher. My research project is 'Development of Standardized Sizing System and Basic Block Patterns for Ghanaian Children Aged 6-11'.

2. Why have I been invited?

You have been invited because your child's age is within the age range of this research project. The researcher therefore needs your concern and willingness to measure your own child at home and record the measurement on the body measurement sheet provided by the researcher.

3. Do I have to take part?

It is up to you to decide. We will describe the study and go through the information sheet, which we will give to you. We will then ask you to sign a consent form to show your willingness and that of your child to take part in a study.

4. What will I be asked to do?

You will be asked to complete the demographic data of your child on the body measurement sheet. You will also be guided with a step by step body measurement guidebook and videos to take the body measurements of your child who is a participant for this research at home. You will be guided to take the body measurement of your child using a tape measure and record the measurement on the body measurement sheet.

5. Are there any risks if I participate?

There is no risk to participants.

Version: 1.3.2 Date: June 2019
Ethical approval number (EthOS): 20470

6. Are there any advantages if I participate?

The study will develop an original database of children's measurements and size chart for the apparel industry in Ghana. This stands to increase efficiency of mass production in the apparel industry. It will aid in the mass production of school uniforms especially the free school uniforms by the government of Ghana to fit children in primary levels as the study will further develop block patterns for each size designation develop.

Also, parent can contract apparel manufactures and seamstresses to produce garment for their wards based on the developed size chart without having to send your ward(s) for their physical body measurements to be taken.

The study will give parent more insight into the process of measuring children which will help them to also track the growth rate of their kids.

7. What will happen with the data I provide?

When you agree to participate in this research, we will collect from you personally identifiable information. The Manchester Metropolitan University ('the University') is the Data Controller in respect of this research and any personal data that you provide.

The University is registered with the Information Commissioner's Office (ICO) and manages personal data in accordance with the General Data Protection Regulation (GDPR) and the University's Data Protection Policy.

We collect personal data as part of this research (such as name, age, weight and height). As a public authority acting in the public interest we rely upon the 'public task' lawful basis. When we collect special category data (such as medical information or ethnicity) we rely upon the research and archiving purposes in the public interest lawful basis.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained.

We will not share your personal data collected in this form with any third parties.

If your data is shared this will be under the terms of a Research Collaboration Agreement which defines use and agrees confidentiality and information security provisions. It is the University's policy to only publish anonymised data unless you have given your explicit written consent to be identified in the research. **The University never sells personal data to third parties.**

We will only retain your personal data for as long as is necessary to achieve the research purpose. During the project duration, your data will be kept on the servers of the University and it will be deleted three years after the project's end. Any data that is published will be fully anonymised so it cannot be traced back to you.

For further information about use of your personal data and your data protection rights please see the University's Data Protection Pages (https://www2.mmu.ac.uk/data-protection/).

What will happen to the results of the research study?

Workshops will be organised for all the trade association in the area of Fashion to educate then on the developed size chart. Copies of the body measurement table and the developed size chart will be given to individual associations.

Copies of the body measurement tables, and the developed sizing system will be given to parents and all schools that participated in the study.

Publications will be made and presented at conferences on the finding of the study.

Who has reviewed this research project?

This research has been reviewed by the supervisory team consisting of Dr Phoebe Apeagyei (Director of Studies); Dr Paula Wren and Dr Abu Sayem (Supervisors of the study). Two independent scrutineers, Dr Paddy Lonergan and Dr Tasneem Sabir. The ethics committee of Manchester Metropolitan University has also reviewed this research project.

Who do I contact if I have concerns about this study or I wish to complain?

In case of general concerns or complaints about the project, kindly contact any of the following:

Adwoa Tweneboaah Twum, Principal researcher, Mobile no. (UK) 0044(0)771135609, Mobile no. (Gh) +233(0)244990874, e-mail address adwoa.t.twum@stu.mmu.ac.uk

Dr Phoebe Apeagyei (Director of Studies), Manchester Metropolitan University, Faculty of Arts and Humanities, School of Fashion, All Saints Campus, Cavendish North, M15 6BG, Tel: (UK) 0044(0)1612472779, e-mail address: P.Apeagyei@mmu.ac.uk

University Research Ethics and Governance Manager, ethics@mmu.ac.uk
Manchester Metropolitan University, Cavendish Street, Cavendish North Building, Room 1.25, Manchester M15 6BG, UK

If you have any concerns regarding the personal data collected from you, our Data Protection Officer can be contacted using the legal@mmu.ac.uk e-mail address, by calling 0044(0)161 247 3331 or in writing to: Data Protection Officer, Legal Services, All Saints Building, Manchester Metropolitan University, Manchester, M15 6BH. You also have a right to lodge a complaint in respect of the processing of your personal data with the Information Commissioner's Office as the supervisory authority. Please see: https://ico.org.uk/global/contact-us/

THANK YOU FOR CONSIDERING PARTICIPATING IN THIS PROJECT

Appendix 11

Participant Withdrawal Form

Ethic ID: 20470

Participant Identification Number: | | | | | |

Title of Project: Development of Standardised Sizing System and Basic Block Patterns for Ghanaian Children Aged 6-11

Name of school:

Please tick (✓) one of the following boxes that applies:

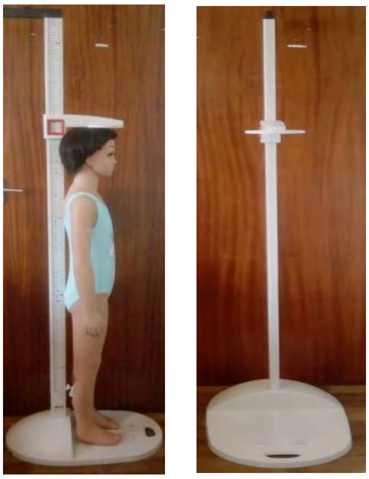
1. Participant withdrew from the study before data collection	
2. Participant withdrew from the study before data analysis and that none of his or her data is included in the study.	

____________________ _______________ _______________

Name of Principal Researcher Date Signature

Appendix 12

Images of tools/ equipment and materials used in the study



Sacca 213 stadiometer
(For measuring height)

Digital weighing scale

Tape measures

Bundle of chord

Chords cut into100cm length

Pens

Pencils

Erasers

Samples of Prepared pack

Appendix 13

Participant Incident Reporting Form

INSTRUCTIONS

You shall report all research related incidents such as minor accidents, complaints and distress using this form. Once completed, this form should be added to the body measurement sheet and submitted to the principal researcher through your school.

Participant number/Date:

Participant name/School:

Title of Project: Development of Standardised Sizing System and Size Charts for Ghanaian Children Aged 6-11

Principal Researcher: Adwoa Tweneboaah Twum

Incident	**Tick suitably**	**Description of incident**	**Any further comment**
1. Minor Accident			
2. Complaints			
3. Distress			

Participant's name and initials are needed for both internal and external examiners and the university for verification of findings and results of the study from the raw data.

