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Physiological traits, anthropometric characteristics and motor development of rural children in Nkonkobe Municipality, South Africa

By

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Declaration

I, Idamokoro Mere, hereby solemnly declare that this dissertation is the result of my own investigation under the supervision of Prof. P. Lyoka and Prof. D.T. Goon. This dissertation has never been previously submitted to any other University for any degree. All citations and sources of information have been appropriately acknowledged in the dissertation.

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Abstract

Aim: The purpose of this study was to examine the physiological, anthropometric and motor development characteristics of rural children between the ages of 5 – 7 years old.

Methods: The study involved 305 school children (159 boys and 146 girls) randomly selected from primary schools in Alice sub-district, Nkonkobe Municipality. Body weight, height, skinfold thickness and girth measurements were measured using standard procedures. Overweight and obesity were defined using body mass index (BMI) for age and gender. Derived variables were: fat mass, fat-free mass, fat mass index, fat-free mass index, waist-to-hip ratio, waist-to-height ratio and subscapular-to-triceps ratio. Motor development levels were measured and assessed using Test of Gross Motor Development –Second Edition (TGMD-2). Blood pressure was measured using aneroid sphygmomanometer.

Results: Boys had higher mean values of blood pressure (69.19 ± 7.30 and 38.15 ± 5.91) compared to girls (68.39 ± 7.97 and 37.11 ± 7.53). The proportion of overweight among girls (15.75%) was higher compared to boys (10.69%). Likewise, the percentage of obesity among boys (16.35%) was higher compared to girls (10.27%). The motor development results showed that girls (40.9 ± 6.54) performed better than boys (39.7 ± 6.64) in locomotor skills test. Conversely, boys (39.8 ± 7.62) performed better than girls (38.6 ± 7.29) in object control.

Conclusion: The prevalence of overweight and obesity among the children is alarmingly high and concerning for the health. At all ages, girls had higher body fat percentage and fat mass than the boys. However, FFMI and WHR were higher in boys compared to the girls. There is no gender difference in the waist-to-height ratio and STR of both boys and girls. The locomotor raw score is higher in girls than in boys; however, the object control raw score is higher in boys compared to girls. The non-correlation of BMI with TGMD-2 tests suggests an equal potential of motor development among the children, regardless of their body fatness. There is need for obesity prevention programme in schools, which should involve all the stakeholders (teachers, parents/guardians, government, NGOs). The programme should focus on creating awareness concerning child body weight, healthy dietary intake and regular BMI screening in schools.

Key words: Body composition, blood pressure, motor development, rural children.

Dedication

I gracefully and heartily dedicate this work to the perfect Trinity (God the Father, God the Son, God the Holy Spirit), my family, friends, loved ones and well-wishers.

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Contents

Chapter one: Introduction

1.1 Introduction

Within the field of movement science, motor development is one of the contemporary constructs of interest to scholars and researchers in the field of movement science, perhaps, because of its significant role in virtually all human activities (Apache, 2005). It is one of the crucial areas of human psychosocial development processes. These processes help to know if an individual is affected either positively or negatively, from environmental or biological factors, which makes or mars the aspirations of such a person, as far as human functions are concerned (Brown *et al*., 2009; Bar-Haim & Bart, 2006). There is a relationship between the physical, social and cognitive development of a child and motor skill development. The child's motor skill development must be taken into serious consideration because it is the foundation of the future growth and development of the child. There is variation in the body structure of children (Leblanc & Dickson, 2011), which suggest that motor development and physical development in children do not progress at the same pace.

Growth is viewed as a quantitative increase in body size or in some parts of the body; whereas development can be due to functional changes including parts of the body which include emotional and social interactions (Behrman & Kliegman, 1996; Beyazova, 1996). Conversely, anthropometry is the study of the measurement of the human body in terms of its dimensions of bone, muscle and adipose (fat) tissue. It is a branch of the human sciences that deals with body measurements, such as size, shape, BMI (body mass index), arm length, leg length, skinfold thickness (triceps, sub-scapular etc.), circumferences (head, waist, arm muscle, mid upper arm etc.), strength and working capacity (Pheasant, 2006). Certain growth indicators are used to describe growth rate; height for age, weight-for-age, weight-for-length, BMI for age (WHO, 2008).

The most recognizable signs of physical growth in children can be seen from the changes in their body parts. Body parts such as the head and chest circumference are important clinical measurements for growth in children (Beyazova, 1996; Bertan & Ozcebe, 1995). These anthropometric measurements can be used in monitoring the growth of children. Moreover, human movement is directly or indirectly supported by the nervous and musculoskeletal systems (Fietzek *et al*., 2000). If one will critically consider the importance of movement to the survival of the human being, it is necessary to give a detailed attention to their developmental processes, especially from childhood which would help a child to significantly exhibits his natural endowments, and maximally fulfill his potentials in life, through his or her motor skill and ability (van der Gaag, 2002; Thelen, 2000).

According to the World Health Organization (WHO, 2005), nearly 230 million children have stunted growth. The case of stunted growth among South Africa children is also reported to be high; with about 41.8% of children been stunted (Monyeki *et al*., 2001). Several factors have been attributed to stunted growth in children. One of the factors includes nutrition (Petrou & Kupek, 2010). The Eastern Cape Province is one of the most indigent provinces in South Africa, with most of the municipal districts experiencing higher poverty rates than the national average (Dimant, 2014). The percentage of unemployment in the Eastern Cape is about 30.4% which is higher than the national unemployment rate (Dimant, 2014). The percentage of people living below the poverty line in the Eastern Cape is about 42.2% compared to the national average of 35.9% and about two thirds of this population live in rural areas (Van Heerden, 2014).

Several studies have linked overweight and obesity to poorer motor development in children (Wrotniak *et al*., 2006; Graf *et al*., 2004a; Graf *et al*., 2004b). Hence, children with poor motor skills are likely to be less active physically, which may adversely lead to overweight and obesity. In other words, excess body weight and fatness could hinder the pace of movement and adequate development of motor skills. Motor development entails the movements from the infants' first spontaneous waving and kicking movements to the adaptive control of reaching, locomotion and complex sport skills at adulthood (Adolph *et al*., 2003).

1.2 Problem statement

The movement development of children is affected by several factors. While other studies considered environmental factors (Pem, 2015; Venetsanous & Kambas, 2010; Giagazoglou *et al*., 2008; McPhillips & Jordan-Black, 2007), others examined biological (de Rocha Nerves *et al*., 2016; Hadders-Algra, 2016; Mayer *et al*., 2010;), emotional factors (Venetsanous & Kambas, 2010; Hafstad *et al*., 2013) nutritional status (Lips, 2010; Ramakrishnan, 2002; Kennedy, 1998), yet, others focused on the role of socioeconomic status of parents (Venetsanous & Kambas, 2010; McPhillips & Jordan-Black, 2007;). However, these studies have been conducted elsewhere. There is paucity of information concerning the motor development and the physiological as well as anthropometric parameters of South African children. The few studies (Kakebeeke *et al*., 2017; Haslofca *et al*., 2016; Burgi *et al*., 2011) are confined to urban setting, in neglect of rural children. Rural children are more likely to be medically underserved when compared to their urban counterparts in terms of having a regular opportunity for health care, health insurance, and access to preventive health services. Information on the motor development of children in relation to their anthropometric is important, judging from the health perspective. The information on motor performance may be used by health care practitioners, teachers and even sport coaches to proffer a possible intervention programme to correct any trend in children having abnormal development and child growth.

1.3 Main objective of the study

The main purpose of the study was to determine the physiological, anthropometric and motor development characteristics of rural children in selected schools in Nkonkobe Municipality of Eastern Cape Province, South Africa.

1.5 Specific objectives

The specific objectives of the study are:

1. To determine gender differences in physiological parameters of rural children in Nkonkobe Municipality.
2. To determine gender differences in the anthropometric characteristics of rural children in Nkonkobe Municipality.
3. To examine gender differences in the motor development of rural children in Nkonkobe Municipality.
4. To examine the relationship between physiological, anthropometric and motor development of rural children in Nkonkobe Municipality.

1.6 Research questions

The following research questions were used to guide the development of this study:

- Would there be gender differences in the physiological parameters of rural children in Nkonkobe Municipality?
- Would there be gender differences in the anthropometric measurements of rural children in Nkonkobe Municipality?
- Would there be gender differences in the motor development of rural children in Nkonkobe Municipality?

- Would there be any relationship between the physiological, anthropometric and motor development characteristics of rural children in Nkonkobe Municipality?

1.7 Primary hypothesis

It is hypothesize that there will be no gender differences in the physiological, anthropometric and motor development characteristics of rural children aged 5-7 years in Nkonkobe Municipality; and there will be no significant relationship between their body composition and motor development.

1.8 Secondary hypothesis

The following specific hypotheses were formulated to guide the investigation:

1. There will be no significant gender differences in the systolic blood pressure (SBP), diastolic blood pressure (DBP), resting heart rate and mean blood pressure (MBP) of rural children in Nkonkobe Municipality.
2. There will be no significant gender differences in the body composition (body mass index (BMI), percentage body fat (% BF), fat mass (FM), fat free mass (FFM), fat mass index (FMI), fat free mass index (FFMI), triceps skinfold (TSKF), subscapular skinfold (SSKF), waist-to-hip (WHR) and waist-to-height (WHtR)) of rural children in Nkonkobe Municipality.
3. There will be no significant gender differences in the motor development variables of rural children in Nkonkobe Municipality.
4. There will be no relationship between physiological, anthropometric and motor development characteristics of rural children in Nkonkobe Municipality.

1.9 Significance of the study

The findings of this study provides information on the physiological, anthropometric and motor development characteristics of rural children in Nkonkobe Municipality, which may be used by health care practitioners, teachers and even sport coaches to proffer a possible intervention programme to correct any trend in children having abnormal development, child growth. Besides, the findings will form a baseline data for future or longitudinal study on the physiological, anthropometric and motor development indicators of children. Conversely, the anthropometric data gathered from the study may be utilized to evaluate the health and dietary status, body composition dynamics and some possible disease risk that may be found among rural children in the study area (if any).

1.10 CHAPTER OUTLINE

The background to the study, problem statement, aim, objectives, and research questions, and significance of the study, are described and presented in Chapter 1. The chapter also describes the division of the study.

Chapter 2 concerns the literature review. In this chapter, anthropometry assessment of growth such as body height, body weight, BMI and skinfold thickness were discussed. Also discussed are: physiological growth pattern, determinants of child growth, role of physical activities on child growth and development, demographic variables correlating with motor performance, motor skills performance of children, relationship between motor development, growth rate and resting blood pressure. More so, the impact of physical activity on the academic performance of children, influence of physiological, anthropometric, growth pattern on motor development of children, qualitative and quantitative assessment of motor development in children. Finally, Gesell maturational theory, Dynamic systems theory and Piaget theory were discussed.

Chapter 3 describes the research methodology that is used in this study. Aspects such as the design used for the execution of the study, the settings, population, sampling and sample size, the research instruments, the validity and reliability, data collection procedure and ethical considerations are discussed. This is followed by data analysis.

Chapter 4 presents the results of the study and discussion.

In Chapter 5, a summary of the pertinent findings, together with the limitations and strengths of the study, are presented. This is followed by the conclusions and recommendations.

Chapter Two: Related Literature Review

2.1. Introduction

This chapter presents the context of related literature review on motor development as supported by physiological traits, and anthropometric characteristics of children.

2.2. Anthropometry assessment for growth

Anthropometry is a generally used, inexpensive and economical method for assessing, evaluating body fatness and assessing the growth, dietary status and physical well-being in growing children using the growth standards and growth references (Wang *et al*., 2006), it is also crucial in monitoring the health status, identifying deviations from normal and providing room for effective interventions. According to Marfell-Jones *et al*. (2006) anthropometric measurements give a good picture of the whole body. These measurements are used for various purposes such as monitoring development, tracing growth, motor performance and relating physical activity and nutrition intercessions to variations in body size, shape and composition. A growth standard reflects optimal growth, signifying that all growing children have the potential to accomplish that level, while a growth reference is simply the distribution used for assessment and comparison (WHO MGRSG, 2006a). There has been a growing debate on the use of sex-and age- specific BMI percentiles as cut-offs rather than weight-for-height z-scores (WHZ) for evaluating overweight and obesity as well as thinness/underweight in children over 2 years old (Wang *et al*., 2006; WHO, 2006; Kuczmarski *et al*., 2002). The widely-used percentiles in growth references and standards based on international data in other countries, using z-scores, or percentiles like 5th, 85th and 95th have been used for the classification of nutritional status in children.

According to World Health Organization (2007) a threshold is set based on single standard deviation spacing:

Underweight: weight for age less than minus 2 standard deviations (SD) of the World Health Organization Child Growth Standards Median; Stunting: height for age less than minus 2 standard deviations (SD) of the World Health Organization Child Growth Standards Median; Wasting: weight for height less than minus 2 standard deviations (SD) of the World Health Organization Child Growth Standards Median; Overweight: weight for height greater than plus 2 standard deviations (SD) of the World Health Organization Child Growth Standards Median.

2.2.1. Body height

Body height was a main indicator of the length of bone, the general body size, monitoring of growth (Flegal *et al*., 2002), pulmonary function (Garshick *et al*., 1997), as a screening factor for detecting children who are suffering from stunting (short height for age) and it is fundamental in calculating the BMI of the children. Recumbent length, arm span and assessment from the knee height may be used in place of stature. Furthermore, ulna length measurement by three diverse apparatus (paper grid, caliper and ruler), carpenter’s tape, laminated graph paper taped to a wall using a head board, steel tape and arm span can provide an accurate and reliable substitute measure of standing height in healthy children where the use of stadiometer is inadequate (Forman *et al*., 2014). The body stature is measured to the nearest centimeter (cm). Figure 2.1 and 2.2 depicts the height-for-age percentiles for boys and girls aged from 2 to 18 years old, respectively.

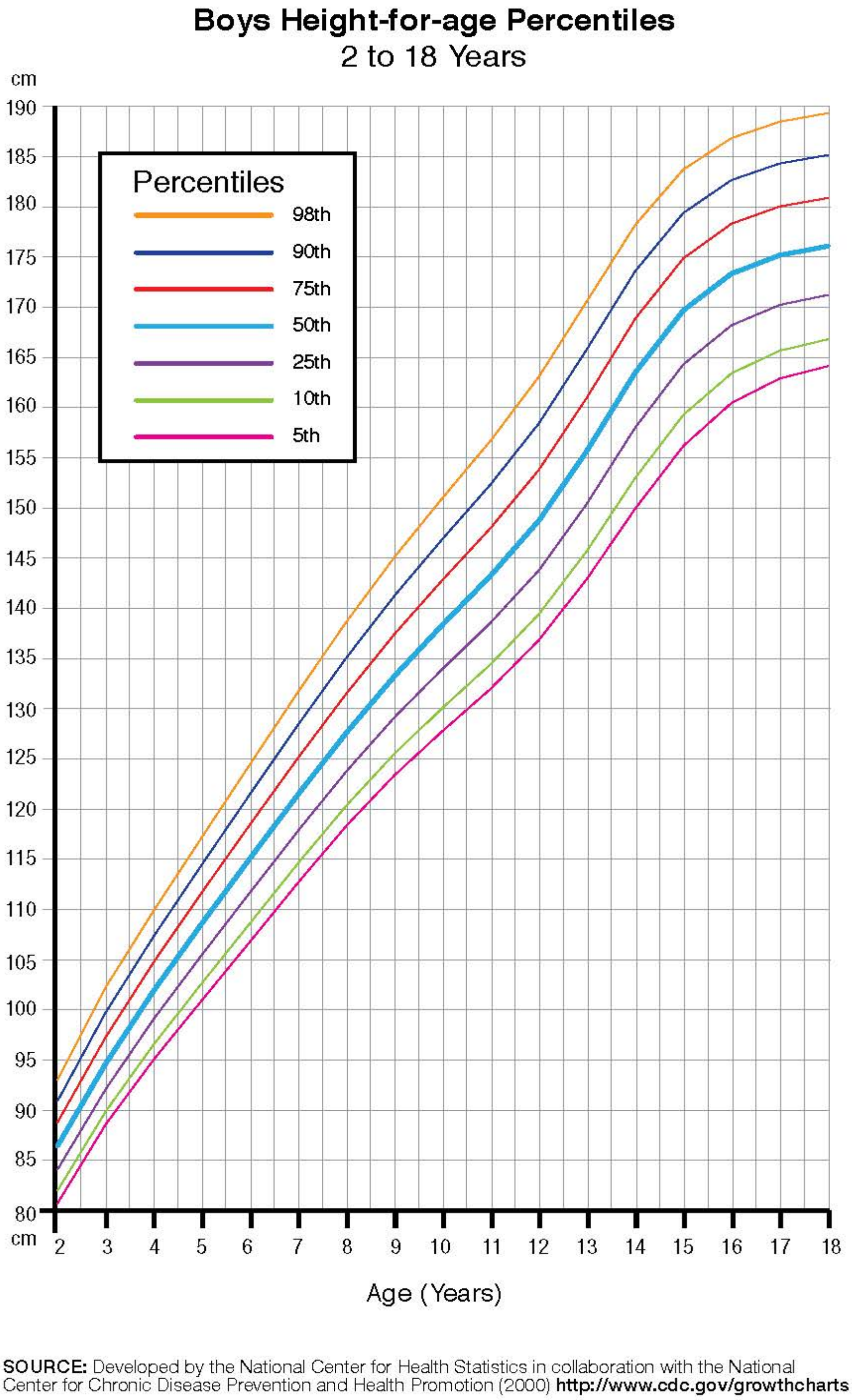

Figure 2.1: Percentiles for boys' heights between the ages of 2-18

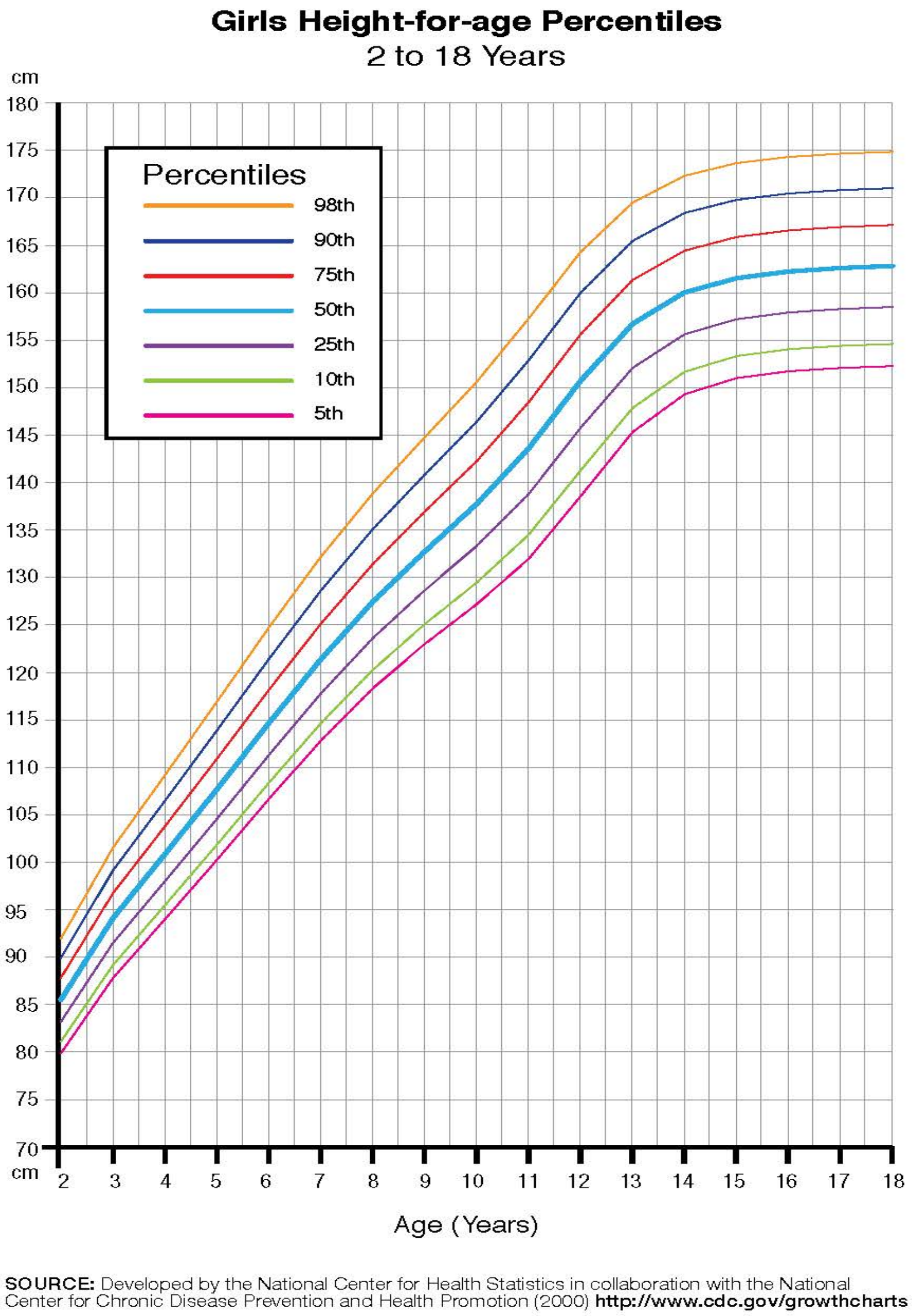

Figure 2.2: Percentiles for girls' heights between the ages of 2-18

2.2.2. Body weight

Weight measurement helps to identify children who may be severely wasted (acute weight loss) because of malnutrition and children who may be obese. Ideal body weight is used clinically for different purposes; most commonly, to estimate renal function before administering drugs to children and predicting pharmacokinetics in morbidly obese patients (Jones, 2011; van Kraligen *et al*., 2011). Figure 2.3 and 2.4 indicates the weight-for age percentiles for boys and girls aged from 2 to 18 years old, respectively.