In case of general concerns or complaints about the project, kindly contact the following:

Adwoa Tweneboaah Twum, Principal researcher, Mobile no. (UK) 0044(0)7721135609 and (Gh) +233(0)244990874, e-mail address adwoa.t.twum@stu.mmu.ac.uk

Dr Phoebe Apeagyei (Director of Studies), Manchester Metropolitan University, Faculty of Arts and Humanities, School of Fashion, All Saints Campus, Cavendish North, M15 6BG, Tel: (UK) 0044(0)1612472779, e-mail address: P.Apeagyei@mmu.ac.uk

University Research Ethics and Governance Manager, ethics@mmu.ac.uk
Manchester Metropolitan University, Cavendish Street, Cavendish North Building, Room 1.25, Manchester M15 6BG

Appendix 14

Percentiles Values for All Participants

Percentiles - All Participants

Variables	Percentiles							
	5	10	25	50	60	75	90	95
Height	113.5	119.0	125.0	132.8	136.0	141.1	149.0	153.0
Weight	23.0	24.4	27.0	31.0	32.0	35.0	38.0	41.0
Head girth	49.0	49.0	50.5	51.2	52.0	53.0	54.0	55.0
Neck girth	24.0	25.0	26.0	28.0	28.0	29.0	31.0	32.0
Chest girth	54.0	56.0	59.0	63.0	65.0	67.9	72.0	75.1
Waist girth	52.0	53.0	56.0	60.0	61.0	62.0	64.0	65.2
Hip girth	58.0	61.0	66.0	71.0	73.0	77.0	85.3	90.0
Armscye girth	24.0	25.0	27.0	30.0	31.0	33.0	36.0	37.0
Upper arm girth	17.0	18.0	19.0	21.0	22.0	23.0	25.0	27.0
Elbow girth	16.9	17.0	18.0	19.0	20.0	21.0	22.0	23.0
Wrist girth	12.0	12.0	13.0	14.0	14.0	15.0	16.0	16.0
Thigh girth	33.0	34.0	38.0	42.0	43.0	46.0	50.5	53.0
Knee girth	24.0	25.0	27.0	29.0	30.0	31.0	33.0	34.0
Ankle girth	17.0	18.0	19.0	20.8	21.0	22.0	23.0	24.0
Shoulder to length	10.0	10.0	11.0	12.0	12.0	13.0	14.0	14.6
Back shoulder width	29.0	30.0	32.0	33.0	34.0	35.0	37.0	38.0
Scye depth	12.0	13.0	14.0	15.0	16.0	17.0	18.0	18.1
Across chest	23.0	23.0	25.0	26.0	27.0	29.0	31.3	33.0
Bust point width	11.0	12.0	12.0	13.0	13.5	15.0	16.0	17.0
Across back	24.0	25.0	27.0	29.0	29.0	30.0	32.0	33.0
Shoulder Elbow	21.0	22.0	23.0	25.0	26.0	27.0	29.0	30.0
Outer arm length	40.0	41.0	44.0	48.0	48.6	51.0	54.0	56.0
Crotch length	39.0	42.0	45.0	49.0	51.0	54.0	58.0	60.0
Body rise	16.0	17.0	18.0	19.0	19.0	20.0	20.0	21.0
Nape to waist	24.0	25.0	27.0	29.0	29.5	30.0	32.0	33.0
Nape to floor	99.0	101.0	107.5	115.0	118.0	123.0	130.0	133.2
Base of throat	22.0	23.0	24.0	26.0	26.0	28.0	30.0	32.0
Front neck to waist	27.0	28.0	29.0	32.0	33.0	35.0	37.0	38.0
Torso height	49.0	50.8	53.0	57.0	59.0	61.8	66.0	68.0
Waist to hip	13.0	14.0	15.0	16.0	16.0	17.0	18.0	18.0
Waist to knee	35.0	38.0	41.0	44.0	45.0	47.0	51.0	53.0
Waist to ankle	64.0	65.0	71.0	77.0	78.0	81.0	87.0	90.6
Waist to floor	70.0	72.0	76.0	81.0	83.0	88.0	93.0	96.0
Knee to floor	34.0	36.0	38.0	41.0	41.0	43.0	46.0	47.0
Inside leg	53.0	56.0	60.0	64.0	67.0	69.0	73.0	76.0

Appendix 15

Fisher's LSD Multiple Comparisons-Across Districts

Dependent Variable	(I) District	(J) District	Mean Difference (I-J)	Std. Error	p	95% Confidence Interval	
						Lower Bound	Upper Bound
Height	Tamale Metro	Sagnarigu District	2.8508*	1.3846	.040	.133	5.569
		Kumasi Metro	-4.8819*	1.4676	.001	-7.763	-2.001
		Ejisu District	3.6624*	1.4960	.015	.726	6.599
		Accra Metro	-3.7521*	1.4426	.009	-6.584	-.920
		GA West Municipal	-.2181	1.4533	.881	-3.071	2.635
	Sagnarigu District	Tamale Metro	-2.8508*	1.3846	.040	-5.569	-.133
		Kumasi Metro	-7.7327*	1.3782	.000	-10.438	-5.027
		Ejisu District	.8116	1.4085	.565	-1.953	3.577
		Accra Metro	-6.6029*	1.3516	.000	-9.256	-3.950
		GA West Municipal	-3.0689*	1.3630	.025	-5.745	-.393
	Kumasi Metro	Tamale Metro	4.8819*	1.4676	.001	2.001	7.763
		Sagnarigu District	7.7327*	1.3782	.000	5.027	10.438
		Ejisu District	8.5444*	1.4901	.000	5.619	11.470
		Accra Metro	1.1299	1.4364	.432	-1.690	3.950
		GA West Municipal	4.6638*	1.4472	.001	1.823	7.505
	Ejisu District	Tamale Metro	-3.6624*	1.4960	.015	-6.599	-.726
		Sagnarigu District	-.8116	1.4085	.565	-3.577	1.953
		Kumasi Metro	-8.5444*	1.4901	.000	-11.470	-5.619
		Accra Metro	-7.4145*	1.4655	.000	-10.291	-4.538
		GA West Municipal	-3.8806*	1.4761	.009	-6.778	-.983
	Accra Metro	Tamale Metro	3.7521*	1.4426	.009	.920	6.584
		Sagnarigu District	6.6029*	1.3516	.000	3.950	9.256
		Kumasi Metro	-1.1299	1.4364	.432	-3.950	1.690
		Ejisu District	7.4145*	1.4655	.000	4.538	10.291
		GA West Municipal	3.5339*	1.4218	.013	.743	6.325
	GA West Municipal	Tamale Metro	.2181	1.4533	.881	-2.635	3.071
		Sagnarigu District	3.0689*	1.3630	.025	.393	5.745
		Kumasi Metro	-4.6638*	1.4472	.001	-7.505	-1.823
		Ejisu District	3.8806*	1.4761	.009	.983	6.778
		Accra Metro	-3.5339*	1.4218	.013	-6.325	-.743
Weight	Tamale Metro	Sagnarigu District	-.0950	.6165	.878	-1.305	1.115

		Kumasi Metro	-3.6276*	.6535	.000	-4.910	-2.345
		Ejisu District	-.5486	.6661	.410	-1.856	.759
		Accra Metro	-1.2193	.6423	.058	-2.480	.042
		GA West Municipal	-.7411	.6471	.252	-2.011	.529
	Sagnarigu District	Tamale Metro	.0950	.6165	.878	-1.115	1.305
		Kumasi Metro	-3.5325*	.6137	.000	-4.737	-2.328
		Ejisu District	-.4535	.6272	.470	-1.685	.778
		Accra Metro	-1.1242	.6018	.062	-2.306	.057
		GA West Municipal	-.6461	.6069	.287	-1.838	.545
	Kumasi Metro	Tamale Metro	3.6276*	.6535	.000	2.345	4.910
		Sagnarigu District	3.5325*	.6137	.000	2.328	4.737
		Ejisu District	3.0790*	.6635	.000	1.776	4.382
		Accra Metro	2.4083*	.6396	.000	1.153	3.664
		GA West Municipal	2.8864*	.6444	.000	1.621	4.151
	Ejisu District	Tamale Metro	.5486	.6661	.410	-.759	1.856
		Sagnarigu District	.4535	.6272	.470	-.778	1.685
		Kumasi Metro	-3.0790*	.6635	.000	-4.382	-1.776
		Accra Metro	-.6707	.6525	.304	-1.952	.610
		GA West Municipal	-.1926	.6573	.770	-1.483	1.098
	Accra Metro	Tamale Metro	1.2193	.6423	.058	-.042	2.480
		Sagnarigu District	1.1242	.6018	.062	-.057	2.306
		Kumasi Metro	-2.4083*	.6396	.000	-3.664	-1.153
		Ejisu District	.6707	.6525	.304	-.610	1.952
		GA West Municipal	.4781	.6331	.450	-.765	1.721
	GA West Municipal	Tamale Metro	.7411	.6471	.252	-.529	2.011
		Sagnarigu District	.6461	.6069	.287	-.545	1.838
		Kumasi Metro	-2.8864*	.6444	.000	-4.151	-1.621
		Ejisu District	.1926	.6573	.770	-1.098	1.483
		Accra Metro	-.4781	.6331	.450	-1.721	.765
Chest girth	Tamale Metro	Sagnarigu District	1.7912*	.7340	.015	.350	3.232
		Kumasi Metro	-3.8301*	.7780	.000	-5.357	-2.303
		Ejisu District	1.4858	.7931	.061	-.071	3.043
		Accra Metro	-.7219	.7647	.345	-2.223	.779
		GA West Municipal	.2275	.7704	.768	-1.285	1.740
	Sagnarigu District	Tamale Metro	-1.7912*	.7340	.015	-3.232	-.350
		Kumasi Metro	-5.6214*	.7307	.000	-7.056	-4.187
		Ejisu District	-.3055	.7467	.683	-1.771	1.160
		Accra Metro	-2.5131*	.7165	.000	-3.920	-1.107
		GA West Municipal	-1.5637*	.7226	.031	-2.982	-.145

	Kumasi Metro	Tamale Metro	3.8301*	.7780	.000	2.303	5.357
		Sagnarigu District	5.6214*	.7307	.000	4.187	7.056
		Ejisu District	5.3159*	.7900	.000	3.765	6.867
		Accra Metro	3.1082*	.7615	.000	1.613	4.603
		GA West Municipal	4.0577*	.7672	.000	2.552	5.564
	Ejisu District	Tamale Metro	-1.4858	.7931	.061	-3.043	.071
		Sagnarigu District	.3055	.7467	.683	-1.160	1.771
		Kumasi Metro	-5.3159*	.7900	.000	-6.867	-3.765
		Accra Metro	-2.2077*	.7769	.005	-3.733	-.683
		GA West Municipal	-1.2582	.7825	.108	-2.794	.278
	Accra Metro	Tamale Metro	.7219	.7647	.345	-.779	2.223
		Sagnarigu District	2.5131*	.7165	.000	1.107	3.920
		Kumasi Metro	-3.1082*	.7615	.000	-4.603	-1.613
		Ejisu District	2.2077*	.7769	.005	.683	3.733
		GA West Municipal	.9494	.7538	.208	-.530	2.429
	GA West Municipal	Tamale Metro	-.2275	.7704	.768	-1.740	1.285
		Sagnarigu District	1.5637*	.7226	.031	.145	2.982
		Kumasi Metro	-4.0577*	.7672	.000	-5.564	-2.552
		Ejisu District	1.2582	.7825	.108	-.278	2.794
		Accra Metro	-.9494	.7538	.208	-2.429	.530
Waist girth	Tamale Metro	Sagnarigu District	.1639	.5027	.744	-.823	1.151
		Kumasi Metro	-2.2164*	.5328	.000	-3.262	-1.170
		Ejisu District	1.2050*	.5431	.027	.139	2.271
		Accra Metro	-.1191	.5237	.820	-1.147	.909
		GA West Municipal	.1588	.5276	.764	-.877	1.195
	Sagnarigu District	Tamale Metro	-.1639	.5027	.744	-1.151	.823
		Kumasi Metro	-2.3804*	.5004	.000	-3.363	-1.398
		Ejisu District	1.0411*	.5114	.042	.037	2.045
		Accra Metro	-.2830	.4907	.564	-1.246	.680
		GA West Municipal	-.0052	.4949	.992	-.977	.966
	Kumasi Metro	Tamale Metro	2.2164*	.5328	.000	1.170	3.262
		Sagnarigu District	2.3804*	.5004	.000	1.398	3.363
		Ejisu District	3.4215*	.5410	.000	2.359	4.483
		Accra Metro	2.0974*	.5215	.000	1.074	3.121
		GA West Municipal	2.3752*	.5254	.000	1.344	3.407
	Ejisu District	Tamale Metro	-1.2050*	.5431	.027	-2.271	-.139
		Sagnarigu District	-1.0411*	.5114	.042	-2.045	-.037
		Kumasi Metro	-3.4215*	.5410	.000	-4.483	-2.359
		Accra Metro	-1.3241*	.5321	.013	-2.369	-.280

		GA West Municipal	-1.0463	.5359	.051	-2.098	.006
	Accra Metro	Tamale Metro	.1191	.5237	.820	-.909	1.147
		Sagnarigu District	.2830	.4907	.564	-.680	1.246
		Kumasi Metro	-2.0974*	.5215	.000	-3.121	-1.074
		Ejisu District	1.3241*	.5321	.013	.280	2.369
		GA West Municipal	.2779	.5162	.591	-.735	1.291
	GA West Municipal	Tamale Metro	-.1588	.5276	.764	-1.195	.877
		Sagnarigu District	.0052	.4949	.992	-.966	.977
		Kumasi Metro	-2.3752*	.5254	.000	-3.407	-1.344
		Ejisu District	1.0463	.5359	.051	-.006	2.098
		Accra Metro	-.2779	.5162	.591	-1.291	.735
Hip girth	Tamale Metro	Sagnarigu District	1.4866	1.0376	.152	-.550	3.523
		Kumasi Metro	-5.1653*	1.0997	.000	-7.324	-3.006
		Ejisu District	1.6549	1.1210	.140	-.546	3.856
		Accra Metro	-2.8267*	1.0810	.009	-4.949	-.705
		GA West Municipal	-.2903	1.0890	.790	-2.428	1.847
	Sagnarigu District	Tamale Metro	-1.4866	1.0376	.152	-3.523	.550
		Kumasi Metro	-6.6519*	1.0328	.000	-8.679	-4.625
		Ejisu District	.1683	1.0554	.873	-1.904	2.240
		Accra Metro	-4.3133*	1.0128	.000	-6.301	-2.325
		GA West Municipal	-1.7769	1.0214	.082	-3.782	.228
	Kumasi Metro	Tamale Metro	5.1653*	1.0997	.000	3.006	7.324
		Sagnarigu District	6.6519*	1.0328	.000	4.625	8.679
		Ejisu District	6.8202*	1.1166	.000	4.628	9.012
		Accra Metro	2.3386*	1.0764	.030	.226	4.452
		GA West Municipal	4.8750*	1.0845	.000	2.746	7.004
	Ejisu District	Tamale Metro	-1.6549	1.1210	.140	-3.856	.546
		Sagnarigu District	-.1683	1.0554	.873	-2.240	1.904
		Kumasi Metro	-6.8202*	1.1166	.000	-9.012	-4.628
		Accra Metro	-4.4815*	1.0981	.000	-6.637	-2.326
		GA West Municipal	-1.9452	1.1061	.079	-4.116	.226
	Accra Metro	Tamale Metro	2.8267*	1.0810	.009	.705	4.949
		Sagnarigu District	4.3133*	1.0128	.000	2.325	6.301
		Kumasi Metro	-2.3386*	1.0764	.030	-4.452	-.226
		Ejisu District	4.4815*	1.0981	.000	2.326	6.637

		GA West Municipal	2.5364*	1.0654	.018	.445	4.628
	GA West Municipal	Tamale Metro	.2903	1.0890	.790	-1.847	2.428
		Sagnarigu District	1.7769	1.0214	.082	-.228	3.782
		Kumasi Metro	-4.8750*	1.0845	.000	-7.004	-2.746
		Ejisu District	1.9452	1.1061	.079	-.226	4.116
		Accra Metro	-2.5364*	1.0654	.018	-4.628	-.445

*. The mean difference is significant at the 0.05 level.