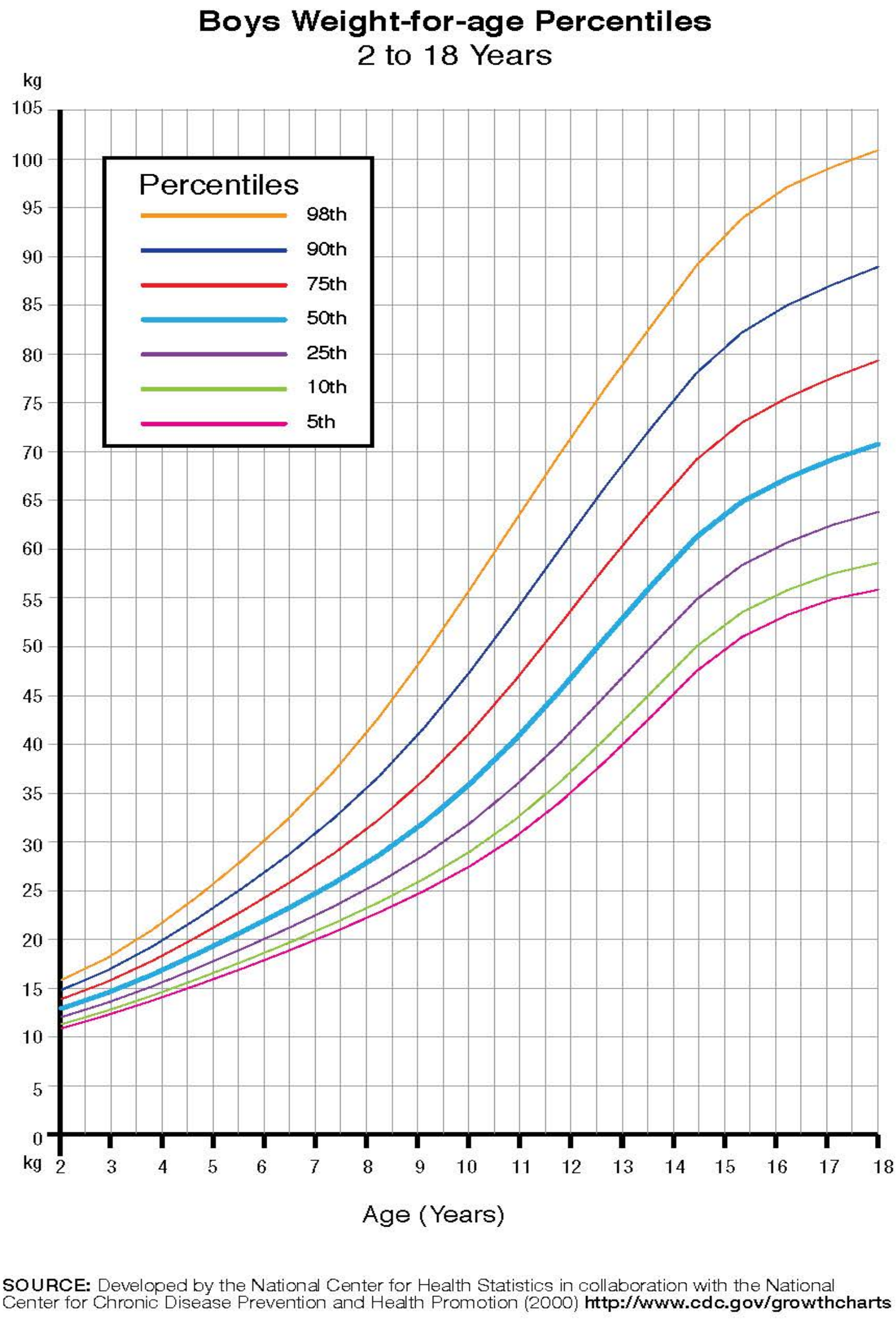

Figure 2.3: Percentiles for boys' weights between the ages of 2-18

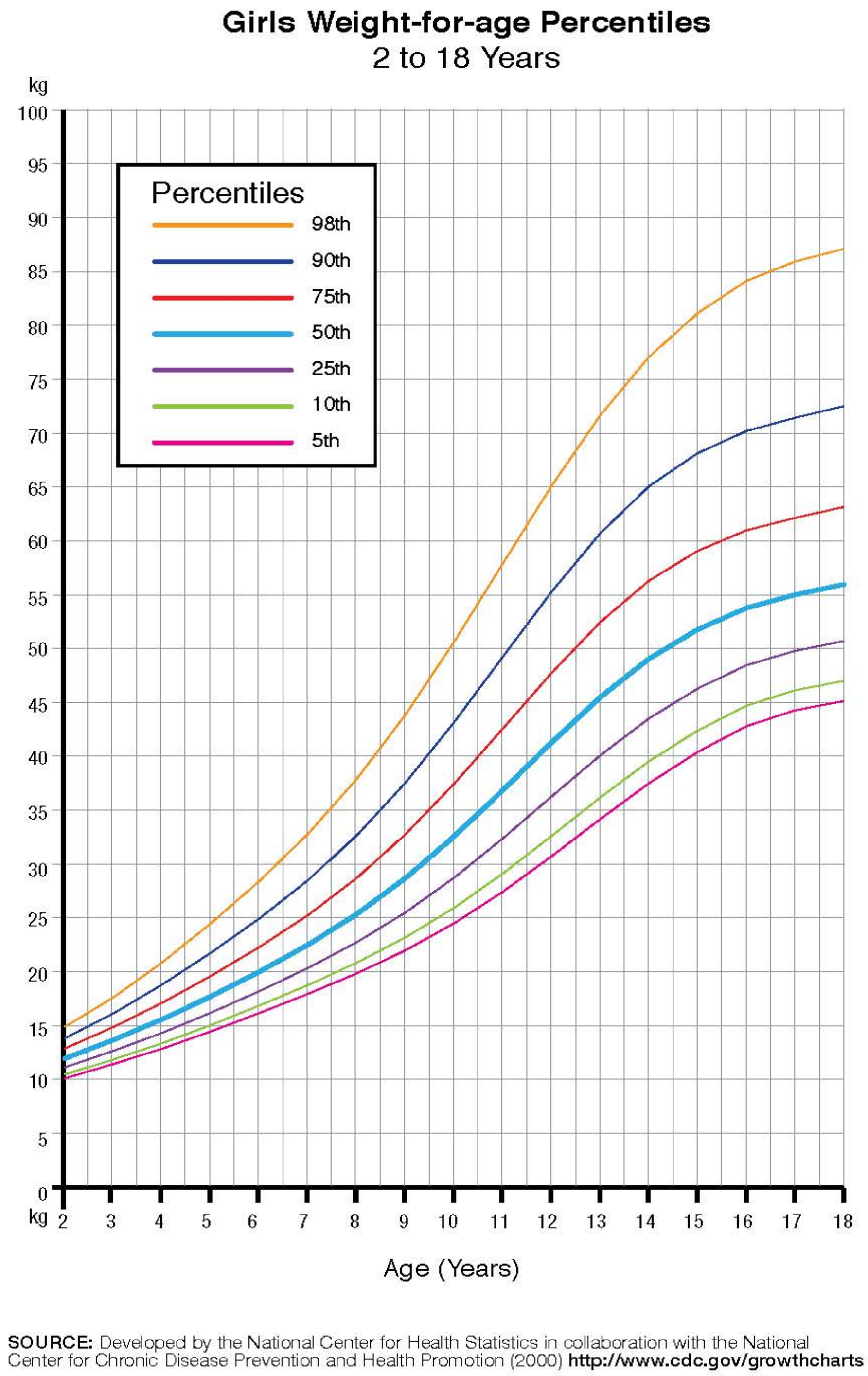

Figure 2.4: Percentiles for boys' heights between the ages of 2-18

2.2.3. Body mass index (BMI)

Body mass index (BMI) as an anthropometric index of weight and height is defined as body weight in kilograms and body height in meters' square:

$$BMI = \frac{\text{Mass (kg)}}{[\text{Height (m)}]^2} \times 10{,}000 \qquad \text{(Equation 1.1)}$$

The certainty of diagnosing obesity and excessive weight gain in children and adolescents with the use of BMI data has been interrogated (Misra, 2003). According to Freedman *et al*. (2007), BMI is widely used by different researchers to ascertain the measurement of adiposity which is a measure of surplus mass relative to stature, rather than excess body fat. The exactness of BMI as a pointer of adiposity varies significantly according to the amount of body fatness. In relatively fat children, BMI is a good sign of surplus adiposity, but differences in the BMIs of relatively thin children could be associated with the differences in fat-free mass. Furthermore, BMI measures are less precise indicators of adiposity as changes in the mechanism of the fat-free mass cannot be notable from the fat mass. Scientific studies generally use BMI to describe excess adiposity rather than excess body mass (Krebs & Jacobson, 2003).

Although, BMI is associated with body fat, it does not differentiate between fat and lean mass (Maynard *et al*., 2001). Nevertheless, BMI has been proven to be a good parameter in estimating the risk for metabolic syndrome and cardiovascular diseases (Choi *et al*., 2017; Zimmet *et al*., 2007). Furthermore, BMI is also easy, cheap and non-invasive means of assessing excess body fat (National Obesity Observatory, 2009). Although, true measures of body fat are expensive to use at population level such as bioelectrical impedance analysis (BIA) (L'Abee *et al*., 2010), hydro densitometry (Lockner *et al*., 2000), dual energy x-ray absorptiometry (DEXA) (L'Abee *et al*., 2010), air displacement plethysmograph (Elberg *et al*., 2004; Lockner *et al*., 2000), isotope dilution (Wells & Fewtrell, 2006), magnetic resonance imaging (MRI) (Wells & Fewtrell, 2006), computed tomography (CT) (Yu *et al*., 2010).

The Department of Health and Human Services Centres for Disease Control and Prevention (CDC) reported that, BMI is a reasonable and logical indicator of body fat for both young and old. Body mass index does not measure or assess body fat directly and so, it should not be used as a diagnostic tool, but rather it should be used to track weight status and a screening tool to recognize potential weight problems in individuals. Further information is required to better comprehend the association between BMI, body fatness, fat distribution and various diseases as well as to illuminate the health risks associated with the 85th and 94th percentiles in children.

It is often known among researchers that a high BMI is not a receptive pointer of surplus body fatness (Wickramasinghe *et al*., 2005; Zimmermann *et al*., 2004). It is also considered that most obese children or overweight children (BMI-for-age between the 85th and 94th percentiles) do not have excess body fatness (Freedman *et al*., 2009). BMI is made up of fat mass and lean body mass and this can be a reduced sign of fatness amid those who have standard or relatively little intensity of percent body fat (Freedman *et al*., 2009; Bray *et al*., 2002).

In summary, the height and mass measures are the two major anthropometric data that are necessary for computing BMI and it is theoretically easy to achieve especially in huge sample surveys. Likewise, height and mass measures are a convenient expression of weight per unit of height that reflects body build and body composition. Variations of this indicator (weight per unit height) have been a frequent subject matter in the field of anthropometry for over 150 years. Body mass index has been a long-time factor that has been used for individual counselling with respect to diet, weight loss, physical wellbeing status, and other fitness factors. This anthropometry data (BMI) is widely and popularly used by researchers to determine level of adiposity in children, adolescent and in adults. The main widely and popularly used categorization systems for BMI levels among children are the CDC growth charts (Ogden *et al*., 2002) (Table 2.1) and the International Obesity Taskforce (IOTF) cut-off points (Chinn, 2006; Cole, 2000). Both categorization systems are based on sex-specific distribution of BMI levels according to age. This study will make do of the CDC growth charts among growing children who are 2 years to 18 years old. Figure 2.5 and 2.6 display the BMI-for-age percentiles for boys and girls between 2 to 18 years old respectively.

Table 2.1: BMI status in children at risk of obesity

Mass status	BMI percentile ranking
Greater or equal to 95th percentile	Obese
85th percentile less than 95th percentile	Over weight
5th percentile less than 85th percentile	Healthy weight
< 5th percentile	Underweight

Source: Centers for Disease Control and Prevention (2009b)

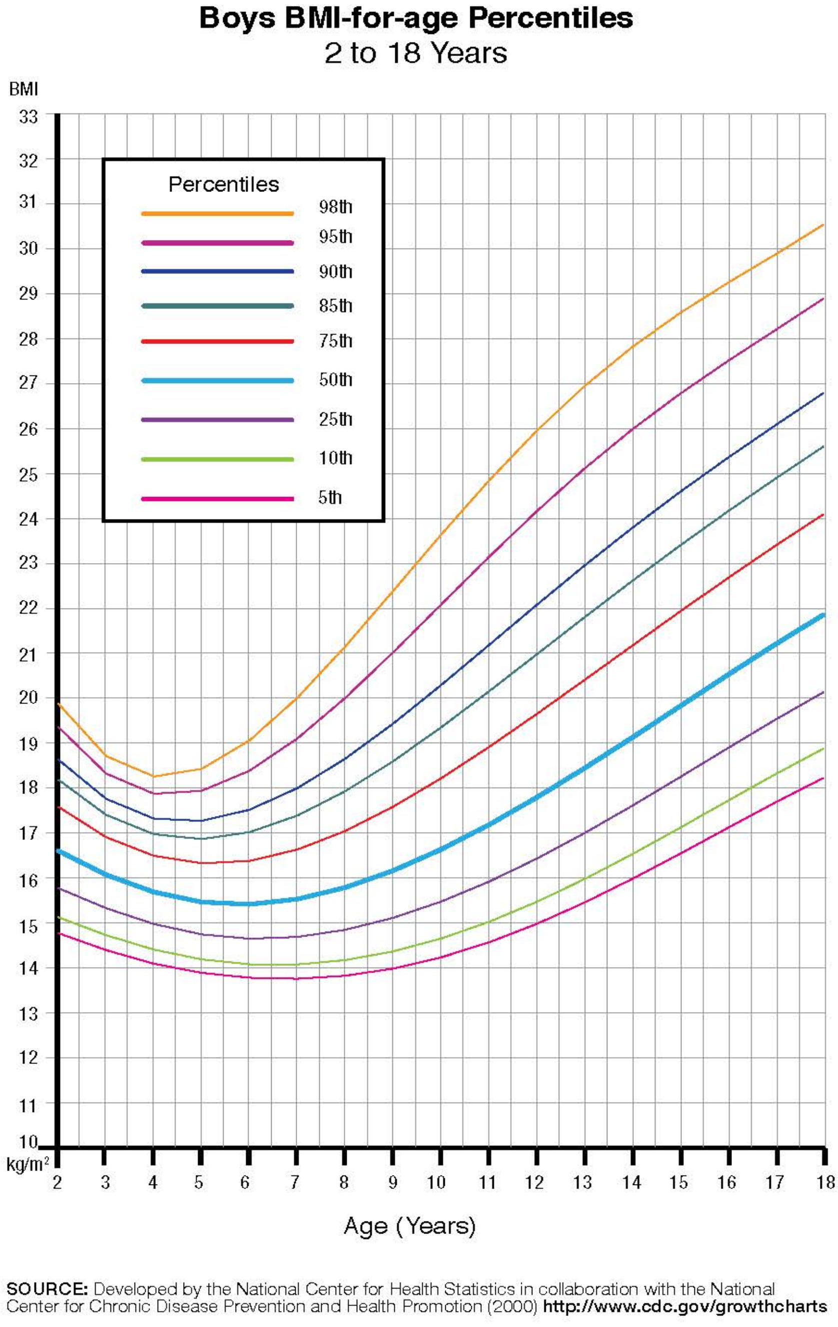

Figure 2.5: Percentiles for boys' body mass index (BMI) between the ages of 2-18

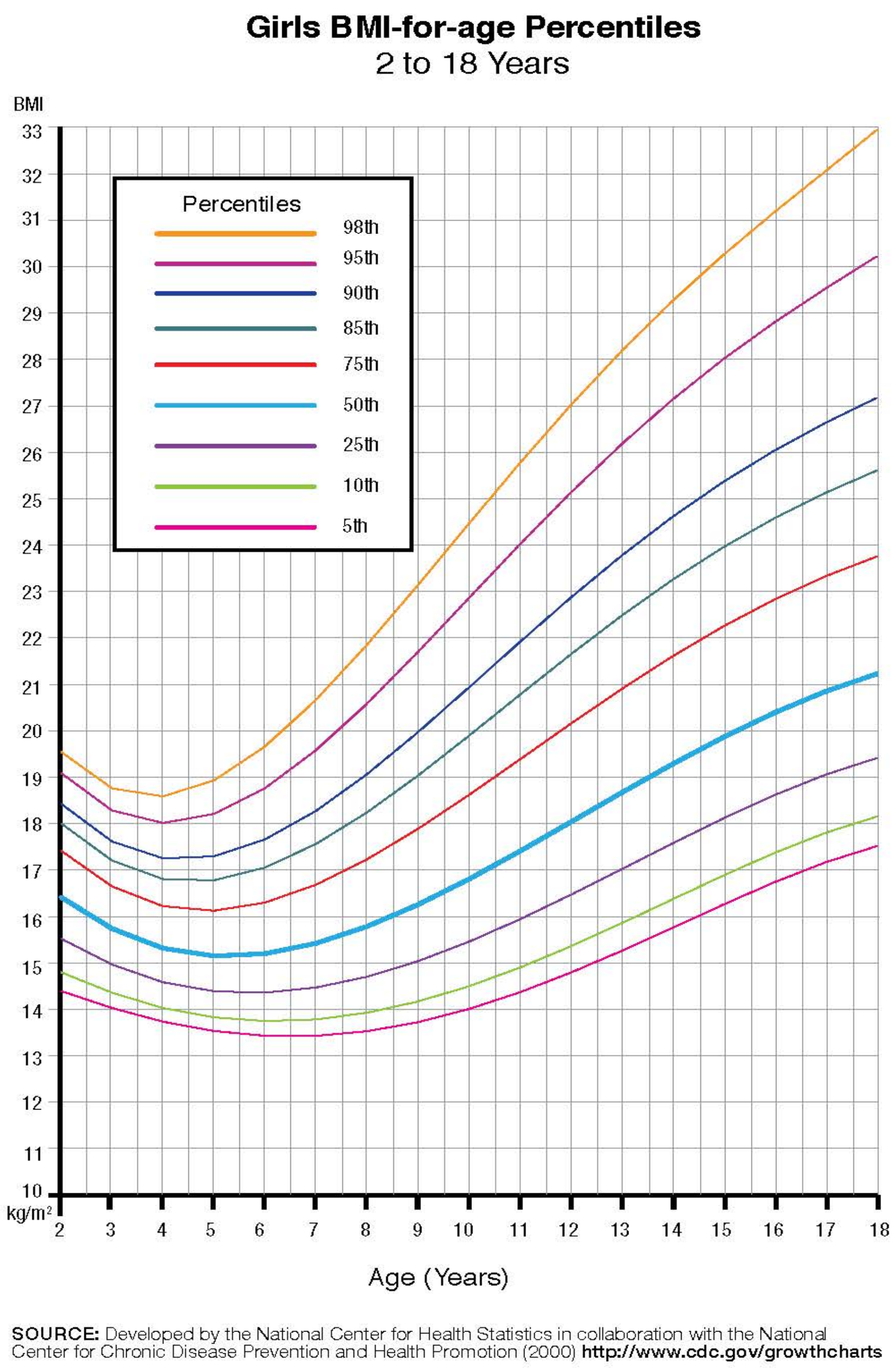

Figure 2.6: Percentiles for girls' body mass index (BMI) between the ages of 2-18

2.2.4. Skinfold thickness

Skinfold thickness measurements are very useful in the indication of subcutaneous fat in the body. It is easy, uncomplicated and a straightforward means for estimating and calculating body composition (Parker *et al*., 2003), consistent and a convincing method of deciding percent body fat and body density (Yeung & Hui, 2010) when compared to the underwater weighing method of estimating body composition. It is also economical, convenient and suitable in laboratory and sports settings such as physical education (PE) lessons, physical fitness centers and homes. More accurate and precise information on fat mass can be obtained by measuring skinfold thickness (SF) (Paineau *et al*., 2008). These measurements require observers with careful training and skills.

Several equations have been used to estimate percent body fat using skinfold measurement. Notably, the Slaughter *et al*. (1988) equation has been widely used because it is applicable to children in different settings. Some researchers have reported the accurateness and suitability of Slaughter equations (Steinberger *et al*., 2006; Louie *et al*., 2001) while Freedman *et al*. (2015) reported that, the equation yielded a partial estimate of body fatness. The Slaughter equations have been verified in participants who were 8 to 17 years of age and found to be consistent and accurate of which is the accepted equations worldwide used for children from diverse racial groups (Janz *et al*., 1993). The Slaughter equations to calculate body fat is thus:

(Triceps + Subscapular) > 35mm)

Boys: % Body fat = 0.783 (TSKF + SSKF) - 1.7 (Equation 1.2)

Girls: % Body fat = 0.546 (TSKF + SSKF) + 9.7(Equation 1.3)

(Triceps + Subscapular) < 35mm)

Boys: % Body fat = 1.21 (TSKF + SSKF) – 0.008 $(TSKF + SSKF)^2$ – 1.7 (Equation 1.4)

Girls: % Body fat = 1.33 (TSKF + SSKF) – 0.013 $(TSKF + SSKF)^2$ - 2.5 (Equation 1.5)

Where:
% = Percentage body fat
TSKF = Triceps skinfold thickness
SSKF = Subscapular skinfold thickness

The triceps and the subscapular skinfolds are highly correlated with BMI (Mehru *et al*., 2016; Freedman *et al*., 2015; Freedman *et al*., 2013; Freedman *et al*., 2009). There are various assumptions when applying the skinfold method to assess total body density in order to obtain percent body fat. Skinfold method is a good method that can be used to measure and determine subcutaneous fat in the body. There is a wide correlation between subcutaneous fat and total body fat. This is because the total of triceps and subscapular measurements can be used to estimate total body fat. Various internal allocation of subcutaneous fat is comparable for all individuals regardless of gender. The skinfold thickness method is used for clinical research and epidemiological purposes in children (Freedman *et al*., 2013; Freedman *et al*., 2009).

According to Billisari & Roche (2005) there is a high connection linking skinfold thickness and percent body fat (r = .7- .9) and there are no differences among other common sites. Skinfold thickness measurement in children with suitable validated prediction equations can be used to calculate approximately their body density and percent body fat (Sopher *et al*., 2005).

2.3. Physical growth pattern

Human growth and development is a constant process that starts from conception and ends at death. The physiology of childhood growth is considered by a speedy modification in the body size; legs growing faster than the chest region and both develop much faster and quicker than the head in proportion to the whole-body length (Rosenbloom, 2008). As growth progresses from infancy, early childhood is a quick period of brain growth with a rise in synapses and connections amid brain regions (Dubois *et al*., 2013). The brain reaches 75% of its adult weight at age 2 and 90% by age 5 while the remaining 10% of development is attained by the ages of 18-20 (Bertan & Guler, 1995).

In the primary phases of life- from infancy to childhood, childhood to adolescence and adolescence to adulthood massive changes occur. Throughout these processes, each person advances in the change of attitudes and values that guides his or her choices, understanding and relationships (Growth and Development, 2014). Each child's progress in growth and development is unlike any other child's, but their achievement of motor skills will occur in the same order as other children. More so, the development of these skills depends on the child's genetic makeup, cultural and environmental influence and everyday practices (Kazimierczak, 2012).

The appraisal and monitoring of child growth is highly dependent on the growth charts. Normally, medical practitioners use the growth chart to evaluate the growth of the child during visits for clinical assessments and evaluations. Diverse methodologies were used by researchers to examine the connection between growth and the future menace of obesity in children. According to Marie-Francoise *et al*. (2011) different parameters to consider include the US CDC United States (the Centres for Disease Control and Prevention); and the WHO Growth references from France, Netherlands, Belgium and UK. These growth indicators are used to assess the growth of breast-fed infants and non-breast fed infants to assess growth and predict future risk of obesity because an extreme increase in weight and length is a good indicator of future risk; and therefore it is vital to be aware of the significances of the methods used in clinical or epidemiologic contexts (Marie-Francoise *et al*., 2011).

2.4. Determinants of child growth

Different factors affect the growth patterns of children during early stages of their life cycle. These factors include: hereditary and environmental factors. Genetics as a hereditary factor acts as a major function in the bodily growth and development of a baby (Han-Na *et al*., 2010). Genes can be said to influence the rate of growth by stipulating the number of hormones to be released. Hormones on the other hand, are chemicals that are formed and secreted into the bloodstream by glands. Genes influence the type of hormones, quantity and rate at which they are released.

The genetic profile of parents may have influence on the physical trait of their children and other traits such as children's stature and rate of growth (Malina & Bouchard, 1991). At birth, there is a secretion of growth hormone which influences the growth of all parts of the body. Mayer *et al*. (2010) reported that children with impaired growth are seen to have deficiencies of growth hormone. Supplements are given to salvage the condition and to help stimulate growth (Hardin *et al*., 2007). Nutrition and malnutrition is an environmental factor that affects growth too (Arija *et al*., 2006).