Appendix 16

Proposed sizes with upper and lower boundaries

Proposed small sizes with upper and lower boundaries- male lower body

Size codes	Small sizes			
	S107-47	**S113-51**	**S119-55**	**S125-59**
Height ranges	104.0 **107.0** 109.9	110.0 **113.0** 115.9	116.0 **119.0** 121.9	122.0 **125.0** 128.0
Waist girth ranges	45.0 **47.0** 48.9	49.0 **51.0** 52.9	53.0 **55.0** 56.9	57.0 **59.0** 60.9

Proposed medium sizes with upper and lower boundaries- male lower body

Size codes	Medium sizes				
	M123-51	**M127-55**	**M131-59**	**M135-63**	**M139-67**
Height ranges	121.0 **123.0** 124.9	125.0 **127.0** 128.9	129.0 **131.0** 132.9	133.0 **135.0** 136.9	137.0 **139.0** 141.0
Waist girth ranges	49.0 **51.0** 52.9	53.0 **55.0** 56.9	57.0 **59.0** 61.9	62.0 **63.0** 64.9	65.0 **67.0** 69.0

Proposed large sizes with upper and lower boundaries- male lower body

Size codes	Large size				
	L134-58	**L140-60**	**L146-62**	**L152-64**	**L158-66**
Height ranges	131.0 **134.0** 136.9	137.0 **140.0** 142.9	143.0 **146.0** 148.9	149.0 **152.0** 154.9	155.0 **158.0** 161.0
Waist ranges	57.0 **58.0** 58.9	59.0 **60.0** 60.9	61.0 **62.0** 62.9	63.0 **64.0** 64.9	65.0 **66.0** 67.0

Proposed small sizes with upper and lower boundaries- female lower body

Size codes	Small size			
	S105-48	**S111-52**	**S117-56**	**S123-60**
Height ranges	102.0 **105.0** 107.9	108.0 **111.0** 113.9	114.0 **117.0** 119.9	120.0 **123.0** 126.0
Waist ranges	46.0 **48.0** 49.9	50.0 **52.0** 53.9	54.0 **56.0** 57.9	58.0 **60.0** 61.9

Proposed medium sizes with upper and lower boundaries- female lower body

Size codes	Medium size				
	M124-51	**M128-55**	**M132-59**	**M136-63**	**M140-67**
Height ranges	122.0 **124.0** 125.9	126.0 **128.0** 129.9	130.0 **132.0** 133.9	134.0 **136.0** 137.9	138.0 **140.0** 142.0
Waist ranges	49.0 **51.0** 52.9	53.0 **55.0** 56.9	57.0 **59.0** 60.9	61.0 **63.0** 64.9	65.0 **67.0** 69.0

Proposed large sizes with upper and lower boundaries- female lower body

Size codes	Large sizes				
	L136-58	**L142-60**	**L148-62**	**L154-64**	**L160-66**
Height ranges	133.0 **136.0** 138.9	139.0 **142.0** 144.9	145.0 **148.0** 150.9	151.0 **154.0** 156.9	157.0 **160.0** 163.0
Waist ranges	57.0 **58.0** 58.9	59.0 **60.0** 60.9	61.0 **62.0** 62.9	63.0 **64.0** 64.9	65.0 **66.0** 67.0

Appendix 17

Body measurement table for small body type for Ghanaian males aged 6-11

Body Measurement Table for Ghanaian Males Age range 6-11 years (Small Sizes) Upper Body (UB) Lower Body (LB)				
		Size Designations		
Body dimensions	**S107-50(UB)** **S107-47(LB)**	**S113-54 (UB)** **S113-51 (LB)**	**S119-58 (UB)** **S119- 55(LB)**	**S125-62(UB)** **S125-59 (LB)**
Height	107	113	119	125
Weight	22	23	24	25
Head girth	48	49	50	51
Neck girth	24.5	25	25	25
Chest girth	51	55	59	63
Waist girth	47	51	55	59
Hip girth	57	61	65	69
Armscye girth	22	24	26	28
Upper arm girth	17	17	18	19
Elbow girth	16	16	17	18
Wrist girth	12	13	13	13
Thigh girth	30	32	34	36
Knee girth	21	23	25	27
Ankle girth	17	17	18	19
Shoulder length	10	10	11	11
Back shoulder width	28	30	30	32
Scye depth	12	13	13	14
Across chest	23	24	24	25
Bust point width	11	11	11	12
Across back	24	25	25	26
Shoulder to elbow	20	21	22	23
Outer arm length	33	37	41	45
Crotch length	37	39	41	44
Body rise	16	17	17	18
Nape to waist	22	24	26	28
Nape to floor	93	97	101	105
Base of throat	20	22	23	25
Front neck to waist	24	26	28	29
Torso height	47	49	51	53
Waist to hip	13	14	14	15
Waist to knee	31	34	37	40
Waist to ankle	57	61	65	69
Waist to floor	59	63	71	75
Knee to floor	32	34	36	38
Inside leg	47	51	55	59

Appendix 18

Body measurement table for large body type for Ghanaian males aged 6-11

Body Measurement Table for Ghanaian Males Age range 6-11 years (Large Body Type) Upper Body (UB) Lower Body (LB)				
	Size Designations			
	L140-66 (UB) **L140-60 (LB)**	**L146-70 (UB)** **L146-62 (LB)**	**L152-74 (UB)** **L152-64 (LB)**	**L158-78(UB)** **L152-66 (LB)**
Body Dimensions				
Height	142	148	154	158
Weight	36	38	40	42
Head girth	53	54	55	55
Neck girth	30	31	32	32
Chest girth	68	72	76	78
Waist girth	60	62	64	66
Hip girth	78	82	86	88
Armscye girth	34	36	37	38
Upper arm girth	23	24	24	26
Elbow girth	21	22	23	23
Wrist girth	15	16	16	16
Thigh girth	46	50	50	52
Knee girth	31	33	34	35
Ankle girth	22	23	24	24
Shoulder length	13	14	14	14
Back shoulder width	36	37	38	38
Scye depth	17	18	18	18
Across chest	31	32	33	19
Bust point width	15	16	17	17
Across back	31	32	33	34
Shoulder to elbow	27	29	30	31
Outer arm length	50	54	58	58
Crotch length	54	57	58	59
Body rise	19	20	21	21
Nape to waist	30	32	33	34
Nape to floor	124	128	130	132
Base of throat	30	31	32	32
Front neck to waist	35	37	38	38
Torso height	64	66	68	68
Waist to hip	17	18	18	19
Waist to knee	54	49	51	52
Waist to ankle	84	86	88	90
Waist to floor	8	92	94	96
Knee to floor	45	46	47	48
Inside leg	71	73	74	75

Appendix 19

Body measurement table for small body type for Ghanaian females aged 6-11

Body measurement Table for Ghanaian Females Age range 6-11 years (Small Sizes) Upper Body (UB) Lower Body (LB)				
	Size Designations			
Body Dimensions	**S107-50 (UB)** **S105-48 (LB)**	**S113-54 (UB)** **S111-52 (LB)**	**S119-58 (UB)** **S117-56 (LB**	**S125-62 (UB)** **S123-60 (LB)**
Height	105	111	117	123
Weight	23	24	25	27
Head girth	48	49	49	50
Neck girth	23	24	25	26
Chest girth	50	54	58	62
Waist girth	48	52	56	60
Hip girth	58	62	66	70
Armscye girth	23	24	25	27
Upper arm girth	17	18	19	19
Elbow girth	17	17	18	18
Wrist girth	10	11	12	13
Thigh girth	33	35	38	39
Knee girth	24	25	25	26
Ankle girth	16	17	18	19
Shoulder length	10	10	10	11
Back shoulder width	27	28	29	30
Scye depth	11	12	13	14
Across chest	19	21	23	25
Bust point width	11	11	12	12
Across back	21	23	25	27
Shoulder to elbow	18	20	22	24
Outer arm length	39	40	41	42
Crotch length	39	40	42	44
Body rise	16	16	17	18
Nape to waist	21	23	25	27
Nape to floor	96	98	100	104
Base of throat	19	21	23	25
Front neck to waist	23	25	27	29
Torso height	48	50	50	52
Waist to hip	13	13	14	15
Waist to knee	32	35	38	41
Waist to ankle	62	64	66	72
Waist to floor	65	69	73	77
Knee to floor	32	34	36	38
Inside leg	54	55	57	58

Appendix 20

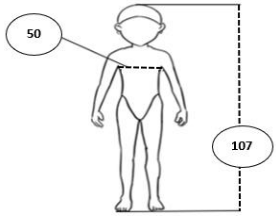
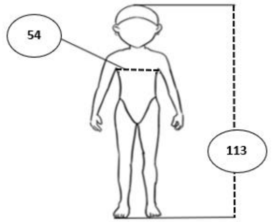
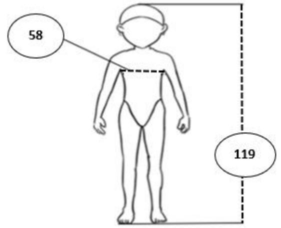
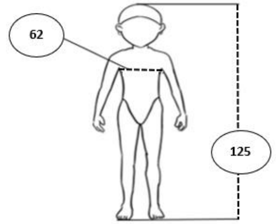
Body measurement table for large body type for Ghanaian females aged 6-11

Body measurement table for Ghanaian Females Age range 6-11 years (large body type)
Upper Body (UB)
Lower body (LB)

Body Dimensions	**L136-62 (UB) L136-58 (LB)**	**L142-66 (UB) L142-60 (LB)**	**L148-70 (UB) L148-62 (LB)**	**L154-74 (UB) L154-64 (LB)**	**L160-78 (UB) L160-66 (LB)**
Height	138	144	150	156	162
Weight	34	36	38	40	42
Head girth	52	53	54	55	55
Neck girth	29	30	31	32	33
Chest girth	65	69	73	77	81
Waist girth	58	60	62	64	66
Hip girth	78	82	86	88	90
Armscye girth	32	34	36	37	38
Upper arm girth	23	24	25	26	27
Elbow girth	21	21	22	23	24
Wrist girth	15	15.5	16	16.5	17
Thigh girth	47	50	52	53	54
Knee girth	31	32	33	34	35
Ankle girth	21	22	23	24	25
Shoulder length	12	13	13.5	13.5	14
Back shoulder width	34	35	36	37	38
Scye depth	16	17	18	19	20
Across chest	29	30	31	32	33
Bust point width	14	15	16	16.5	16.5
Across back	30	31	32.5	33	34
Shoulder to elbow	25	27	29	31	33
Outer arm length	51	53	55	55.5	56
Crotch length	54	56	58	60	62
Body rise	20	20	20	21	21
Nape to waist	29	31	33	35	37
Nape to floor	124	126	130	134	138
Base of throat to waist	28	29	30	31	32
Front neck to waist	35	36	37	38	39
Torso height	62	64	66	67	68
Waist to hip	17	18	18	18	19
Waist to knee	49	50	51	52	54
Waist to ankle	82	85	88	90	92
Waist to floor	90	92	94	96	98
Knee to floor	41	43	45	47	49
Inside leg	70	73	75	77	77

Appendix 21

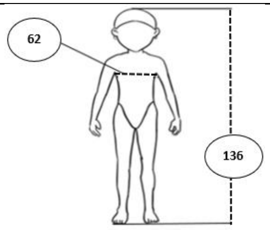
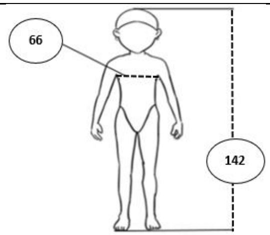
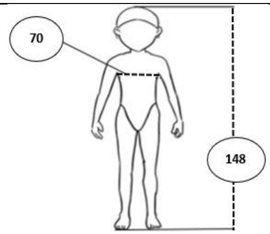
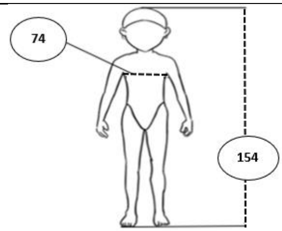
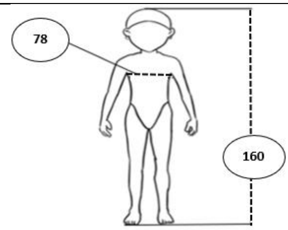
Size chart for small sizes upper body garments for Ghanaian females aged 6-11

Size Chart for Ghanaian Females (Small Sizes) Bodice					
Size Designation	 **Size code S107-50** Height 104-110cm Chest girth 48-52cm	 **Size code S113-54** Height 110- 116cm Chest girth 52-56cm	 **Size code S119-58** Height 116-122cm Chest girth 56-60cm	 **Size code S125-62** Height 122-128cm Chest girth 60-64cm	**Ease allowance**
Body Dimensions					
Chest girth	50 **(60)**	54 **(64)**	58 **(68)**	64 **(74)**	+10
Waist girth	48 **(54)**	52 **(58)**	56 **(62)**	60 (66)	+6
Neck girth	23 **(25)**	24 **(26)**	25 **(27)**	26 **(28)**	+2
Shoulder length	10 **(10)**	10 **(10)**	10 **(10)**	11 **(11)**	0
Across chest	19 **(20)**	21 **(22)**	23 **(24)**	25 **(26)**	+1
Across back	21 **(23)**	23 **(25)**	25 **(27)**	27 **(29)**	+2
Scye depth	11 **(12.5)**	12 **(13.5)**	13 **(14.5)**	14 **(15.5)**	+1.5
Front neck to waist	23 **(23)**	25 **(25)**	27 **(27)**	29 **(29)**	0
Base of throat to waist	19 **(19)**	21 **(21)**	23 **(23)**	25 **(25)**	0
Nape to waist	21 **(21)**	23 **(23)**	25 **(25)**	27 **(27)**	0
Upper arm girth	19 **(25)**	18 **(24)**	19 **(25)**	19 **(25)**	+6
Elbow girth	17 **(23)**	17 **(23)**	18 **(24)**	18 **(24)**	+6
Wrist girth	10 **(13)**	11 **(14)**	12 **(15)**	13 **(16)**	+3
Outer arm length	39 **(39)**	40 **(40)**	41 **(41)**	42 **(42)**	0

All measurements are in centimetres (cm)