Generally, growth is a significant indicator of good wellbeing and this lies mostly on diet or nutrition. Malnutrition also affects growth. Malnutrition is a main contributor to the double burden of disease in South African children and adolescents. Malnutrition can either be over nutrition or under nutrition. According to Reddy *et al*. (2008), as in many other developing nations in evolution, South Africa is experiencing both under nutrition and over nutrition. Furthermore, these problems are excessively distributed by socio- economic and cultural factors. Under nutrition or over nutrition is a global public health challenge (Reddy, 2009) and it is very important to note these trends in children and adolescents and its harmful effects on health generally (Monyeki *et al*., 2012).

2.4.1. Over nutrition (overweight or obesity)

Overweight and obesity has become a global health challenge. It is reported in 2013, that 42 million (7%) children under five (5) years of age were overweight, an increase of 54% from 28 million in 1990 (UNICEF, WHO, The World Bank, 2013). The trend in overweight is rising in many regions. Between the year 2000 and 2013 overweight prevalence increased from 1% to 19% in South Africa (UNICEF, WHO, The World Bank, 2013). Uncontrolled overweight can lead to early onset of chronic non-communicable diseases like stroke, diabetes and cancer (WHO, 2012). These chronic and deadly diseases were the cause of 35 million deaths worldwide in 2005, 80% of people who were affected were said to be in low and middle income countries (WHO, 2012). These afore mentioned diseases lead to the decline of not only health-related physical fitness (Kruger *et al*., 2004), academic readiness and achievement (Wu *et al*., 2017; Florin *et al*., 2011; Daniels, 2008; Taras & Potts-Datema, 2005), discrimination, reduced psychological well-being and stigma such as isolation and social withdrawal (Puhl & Heuer, 2010).

The incidence of overweight and obesity in South African children at current is said to be at least like that seen in developed countries more than ten years ago (Truter *et al*., 2010; Armstrong *et al*., 2006) and it has also been said to be on equivalence with that of many industrialized nations and amongst the highest in Africa (Reddy *et al*., 2008). These statistics are rather frightening as the WHO stated that the fastest increasing rates in overweight and obesity are in Africa with the number of overweight or obese children in 2010 more than twice that in 1990 (De Onis, 2000).

One of the major causes of being overweight or obese in children is their dietary intake, bad eating patterns and habits. These bad habits have been positively associated with overweight status in children (Nicklas *et al*., 2003) this includes high consumption of sweetened and sugared beverages, sweets, meats and total gram consumption of low-quality foods such as snacks and soft drinks which adds no worth to their health (Ludwig *et al*., 2001; Basiotis *et al*., 1998; Dennison *et al*., 1997). Overweight or obesity in children is also associated with sedentary lifestyles and massive intake of energy dense foods over balanced diets following increasing expansion of technology (WHO, 2014; Jinabhai *et al*., 2007; Vorster *et al*., 2005), geographical area, environmental and socio-economic factors (Grassi *et al*., 2016).

Childhood obesity is associated with reduced motor skills, social skills and daily activities (Cawley & Spiess, 2008). The literature has showed that overweight or obesity in childhood and adolescents increase the prevalence of adulthood risk for disability pension, untimely death and morbidity (Reilly & Kelly, 2010). It was predicted that non- contagious diseases such as obesity related ailments, could be the cause of 7 out of every 10 deaths by 2020 (Boutayeb & Boutayeb, 2005). It is vital to know that a person's lifestyles are determined by his or her untimely life experiences. If children could be exposed to quality healthy life experiences, there are high chances that they could adapt to them in their adult lifestyle. Preventing childhood obesity must be the fore most focus of plans and strategy put in place to reduce the health-related costs of obesity (Paxson *et al*., 2006).

2.4.2. Under nutrition (stunting or wasting)

Globally, there is an alarming increase of under nutrition in children under five years of age. In 2011, it is reported that, 99 million (15%) children under five (5) years of age were underweight, 161 million (25%) were stunted and 51 million (8%) were wasted (UNICEF, WHO, The World Bank, 2013). Interestingly, 90% of the world's stunted children live in Africa and Asia (UNICEF, WHO, The World Bank, 2013). Inadequate nutrition has been linked with stunted growth, wasting, health challenges (kwashiorkor, scurvy, beriberi), poor academic performance, poor relationship with peers and mates (Hampton, 2007; Galal & Hulett, 2003; Alaimo *et al*., 2001). A major public health challenge in many countries is the issue of child under nutrition and this continues to threaten the bodily growth and psychological development of children which indeed pose a threat to their very survival.

The WHO indicates that deprived diet is the sole significant menace to the world's wellbeing. The effects of under nutrition are long term and ensnare the on coming generations of individuals and communities with deficiency and poverty. Other effects of under nutrition on the child are the increase in morbidity, mortality, impaired mental and scholarly development. Retarded growth in early childhood can lead towards delayed achievement of motor skills (Heywood *et al*., 1991) and delayed mental development (Mendez & Adair, 1999) tracking to adulthood (WHO, 1995).

In Ball *et al*. (2008) study conducted in North Carolina, involving 20 child care centers to examine the extent to which the child care centers diet matched with the federal recommendations for children aged 2 to 5 years, only about one half to one third of these centers met the recommendations for milk, 13% for whole grains and 7% for dark vegetables.

Young growing children in full time child care center consume diets that may not meet the federal guidelines for nutrition which can pose a threat to their growth (Ball *et al*., 2008). Dietary deficiencies like vitamins A, B, D and K as well as iron and calcium may have negative penalties in the growth and development of the children globally (Lips, 2010; Ramakrishnan, 2002).

According to McDonald *et al*. (1994) drought can be a threatening factor to the growth of children as food intake can decline drastically. For example, research has shown that children under the age 2 who are undernourished had lower scores on cognitive measures throughout childhood and into adulthood than did those who were older (ages 6-8) (Ampaabeng & Tan, 2013). There are impairments in motivation, inspiration, curiosity and the capability to interact with the environment (Smithers *et al*., 2011; Arija *et al*., 2006), being less active during play and loss of concentration in class (McDonald *et al*., 1994).

Socioeconomic factors affect malnutrition of children. Monyeki *et al*. (2015) revealed that 0.7% - 66% of underweight was reported among children in rural areas of South Africa and 14.9% wasting in South Africa children compared to 2.6% of children in urban settlement. Low income families have difficulty in providing their children with healthy foods for healthy growth. In 2013, about 14% (17.5 million) households lack monetary means and income to supply adequate food and provisions for their children (Coleman-Jensen *et al*., 2014). Inadequate nutrition has been linked with stunted growth, wasting, health challenges, poor academic performance, poor relationship with peers and mates (Hampton, 2007; Galal & Hulett, 2003; Alaimo *et al*., 2001), kwashiorkor, scurvy, beriberi among others.

2.5. Role of physical motor activities on child growth and development

World Health Organization (WHO, 2011) defined physical activity as any physical movement produced by skeletal muscles that requires power expenditure or disbursement. Exercise should not be mistaken with physical activity. Exercise consists of activities that are planned, structured, repetitive and purposeful body movement to improve or maintain the components of physical fitness. In its broad context, PA includes exercises and other activities which involve physical movement and these are done as part of playing, walking, working, active transportation, house chores, recreational activities etc. Depending on the environmental conditions, a healthy child should participate in both physical exertion levels. According to WHO (2011), physical inactivity is the fourth foremost threat against chronic diseases including obesity, cardiovascular diseases, hypertension, and diabetes. Globally, physical inactivity has been responsible for 6% of deaths which is about 3.2 million deaths per year. The data includes 2.6 million people from low and middle income countries and 670,000 of these deaths are premature and untimely (WHO, 2011).

Recent PA guidelines recommend that preschool children should amass at least 3 hours of PA spread throughout the day (Department of Health, 2011). The value and worth of physical activity to normal growth and development of children including their health and well-being cannot be over emphasized. Nutrition, exercise, physical and motor activities are main considerations affecting growth and development of children (Karim *et al*., 2015). Good eating habits and physical activity promotes health status, mental and physical well-being of the individual (Stang *et al*., 2005). However, over consumption of calories and reduced physical activity leads to childhood obesity which have negative impact on both physical and psychological health (such as depression) of the child (Dehghan *et al*., 2005). Regular physical activities inculcated during the early years of young children provide the utmost impact on mortality and longevity.

Regular active participation in PA in children does improve the quality of life, health status, enhance physiological capacities such as cardiovascular fitness, prevent non-communicable diseases, strengthen the bones and muscles, helps in endocrine glands secretion, improve psychological fitness, boosts number of hormones circulating in the body of the children (Pradeep, 2014). According to Pradhan & Behera (2013), regular PA improves respiratory function.

Understandably, PA not only contributes to the physical development of children (Biddle *et al*., 2004), but also the formation of social structures, improves sensory and emotional intelligence and stimulate cognitive development (Milteer & Ginsburg, 2012). Physical education in schools should be administered during the beginning or middle part of the day and not at the closing hour of daily teaching (Travlos, 2010). Making physical education a priority of the school day’s activities helps to improve the physical health of the child and helps to maximize the child’s academic potential (Institute of Medicine, 2013). Developing a good practice of physical activity will help benefit and recover the physical condition of the body (Pradeep, 2014).

Physical activity is essential for regular and normal growth and development of the bones, muscles and organs which helps in carrying and transporting of oxygen (Meen & Oseid, 1982). An evident impact of physical activity in growing children is the change of the environmental factors (Hills *et al*., 2002).

Previous studies show that active involvement in physical activity during childhood could have short term and long term implications for adulthood and old age (Telama *et al*., 2005; Tammelin *et al*., 2003; Telama *et al*., 1997). Besides, enhancing the physiological qualities, frequent PA should prevent childhood obesity as it speeds up the process of fat oxidation (fat loss) which is extremely important for the body to function optimally. In view of this, one may conclude that PA is considered as an essential measure for healthy strong growth and development in growing children. It was once said that “All work without play make Jake a dull boy”.

2.5.1. Research Interventions

Physical education should be integrated into the school curriculum. According to Pate *et al*. (2004), classroom teachers have a significant role to play in order to make young children active. Teachers in classroom may need to provide longer play periods and more energetic and convenient playground interventions in order to help children reach and sustain the levels of activity needed for healthy development.

Schneider & Lounsbery (2008) reported that competent teachers should be authorized to handle the physical education programmes during early childhood growth. Play and motor stimulating activities should be made enjoyable while schools should increase outdoor play time; parents should also do same at home (Timmons *et al*., 2007). Classroom teachers and caregivers should make sure that all children under their jurisdiction engage in a minimum of 60 minutes of moderate to energetic physical activity daily. This can be achieved by adjusting the daily school timetable to afford more outdoor activities and engaging children in more active play on the well-structured playground. Special attention should be given to girls’ activity level thereby, prompting them to engage in more active play (Tucker, 2008).

Apart from school teachers and parents, the community and it’s environ should play an important role in promoting physical activity for children from birth to early childhood (Institute of Medicine, 2011). Health and education professionals should provide guidance to parents of young children and care givers in the ways they can promote the physical activities of their children and reduce their sedentary activities (Institute of Medicine, 2011).

2.6. Correlations of Demographic variables with motor performance

Amidst other variables that affect motor performance of children, age and gender greatly play a role in the motor performance of children; other variables like temperament, home environment, social status, school adjustment, physical activity level, and body composition also influence motor development of children. Contemporary studies showed that generally, at all ages, the males are physically active compared to their female counterparts. The reasons for this variation may be attributed to the differences in motor skills refinement which includes frequent play opportunities leading to body expansion and physical fitness level (Wrotniak *et al*., 2006; Graf *et al*., 2004a). In a longitudinal study to examine the reason why girls are less physically active than boys, Telford *et al*. (2016) reported that the family, socio-ecological factors, school and environment act as negative determinants of girls less participation in PA. Other studies have reported higher participation of boys in PA compared to the girls (Wang *et al*., 2013; Belcher *et al*., 2010; Lee *et al*., 2006; Tudor-Locke *et al*., 2003). Based on assessments, boys performed better than girls in both locomotor and object control skills (Goodway *et al*., 2010).

In addition, studies have shown that, Gross Motor Development (GMD) is dependent on gender and sequential age (Malina *et al*., 2004). According to Campbell & Eaton (1999) gender differences have effect on the PA and motor skills performance in infants. Studies on the level of PA in 3 to 5 years old preschoolers by Metallinos-Katsaras *et al*. (2007) and Fisher *et al*. (2005) reports gender differences in PA and motor development, with the males being more active and agile than females. However, Cliff *et al*. (2009) observed no gender differences in PA performances and motor development of similar age children. The gender variations in motor skills of preschoolers from different studies have been associated with genetics, nutritional status of children and the geographical setting (Cliff *et al*., 2009; Fisher *et al*., 2005).

Environmental factors have profound influence on gross motor development (GMD) of children. According to Bouchard *et al*. (1997), the school situation plays a major role in the motor development of a child. In reality, the school is the most extremely structured and organized institution in the society where children use most part of their everyday life (Morgan *et al*., 2013). The school also plays an important role in a child’s motor development, thereby providing sufficient and enriching motor opportunities (Chaves *et al*., 2015). During physical education classes in the school the children's motor development may be influenced and improved in many ways.

Gestational age has been found to be a significant determinant of late motor skill development. Children born before 29 weeks of age or below 1000g birth weight (Piek *et* a*l*., 2008) are reported to have slow motor skill development. According to Keller *et al*. (1998), low birth weight poses a strong threat for delayed motor development during childhood. On the contrary, Chaves *et al*. (2015) in their study observed that, low birth weight of children may not have effect on the gross motor development of children if proper measures are put in place. They concluded that, the negative consequences of low birth weight may be corrected if children with low birth weight are exposed to different motor opportunities during their early phase of life. High risk pregnancy has also been seen to cause delay in the motor development of children (Torabi *et al*., 2012).

Jozic & Hrzenjak (2006) in their study on the relationships between morphological and motor skills of children observed that, there is a statistical significant correlation of subcutaneous adipose fat on the general motor abilities in children that is to say body composition can also affect the motor performance of children. Despite the well-known physical and health benefits of PA for children, many of today's children do not meet the recognized PA guidelines and spend a significant amount of their time on sedentary activities (Hills *et al*., 2007; Strong *et al*., 2005; Pate *et al*., 2002). Childhood overweight and obesity as well as lower motor skill levels have related to less active lifestyles (Kambas *et al*., 2012; Jimenez-Paron *et al*., 2010; Deforche *et al*., 2009; Wrotniak *et al*., 2006), PA might turn to be an important mediator (Barnett *et al*., 2011; Lubans *et al*., 2010; Stodden *et al*., 2008). More so, excessive body weight and fatness can compromise children's movement abilities thereby delaying the development of some motor skills. Therefore, lower motor ability and reduced PA levels may be considered as a factor that may have negative consequence on overweight and obese children (Barnett *et al*., 2011; Barnett *et al*., 2009; Stodden *et al*., 2008).

In their study on motor skill performance and physical activity in preschool children, Williams *et al*. (2008) reported that children with well and better developed motor skills are more agile than children with poor and worse motor skill performance. They concluded in their research that there is a connection linking motor skill performance and physical activity; and this could be an important intervention scheme to the health and well-being of growing children, mostly the obese. Increasing physical and motor activities have been seen to have positive impact on the accomplishment level of motor development, which in return positively influences the general development of children (Ketelhut *et al*., 2005; Kambas *et al*., 2004). Physical activity is not only significant in the physical development of children's body (Biddle *et al*., 2004), it is also vital to say social structures, improved sensory and emotional cleverness, and cognitive function in children (Milteer & Ginsburg, 2012) are also developed. Absent or retardation in motor development in timely and untimely years of infancy has caused a retrogression in the accomplishment of success in school, lack of attentiveness, low self-esteem, reduced social competency, behavioral related struggle etc. (Baumann *et al*., 2004; Dewey *et al*., 2002; Rose & Larkin, 2002). Furthermore, there is a bigger occurrence of difficulty in making suitable social and emotional adjustments to both play and learning situations in children whose motor skills are less well developed than those of other children whose motor skills are well developed within the same age bracket.

Lack of motor skills usually discourages children from participating in group games with their mates and other sports that encourage and promote social interaction. Hence, it is recommended that motor skill development should be encouraged in children since it serves as a strategic key in childhood interventions in order to promote and sustain long term physical activity (Barnett *et al*., 2009).

2.7. Motor skills performance of children

Motor development can be defined as the changes that occur in children's capability to oversee their body movement, natural waving and kicking movements that occur during birth to the adaptive control of reaching, bodily movement and complex sport skills (Adolph *et al*., 2003). At infancy, the gross motor development involves gaining control over the skills of crawling, walking and standing (Berk, 2003). Children at age 2 begins with smooth and rhythmic movement like running and jumping while children between the ages 3 – 6 years hop, gallop and skip. Thereafter, the upper and lower body skills unite into more efficient actions (Haywood & Getchell, 2005).

According to the American Academy of Pediatrics (2006), by the end of three years, a child should be able to climb well, walk up and down the stairs with alternating feet, kick a ball with the preferred foot, run easily, pedal a tricycle and bend over easily without falling. The developments of milestones are primer for the development of gross motor skills of children between 6 and 7. Children between 6 and 7 years old can do many physical activities: gallop smoothly, catch small balls thrown over greater distances, run with increasing speed increases to more than 18 feet per minute, increase power during throwing and coordination during catching. Motor development requires complex brain networking, therefore the development of motor skills starts before the child is even born. Post-natal phase children need to engage in a diversity of PA because play activities support and promote their motor development. Several researchers have postulated that there may be a connection between the status of children's motor skill performance and their levels of PA (Raudsepp & Pall, 2006; Wrotniak *et al*., 2006; Graf *et al*., 2004; Okely *et al*., 2001; Ulrich, 1987). The preschool years are categorized by important changes in the attainment and performances of children's locomotor and object control skills. Successful motor development in the early years of childhood is very important because it is tracked into adolescent stage (Skinner & Piek, 2001).

Several studies have revealed that good and suitable amounts of physical fitness can lead to satisfactory development of motor skills during a child‘s preschool years (Burgi *et al*., 2011; Eliakim *et al*., 2007; Reilly *et al*., 2006). The preschool years in children are seen as a critical period in their lives whereby children's PA habits are being developed (Ward *et al*., 2010) and this in turn, help to achieve well-developed motor skills. Children who do more or engage themselves in PA are always seen to have a high level of motor skill performance which also helps them to boost their future partaking in sports and club activities (Okely *et al*., 2004).

It is recognized that children with severe developmental delays are seen to have poor motor skills performance. Williams *et al*. (2008) study concluded that children with well and better developed motor skills are physically active than children with poor motor skills, which was predicated on active participation in PA.

Okely *et al*. (2004) revealed that there is a significant correlation between performance of locomotor skills and weight status among children. This suggests that intervention plans to stop unhealthy weight gain among children might helpfully involve heightening the ability of locomotor skill. However, motor skill performances in children are known to have a great impact and role in their health status.

2.8. Relationship between motor development, growth rate and resting blood pressure

Motor development is widely associated with maturation and growth of children. Growth rate is also defined as increase in height and body stature. Certain growth indicators are used to describe growth rate; height for age, weight for age, weight-for-length and BMI-for-age

(WHO, 2008). The general progress of a child depends on the motor skill development of the child. The level of progress in a child's motor skill development must be taken into serious consideration in order to institute a baseline in which the growth and development of the child will be monitored. It has been reported that overweight and obese children have a deficit in motor development (Williams *et al*., 2008). Resting blood pressure is the pressure exerted by circulating blood upon the walls of blood vessels. Blood pressure is often expressed in terms of the systolic (maximum) pressure over diastolic (minimum) pressure and is measured in millimeters of mercury (mmHg). According to the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004), the normal blood pressure in children is defined as systolic blood pressure (SBP) and diastolic blood pressure (DBP) less than 90^{th} percentile for age, sex and height. For each heartbeat, a systolic and diastolic pressure varies. Systolic pressure is the peak pressure in the arteries, which occurs near the end of the cardiac cycle when the ventricles are contracting. Diastolic on the other hand is the minimum pressure in the arteries, which occurs near the beginning of the cardiac cycle when the ventricles are filled with blood. Appendix C and D show the blood pressure reading for both boys and girls according to age and height.

Table 2.2: Classification of hypertension in children and adolescents (norm)

Class	SBP and DBP Percentile
Normal	$< 90^{th}$
High- normal	$\geq$ 90th to $< 95^{th}$
	≥120/80 even if below 90th percentile in adolescents
Stage 1 hypertension	95th percentile to the 99th percentile plus 5mmHg
Stage 2 hypertension	> 99th percentile plus 5mmHg

Source: National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004).

The occurrence of raised BP is high globally; two-thirds of those affected are from developed countries while one-thirds of those affected are from developing countries (Kearney *et al*., 2005). This suggests that cardio-metabolic and renal diseases could spread to an epidemic proportion in the nearest future. The National Institute of Health National Heart, Lung and Blood Institute (2007) recommends regular BP measurements starting at 3 years old this is to track BP trends over time in order to easily detect any potential problem that may affect the child in future.

According to Gellermann *et al*. (1997) children with blood pressure reading of > 95th percentile must have their BP repeated at least three successive visits before they can be called hypertensive. In children, the normal range of BP standards is based on sex, age and height as these parameters offer a more accurate categorization of BP according to body size. A weight loss in overweight children is associated with a decrease in BP (Sinaiko *et al*., 2002) and excess body fat can raise BP (National Institute of Health National Heart, Lung and Blood Institute 2007).

A child's risk factors for high BP depend on whether the cause is a basic health condition or a lifestyle. The levels of BP change substantially with growth (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004). Children who have retarded growth from birth can be as a result of high BP of their mothers during pregnancy (Law *et al*., 2001; Yajnik *et al*., 2000). In relation to this, high BP among children in developed countries is related to small birth size irrespective of their current size (Law *et al*., 2000). According to Law *et al*. (2000) undernourished mothers also give birth to children whose growths are retarded; and children whose growths are retarded also tend to have poor motor development.

Cardiovascular risk factors in children are also associated to low birth size (Bavdekar *et al*., 1999) which also goes a long way in affecting their motor development. It is no exaggeration to suggest that keeping your BP under control is one of the most important things you can do to extend your lifespan.

2.9. The impact of physical activity (PA) on the academic performance of children

The all-round benefits of PA cannot be over emphasized. Previous research confirm that frequent involvement in PA can have many benefits to the child including improved general health status (United States Department of Health and Human Services, 2008), reduced risk of mental illnesses (Carek, 2011), cognitive functioning (Fedewa & Ahn, 2011), improved brain function, increased energy levels, body building, improved self-esteem, behavioral modification and improved academic performance (Dwyer *et al*., 2001).

Schools have been known as centres for promoting physical activity because children spend most of their time in school (Pate *et al*., 2006). However, decline in physical activity involvement in public schools has become a challenge of research. One of the pioneer studies reported that the percentage of overweight children has doubled (Hedley *et al*., 2004). Another follow up study reported that hypokinetic syndrome has led to the increase in metabolic complications, high blood pressure and other related lifestyle diseases (DuBose *et al*., 2006).

It has been reported that both fitness and fatness appear to be associated with academic achievement (Shore *et al*., 2008; Datar *et al*., 2004) and cognitive function (Roberts *et al*., 2010; Yu *et al*., 2010; Li *et al*., 2008) in children. In a recent review, it has been suggested that, the effects of PA on academic performance include improved cognitive functions specifically attention span, concentration and increased working memory (Donnelly *et al*., 2016; Mura *et al*., 2015; Norris *et al*., 2015; Singh *et al*., 2012; Fedewa & Ahn, 2011; Rasberry *et al*., 2011; Bailey *et al*., 2009; Tomporowski *et al*., 2008; Trudeau & Shephard, 2008).

Other research based recommendations show that there was a strong correlation (positive) between physical fitness and academic performance in children (Eveland-sayers *et al*., 2009). Also, physically active academic lessons are cost effective, do not need extra teacher preparation time, should be enjoyable for teacher and children and should yield positive end result in terms of academic achievement (Donnelly & Lambourne, 2011). Based on meta-analysis, Sibley and Etnier, (2003) reported a positive relationship found between physical activity and cognitive function including perceptual skills, intelligence quotient, academic achievement, verbal tests, mathematics test, developmental level and academic readiness in school-age children (age 4 – 18 years).

Several studies (Tomporowski *et al*., 2008; Trudeau & Shephard, 2008; Ahamed *et al*., 2007; Coe *et al*., 2006), have explored the association between physical activity and academic achievement and their findings suggests that physical activity may have a positive impact on learning and memory. Research also has explored the associations between physical education, physical activity, fitness levels, motor skill development and academic performance. Other studies have revealed that enhanced motor skill levels are positively related to improvements in academic achievement (Nourbakhsh, 2006; Son & Meisels, 2006). This justifies the fact that there is a positive association between increased physical fitness levels and children's academic achievement (Castelli *et al*., 2007; Martin & Chalmers, 2007; Themane *et al*., 2006; California Department of Education, 2005; Grissom, 2005; Kim *et al*., 2003; Dwyer *et al*., 2001).

2.9.1. Strategic approaches to blend PA in teaching

Exploring new teaching and learning skills to improve children's academic performance is very important and necessary. PA may be an effective strategy or plan in positively affecting the academic performance of children. A handful of studies have been carried out to assess the impact of classroom-based PA on children's academic performance, and lots of benefits were seen. Children's behaviour were improved (Mahar *et al*., 2006; Maeda & Randall, 2003), concentration (Norlander *et al*., 2005), recognition and memory (Fedewa & Ahn, 2011), reading and mathematical skills (Erwin *et al*., 2012; Uhrich & Swalm, 2007; Fredericks *et al*., 2006), improved numeracy in children with low scores (Resaland *et al*., 2016), positive learning and health outcomes (Martin & Murtagh, 2017) and many more from physical activities performed in the classroom setting. Elementary teachers are advised to create time for PA during their lessons in the classroom due to the numerous positive outcomes in children (Erwin *et al*., 2012). In addition, children can also engage in PA either within or outside the school setting in order to boost their performance.

2.10. Influence of blood pressure, anthropometric, growth pattern on motor development of children

There are various factors that can influence the motor development of children but this study focuses on the physiological, anthropometric and growth pattern on motor development of children. As a result of motor development, there are significant physiological changes which occur in childhood and adolescents. The blood pressure (BP) levels of children changes with growth (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004), increases with age among boys and girls which is positively associated with stature, body mass, BMI, body fat and the sum of skinfolds (Adiele & Morgan, 2017; Goon *et al*., 2013; Moselakgomo *et al*., 2012).

According to Cawley and Spiess (2008), high percentile ($85^{th} \geq 95^{th}$) of BMI in children is associated with reduced motor skills. Đokić and Međedović (2013) confirmed in their study on the effect of overweight and obesity on motor skills of children. Krombholz (2012); Logan *et al*., (2011); Morano *et al*., (2011); Nervik *et al*., (2011) also reported that children whose BMI are above the 85th percentile are seen to have impairment in motor development.

Children who are overweight and obese do not necessarily exhibit medical symptoms, but the essential physiological changes that may lead to medical conditions such as cardiovascular disease (CVD), hypertension and type 2 diabetes, begin in this early stage of development (Daniels, 2006). More so, it is normally believed that the frequency of physical motor mobility develops naturally with physical growth and maturation. Young children who show signs of low motor skill development will be less physically active, thereby resulting to higher obesity rates (Stodden *et al*., 2008; Stodden & Goodway, 2007). This is due to extra weight gained as a result of poor movement by obese children which may affect the development of motor skill proficiency in other skills (Clark, 2007).

According to Adolph (1997), infants who are slimmer begin walking sooner than heavier infants. More so, little is known about the effects of physical growth on motor development of children with a high occurrence of growth retardation. Studies have reported body composition to be negatively related to locomotor skill proficiency (e.g. running, jumping, galloping, hopping) but did not reveal same in object control skill (e.g. kicking, catching, striking, dribbling, throwing) (Castetbon & Andreyeva, 2012; Cliff *et al*., 2011; Poulsen *et al*., 2011; Morano *et al*., 2010; Jones *et al*., 2009; Okely *et al*., 2004; Southall *et al*., 2004). The findings of Paganini *et* al. (2016); Kariger *et al*. (2005); Kuklina *et al*. (2004); Black *et* al. (2003); Lozoff *et al*. (2003), reveal the influence of nutritional factors on motor development of children who are nutritionally at risk, in other words, growth rate can affect the motor development of children. It has been suggested that there is a connection between growth performance and motor development in children (Carrel *et al*., 2004; Cooke & Foulder-Hughes, 2003). Growth restriction which appears as a limitation in children who are affected can be amendable to intervention and subsequent improvement as outcome.

2.11. Qualitative and quantitative assessment of motor development in children

The early age of children is very sensitive where the fundamental movement skills of children are considered to be developed (Gallahue & Donnely, 2003). During infancy, skills development can be based on holistic appraisal of the child's motor development (Berk, 2003). The motor skills of a child are considered to be developed once the child can sit, move, grasp, reach for an object, and walk among others. However, as the child grows and matures emphasis in development of complex movement skills are reduced while the cognitive, social and emotional aspects of development receive more attention. The assessment of motor development in children is very important therefore, when dysfunctions or ineffective motor behavior appears motor development must be taken into consideration (Davies, 2003). The assessment of movement skill helps to plan an effective and efficient movement program which supports the child with special needs and also considers both the process and product of the child's movement (Ulrich, 2002).

There are many assessment tools that can be used to qualitatively and quantitatively assess the motor development in early childhood (Barnett & Peters, 2004). These movement skill assessment tools differ from each other in specific applications, usage and practice, but the basic idea of assessment and the achieved goals are similar and comparable. There are various types of tools that can qualitatively and quantitatively assess the motor development of children. Some can assess motor development in children qualitatively, some quantitatively and some can assess both qualitatively and quantitatively. Examples are: Test of gross motor development, second edition (TGMD – 2) (Ulrich, 1985; Ulrich, 2000), Movement assessment battery for children (Movement – ABC, Movement – ABC-2) (Henderson & Sugden, 1992; Henderson, Sugden & Barnett, 2007), Maastrichtse motoriek test (MMT) (Vles *et al*., 2004), Peabody developmental motor scales – second edition (PDMS – 2) (Folio & Fewell, 1983; Folio & Fewell, 2000), Motoriktest fùr vier-bis sechsjährige kinder (MOT 4-6) (Zimmer & Volkamer, 1987), Kòrperkoordinationtest fùr kinder (KTK) (Kiphard & Shilling, 1974; Kiphard & Shilling, 2007) among others.

In recent times, the most frequently used assessment tools for development of fundamental movement skill have been qualitative measures. These assessments use rubrics which have detailed attention on the technique of movement during movement. However, this has to do with how a child moves his or her body while performing a motor task. A typical example of this is by observing how the body is positioned when children are performing a high jump or floor gymnastics.

Quantitative assessment on the other hand, involves measuring the product or outcome of the performance of the child. The item score is a number which is used to compare the performance of a normative group. For example, the number of successful hops in 10 seconds or the distance in centimeters jumped. The scores are usually converted into standard scores and percentiles. This information enables the comparison of a child's performance to their chronological peers and could be used to screen for children with movement deficits.

2.12. Theoretical Framework

A theory is a principle or idea that is proposed, researched and generally accepted as an explanation. A theory of development is a scheme or system of ideas that is based on evidence and attempts to explain, describe and predict behaviour and development. This study employed the theory of motor development as postulated by Gesell (1940).

2.12.1. Maturational theory of motor development

Gesell in 1940 became the first psychologist to investigate human motor development in children. According to Gesell (1940), motor development starts from all parts of the child's body and then proceeds to specific parts of the body in two directions. The most recognizable signs of development in infancy are the achievement of these various milestones which are sitting, crawling, standing, walking, running, throwing, catching among others. Parents are very happy when these developments take place in their children. The development of motor skills in children has very important implications for other aspects of development. The development of motor skills in children increases with age and is also mainly determined by neurological maturation of the brain. The first direction is called the cephalocaudal trend where development starts from the head along the length of the body. The second direction is called the proximodistal trend, where motor control starts from the centre of the body outwards to more peripheral segments that is, the head, trunk and pelvic girdle.

2.12.1.1. Strengths and weaknesses of Gesell's theory

In relation to the current study, Gesell (1940) maturational theory of motor development was preferred because of its relevance to this study. Gesell (1940) postulated that the child's development is controlled by a maturational timetable which is linked to the nervous system and also to muscular development. When a child receives enriched motor training (climbing, throwing, catching etc.) there will be rapid motor development. He determined the standard progression of development in children that is at what certain age should children do certain things like sit up, roll over, crawl, grasp objects, walk, climb, and run etc. These age-norms he discovered are used today by medical profession, psychology profession and all child related fields. These age-norms provide us with a standard by which a child's development can been monitored.

However, the theory does not account for the considerable individual differences in the acquisition of various motor skills. More so, the fact that motor skills develop in a regular sequence does not prove a genetic cause i.e., other factors can also affect the development of motor skills of children. Gesell also opposed the idea of teaching children things ahead of their developmental program that once the nervous system of the child is well matured a child would begin mastering tasks like sitting up, standing up, walking, running and talking from their own inner urges (Slee *et al*., 2012). Furthermore, Gesell's theory centers more on maturation rather than environmental factors such as learning (Hupp & Jewell, 2014; Rathus, 2003), developmental stages explained by Gesell imply too much uniformity as if all children go through the developmental stages at the same age (Developmental behavioural pediatrics: Evidence and practice, 2008). Newborns have been found to be a lot smarter than Gesell originally view showing advanced competencies at early age (Crain, 2011).

2.12.2. Dynamic Systems Theory

Dynamic Systems Theory is a theory that shows how human gain knowledge from their everyday actions (Thelen & Smith, 1994). Dynamic Systems Theory can be applied to perceptual, motor and cognitive development in infants and early childhood (Thelen & Smith, 1994; Jones & Smith, 1993; Thelen & Ulrich, 1991; Thelen, 1989). In view of Dynamic Systems Theory, motor development is acquiring more complex systems of action. In light of this, infants (and children) develop skills in different ways. For example, there are infants who do not like to crawl, they will stand and walk before they crawl. Those infants who do not crawl will learn the skill in their own individual ways (Adolph *et al*., 1998).

The "Microgenetic studies" reveal that children first attempt of a new skill such as crawling, walking, and running etc. perform and master these skills effortlessly. Therefore, infants' attainment of a new motor skill is much the same as that of adults learning a new motor skill- the beginnings are usually fumbling and poor due to the trial and error type of learning. However, with significant attention, gradually there is accomplished skillful activity which is used in the development of new motor skills.

According to the dynamic systems theory a dynamic and continual interaction of the nervous system development, capabilities and biomechanics of the body and the environmental constraints and support results in the development of a new motor skill. Also, new motor skills are learned through a process of modifying and developing their already obtainable abilities.

2.12.3. Piaget Theory of Cognitive Development

As far as the concept of cognitive development of children is concerned, Jean Piaget was the most famous developmentalist who explained the relationship between cognitive and motor development (Armstrong *et al*., 2014). According to Piaget he believed that children are solely the active agent that can completely shape their own development and behavior by motivating themselves intrinsically rather than extrinsically. Piaget's theory is also referred to as the "constructivist theory" this is because children are supposed to shape their own behavioral development in relation with their environment (Piaget, 1970). This suggests that children learn to acclimatize to their environmental condition through cognitive adaptations. In view of these Piaget proposed four stages of cognitive development in children: Sensorimotor stage of infancy, the preoperational stage of early childhood, the concrete operation stage of middle childhood, the formal operation stage of adolescence and beyond

2.12.3.1. Strengths and weaknesses of Piaget's theory of cognitive development

The level of cognitive reasoning in a child helps in structuring the motor development of that child. A mental retarded will definitely have some challenges with his or her motor development. The cognitive part would not adequately help the child to structure his or her motor development and skills when exposed to opportunities for interacting with the environment. One of the major criticisms of this theory is that cognitive behavior does not develop beyond the formal operational stage (age 11 to 12) but researches with adults have shown to us that cognitive behavior continues to develop until late twenties. The Piaget's theory of cognitive development is still accepted as the guide in understanding human development.

Chapter Three: Research Methodology

3.1. Introduction

This chapter provides an overview of the research design and methodology used in evaluating the physiological, anthropometric and motor development characteristics of rural children in Nkonkobe Municipality. This section describes the research design, setting, population, sampling and sample size of the study, the research instrument, the validity and reliability, data collection procedure, ethical issues and data analysis techniques employed.

3.2. Research design

This was a cross-sectional descriptive study to evaluate the physiological, anthropometric and motor development characteristics of rural children in Nkonkobe Municipality.

3.3. Geographic location

This study was carried out in Alice sub-district, Nkonkobe Municipality. Nkonkobe Municipality is situated in the Eastern Cape Province of South Africa. It will amaze you to know that the Eastern Cape Province is one of the most indigent provinces in South Africa, with most of the municipal districts experiencing higher poverty rates than the national average (Dimant, 2014).

Nkonkobe Local Municipality with her code number (EC 127) was an administrative area in the Amatole district of the Eastern Cape in South Africa. The Municipality is named after the Winterberg mountain range, Nkonkobe in isiXhosa. Nkonkobe Local Municipality was established in 2000 and is made up of now disestablished Transitional Local Councils. Alice is a legislative seat and Fort Beaufort is the administrative seat. The latter is situated about 140km north-west of East London on the R63 and is approximately 200km north-east of Port Elizabeth.

The Municipality is the second largest local municipality, constituting 16% of the surface area of the Amathole District Municipality. The cities/towns in this municipality are: Alice, Beaufort, Hogsback, Middledrift and Seymore. Geographically, the total land area is 3 626km^2. It is located between 32^0 47^{1}S and 26^0 38^{1}E, with an approximate population of 127,115 thousand people (Statistics South Africa, Retrieved 27 September 2015). The Black Africans are the highest dominants in this municipality having 94.54%, coloured 4.00% and white 1.02%, others 0.26%, Indian or Asian 0.17% (Local Municipality 276 from Census 2011). The main language spoken is the isiXhosa other languages include- Afrikaans, English and others like: Zulu, Sesotho, Sepedi, isiNdebele, Setswana, SiSwati, Tshivenda and Xitsonga (Statistics South Africa, Retrieved 27 September 2015).

3.4. Study population

The target population for this study was rural school children aged between 5-7 years (grade 1 and 2) attending primary schools in Nkonkobe Municipality.

3.5. Sample and sampling procedure

A convenient selection of four schools comprising two public and private schools in Alice sub-district were selected. The following formula was applied for sample size calculation:

$$n = (z^2 \times p \times q / r \times e^2) \times \text{design effect}$$

where z = the standard normal deviate set at 2.4 and a confidence level of 95%, p = estimated population, q = 1-p, r = response rate and e = precision level). Thus, the appropriate sample size based on a study population of 1459 school learners was 305. The second stage involved the purposive selection of grade levels one and two in each of the selected schools. These grade levels were selected because the targeted ages were 5-7 years. In each of the selected grades in the school, simple random balloting was used to select the participants. This afforded all learners in each of the selected classes the eligibility to participate in the study. Children were asked to pick a blinded "Yes" and "No" paper. The "Yes" papers were selected to participate in the study.

3.5. Ethical considerations

Approval to conduct the study was granted by the University of Fort Hare ethical committee (Appendix H). Permission was obtained from the school principals of the selected schools (Appendix A). The children were briefed on the aim and nature of the study prior to data collection. Also, informed consent was obtained from the parents/guardians and the child (Appendix E).

3.6. Pilot study

A pilot study was conducted in October, 2016 to determine the logistics involved, technical procedures for data collection and also to validate the equipment to be used for the study. The sample for the pilot test consisted of 15 children from St. Joseph school in Alice town in Nkonkobe Municipality. The children and the school did not participate in the main study.

3.7. Data collection instrumentation

The demographic details of each child were obtained from the individual child and the school record register. Resting blood pressure was measured using aneroid sphygmomanometer according to standardized guidelines (National Heart, Lung and Blood Institute/ National High Blood Pressure Education Program: NHBPEP Coordinating Committee, Second Task Force on Blood Pressure Control in Children, 1987). Anthropometric measurements include height, body weight and girths (waist and hip circumferences), skinfolds (triceps and subscapular) using standard procedures (Marfell-Jones *et al*., 2006). The Test of Gross Motor Development- Second Edition (TGMD-2; Ulrich, 2000) was adapted to describe the motor skills development of the participants. The TGMD-2 is a standard and decisive factor which is used to measure the gross motor development skills for children within the age range of 3 to 10 or 11 years old. The TGMD-2 specifically assesses twelve (12) different tasks within two realms of motor development: the locomotor (run, gallop, hop, leap, horizontal jump, slide) and object control (striking a stationary ball, stationary dribble, catch, kick, overhand throw, underhand roll) domains. According to the TGMD-2 manual, individual performance was scored 1 to show the presence of that skill and 0 to show the absence of that skill, the scores range was between 6 to 10 points. The test was ideally administered on an individual basis. The test items were completed between 15 to 20 minutes.

The examiner demonstrated the desired skills to the participants and also verbally explained the skills before allowing the participants to perform and if the child failed to understand, the examiner repeated the demonstration and two test trials were assessed and appropriate performance score for each trial was recorded.

The scores of “0” or “1” are recorded for each task performed then the scores are summed up to generate a raw skill score based on each component of the motor skill. The total sum of these scores based on each domain yielded a raw subtest score for the locomotor and object control skills. Standard scores for both subtests were added and converted to an overall Gross Motor Quotient.

The TGMD-2 required equipment includes: cones, masking tape, 4-5" bean bags, plastic bat, nerf ball, batting tee, 8-10" plastic playground ball or soccer ball, 4" plastic ball and a tennis ball.

The reliability coefficients for the total scale i.e. locomotor and object control subscales have been reported based on three different sources of error variance: Internal consistency which reflects the degree of similarity among the skills tested; reliability coefficients >0.8 and low standard error measures suggests the TGMD-2 is a reliable test (Ulrich, 2000). Time sampling which indicated high magnitude of correlation (≥ 0.88) between the two trials suggesting its reliability in terms of stability overtime (Ulrich, 2000). Interscorer/intrascorer differences: This means there is a strong intertester reliability of 0.98 which suggests its consistency of scores (Ulrich, 2000).

3.8. Procedures for anthropometric measurements

The anthropometric measurements were performed according to the standard procedure of International Society for the Advancement of Kinanthropometry (ISAK) (Norton & Olds, 1996). The order of anthropometric measurements is shown in (Appendix B).

3.9. Basic measurements

3.9.1. Body stature

The body stature of the children was measured using the standard stadiometer. The children stood on bare foot (without shoes) with their feet together on a leveled cemented floor. Each participant's head was held erect with the eyes looking forward during measurement. The measurement was taken to the nearest 0.1cm.

3.9.2. Body weight

The body weight of the children was taken on minimal clothing and without shoes. The children stood on the center of the SECA scale without any support; the weight of the children was distributed evenly on both feet. All measurements were taken to the nearest 0.1kg.

3.9.3. Body Mass Index

The body mass index (BMI) of each of the participants was calculated as the ratio from weight kg / height^2.

3.10. Skinfold thickness

The second station was the skinfold thickness which measures the triceps and the subscapular sites. Skinfold thickness measures the fat located just underneath the skin (subcutaneous fat) (WHO, 1983) which is an alternative pointer of total fat. Measurement can be done in a number of sites including the triceps (the back part of the upper arm) and the subscapular area (site just below the shoulder blade) these are the major sites that were used in this study. Ross craft plastic slim guide caliper was used to measure skinfold thickness. Skinfold thickness was measured by grasping a fold of skin and the underlying subcutaneous tissue at the site to be measured. The fold was pulled away from the underlying muscle and the jaws of the calipers were placed on either side of the site at a depth of about one centimeter away from the edge of the thumb and finger. The skinfold was held tightly throughout the application of the caliper and the reading was taken when the needle became steady after the full pressure of the caliper jaws had been applied (less than two to three seconds). The calipers were applied at right angles to the fold at all times. All skinfold measurements were done on the right side of each child/participant. The measurements were recorded in millimeters (mm) with a required accuracy of less than 1.5 mm.

3.10.1. Triceps

The triceps is located at the back part of the upper arm. The triceps skinfold was raised with the left thumb and index finger on the marked posterior mid-acromial-radial line. The fold was erect and equivalent to the line of the upper arm. The skinfold was taken on the most posterior plane of the arm over the triceps muscle when viewed from the side. For measurement, each child’s arm was relaxed with the shoulder joint slightly outwardly rotated and elbow extended by the side of the body. The triceps skinfold was measured to the last 0.1 millimeter (mm). Each child was asked to stand erect with the feet together, shoulders relaxed and the arms hanging freely on the sides. The tester also stood behind the child’s right side. The point on the posterior surface of the right upper arm is located in the same area as the marked midpoint of the upper circumference. A fold of the skin and subcutaneous adipose tissue was grasped gently with the thumb and fingers approximately 2.0 centimeters (cm) above the marked level with the skinfold parallel to the long axis of the arm. The jaws of the calipers were placed at the marked level, perpendicular to the length of the fold, and the skinfold thickness was measured three times to the nearest 0.1mm while the fingers continued to hold the skinfold and readings recorded.

3.10.2. Subscapular

This is the site just below the shoulder blade, situated at the inferior border or on the underside of the scapular. The subscapular skinfold was measured to the nearest 0.1mm. The child stood erect with the shoulders and arms relaxed at the side. The examiner marked the inferior angle of the scapular with the cosmetic pencil marker. The examiner then grasped a fold of skin and subcutaneous adipose tissue directly below (0.1cm) and medial to the inferior angle. The skin forms a line about 45 degrees below the horizontal extending diagonally toward the right elbow. The jaw of the caliper was placed at the marked level, perpendicular to the length of the fold about 2.0 cm laterals to the fingers with the top jaw of the caliper on the mark over the inferior angle of the scapular. The skinfold thickness was measured to the nearest 0.1mm while the fingers continued to hold the skinfold and readings recorded.

Following these measurements, body fat percentage was calculated, fat mass, fat mass index, fat free mass and fat free mass index were calculated using the formula below.

3.10.3. Body Fat Percentage

In order to predict body fat of children, the skinfold equation of Slaughter *et al*. (1988) was used. The equation use the sum of triceps and subscapular skinfold thickness to predict body fat. The present study utilized the following equations to predict body fat:

(Triceps + Subscapular) > 35mm)

Boys: % Body fat = 0.783 (TSKF + SSKF) - 1.7

Girls: % Body fat = 0.546 (TSKF + SSKF) + 9.7

(Triceps + Subscapular) < 35mm)

Boys: % Body fat = 1.21 (TSKF + SSKF) – 0.008 $(TSKF + SSKF)^2$ – 1.7

Girls: % Body fat = 1.33 (TSKF + SSKF) – 0.013 $(TSKF + SSKF)^2$ - 2.5

Where:

% = Percentage body fat

TSKF = Triceps skinfold thickness

SSKF = Subscapular skinfold thickness

3.10.4. Fat Mass

Fat mass (FM) was calculated using percentage fat and body weight:

Fat mass (kg) = body weight (kg) x % Fat/100

3.10.5. Fat- Free Mass

Fat-free mass and fat mass indices provide important information about changes in body composition in weight gain or loss in children, adolescents and adults. It is calculated as:

Fat-free mass (kg) = body weight (kg) – fat mass (kg)

3.10.6. Fat Mass Index

Fat mass index (FMI) was calculated by dividing fat mass by stature-squared:

FMI (kg m^{-2}) = FM/$Stature^2$

3.10.7. Fat-Free Mass Index

Fat-free mass index is the fat free component of body mass which is expressed relative to stature which is calculated as:

FFMI (kg m^{-2}) = FFM/$Stature^2$

3.11. Girths measurement

This is the third section of anthropometric measurement. The girths measurements that were used in this study are the waist and hip circumference.