Appendix 22

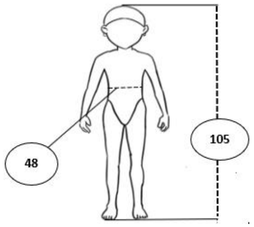
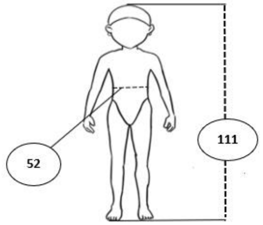
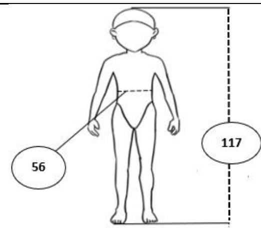
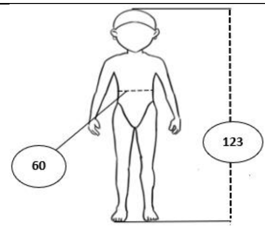
Size chart for large sizes upper body garments for Ghanaian females aged 6-11

Size Chart for Ghanaian Females (large sizes) Bodice						
Size Designation	 **Size code L136- 62** Height 133-139cm Chest girth 60-64cm	 **Size code L142- 66** Height 139-145cm Chest girth 64-68cm	 **Size code L148- 70** Height 145-151cm Chest girth 68-72cm	 **Size code L154- 74** Height 151-157cm Chest girth 72-76cm	 **Size code L160- 78** Height 157-163cm Chest girth 76-80cm	**Ease allowance**
Body Dimensions						
Chest girth	65 **(75)**	69 **(79)**	73 **(83)**	77 **(87)**	81 **(91)**	+10
Waist girth	61 **(67)**	63 **(69)**	65 **(71)**	67 **(73)**	69 **(76)**	+6
Neck girth	29 **(31)**	30 **(32)**	31 **(33)**	32 **(34)**	33 **(35)**	+2
Shoulder length	12 **(12)**	13 **(13)**	13 **(13)**	13.5 **(13.5)**	14 **(14)**	0
Across chest	29 **(30)**	30 **(31)**	31 **(32)**	32 **(33)**	33 **(34)**	+1
Across back	30 **(32)**	31 **(33)**	32 **(34)**	33 **(35)**	34 **(36)**	+2
Scye depth	16 **(17.5)**	17 **(18.5)**	18 **(19.5)**	19 **(20.5)**	20 **(21.5)**	+1.5
Front neck to waist	35 **(35)**	36 **(36)**	37 **(37)**	38 **(38)**	39 **(39)**	0
Base of throat to waist	28 **(28)**	29 **(29)**	30 **(30)**	31 **(31)**	32 **(32)**	0
Nape to waist	30 **(30)**	31 **(31)**	32.5 **(32.5)**	33 **(33)**	34 **(34)**	0
Upper arm girth	23 **(29)**	24 **(30)**	25 **(31)**	26 **(32)**	27 **(33)**	+6
Elbow girth	21 **(27)**	21 **(28)**	22 **(25)**	23 **(29)**	24 **(30)**	+6
Wrist girth	15 **(18)**	15.5 **(18.5)**	16 **(19)**	16.5 **(19.5)**	17 **(20)**	+3
Outer arm length	51 **(51)**	53 **(53)**	55 **(55)**	55.5 **(55.5)**	56 **(56)**	0

All measurements are in centimetres (cm)

Appendix 23

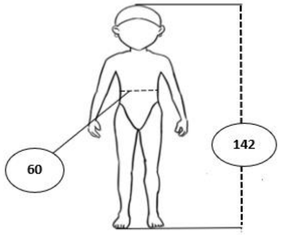
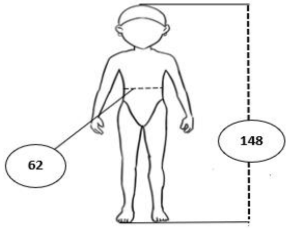
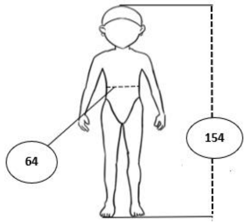
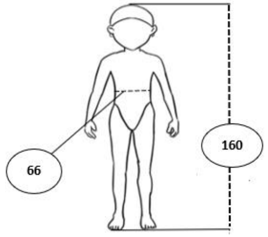
Size chart for small sizes lower body garments for Ghanaian females aged 6-11

Size chart for Ghanaian females (small sizes) Skirt/Shorts/Trousers					
Size Designation	 **Size code S105-48** Height 102-108cm waist girth 46-50cm	 **Size code S111-52** Height 108-114cm waist girth 50-54cm	 **Size code S117-56** Height 114-120cm waist girth 54-58cm	 **Size code S123- 60** Height 120-126cm waist girth 58-62cm	**Ease Allowance**
Body Dimensions					
Waist girth	48 **(54)**	52 **(58)**	56 **(62)**	60 **(66)**	+6
Hip girth	58 **(64)**	62 **(68)**	66 **(72)**	70 **(76)**	+6
Thigh girth	33 **(39)**	35 **(41)**	38 **(44)**	39 **(45)**	+6
Knee girth	24 **(30)**	25 **(31)**	25 **(31)**	26 **(32)**	+6
Ankle girth	17 **(20)**	17 **(20)**	18 **(21)**	19 **(22)**	+3
Crotch length	39 **(39)**	40 **(40)**	42 **(42)**	44 **(44)**	0
Body rise	16 **(17)**	16 **(17)**	17 **(18)**	18 **(19)**	+1
Waist to hip	13 **(13)**	13 **(13)**	14 **(14)**	15 **(15)**	0
Waist to knee	32 **(32)**	35 **(35)**	38 **(38)**	41 **(41)**	0
Waist to ankle	62 **(62)**	64 **(64)**	66 **(66)**	72 **(72)**	0
Inside leg length	53 **(54)**	55 **(55)**	57 **(57)**	58 **(58)**	0

All measurements are in centimetres (cm)

Appendix 24

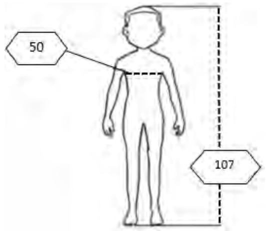
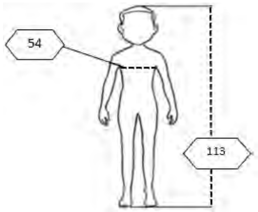
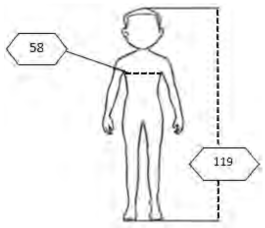
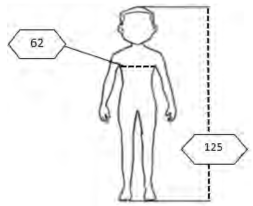
Size chart for large sizes lower body garments for Ghanaian females aged 6-11

Size chart for Ghanaian females (large sizes) Skirt/shorts/trousers					
	 **Size code L142-60** Height 139-145cm waist girth 59-61	 **Size code L148-62** Height 145-151 waist girth 61-63	 **Size code L154-64** Height 151-157 waist girth 63-65	 **Size code L160-66** Height 157-163 waist girth 65-67	**Ease Allowance**
Body Dimensions					
Waist girth	60 **(66)**	62 **(68)**	64 **(70)**	66 **(72)**	+6
Hip girth	82 **(88)**	86 **(92)**	88 **(94)**	90 **(96)**	+6
Thigh girth	50 **(56)**	52 **(58)**	53 **(59)**	54 **(60)**	+6
Knee girth	32 **(38)**	33 **(39)**	34 **(40)**	35 **(41)**	+6
Ankle girth	22 **(25)**	23 **(26)**	24 **(27)**	25 **(28)**	+3
Crotch length	56 **(59)**	58 **(61)**	60 **(63)**	62 **(65)**	+3
Body rise	20 **(20)**	20 **(20)**	21 **(21)**	21 **(21)**	0
Waist to hip	18 **(18)**	18 **(18)**	18 **(21)**	19 **(19)**	0
Waist to knee	50 **(50)**	51 **(51)**	52 **(52)**	54 **(54)**	0
Waist to ankle	85 **(85)**	88 **(88)**	90 **(90)**	92 **(92)**	0
Inside leg length	73 **(73)**	75 **(75)**	77 **(77)**	77 **(77)**	0