3.11.1. Waist circumference

Waist (minimal girth of the abdomen) circumference was measured using the Lufkin non-extensible flexible steel anthropometric tape to the nearest 0.1cm while the children were in a standing position. The horizontal contour at the high point of the iliac crest across the mid axillary line of the body was marked with a cosmetic pencil by the examiner. This was at the point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration. The examiner stood on the child’s right side and placed the measuring tape around the trunk in a horizontal plane at the level marked on the right side of the trunk. The measurement was made at the minimal respiration to the nearest 0.1cm and recorded.

3.11.2. Hip circumference

Hip (maximal girth of the buttocks) circumference was measured to the nearest 0.1cm using the Lufkin non-extensible flexible steel anthropometric tape while the child was in a standing position. The child was asked to stand erect with feet together and weight evenly distributed on the feet. The widest part of the hip was located and marked. i.e. at the level of greater trochanters. The examiner squatted on the right side of the subject and placed the measuring tape around the buttocks at the maximum extension of the buttocks. The examiner adjusted the sides of the measuring tape and checked the front and sides so that the plane of the tape was horizontal. The zero end of the tape was held at standing point. The tape was then held snug but not tight. The examiner took the measurement from the right side and recorded.

3.11.3. Waist-to-hip ratio (WHR)

The WHR was calculated by dividing waist circumference (cm) by hip circumference (cm).

WHR = WC/HC

Where:

WHR = Waist-to-hip ratio

WC = Waist circumference

HC = Hip circumference

3.11.4. Waist-to-height ratio (WHtR)

The anthropometric indexes **(WHR and WHtR)** also assess the pattern of fat distribution among children.

WHtR = WC/HC

Where:

WHtR = Waist-to-height ratio

WC = Waist circumference

HC = Height circumference

3.12. Resting blood pressure

Resting blood pressure (RBP) was measured using aneroid sphygmomanometer, according to standardized guidelines (National Heart, Lung and Blood Institute/ National High Blood Pressure Education Program: NHBPEP Coordinating Committee, Second Task Force on Blood Pressure Control in Children, 1987). The children were all seated with their right hand stretched as the blood pressure readings were carried out. All the readings were taken in duplicate on the right arm. The procedure was explained to the participants before the measurement. The readings at the first and third BP monitors were taken as systolic and diastolic BP (SBP and DBP), respectively. The BP measurements were recorded in the physiological proforma. Aneroid sphygmomanometer was used because it is handy designed and portable. Saxena *et al*. (2011) demonstrated in their study that aneroid sphygmomanometer achieved grade B performance according to the British Hypertensive Society Criteria. This confirmed the authenticity of this device.

3.12. Protocol of Data Collection

3.12.1. Assessing gross motor performances

The TGMD-2 test was used to assess the children's motor skills development as per its manual description for assessment standards (Ulrich, 2000). The test items were as follows: Locomotor subtest focused on (run, gallop, hop, leap, horizontal jump and slide skills) and object control subtests focused on (striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll) (Appendix F and G).

3.13. Data analysis

The participants' physiological, anthropometric, body composition and motoric data was analysed using descriptive statistics, i.e. means and standard deviations. A t-test was used to determine the gender differences in the physiological, anthropometric, and motoric variables of the participants. A probability level of 0.05 or less was used to indicate statistical significance. Finally, Pearson correlation was applied to determine the relationship between body composition and motor performance. All statistical analyses were carried out using the Statistical Package for Social Sciences (SPSS), version 22.0 for Windows (SPSS Inc., Chicago, IL, USA).

Chapter Four: Result and Discussion

4.1. Introduction

This chapter presents the results of the anthropometric, physiological and motor development of the participants involved in the study. Also, the findings of the study are discussed.

4.1.1. Sample distribution of the participants

The sample distribution of the participants showed that 305 children participated in the study. 159 (52.1 %) were boys and 146 (47.9 %) were girls. The mean age of the participants was 5.91 ± 0.83 years. The age and gender distributions of the sample are listed in Table 4.1.

Table 4.1: Sample distribution of the participants stratified by age and gender

Age (years)	Boys n (%)	Girls n (%)	Combined n (%)
5	59 (49.2)	61 (50.8)	120 (39.3)
6	55 (59.1)	38 (40.9)	93 (30.5)
7	45 (48.9)	47 (51.1)	92 (30.2)
Total	159 (52.1)	146 (47.9)	305 (100)

n = Number, % = Percentage

4.2. Descriptive variables of the study sample

Shown in Table 4.2 are the descriptive characteristics of the participants according to gender. The mean ages of boys and girls were 5.91 ± 0.81 and 5.90 ± 0.86 years, respectively. No significant difference ($p > 0.05$) was observed for age. The body mass (kg) and stature (cm) of the male participants (22.01 ± 4.39; 115.53 ± 6.64) were numerically higher than the female participants (21.27 ± 4.08; 114.77 ± 7.30). Most of the anthropometric variables (body mass, triceps, stature, waist, gluteal (hip)) and the physiological variables were not significantly different ($p > 0.05$). However, there was significant difference ($p < 0.05$) in the subscapular measurement between boys and girls. The derived variables are shown in Table 4.3. No significant differences were found in the derived variables of all participants across gender. The mean values of body mass index (BMI), fat-free mass (FFM), fat-free mass index (FFMI), waist-to-hip ratio (WHR) and mean arterial pressure (MAP) of male participants was observed to be higher than the female participants. However, the female participants had higher mean values in percentage body fat (%BF), fat mass (FM), fat mass index (FMI) and sum of skinfolds (SSF) than the male participants, while there was no gender difference in the mean values of waist-to-height ratio (WHtR) and sub-scapular-to-triceps ratio (STR).

Table 4.2: Mean and standard deviation (SD) for anthropometric and physiological measurements of the participants by gender

Variables	Boys (n = 159) Mean ± SD	Girls (n = 146) Mean ± SD	Combined (n = 305) Mean ± SD	p-value
Age (years)	5.91 ± 0.81	5.90 ± 0.86	5.91 ± 0.83	0.10
Body mass (kg)	22.01 ± 4.39	21.27 ± 4.08	21.66 ± 4.26	0.69
Stature (cm)	115.53 ± 6.64	114.77 ± 7.30	115.17 ± 6.96	0.20
Triceps (mm)	8.72 ± 3.14	9.62 ± 2.95	9.15 ± 3.07	0.44
Subscapular (mm)	5.76 ± 2.48	6.51 ± 2.55	6.12 ± 2.54	0.05*
Waist circumference(cm)	53.37 ± 4.05	52.27 ± 4.81	52.84 ± 4.46	0.07
Hip circumference (cm)	61.04 ± 6.59	61.37 ± 5.59	61.20 ± 6.12	0.99
Systolic blood pressure (mmHg)	69.19 ± 7.30	68.39 ± 7.97	68.81 ± 7.63	0.37
Diastolic blood pressure (mmHg)	38.15 ± 5.91	37.11 ± 7.53	37.65 ± 6.74	0.19

* Statistically significant at $p \leq 0.05$; SD = standard deviation

Table 4.3: Mean and standard deviation (SD) for derived anthropometric and physiological measurements of the participants by gender

Variables	Boys (n = 159) Mean ± SD	Girls (n= 146) Mean ± SD	Combined (n= 305) Mean ± SD	p-value
BMI ($kg.m^{-2}$)	16.39 ± 2.16	16.05 ± 2.00	16.23 ± 2.09	0.94
Body fat (%)	12.09 ± 4.90	14.71 ± 4.26	13.34 ± 4.78	0.38
Fat mass (kg)	2.78 ± 1.78	3.21 ± 1.43	2.99 ± 1.60	0.60
FFM (kg)	19.24 ± 3.17	18.07 ± 3.09	18.65 ± 3.13	0.12
FMI ($kg\ m^{-2}$)	2.06 ± 1.16	2.41 ± 0.94	2.23 ± 1.05	0.51
FFMI($kg.m^{-2}$	14.33 ± 1.34	13.64 ± 1.43	13.99 ± 1.38	0.13
∑2SKF	14.30 ± 5.50	16.02 ± 5.37	15.12 ± 5.50	0.73
WHR	0.88 ± 0.08	0.85 ± 0.05	0.87 ± 0.71	0.44
WHtR	0.46 ± 0.03	0.46 ± 0.04	0.46 ± 0.03	0.38
STR	0.68 ± 0.17	0.68 ± 0.16	0.68 ± 0.16	0.43
MAP	53.67 ± 5.68	52.75 ± 6.99	53.23 ± 6.35	0.22

* Statistically significant at $p \leq 0.05$; BMI = Body mass index; FFM = Fat-free mass; FMI= Fat mass index; FFMI = Fat-free mass index; Σ2SKF = Sum of two skinfolds (triceps and subscapular); WHR = waist-to-hip ratio; WHtR = waist-to-height ratio; STR = Subscapular-to-triceps ratio; MAP= Mean arterial pressure

4.3: Body size measurements

4.3.1. Body mass

Boys were heavier than girls for the age groups 5 and 7 and both sexes had similar mean values for age 6, respectively. However, body mass increased with advancing age in both sexes, with means ranging from 20.2kg to 24.7kg in boys and 19.2kg to 23.5kg in girls. Figure 4.1 showed the changes in body mass of both boys and girls with advancing age.

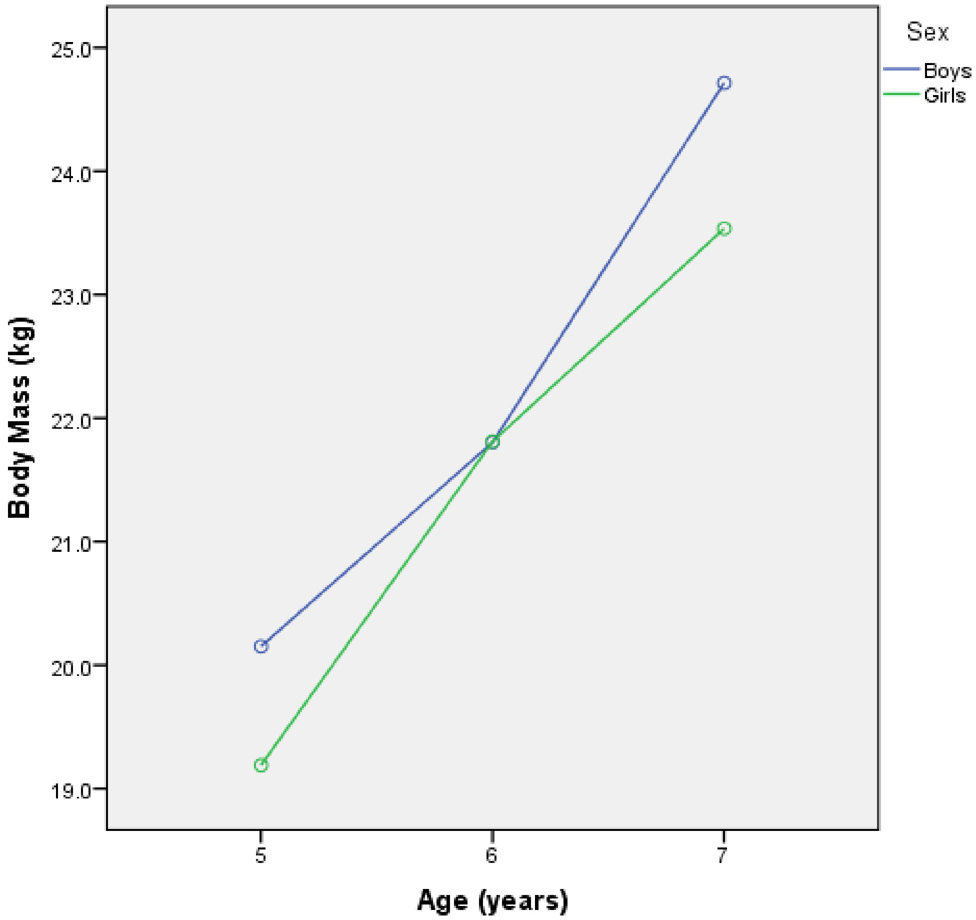

Figure 4.1: Age trend analysis of body mass

4.3.2. Stature

Boys at age 5 were taller when compared to girls of the same age group. Both boys and girls had similar mean stature at age 6 and 7, respectively. Stature increased with age in both boys and girls (Figure 4.2).

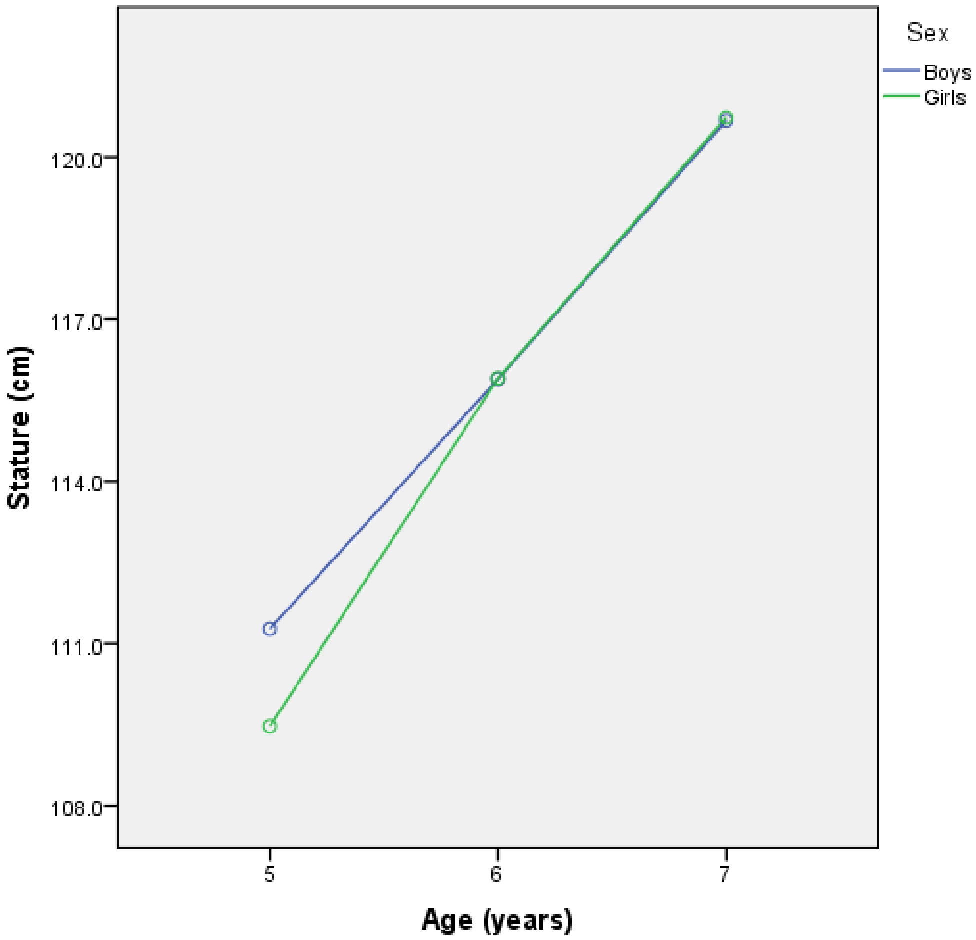

Figure 4.2: Age trend analysis of stature

4.4: Body composition

4.4.1. Body Mass Index

The mean BMI of boys was higher than that of girls in all ages 5, 6 and 7, respectively. The BMI varied considerably with age and gender. There was a sharp increase in the mean BMI of boys at 7, while the BMI of girls was fairly distributed across ages (Figure 4.3).

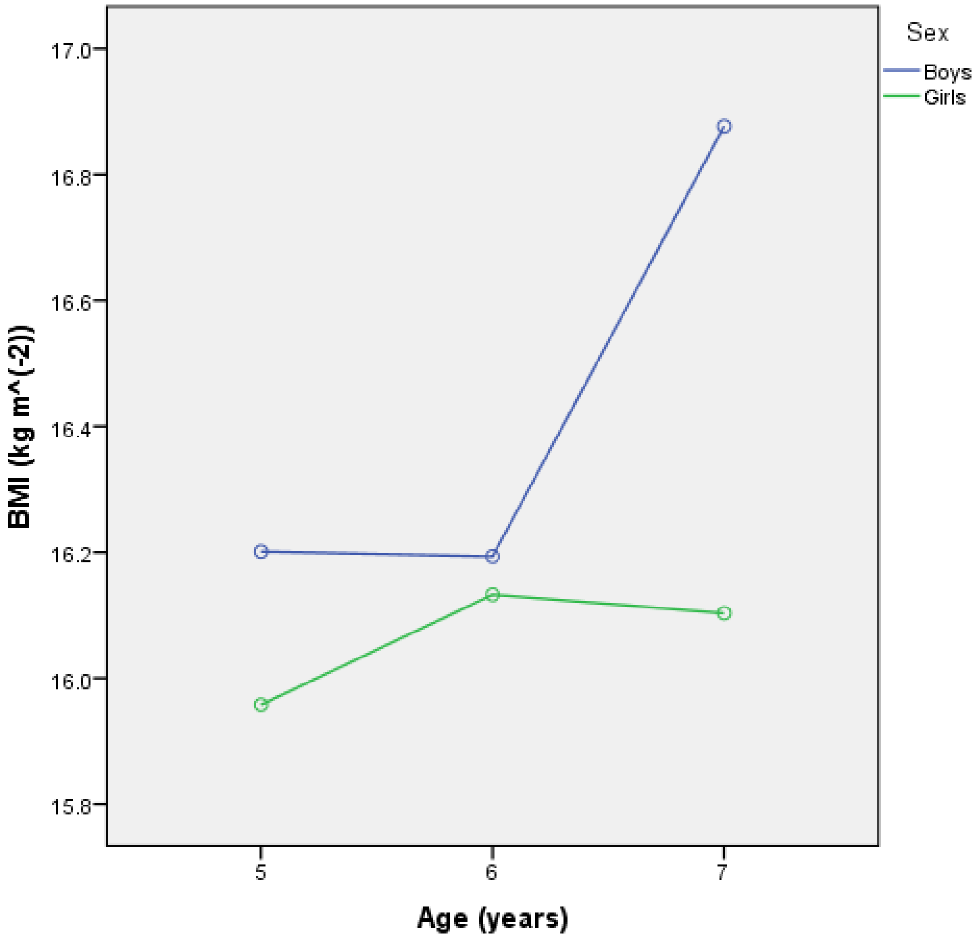

Figure 4.3: Differences in body mass index of boys and girls stratified by age and gender

There CDC definition of weight in children is as follows: weight less than the 5th percentile indicates underweight, weight over the 85th percentile indicates excessive weight and above the 95th percentile indicates obesity (Cole *et al*., 2000). The prevalence of obesity, excessive weight and underweight using the CDC BMI based cut-off points among children according to age and gender in this study is presented in Table 4.4. The result showed that 13 (4.26%) participants were underweight, 214 (70.16%) had normal weight, 40 (13.12%) overweight and 38 (12.46%) were obese (Table 4.4). Among the boys, 8 (5.03%) were underweight, 111 (69.81%) had normal, 17 (10.69%) overweight and 26 (16.35%) were obese. The corresponding figures for the girls were 5 (3.43%) underweight, 103 (70.55%) normal, 23 (15.75%) overweight and 15 (10.27%) obese. Boys had higher percentages of underweight (5.03%) and obesity (16.35%), while girls had higher percentages of normal weight (70.55%) and overweight (15.75%).

Table 4.4: Prevalence of obesity, excessive weight and being underweight among school children in different age groups by gender

			CDC definition		
		Underweight	Normal	Overweight	Obesity
Age (years)	N	n (%)	n (%)	n (%)	n (%)
Boys					
5	59	4 (6.78)	40 (67.80)	6 (10.17)	9 (15.25)
6	55	4 (7.27)	36 (65.46)	8 (14.55)	7 (12.73)
7	45	0	35 (77.78)	3 (6.67)	7 (15.56)
Total	159	8 (5.03)	111 (69.81)	17 (10.69)	26 (16.35)
Girls					
5	61	2 (3.28)	42 (68.85)	10 (16.39)	7 (11.48)
6	38	0	28 (73.68)	6 (15.79)	4 (10.53)
7	47	3 (6.38)	33 (70.21)	7 (14.89)	4 (8.51)
Total	146	5 (3.43)	103 (70.55)	23 (15.75)	15 (10.27)
Boys + Girls	305	13 (4.26)	214 (70.16)	40 (13.12)	38 (12.46)

Pearson chi2 (2) = 21.1p = 0.000; *Based on CDC's BMI age and sex-specific (Cole *et al*., 2000)

4.4.2. Body Fat Percentage

The females had a higher mean value of percentage body fat compared to the male participants. However, percentage body fat fluctuated with age in both boys and girls as shown in Figure 4.4.

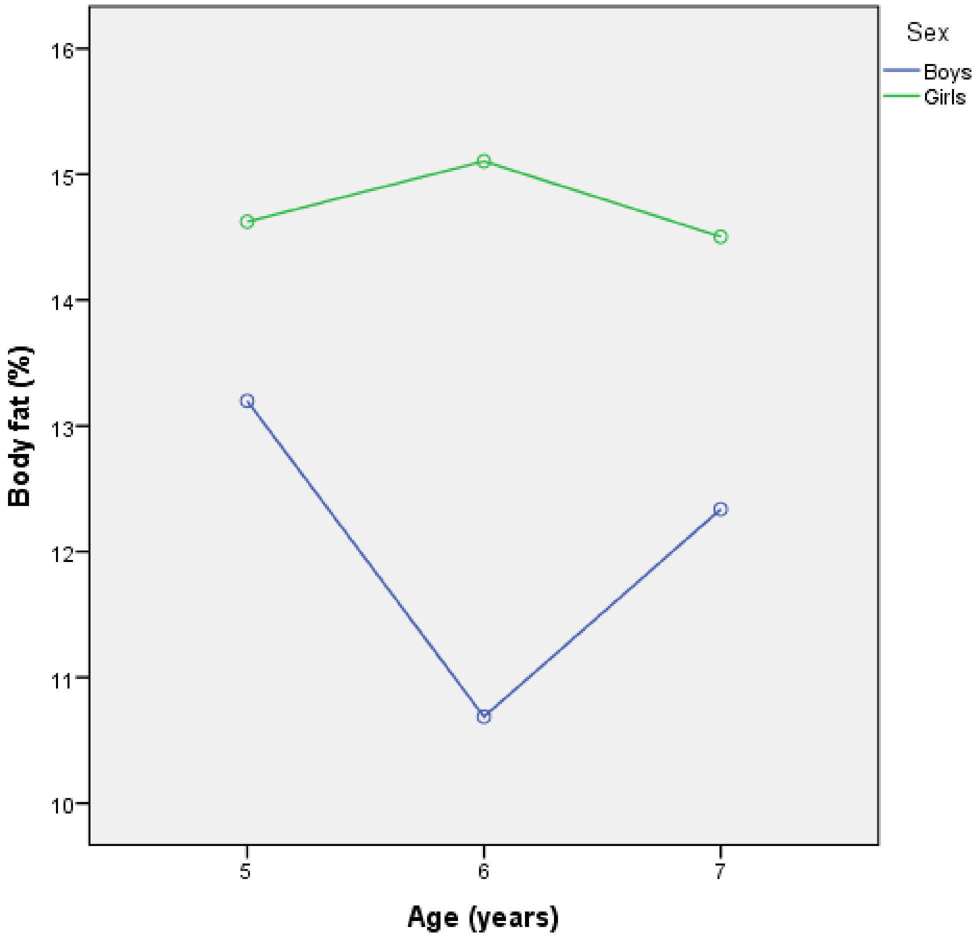

Figure 4.4: Differences in the body fat percentage of boys and girls stratified by age and gender

4.4.3. Fat Mass

The mean fat mass value of girls (3.21 ± 1.43 kg) was higher than that of the boys (2.78 ± 1.78 kg). In all ages, girls had higher fat mass compared to boys; however, there was fluctuating trend in the fat mass of both boys and girls in ages (Figure 4.5).

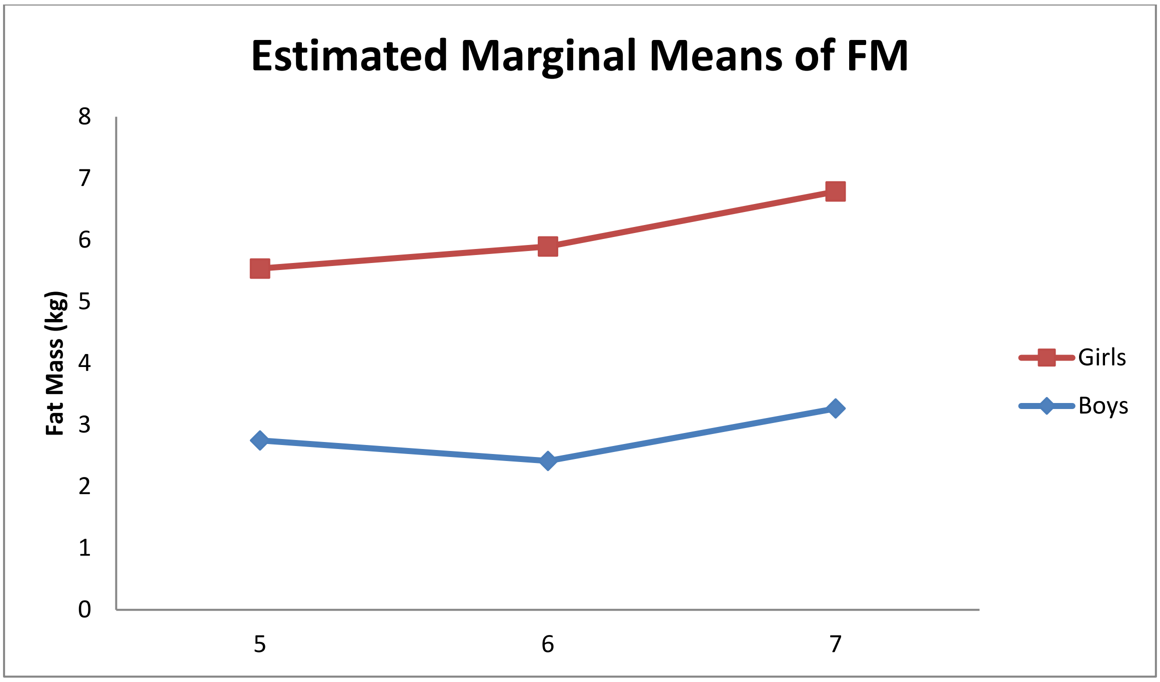

Figure 4.5: Age trend analysis of fat mass

4.4.4. Fat-Free Mass

Boys (19.24 ± 3.17 kg) had higher mean value of fat-free mass than girls (18.07 ± 3.09 kg). The fat-free mass of both boys and girls increased with age (Figure 4.6).

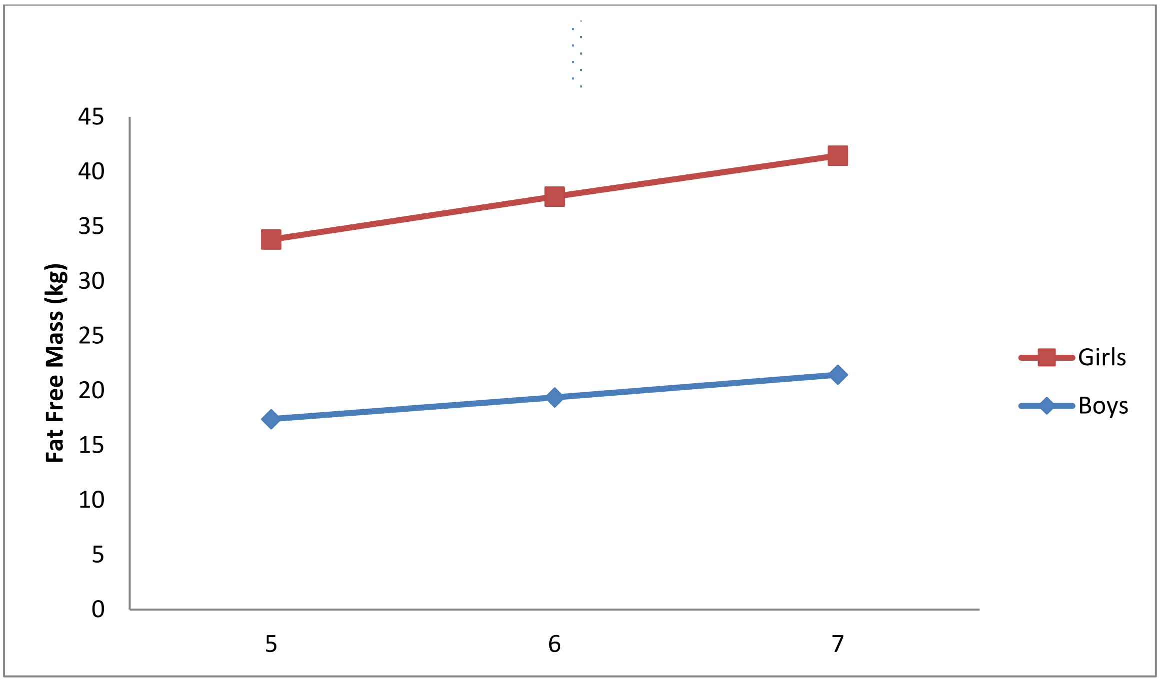

Figure 4.6: Age trend analysis of fat-free mass

4.4.5. Fat Mass Index

The fat mass index of girls (2.41 ± 0.94kgm^{-2}) was higher than the boys (2.06 ± 1.16kgm^{-2}) (Table 4.3). There was a fluctuating trend in the fat mass index of both boys and girls (Figure 4.7).

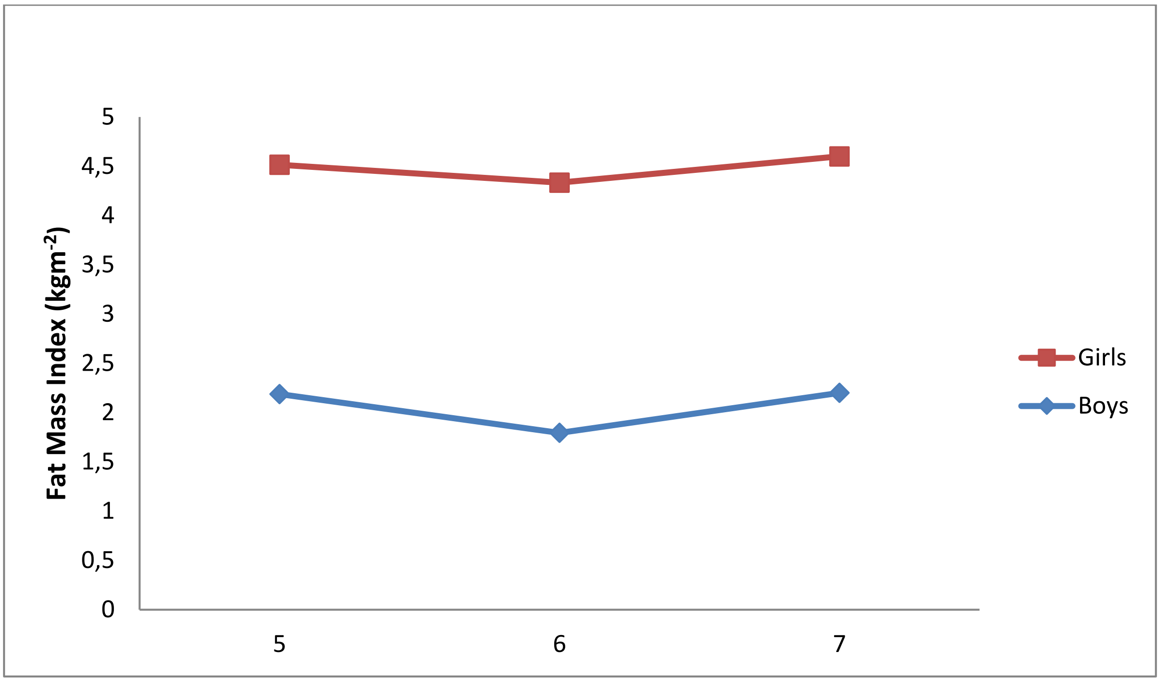

Figure 4.7: Age trend analysis of fat mass index

4.4.6. Fat-Free Mass Index

The mean value of fat-free mass index of boys (14.33 ± 1.34kgm^{-2}) was higher than the girls (13.64 ± 1.43kgm^{-2}). Figure 4.8 illustrated the changes in fat-free mass index of all participants according to age groups.

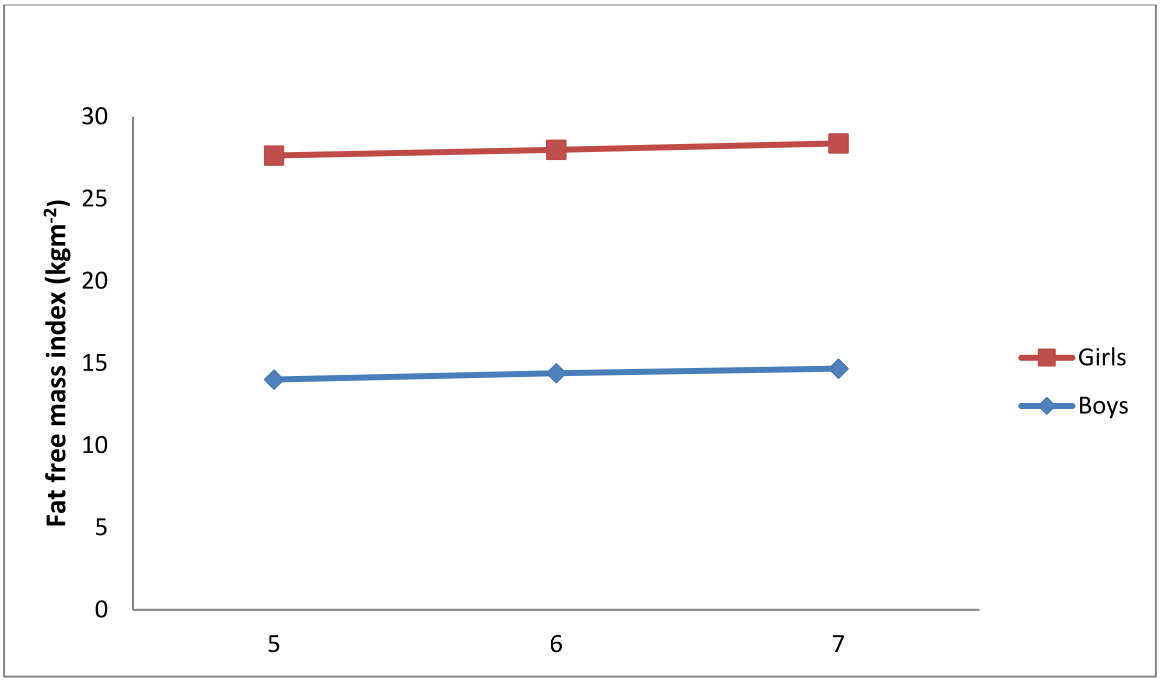

Figure 4.8: Age trend analysis of fat-free mass index

4.5: Fat Patterning Indices

4.5.1. Waist-to-Height Ratio

Although, there was no statistical gender difference in the mean values of waist-to-height ratio of boys and girls, boys had higher mean values of waist-to-height ratio compared to the girls. However, there was a downward trend in the waist-to-height ratio in both boys and girls (Figure 4.9). The ratio decreased with increasing age.

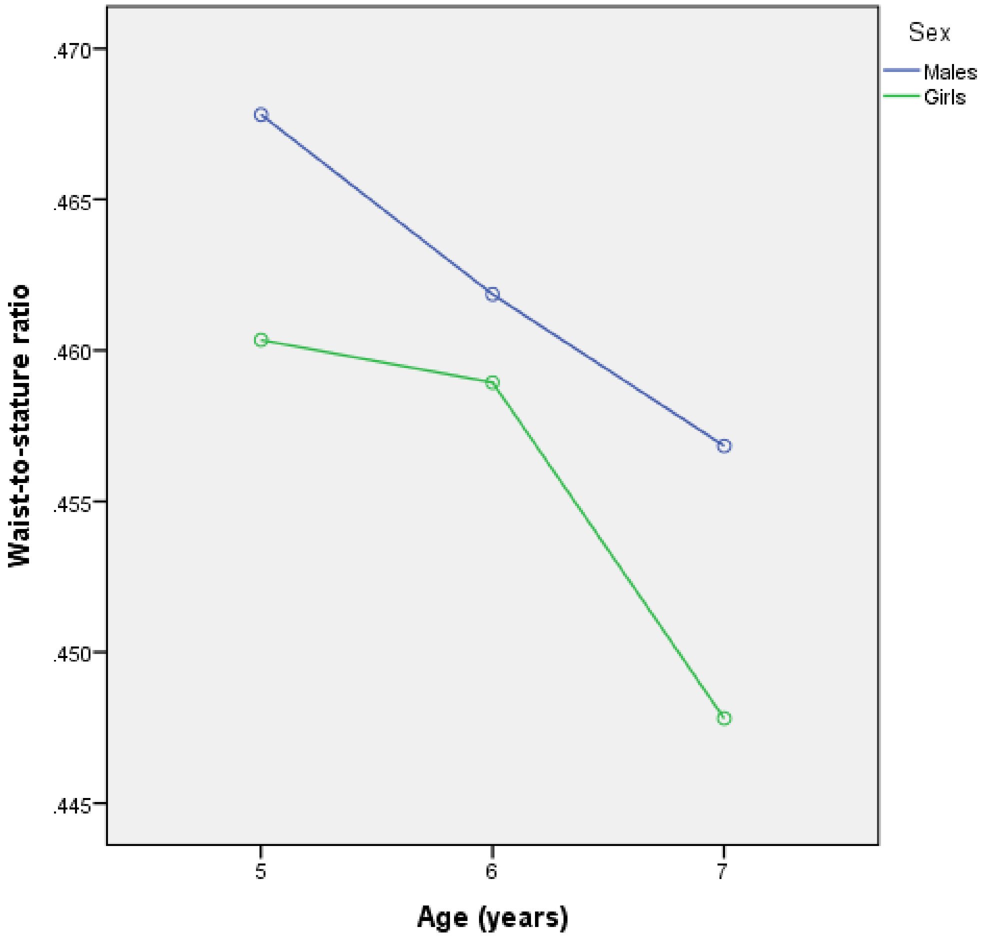

Figure 4.9: Age trend analysis of waist-to-height ratio

4.5.2. Waist-to-Hip Ratio

In all age groups, boys had greater mean value of waist-to-hip ratio than girls (Figure 4.10). Waist-to-hip ratio "peaks" at 6 and goes down at 7 for both genders.

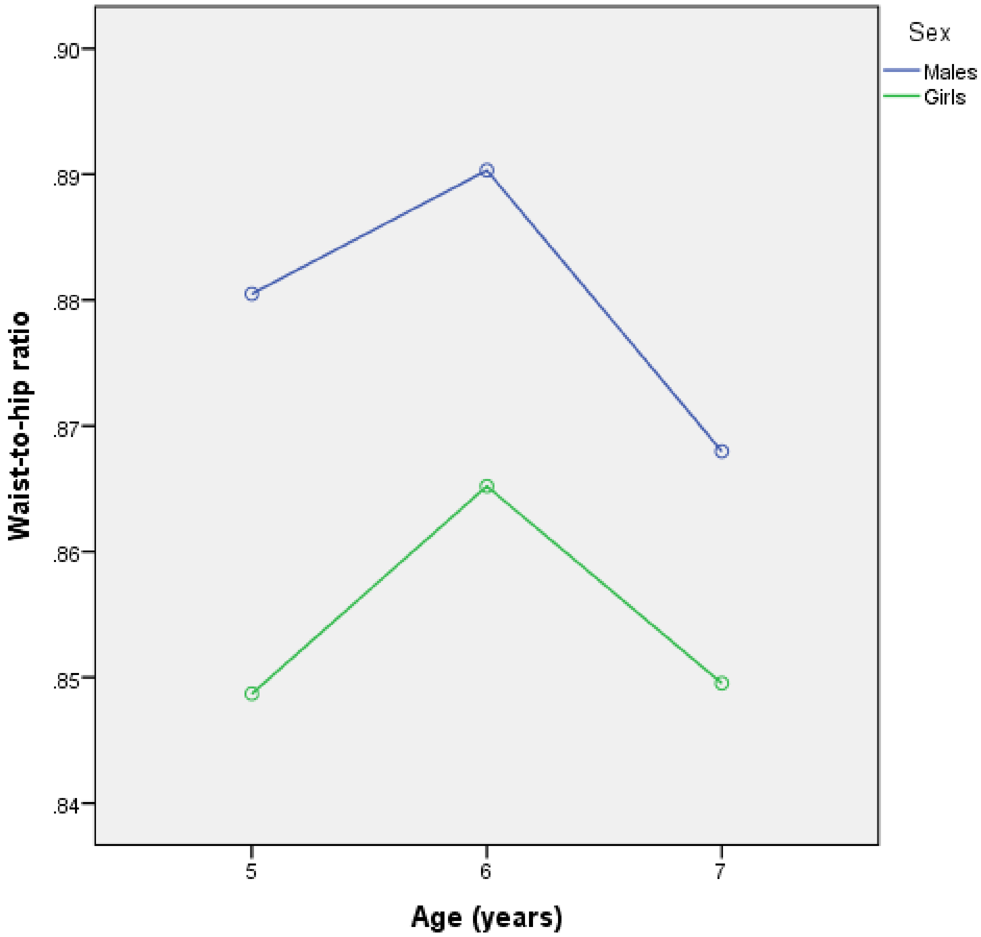

Figure 4.10: Age trend analysis of waist-to-hip ratio

4.5.3. Sum of Skinfolds

In this study, girls' total mean sum of two skinfolds was (16.02 ± 5.37mm) was higher compared to the boys (14.30 ± 5.50mm) (Table 4.3). The sum of two skinfolds in girls was higher than that of the boys in all age groups. Figure 4.11 indicates the age differences in the sum of two skinfolds in both genders. Sum of skinfolds in girls decreased with increasing age.

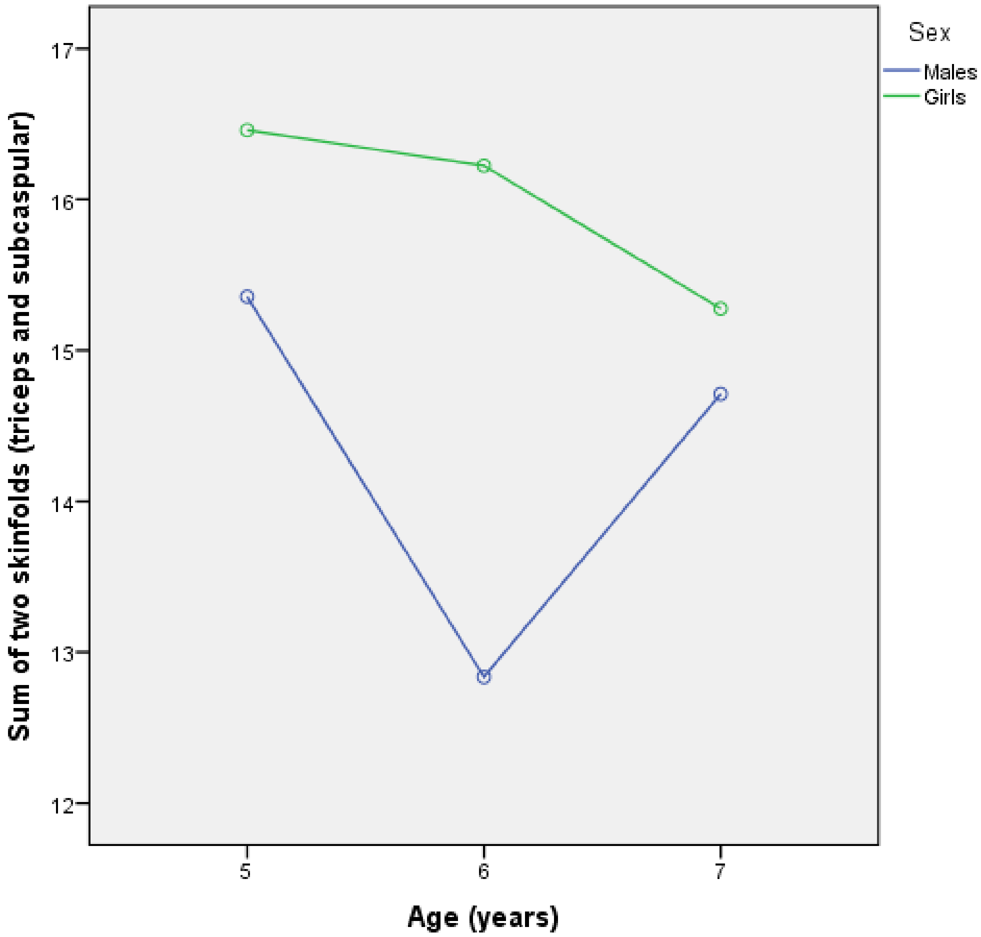

Figure 4.11: Age trend analysis of sum of two skinfolds

4.5.4. Subscapular-to-Triceps Ratio

There was no gender difference in the subscapular-to-triceps ratio for both boys and girls. Boys had 0.68 ± 0.17cm and girls 0.68 ± 0.16cm, respectively (Table 4.3). However, subscapular-to-triceps ratio of both boys and girls peaked at age 6; with a sharp decline afterwards (Figure 4.12).