All measurements are in centimetres (cm)

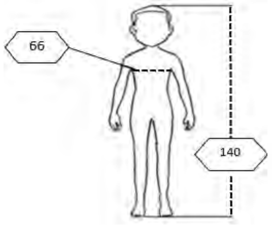
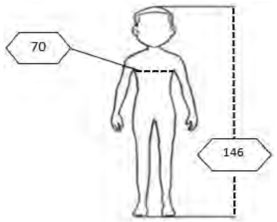
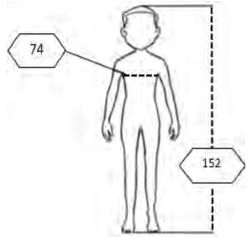
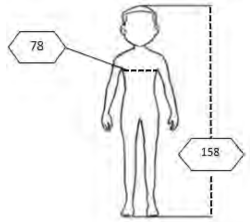
Appendix 25

Size chart for small sizes upper body garments for Ghanaian males aged 6-11

Size chart for Ghanaian males (small sizes)					
Size Designation	 **Size code S107-50** Height 104-110cm Chest girth 48-52cm	 **Size code S113-54** Height 110-116cm Chest girth 52-56cm	 **Size code S119- 58** Height 116-122cm Chest girth 56-60cm	 **Size code S125-62** Height 122-128cm Chest girth 60-64cm	**Ease allowance**
Body Dimensions					
Chest girth	50 **(60)**	54 **(64)**	58 **(68)**	62 **(72)**	+10
Waist girth	47 **(53)**	51 **(57)**	55 **(61)**	59 **(65)**	+6
Neck girth	24.5 **(26.5)**	25 **(27)**	25 **(27)**	25 **(27)**	+2
Shoulder length	10 **(10)**	10 **(10)**	11 **(11)**	11 **(11)**	0
Back shoulder width	30 **(30)**	30 **(30)**	32 **(32)**	33 **(33)**	0
Across chest	23 **(24)**	24 **(25)**	24 **(25)**	25 **(26)**	+1
Across back	24 **(26)**	25 **(27)**	25 **(27)**	26 **(28)**	+2
Scye depth	12 **(13.5)**	13 **(14.5)**	13 **(14.5)**	13 **(14.5)**	+1.5
Front neck to waist	27 **(27)**	27 **(27)**	28 **(28)**	29 **(29)**	0
Waist to hip	14 **(14)**	14 **(14)**	14 **(14)**	15 **(15)**	0
Upper arm girth	18 **(24)**	18 **(24)**	19 **(25)**	19 **(25)**	+6
Elbow girth	17 **(23)**	17 **(23)**	18 **(24)**	18 **(24)**	+6
Wrist girth	12 **(15)**	12 **(15)**	13 **(16)**	13 **(16)**	+3
Outer arm length	39 **(39)**	40 **(40)**	41 **(41)**	44 **(44)**	0

Appendix 26

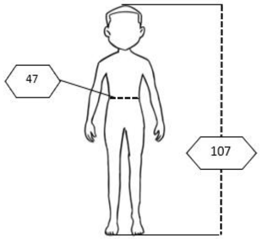
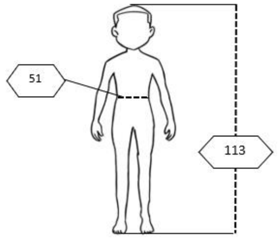
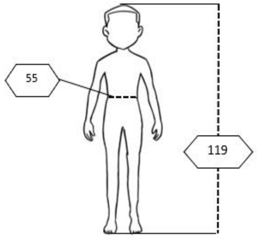
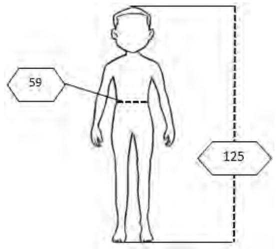
Size chart for large sizes upper body garments for Ghanaian males aged 6-11

Size Chart for upper body garments for Ghanaian males (large Sizes)					
Size Designation	 **Size code L140-66** Height 137-143cm Chest girth 64-68cm	 **Size code L146-70** Height 143-149cm Chest girth 68-72cm	 **Size code L152-74** Height 149-155cm Chest girth 72-76cm	 **Size code L158-78** Height 155-161cm Chest girth 76-80cm	**Ease allowance**
Body Dimensions					
Chest girth	68 **(78)**	72 **(82)**	76 **(86)**	78 **(88)**	+10
Waist girth	60 **(66)**	62 **(68)**	64 **(70)**	66 **(72)**	+6
Neck girth	30 **(32)**	31 **(33)**	32 **(34)**	32 **(34)**	+2
Shoulder length	13 **(13)**	14 **(14)**	14 **(14)**	14 **(14)**	0
Back shoulder width	36 **(36)**	37 **(37)**	38 **(38)**	38 **(38)**	0
Across chest	31 **(32)**	32 **(33)**	33 **(34)**	33 **(34)**	+1
Across back	31 **(33)**	32 **(34)**	33 **(35)**	34 **(36)**	+2
Scye depth	17 **(18.5)**	18 **(19.5)**	18 **(19.5)**	18 **(19.5)**	+1.5
Front neck to waist	35 **(35)**	37 **(37)**	38 **(38)**	38 **(38)**	0
Waist to hip	18 **(18)**	18 **(18)**	18 **(18)**	19 **(19)**	0
Upper arm girth	23 **(29)**	24 **(30)**	24 **(30)**	26 **(32)**	+6
Elbow girth	21 **(27)**	22 **(28)**	22 **(28)**	22 **(28)**	+6
Wrist girth	15 **(18)**	16 **(19)**	16 **(19)**	16 **(19)**	+3
Outer arm length	52 **(52)**	54 **(54)**	56 **(56)**	56 **(56)**	0

All measurements are in centimetres (cm)

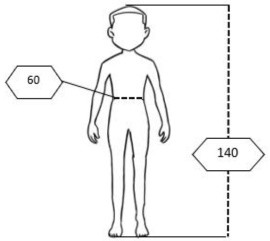
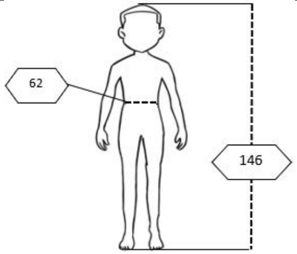
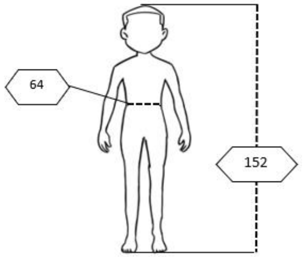
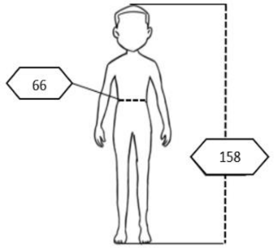
Appendix 27