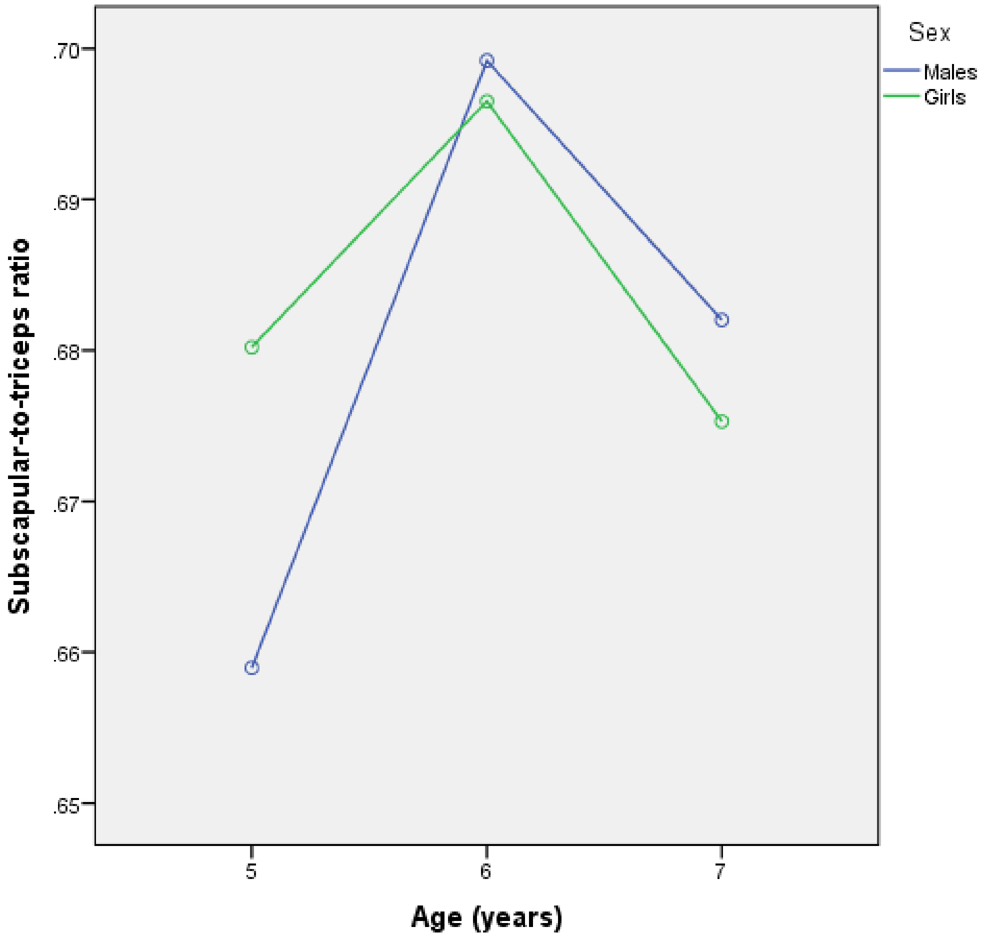

Figure 4.12: Age trend analysis of subscapular-to-triceps ratio

Table: 4.5: Pearson correlation coefficients of anthropometric and motoric variables

Variables	BMI (kgm^{-2})	%BF	FM (kg)	FFM (kg)	FMI (kgm^{-2})	FFMI (kgm^{-2})	WC (cm)	HC (cm)	WHR (cm)	WHtR (mm)	LSTRS	OCSTRS	SSOC	SSLO	SSS
BMI (kgm^{-2})	1														
% BF	.564**	1													
FM (kg)	.782**	.884**	1												
FFM (kg)	.628**	.034	.453**	1											
FMI (kgm^{-2})	.777**	.948**	.960**	.250**	1										
FFMI (kgm^{-2})	.824**	.007	.326**	.731**	.283**	1									
WC (cm)	.734**	.384**	.673**	.730**	.566**	.614**	1								
HC (cm)	.751**	.502**	.757**	.721**	653**	.555**	.740**	1							
WHR (cm)	-.117*	-.160*	.163**	-.104	-.152**	-.035	.137*	.529**	1						
WHtR (mm)	.442**	.275**	.310**	.086	.372**	.345**	.713**	.393**	.644**	1					
LSTRS	.026	.093	.045	-.018	.058	-.010	.012	.068	-.104	-.021	1				
OCSTRS	.071	-.020	.038	.096	.022	.088	.087	.081	-.047	-.003	.142*	1			
SSOC	.047	.255**	.151**	-.189**	.212**	-.122*	-.037	.011	-.081	.047	.112	.827**	1		
SSLO	.033	.157**	.019	-.212**	.103	-.041	-.102	-.034	-.103	.041	.886**	.101	.256**	1	
SSS	.043	.256**	.109	-.239**	.194**	-.110	-.085	-.015	-.017	.161**	.649**	.580**	.783**	.801**	1

*Correlations statistically significant at the 0.05 level (two-tailed). ** Correlations significant at 0.01 level (two tailed) BMI = Body mass index; %BF = Percentage body fat; FM = Fat mass; FFM = fat-free mass; FMI = fat mass index; FFMI = fat-free mass index; WC = waist circumference; HC = hip circumference; WHR = waist-to hip ratio; WHtR = waist-to-height ratio; LSTRS = Locomotor sub test raw score; OCSTRS = Object control sub test raw score; SSOC = Standard score for object control; SSLO = Standard score for locomotor; SSS = Sum of standard score

Shown in Table 4.5 are the Pearson correlation coefficients of anthropometric and motoric variables of the participants. A significant positive relationship existed between %BF and BMI (r = 0.564, p<.05); FM and BMI (r = 0.782, p<.05); FFM and BMI (r = 0.628, p<.05); FMI and BMI (r = 0.777, p<.05); FFMI and BMI (r = 0.824, p<.05); WC and BMI (r = 0.734, p<.05); HC and BMI (r = 0.751, p<.05); and WHtR and BMI (r = 0.442, p<.05). A moderate significant negative relationship was observed between WHR and BMI (r = -0.117, p<.05). Concerning the anthropometric and the motoric variables, there was no significant relationship between LSTRS and BMI (r = 0.026, p>.05); OCSTRS and BMI (r = 0.071, p>.05); SSOC and BMI (r = 0.047, p>.05); SSLO and BMI (r = 0.033, p>.05) and SSS and BMI (r = 0.043, p>.05).

A significant positive relationship existed between FM and %BF (r = 0.884, p<.05); FMI and %BF (r = 0.948, p<.05); WC and %BF (r = 0.384, p<.05); HC and %BF (r = 0.502, p<.05); WHtR and %BF (r = 0.275, p<.05). A moderate significant negative relationship was seen between WHR and %BF (r = -0.160, p<.05). There was no significant relationship between FFM and %BF (r = 0.034, p>.05); FFMI and %BF (r = 0.007, p>.05). Concerning the anthropometric and the motoric variables, there was no significant relationship between LSTRS and %BF (r = 0.093, p>.05) and OCSTRS and %BF (r = -0.020, p>.05). A significant positive relationship exist between SSOC and %BF (r = 0.255, p<.05); SSLO and %BF (r = 0.157, p<.05); and SSS and %BF (r = 0.256, p<.05).

A significant positive relationship was observed between FFM and FM (r = 0.453, p<.05); FMI and FM (r = 0.960, p<.05); FFMI and FM (r = 0.326, p<.05); WC and FM (r = 0.673, p<.05); HC and FM (r = 0.757, p<.05); WHtR and FM (r = 0.310, p<.05). A significant negative relationship was observed between WHR and FM (r = -0.163, p<.05). Concerning the anthropometric and the motoric variables, there is no significant relationship between LSTRS and FM (r = 0.045, p>.05); OCSTRS and FM (r = 0.038, p>.05); SSLO and FM (r = 0.019, p>.05); and SSS and FM (r = 0.109, p>.05). A significant positive relationship was observed between SSOC and FM (r = 0.151, p<.05).

There was a significant positive relationship between FMI and FFM (r = 0.250, p<.05); FFMI and FFM (r = 0.731, p<.05); WC and FFM (r = 0.730, p<.05); HC and FFM (r = 0.721, p<.05). However, no significant relationship exist between WHR and FFM (r = 0.104, p>.05) and WHtR and FFM (r = 0.086, p>.05). Similarly, no significant relationship between LSTRS and FFM (r = -0.018, p>.05); OCSTRS and FFM (r = 0.096, p>.05); while there is a significant negative relationship between SSOC and FFM (r = -0.189, $p<.05$); SSLO and FFM (r = -0.212, $p<.05$); and SSS and FFM (r = -0.239, $p<.05$).

A significant positive relationship was observed between FFMI and FMI (r = 0.283, $p<.05$); WC and FMI (r = -0.566, $p<.05$); HC and FMI (r = 0.653, $p<.05$); WHtR and FMI (r = 0.372, $p<.05$); WHR and FMI (r = -0.152, $p<.05$); and FMI (r = 0.058, $p>.05$); OCSTRS and FMI (r = 0.022, $p>.05$); and SSLO and FMI (r = 0.103, $p>.05$); SSOC and FMI (r = 0.212, $p<.05$); and SSS and FMI (r = 0.194, $p<.05$).

A significant positive relationship existed between WC and FFMI (r = 0.614, $p<.05$); HC and FFMI (r = 0.555, $p<.05$); WHtR and FFMI (r = 0.345, $p<.05$). There was no significant relationship between WHR and FFMI (r = -0.035, $p>.05$). Concerning the anthropometric and the motoric variables, there was no significant relationship between LSTRS and FFMI (r = -0.010, $p>.05$); OCSTRS and FFMI (r = 0.088, $p>.05$); SSLO and FFMI (r = -0.041, $p>.05$); and SSS and FFMI (r = -0.110, $p>.05$). A moderate negative relationship existed between SSOC and FFMI (r = -0.122, $p<.05$).

A significant positive relationship was observed between HC and WC (r = 0.740, $p<.05$); WHtR and WC (r = 0.713, $p<.05$). There was a moderate positive relationship between WHR and WC (r = 0.137, $p<.05$). Concerning the anthropometric and the motoric variables, there was no significant relationship between LSTRS and WC (r = 0.012, $p>.05$); OCSTRS and WC (r = 0.087, $p>.05$); SSOC and WC (r = -0.037, $p>.05$); SSLO and WC (r = -0.102, $p>.05$); and SSS and WC (r = -0.085, $p>.05$).

A significant negative relationship was seen between WHR and HC (r = -0.529, $p<.05$). A significant positive relationship was seen between WHtR and HC (r = 0.393, $p<.05$). Concerning the anthropometric and the motoric variables, there was no significant relationship between LSTRS and HC (r = 0.068, $p>.05$); OCSTRS and HC (r = 0.081, $p>.05$); SSOC and HC (r = 0.011, $p>.05$); SSLO and HC (r = -0.034, $p>.05$); and SSS and HC (r = -0.015, $p>.05$). A significant positive relationship was observed between WHtR and WHR (r = 0.644, $p<.05$). Concerning the anthropometric and the motoric variables, there was no significant relationship between LSTRS and WHR (r = -0.104, $p>.05$); OCSTRS and WHR (r = -0.047, $p>.05$); SSOC and WHR (r = -0.081, $p>.05$); SSLO and WHR (r = -0.103, $p>.05$); and SSS and WHR (r = 0.017, $p>.05$). There was no significant relationship between LSTRS and WHtR (r = -0.021, $p>.05$); OCSTRS and WHtR (r = -0.003, $p>.05$); SSOC and WHtR (r = 0.047, $p>.05$); SSLO and WHtR (r = 0.041, $p>.05$). There was a significant positive relationship between SSS and WHtR (r = 0.161, $p<.05$).

There was a significant relationship between OCSTRS and LSTRS (r = 0.142, p<.05); SSOC and LSTRS (r = 0.112, p>.05); SSLO and LSTRS (r = 0.886, p<.05); and SSS and LSTRS (r = 0.649, p<.05); SSOC and OCSTRS (r = 0.827, p<.05); SSLO and OCSTRS (r = 0.101, p>.05); SSS and OCSTRS (r = 0.580, p<.05); SSLO and SSOC (r = 0.256, p<.05); SSS and SSOC (r = 0.783, p<.05); SSS and SSLO (r = 0.801, p<.05).

4.6: Motoric variables

The mean and standard deviation (SD) for motoric variables according to gender and age are shown in Table 4.6 and Table 4.7, respectively. The results revealed that female participants scored higher in the locomotor subtest (40.9 ± 6.54) than the male participants (39.7 ± 6.64). On the other hand, the male participants scored higher in the object control subtest (39.8 ± 7.62) than the female participants (38.6 ± 7.29). There was no significant difference ($p > 0.05$) in the motor variables (Locomotor raw score, standard score for locomotor, object control raw score, standard score for object control, sum of standard score and gross motor quotient) across gender. However, there were significant differences ($p < 0.05$) in locomotor raw score, standard score for locomotor, standard score for object control, sum of standard score and gross motor quotient except object control raw score across age as shown in Table 4.6. The descriptive rating of Gross Motor Quotient of both boys and girls according to age is shown in Table 4.8. The gross motor quotient is statistically different among age group in boys (χ^2= 46.066, df =12, p= 0. 0001*); and also statistically different among age group in girls (χ^2= 34.597, df =10, p= 0. 0001*).

Table 4.6: Mean and standard deviation (SD) for motoric variables of boys and girls according to gender

	Boys (n = 159)	Girls (n= 146)	Combined (n= 305)	p-value
Variables	Mean ± SD	Mean ± SD	Mean ± SD	
Locomotor(RS)	39.7 ± 6.64	40.9 ± 6.54	40.3 ± 6.6	0.705
Standard score	11.1 ± 3.76	11.8 ± 3.63	11.4 ± 3.7	0.914
Obj.control(RS)	39.8 ± 7.62	38.6 ± 7.29	39.2 ± 7.47	0.860
Standard score	10.9 ± 3.35	12.7 ± 3.44	11.8 ± 3.50	0.969
Sum of SS	21.7 ± 6.21	24.5 ± 5.31	23.1 ± 6.0	0.082
GMQ	104.8 ± 19.7	113.6 ± 15.9	109.0 ± 18.5	0.069

* Statistically significant ($p \leq 0.05$); Locomotor (RS) = Locomotor raw score; Obj. control (RS) = Object control raw score; Sum of SS = Sum of standard scores; GMQ = Gross motor quotient

Table 4.7: Mean and standard deviation (SD) for motoric variables of boys and girls according to age

Variables	5 years (n = 120)	6 years (n= 93)	7 years (n= 92)	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	
Locomotor(RS)	40.4 ± 7.08	38.5 ± 6.82	41.9 ± 5.25	.002*
Standard score	13.1 ± 3.82	10.2 ± 3.30	10.5 ± 2.95	.000*
Obj.control(RS)	38.9 ± 6.63	39.2 ± 8.20	39.7 ± 7.81	.740
Standard score	13.1 ± 2.86	11.6 ± 3.69	10.2 ± 3.44	.000*
Sum of SS	26.2 ± 4.96	21.4 ± 6.10	20.6 ± 5.18	.000*
GMQ	118.6 ± 14.87	103.9 ± 20.19	101.7 ± 15.53	.000*

* Statistically significant ($p \leq 0.05$); Locomotor (RS) = Locomotor raw score; Obj. control (RS) = Object control raw score; Sum of SS = Sum of standard scores; GMQ = Gross motor quotient

Table 4.8: Descriptive ratings of Gross Motor Quotient of boys and girls according to age

Age (Years)	N	Very Poor n (%)	Poor n (%)	Below Average n (%)	Average n (%)	Above Average n (%)	Superior n (%)	Very Superior n (%)
Boys								
5	59	0	0	3 (5.1)	16 (27.1)	12 (20.3)	21 (35.6)	7 (11.9)
6	55	0	1 (1.8)	10 (18.2)	25 (45.5)	10 (18.2)	4 (7.3)	2 (3.6)
7	45	3 (6.7)	3(6.7)	7 (15.6)	22 (48.9)	8 (17.8)	2 (4.4)	0
Total	159	3 (1.9)	4 (2.5)	20 (12.6)	63 (39.6)	30 (18.9)	27 (17.0)	9 (5.7)
Girls								
5	61	0	0	0	14 (23.0)	13 (21.3)	19 (31.2)	15 (24.6)
6	38	0	1 (2.6)	0	18 (47.4)	9 (23.7)	6 (15.8)	4 (10.5)
7	47	0	3 (6.4)	4 (8.5)	23 (48.9)	9 (19.2)	8 (17.0)	0
Total	146	0	4 (2.7)	4 (2.7)	55 (37.7)	31 (21.2)	33 (22.6)	19 (13.0)
Boys+ Girls	305	3 (1.0)	8 (2.6)	24 (7.9)	118 (38.7)	61 (20)	60 (19.7)	28 (9.2)

Male (χ^2= 46.066, df =12, p= 0. 0001*); female (χ^2= 34.597, df =10, p= 0. 0001*), *. The Chi-square statistic is significant at the .05 level.

4.7: Discussion

4.8. Anthropometric indices

4.8.1. Body Mass Index

Notwithstanding the drawback of body mass index (BMI) in differentiating between fat mass and fat-free mass, this anthropometric indicator has been widely used to screen for health risk in populations because it is inexpensive, non-invasive and suitable for large-scale surveys (Goon *et al*., 2017). Body mass index is used in public health and clinical nutrition to provide a quick evaluation of nutritional status, in terms of obesity or malnutrition risk (World Health Organization, 2014).

In this study, the BMI was used as a screening tool for identifying possible weight challenges that may affect the health of children (Cole, 2000), pose a threat to their lives and a consistent indicator of body fatness for most children and teens (Centre for Diseases Control and Prevention, 2007).

A few research studies carried out in preschool children propose that a higher BMI is related or connected with a lower cardiorespiratory fitness (Agha-Alinejad *et al*., 2015; Martinez-Tellez *et al*., 2015; Galvan *et al*., 2014; Niederer *et al*., 2012) but with a higher upper body muscular strength (Cadenas-Sanchez *et al*., 2015; Martinez-Tellez *et al*., 2015). According to Wickramsinghe *et al*. (2005) BMI changes with growth from formative years through childhood to teenage years irrespective of gender. In this study, the BMI of the children varied considerable with age. Boys in this study had a higher BMI than girls (Table 4.3) which is similar with other studies (Yu *et al*., 2010; Joens-Matre *et al*., 2008; *K*o *et al*., 2008; Chen *et al*., 2006; Koutedakis *et al*., 2005), but other studies (Ramírez-Vélez *et al*., 2016; Freedman *et al*., 2015; McKersie & Baard, 2014; Goon *et al*., 2013; Amusa *et al*., 2011; Goon *et al*., 2010; Whelton *et al*., 2007) reported higher BMI in girls than boys.

4.8.2: Percentage Body Fat

Surplus body fat can lead to serious reduction in physical performance and health challenges. Body fat percentage varies between boys and girls and between age groups. Generally, research seems to indicate that the percentage body fat of boys is lower compared to girls. In this study, the results showed that, girls had a higher body fat percentage than boys in all the ages (Figure 4.4). This was similar to the findings of de Oliveira *et al*. (2016), Eissa *et al*.

(2009), Webster-Gandy *et al*. (2003) and Mantsena *et al*. (2002) who reported higher body fat percentage for girls compared to boys. However, this is contrary to the study by Gultekin *et al*. (2005) who reported higher mean values of body fat percentage in boys compared to girls. Goon *et al*. (2013) in their study also reported that, girls engage less in physical activity than boys which could lead to high body fat percentage in girls than in boys.

According to Quinn (2006) the minimum percent body fat which is considered safe and healthy is 5% for males and 12% for females. Adult males have between 15% - 18% while adult females have between 22% - 25%. In the present study, the mean values of body fat percentage in boys were between the ranges of 10.7% - 13.2% while that of girls were between the ranges of 14.5% - 15.1%. The body fat percentage of children in the current study seems to be high compared to the standard range value for children. According to Monyeki *et al*. (2006), it was reported that, children from rural area in Limpopo Province had high percentage of body fat which could be as a result of physical inactivity and higher energy food intake. Likewise, Goon *et al*. (2013) in their study reported that, the percentage fat values of boys ranged between 16.4% - 20.0% while that of girls was given to be between the ranges of 20.2% - 24.1%. The reason suggested by these authors for high body fat percentage was as a result of junk and unhealthy food eaten by children. However, the present study did not consider the nutritional assessment and physical activity level of the children under consideration. It is noteworthy to state that, most people in the current area of study eat large quantity of meat and the common staple food is pap (mieli-meal) which is high in calorie. This eating habit could be a contributing factor to the high body fat percentage of the children observed in this study. According to Gultekin *et al*. (2005), high consumption of meat and carbohydrates and less consumption of vegetables may result in children being overweight and obese.

The high body fat percentage of children observed in the current study may have a scientific, medical and public health implication in the future. Too much body fat and low physical fitness/ physical inactivity could lead to chronic diseases and poor physical performance. On the other hand, too little fat or low body fat percentage can also affect metabolism, health and eating disorder resulting to anorexia nervosa (Lohman, 1999).

4.8.2.1: Prevalence of overweight and obesity among school children

The prevalence of overweight and obesity was 13.12% and 12.46%, respectively. Overweight was reported to be more in girls (15.75%) and obesity more in boys (16.35%). In the study of Goon *et al*. (2013) and Reddy *et al*. (2008) similar results were also reported of overweight occurring more in girls (4.7%) and boys (24.5%), respectively. The percentage of overweight and obesity among children in this study is worrisome, given that overweight and obesity predisposes individuals to cardiovascular diseases and ill health. It has been reported that overweight and obese children have a more than twofold increased risk of developing prehypertension and more than fourfold increased risk of developing hypertension compared to their counterpart with healthy weight (Liang *et al*., 2011). Therefore, it is very important to screen and monitor the weight and BMI of children in order to secure their future.

In the present study, overweight was more pronounced in girls (15.75%) than in boys (10.69%). Previous studies conducted in different settings have reported overweight occurring more in girls compared to boys (Kautiainen *et al*., 2010; Ogden *et al*., 2010; Pearson *et al*., 2010; Kolle *et al*., 2009; Vanhala *et al*., 2009; Blomquist & Bergström, 2007; Hakanen *et al*., 2006; Padez *et al*., 2005). However, obesity was more prevalent in boys (16.35%) compared to girls (10.27%). This finding is consistent with Freedman *et al*. (2015) and Ogden *et al*. (2010) studies involving 6 to 19 years old. However, other researchers have considered economic status, settlements, and so on as contributing factors of overweight and obesity among children but the present study did not consider economic status and settlements as a result of the high prevalence of overweight and obesity among the participants despite the fact that the children were from a rural area unlike studies by Kautiainen *et al*., 2009 who reported higher prevalence of overweight in children from rural areas. However, other studies have reported higher prevalence of overweight in children from lower socioeconomic status and living in rural areas in developing countries (Broyles *et al*., 2010; Neovius & Rasmussen, 2008; Shrewsbury & Wardle, 2008; Neovius *et al*., 2006; Ekblom *et al*., 2004; Laitinen *et al*., 2001).

4.8.3. Fat Mass

The results in this present study showed that, girls had higher mean values of fat mass in all age groupings compared to boys (Figure 4.3). Similar findings have also been reported by other researchers (de Oliveira *et al*., 2016; Santos *et al*., 2016; Eissa *et al*., 2009; Goon *et al*., 2008; Ittenbach *et al*., 2006; Wickramasinghe *et al*., 2005; Gaskin & Walker, 2003). Generally, fat mass in females tends to be evident during puberty, however, according to Sweeting (2007), higher levels of fat mass have been found in younger females below puberty age. An increase in fat mass and a decreased percentage in fat-free mass through childhood period have been reported to be related with increased risks of developing chronic diseases in adulthood (Barker, 2005).

4.8.4. Fat-Free Mass

The results of this present study demonstrate a gender difference in the fat-free mass of the participants. Fat-free mass was higher in boys than in girls. Boys in all age groups had higher fat-free mass than girls. Similar findings were also observed by other researchers (Santos *et al*., 2016; Yu *et al*., 2010; Koutedakis *et al*., 2005; Shaibi *et al*., 2005). A larger fat-free mass is responsible for the larger increase of the BMI in boys. In the present study, fat-free mass increased with age in both boys and girls. This is in line with the findings of Malina *et al*. (2004) who reported that fat free mass increased with age in children. According to McMurray *et al*. (2003), normal children especially in males experience increase in fat-free mass as age and pubertal status increases. Bell (1993) reported that, increase in fat-free mass is highly associated with stature and body mass. This is similar to the present study.