Size chart for small sizes lower body garments for Ghanaian males aged 6-11

Size Chart for Ghanaian Males (small sizes) Shorts/trousers					
Size Designations	 **Size code S107-47** Height 104-110cm waist girth 45-49cm	 **Size code S113-51** Height 110-116cm waist girth 49-53cm	 **Size code S119-55** Height 116-122cm waist girth 53-57cm	 **Size code S125-59** Height 122-128cm waist girth 57-61cm	**Ease Allowance**
Body Dimensions					
Waist girth	48 **(54)**	52 **(58)**	56 **(62)**	60 **(66)**	+6
Hip girth	57 **(63)**	61 **(67)**	65 **(71)**	69 **(75)**	+6
Thigh girth	34 **(40)**	36 **(42)**	38 **(44)**	40 **(46)**	+6
Knee girth	24 **(30)**	25 **(31)**	27 **(33)**	28 **(34)**	+6
Ankle girth	18 **(21)**	19 **(22)**	20 **(23)**	20 **(23)**	+3
Crotch length	39 **(42)**	40 **(43)**	41 **(44)**	42 **(45)**	+3
Body rise	16 **(17)**	17 **(18)**	17 **(18)**	18 **(19)**	+1
Waist to hip	14 **(14)**	14 **(14)**	14 **(14)**	15 **(15)**	0
Waist to knee	35 **(35)**	35 **(35)**	37 **(37)**	40 **(40)**	0
Waist to ankle	64 **(64)**	64 **(64)**	65 **(65)**	71 **(71)**	0
Inside leg length	53 **(53)**	54 **(54)**	55 **(55)**	57 **(57)**	0

Appendix 28

Size chart for large sizes lower body garments for Ghanaian males aged 6-11

Size Chart for Ghanaian Males (large sizes) Shorts/trousers					
Size Designations	 **Size code L140-60** Height 137-143cm waist girth 59-61cm	 **Size code L146-62** Height 143-149cm waist girth 61-63cm	 **Size code L152-64** Height 149-155cm waist girth 63-65cm	 **Size code L158-66** Height 155-161cm waist girth 65-67cm	**Ease Allowance**
Body Dimensions					
Waist girth	60 **(66)**	62 **(68)**	64 **(70)**	66 **(72)**	+6
Hip girth	78 **(84)**	82 **(88)**	86 **(92)**	88 **(94)**	+6
Thigh girth	48 **(54)**	50 **(56)**	51 **(57)**	51 **(57)**	+6
Knee girth	33 **(39)**	33 **(39)**	34 **(40)**	34 **(40)**	+6
Ankle girth	22 **(25)**	23 **(26)**	24 **(27)**	24 **(27)**	+3
Crotch length	55 **(58)**	57 **(60)**	58 **(61)**	59 **(63)**	+3
Body rise	20 **(21)**	20 **(21)**	21 **(22)**	21 **(22)**	+1
Waist to hip	18 **(18)**	18 **(18)**	18 **(18)**	19 **(19)**	0
Waist to knee	47 **(47)**	49 **(49)**	51 **(51)**	52 **(52)**	0
Waist to ankle	82 **(82)**	86 **(86)**	87 **(87)**	89 **(89)**	0
Inside leg length	71 **(71)**	73 **(73)**	74 **(74)**	75 **(75)**	0

Appendix 29

Fit Evaluation Sheet

(Female Aged 6-11)

Instructions

Please put the sample garment (toile) on your child who participated in the survey and together with the expert kindly rate the fit of the sample garment on the child.

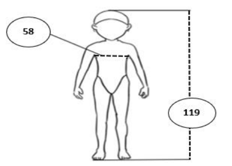
The underlisted points should guide your assessment

- The garment should be neat and smooth on the child's body
- The child should be very comfortable
- The child should be able to move freely without restriction

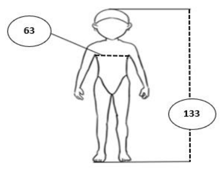
Kindly **tick (✓)** the options that apply

Age of fit model: 6 7 8 9 10 11

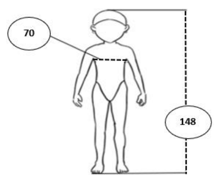
Sizes label



S119-58 (upper body)
S117-56 (lower body)



M133-63 (upper body)
M132-59 (lower body)



L148-70 (upper body)
L148-62 (lower body)

Please tick **(✓)** the most appropriate response based on the corresponding scale: **Yes** or **No**

Descriptions of garment areas		**YES**	**NO**	**Comments**
Correct position of the following:	Neckline			
	Chest line			
	Waistline			
	Hipline			
	Shoulder seamline			
	Across chest			
	Across back			
Appropriate length- neckline and waistline				
Appropriate length- waistline and hip level				
Appropriate sleeve length				
Appropriate length of skirt (females)				

Side seams of sample garment hang straight and perpendicular to the floor.				
No unpleasant vertical wrinkles				
No unpleasant horizontal wrinkles				
The hemlines are even and parallel to the floor				
The apparel hangs generously without pulling				
Right amount of ease across the	Chest level			
	Waist level			
	Hip level			
	Biceps			

Part II

A. Describe the fit of the garment as the participant performs the underlisted activities by Ticking **(✓)** underneath the appropriate column

Activities	**Good**	**Satisfactory**	**Poor**
1. Standing			
2. Sitting			
3. Bending			
4. Walking			
5. Arms are raised above the head			

B. Overall, how rate the fit of the sample garment?

Good　Satisfactory　Poor

(Based on Amaden-Crawford, 2012; Betzina, 2001)

Thank you

Appendix 30

FIT EVALUATION SHEET
(Male Aged 6-11)

Instructions

Please put the sample garment (toile) on your child who participated in the survey and together with the expert kindly rate the fit of the sample garment on the child.

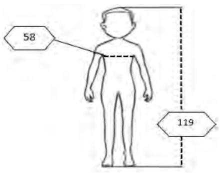
The underlisted points should guide your assessment

- The garment should be neat and smooth on the child's body
- The child should be very comfortable
- The child should be able to move freely without restriction

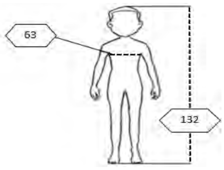
Kindly **tick (✓)** the options that apply

Age of fit model: 6 7 8 9 10 11

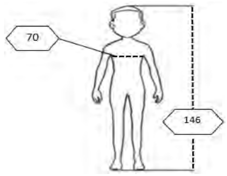
Sizes label:



S119-58 (upper body)
S119-55 (lower body)



M132-63 (upper body)
M131-59 (lower body)



L146-70 (upper body)
L146-62 (lower body)

Please tick **(✓)** the most appropriate response based on the corresponding scale: **Yes** or **No**

Descriptions of garment areas		**YES**	**NO**	**Comments**
Correct position of the following:	Neckline			
	Chest line			
	Waistline			
	Hipline			
	Shoulder seamline			
	Across chest			
	Across back			
Appropriate length between the neckline and waistline				
Suitable length between the waistline and hipline				
Appropriate sleeve length				
Appropriate length of trouser				

Side seams of sample garment hang straight and perpendicular to the floor.				
No unpleasant vertical wrinkles				
No unpleasant horizontal wrinkles				
The hemlines are even and parallel to the floor				
The apparel hangs generously without pulling				
Right amount of ease across the following:	Chest level			
	Waist level			
	Hip level			
	Biceps			
	Thigh			
	Ankle			

Part II

Describe the fit of the garment as the participant performs the underlisted activities by Ticking **(✓)** underneath the appropriate column

Activities	**Good**	**Satisfactory**	**Poor**
1. standing			
2. Sitting			
3. Bending			
4. Walking			
5. Arms are raised above the head			

B. Overall, how rate the fit of the sample garment?

Good   Satisfactory   Poor

(Based on Amaden-Crawford, 2012; Betzina, 2001)

Thank you