4.8.5. Fat Mass Index and Fat-Free Mass Index

Fat-free mass index and fat mass index are both distinct and are related to body size (Van Itallie *et al*., 1990). The fat free constituent of body mass can be expressed relative to body size as fat free mass index which accounts for the amount of muscle mass possessed by a person. This relates to the stature (FFMI = fat free mass/stature^2) of the children. On the other hand, fat mass index is the amount of fat mass possessed by a person which relates to his/her stature (FMI = fat mass/stature^2) (Chowdhury *et al*., 2006). The usefulness and the reference values of FMI and FFMI are not well known, which is due to the lack of specific cutoffs (Eto *et al*., 2004; Schutz *et al*., 2002; Franken field *et al*., 2001). BMI is generally known to be the simplest and most convenient method of assessing body fat. However, since BMI is mathematically equal to the sum of FMI and FFMI (Eto *et al*., 2004; Schutz *et al*., 2002; Wells *et al*., 2002), the use of FMI and FFMI as a measure of adiposity is more suitable and relates well to the adiposity content of BMI.

In this study, boys had higher mean value of FFMI than girls at all ages while girls had higher mean value of FMI than boys at all ages which corroborates the study by de Oliveira *et al*. (2016), Henriksson *et al*. (2016). The reason for higher FFMI and lower FMI in boys follows a normal trend in the body development of children. There is a mathematical relationship between FFMI and FMI. Fat free mass index is known to increase as the fat mass index decrease with constant BMI. Fat mass index is very useful in helping clinicians interpret FM data from obese individual who differ in stature (El-Masry & Hassan, 2010). Likewise FMI is used to accurately classify obesity when compared to percentage body fat ((Peltz *et al*., 2010). Fat mass index and FFMI can be utilized as problem-solving values for the evaluation and assessment of nutritional status (over nutrition and under nutrition) of healthy subjects (Pichard *et al*., 2000).

4.8.6. Sum of Skinfolds

The triceps and subscapular skinfold measurements are the two most regular anthropometric parameters often used by researchers (González-Jiménez, 2013; Kromeyer-Hauschild *et al*., 2012) to assess body fat in children. Professional panels from the USA suggest the measurements from these two sites (triceps and subscapular) provide in-depth information on the medical assessment for children and adolescents with high BMI (Himes & Dietz, 1994). However, Kromeyer-Hauschild *et al*. (2012) maintained that skinfolds measurement varies significantly according to BMI levels. The results from the present study revealed that, the sum of skinfolds for girls was higher than that of boys. This is in agreement with other studies (Ramírez-Vélez *et al*., 2016; Aristizabal *et al*., 2015; Nagy *et al*., 2014). However, Moreno *et al*. (2007) in their study reported that, boys had higher sum of skinfolds than girls which was contrary to the finding of this present study.

4.9. Fat Patterning Anthropometric Indices

4.9.1. Waist-to-Hip Ratio

Waist-to-hip ratio, waist circumference and waist-to-height ratio have been recommended as being superior to BMI in predicting the risk of cardiovascular disease (Lee *et al*., 2008). Waist circumference and waist-to-hip ratio emerge to be more strongly related with metabolic risk factors (Ghazali & Sanusi, 2010; Despres & Lemieux, 2006; Wang *et al*., 2005). The measurement of abdominal obesity by waist circumference and waist-to-hip ratio is significantly connected with high risk of cardiovascular disease. More so, a one cm increase in waist circumference is related to a 2% increase in risk of future cardiovascular disease and a 0.01 increase in waist-to-hip ratio is related with a 5% increase in risk (de Koning *et al*., 2007). The present study revealed that, boys had a higher waist-to-hip ratio mean value than girls. According to age grouping, boys in all age groups had higher waist-to-hip ratio than girls of the same age group. This finding is related to previous reports by other authors (Goon *et al*., 2008; Monyeki *et al*., 2005; Webster-Gandy *et al*., 2003). However, this was contrary to the findings by Daniels *et al*. (2000) who reported that, girls had a higher waist-to-hip ratio compared to boys in their study. The present study did not show a linear trend in waist-to-hip ratio with age among boys and girls. The inconsistency in the distribution of waist-to-hip ratio among boys and girls across all age groups might possibly be as a result of individual differences in pubertal stage. According to Ashwell and Gibson (2009), the waist circumference should be maintained at a percentage less than half the height for a normal body shape.

4.9.2. Waist-to-Height Ratio

Waist-to-height ratio is an index of proportionality that is used to know whether the amount of upper body fat accumulation in relation to height or stature is appropriate (McCarthy & Ashwell, 2006). Waist-to height ratio is a simple and efficient, non-invasive screening tool for CVD risk factor (Ashwell & Gibson, 2009) and a good predictor for elevated blood pressure in school children aged seven (Chen *et al*., 2011). Waist-to-height ratio may be easy to measure and it is a more useful predictive sign of the early health risks' related with central adiposity (Ashwell & Gibson, 2016). Findings in many populations have supported that waist-to-height ratio is an easy and effective anthropometric index which is used to identify health risks (Ashwell *et al*., 2012; Savva *et al*., 2013). Previous studies have revealed relationships between waist-to-height ratio and BMI or waist circumference or both. Furthermore, reports from previous studies showed that, waist-to-height ratio and waist circumference were important predictors of cardio metabolic outcomes than BMI (Browning *et al*., 2010). The waist-to-height ratio of both boys and girls in this study were similar. Boys in all the age groups were observed to have higher waist-to-height ratio than girls. These differences are likely to be due to the differences in the overall adiposity of boys compared to girls. The result of our findings is similar to those of other studies (Cintra *et al*., 2014; Freedman *et al*., 2007; Moreno *et al*., 2007; McCarthy & Ashwell, 2006) who reported similar waist-to-height for boys and girls, but there was a decrease in waist-to-height ratio as the age of the children increased in both boys and girls which is similar to the findings of Sung *et al*. (2008).

4.9.3. Subscapular-to-Triceps Ratio

The subscapular-to-triceps ratio is an indicator of the central vs. peripheral distribution of subcutaneous fat, and as such, it is considered as a helpful predictor of vulnerability to type II diabetes, hypertension and other metabolic disorders (Haffner *et al*., 1987). In this study, the STR for both boys and girls were similar (Figure 4.12) which is also similar to the study reported by Gultekin *et al*. (2005). Girls at age 5 had a little higher of STR than boys at age 5 but in age 6 and 7 both boys and girls recorded same STR. Previous studies have recorded higher STR in boys compared to girls (Amusa *et al*., 2007; Moreno *et al*., 2007; Monyeki *et al*., 2006; Webster-Gandy *et al*., 2003).

4.10. Correlation of anthropometric variables and motor development variables

In this study, there was a significant correlation between body composition parameters (BMI, %BF, FM, FFM, FMI, FFMI, WC, HC, WHR and WHtR) and motor development parameters. Similar to other studies (Rao *et al*., 2012; Gayen & Bandyopadhyay, 2015), there was significant correlation between BMI, %BF and FMI. The significant positive correlation between BMI and WC signifies a good predictor of abdominal adipose tissue in children (Brambilla *et al*., 2006; Milanese *et al*., 2010). No correlation existed between BMI and TGMD-2 tests, showing an equal potential of motor development for all children, not being constrained by body fatness (Catenassi *et al*., 2007). Several studies (Singh *et al*., 2015; Milanese *et al*., 2010; Tokmakidis *et al*., 2006; Graf *et al*., 2004b) have reported no significant correlation between BMI and motor development in children of varying ages. Contrastingly, McKenzie *et al*. (2002) reported a moderate correlation between body composition and motor abilities of children while Okely *et al*. (2004) reported a significant correlation of BMI with fundamental motor skills and locomotor skills.

4.11. Motor development

In the present study, the locomotor raw score was higher in girls than in boys and the object control raw score was higher in boys than in girls (Table 4.6). This result is similar to the study of Cliff *et al*. (2009) who reported girls having higher scores in locomotor than boys but no significant difference in object control between boys and girls. Hardy *et al*. (2010) reported locomotor skills higher in girls than in boys and object control skills higher in boys than in girls. The Gross Motor Quotient is the most reliable score for the TGMD -2 because it is a composite of the results of the two subtests. The Gross Motor Quotient rating of 5 years old children of both boys and girls in this study were higher compared to age 6 and 7 of both boys and girls. Very superior was higher in 5 years old boys and girls, and this suggests that younger children were more likely to have greater improvements as compared to older children. This supports the early work of Barley (1936) that suggests development, in particular motor control which occurs very rapidly until approximately 21 months and then slows down. The differences in TGMD -2 results were significant in locomotor, standard scores for locomotor and object control, sum of standard scores and gross motor quotient in all participants. This result is similar to Kondi *et al*. (2012). However, baseline TGMD -2 subtests scores of the participants in this study were in the range of reported data from the United States (Ulrich, 2000) (Table 4.10).

Table 4.10: Comparison of TGMD -2 standard scores of subjects in this study with reported data from subgroup for TGMD -2, Mean (SD)

	Present study		TGMD – 2	
Subtest	Male	Female	Male	Female
Locomotor	11 (3)	11 (3)	10 (3)	10 (3)
Object Control	10 (3)	12 (3)	10 (3)	10 (3)
Gross Motor Quotient	104 (19)	113 (15)	99 (15)	100 (14)

Chapter Five: Summary, Conclusion and Recommendation

5.1: Summary

Several studies (Wrotniak *et al*., 2006; Graf *et al*., 2004a; Graf *et al*., 2004b) have linked overweight and obesity to poorer motor development in children. Hence, children with poor motor skills are likely to be less active physically, which may adversely lead to being overweight and obese. In other words, excess body weight and fatness could hinder the pace of movement and adequate development of motor skills. Motor development entails the movements from the infants' first spontaneous waving and kicking movements to the adaptive control of reaching, locomotion and complex sport skills at adulthood (Adolph *et al*., 2003). One of the major concerns of childhood development is the early incidence of cardio-vascular risk problems. Several factors indicating cardio-vascular risk problems are related to physiological status (Sun *et al*., 2006) and anthropometric measurements such as BMI, body mass, height, weight-to-height ratio and percent body of children fatness (Ashwell & Gibson, 2009). Rural children are more likely to be medically underserved when compared to their urban counterparts in terms of having a regular opportunity for health care, health insurance, and access to preventive health services. Previous studies on movement development of children have exerted scholarly efforts in investigating the causes of distortion in motor development among children (Connolly & Michael, 1986). Some of the studies considered only the role of environmental factors towards motor development of children (McPhillips & Jordan-Black, 2007). Others examined biological (Mayer *et al*., 2010) or emotional factors influencing the nutritional status (Lips, 2010; Ramakrishnan, 2002; Kennedy, 1998) while others focused on the role of socioeconomic status of parents (McPhillips & Jordan-Black, 2007). However, these studies have been carried from other countries outside South Africa. Based on a broad search of literature, there are scanty studies on the correlation between physiological status and anthropometric characteristics as determinants of motor development of children in Nkonkobe Municipality, Eastern Cape Province.

The main purpose of the study was to determine the physiological, anthropometric and motor development characteristics of rural children in selected schools in Nkonkobe Municipality of Eastern Cape Province, South Africa.

The specific objectives of the study were:

- To determine gender differences in the physiological variables of rural children between 5 to 7 years.
- To assess anthropometric gender differences of rural children between 5 to 7 years.
- To assess gender differences in the motor development of rural children between 5 to 7 years.
- To evaluate the relationship between anthropometric and motor development of rural children between 5 to 7 years.

The following research questions were framed to answer the research objectives:

- Would there be a difference in the physiological of male and female children in Nkonkobe Municipality, Eastern Cape?
- Would there be a difference in the anthropometric variables of male and female children in Nkonkobe Municipality, Eastern Cape?
- Would there be a difference in the motor development of male and female children in Nkonkobe Municipality, Eastern Cape?
- Would there be a relationship between the anthropometric and motor development of male and female children in Nkonkobe Municipality, Eastern Cape?

It was hypothesize that there will be no significant gender differences in the physiological, anthropometric and motor development characteristics of boys and girls between the age 5 to 7 years in Nkonkobe Municipality, in the Eastern Cape Province.

This was a cross-sectional, descriptive research study involving 305 randomly selected children between the ages of 5-7 years in Nkonkobe Municipality, Eastern Cape Province, South Africa.

Approval to conduct the study was granted by the university of Fort Hare ethical committee. The nature, purpose and importance of the study were explained to the children, their parents and legal guardians who gave their consent.

Resting blood pressure (RBP) was measured using aneroid sphygmomanometer, according to standardized guidelines (National Heart, Lung and Blood Institute/ National High Blood Pressure Education Program: NHBPEP Coordinating Committee, Second Task Force on Blood Pressure Control in Children, 1987). Anthropometric measurements included body weight, stature, waist and hip circumferences, triceps and subscapular skinfolds. The Test of

Gross Motor Development- Second Edition (TGMD-2; Ulrich, 2000) was adapted to describe the motor skills development of the participants. The TGMD-2 is a standard and decisive factor which is used to measure the gross motor development skills for children within the age range of 3 to 10 or 11 years.

The participants' physiological, anthropometric, body composition and motoric data was analyzed using descriptive statistics, i.e. means and standard deviations. A probability level of 0.05 or less was used to indicate statistical significance. Finally, the Pearson correlation analysis was applied to determine the relationship between body composition and motor performance.

5.2 Major findings of the study

The major findings of the study were:

- The BMI of the children varied considerable with age. Boys in this study had a higher BMI than girls.
- Girls had a higher body fat percentage than boys in all the ages.
- The mean values of body fat percentage in boys were between the ranges of 10.7% - 13.2% while that of girls were between the ranges of 14.5% - 15.1%. The body fat percentage of children in the current study seems to be high compared to the standard range value for children.
- There was a high prevalence of overweight (13.2%) and obesity (12.46%) among the children; and the prevalence of higher in girls (15.75%) compared to boys (10.69%).
- The results in this present study showed that, girls had higher mean values of fat mass in all age groupings compared to boys
- There was gender difference in the fat-free mass of the participants, with the boys having higher fat-free-mass compared to the girls. However, boys in all age groups had higher fat-free mass than girls.
- Boys had higher mean value of FFMI than girls at all ages, while girls had higher mean value of FMI than boys at all ages.
- The results from the present study revealed that the sum of skinfolds for girls was higher than that of boys.
- The boys had a higher waist-to-hip ratio mean value than girls; and no linear age trend in waist-to-hip ratio was observed among boys and girls.

- There was no gender difference in the waist-to-height ratio and STR of both boys and girls
- In the present study, the locomotor raw score was higher in girls than in boys, however, the object control raw score was higher in boys than in girls
- The Gross Motor Quotient rating of 5 years old children of both boys and girls in this study were higher compared to both boys and girls at ages 6 and 7 years.
- There was no correlation between BMI and TGMD-2 tests.
- Most body composition indicators (%BF, FM, FFM, FMI, FFMI, WC, HC, WHtR) were significantly positively correlated with BMI. However, WHR showed a moderate negative correlation with BMI.

5.3: Limitations

The limitations of this study should be noted when interpreting the findings of the study. Only school children were studied, so that the results do not necessarily apply to all the children in Nkonkobe Municipality, nor was the study reflective of the provincial or national level. Also, maturational status, habitual physical activity and diet may have affected changes in body composition of the children, which were not assessed in the present study. Additionally, the sample size of the study was small and the results may not represent the whole population. The limited size of this sample does not allow one to apply statistical analysis of age adjustment. Besides, it should be noted that assessment of body composition in children can be done through several methods. Ideally, objective criterion measures such as CT and DEXA are advocated. However, the use of such "gold standard" methods, has limited applicability, especially in developing countries like South Africa, largely because it is expensive, unavailable and time-consuming. In its place, measurements of anthropometry (stature, body mass, skinfold thickness and circumferences) were taken to determine BMI, %BF and central fat patterning and general adiposity in a group of children living in Nkonkobe Municipality region. The use of this method has been validated (Monyeki *et al*. 2005). Although these anthropometric measures can introduce measurement error, such error is likely to be random and thus would not bias the observed results. Notwithstanding these limitations, this study was conducted in rural black understudied setting, thus providing an opportunity to collect information on physiological, anthropometric and motoric characteristics of school-going children that can now be compared with results of previous studies undertaken in South Africa, although with differing methodological and geographical settings.

5.4: Conclusion

Based on the findings of the study, the following conclusions were drawn:

- There is a considerable variation in the BMI of the children, and the BMI of the boys is higher compared to the girls.
- Consistent with the literature, the body fat percentage of the girls is higher than boys at all ages. The higher percentage of body fat observed among the children with values ranging from 10.7%-15.1%, given their ages (5-7 years) portends implications for their future health.
- The prevalence of overweight and obesity among the children is alarmingly high and a concern for their health.
- Consistent with the literature, the fat mass of the girls is all ages was higher compared to boys; while there is no gender differences in the fat-free mass of the participants.
- The FFMI is higher in boys at all ages, compared to the girls.
- The waist-to-hip ratio of boys was higher compared to the girls, although there is apparent no linear age trend among the genders.
- There is no gender difference in the waist-to-height ratio and STR of both boys and girls
- In the present study, the locomotor raw score is higher in girls than in boys; however, the object control raw score was higher in boys compared to girls
- The Gross Motor Quotient rating of 5 years old children of both boys and girls in this study is higher compared to both boys and girls at ages 6 and 7 years.
- The non-correlation of BMI with TGMD-2 tests suggests an equal potential of motor development among the children, regardless of their body fatness.

5.5: Recommendation

Based on the findings and conclusions of the study, the following recommendations were drawn:

- There is need for obesity prevention programme in schools, which should involve all the stakeholders (teachers, parents/guardians, government, NGOs). The programme should focus on creating awareness concerning child body weight, healthy dietary intake and regular BMI screening in schools.
- Physical activity has benefit effects on the academic, improvement of motor skills performance, cardiovascular and musculoskeletal health and promoting desirable weight.

In this regards, physical activity should be incorporated into the school curriculum. In this case, physical education should be re-instated back in South African schools.

- Further studies should endeavor to explore the relationship between nutrition, physical activity levels and body composition of children in relation to their motor development skills.
- It is also crucial to develop population-specific percentiles to define obesity among South African children rather than using cut-off points that were originated from other geographical settings, socio-economic levels and cultural perceptions.

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Appendices

University of Fort Hare
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CONSENT LETTER

Appendix A

About the researcher: I, Idamokoro Mere a Masters student in the university of Fort Hare Alice campus with the student number 201609572 from the department of Human Movement Science. I am conducting a research study title "**physiological, anthropometric and motor development of rural children in Alice sub-district, Nkonkobe Municipality in Eastern Cape Province, South Africa**".

Purpose of the study: the purpose of this research study is to evaluate and to assess the physiological status, anthropometric characteristics (such as the weight, height, skinfold thickness and waist and hip circumference) which will help to determine underweight, overweight, obesity, and how these variables affects the motor development of growing children within 5 to 7 years old.

Risks involve: there are no physical or mental risks involved in this study and all measurements taken are pain free.

Benefits involve: there are no monetary benefits involve in participating in this study. The results from the study will be made available to policy makers and government agencies. This the researcher's hopes will bring about improved child health within the Eastern Cape Province and South Africa in general.

Queries: all queries can be directed to the researcher. Queries like more enlightenment or explaination in the study and also who to reach if any questions spring up at the course of participation, concerns and comments concerning the results are also welcome.

Use of results: the results obtained in the course of the research will be treated with high confidentiality and use for scientific purposes.

Freedom of consent: participation in this study is voluntary and not compulsory. Children are free to opt out anytime if they are not willing to continue.

I hereby consent that my ward(s) is/are free to fully participate in the research study, having understood the purpose of the study, risks involve and the benefits to the health of my ward(s). Also, questions asked have been answered satisfactorily.

Declaration by parent/legal guardian: By signing below, I *(name of parent/legal guardian)* …………………………………...……. agree to allow my child (name of child) ……………………………………..… who is ………. years old, to take part in a research study entitled *(insert title of study)*

... **...**

Date **Name/ Signature of parent/legal guardian**

Appendix B

ANTHROPOMETRIC DATA COLLECTION FORM

ANTHROPOMETRIC AND PHYSIOLOGICAL PROFORMA

Participant No:

Name:……………..(Optional)

Test Date:……………….. DOB:……………………………. M ☐ F ☐

dd mm yy

Name/ address of school:

……………………………..

Anthropometry

	ID	Site	Trial 1	Trial 2	Trial 3	Median
Station 1: Basic	1	Body mass (kg)				
	2	Stature (cm)				
Station 2: Skinfolds (cm)	3	Triceps				
	4	Subscapular				
Station 3: Girths (cm)	5	Waist				
		Hip				

Physiological

Resting Blood Pressure (mmHg)	Trial 1	Trial 2	Trial 3	Median
Systolic Blood Pressure (SBP)				
Diastolic Blood Pressure (DBP)				

Appendix C: A table showing blood pressure (BP) for boys by age and height percentiles

		Systolic (mmHg) percentile of height							Diastolic (mmHg) percentile of height						
Age (yrs)	BP percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86

Source: Adapted from; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004).

Appendix D: A table showing blood pressure (BP) for girls by age and height percentiles

		Systolic (mmHg) percentile of height							Diastolic (mmHg) percentile of height						
Age (yrs)	BP percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	64	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	114	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84

Source: Adapted; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004).

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APPENDIX E: CHILD ASSENT FORM

This study is being done by Mrs Mere Idamokoro. I am doing this study to get my Master's Degree in Human Movement Science. The aim of the study is to assess the physiological, anthropometrics and motor development of rural schoolchildren.

I ________________________________, will attend a screening testing day at my school, where I will have to undergo eight screening tests: Blood pressure, body mass, stature, waist and hip circumferences, triceps and subscapular measurements and motor development test. The results of these tests will be used by Mrs Mere Idamokoro to determine if children are at risk of developing cardiometabolic problems and possible reasons for it.

I understand that no risks/harm is involved if I agree to participate in the study. I also understand that there are possible benefits if I take part in the study. These benefits might be a better understanding of cardiometabolic screening, a better understanding of my weight, blood pressure and fitness status and an increased motivation to sustain or if in the negative way, help me to improve on my health pertaining to these variables screened on.

I understand that my parents/guardians have given permission (said it's ok) for me to take part in the study. I am taking part because I want to, and I have been told that I can stop at any time I want to and I won't get in trouble.

____________________ ____________________

Date *Signature of parent/guardian*

____________________ ____________________

Date *Signature of researcher*

Appendix F: Locomotor subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Run	60 feet of clear space, and two cones	Place two cones 50 feet apart. Make sure there is at least 8 to 10 feet of space beyond the second cone for a safe stopping distance. Tell the child to run as fast as he/she can from one cone to the other when you say "Go". Repeat a second trial.	1. Arms move in opposition to legs, elbows bent			
			2. Brief period where both feet are off the ground			
			3. Narrow foot placement landing on heel or toe (i.e., not flat footed)			
			4. Nonsupport leg bent approximately 90 degrees (i.e., close to buttocks)			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Gallop	25 feet of clear space, and tape or two cones	Mark off a distance of 25 feet with two cones or tape. Tell the child to gallop from one cone to the other. Repeat a second trial by galloping back to the original cone.	1. Arms bent and lifted to waist level at takeoff			
			2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot			
			3. Brief period when both feet are off the floor			
			4. Maintains a rhythmic pattern for four consecutive gallops			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Hop	A minimum of 15 feet of clear space	Tell the child to hop three times on his/her preferred foot (established before testing) and then three times on the other foot . Repeat a second trial.	1. Nonsupport leg swings forward in pendular fashion to produce force			
			2. Foot of nonsupport leg remains behind body			
			3. Arms flexed and swing forward to produce force			
			4. Takes off and lands three consecutive times on preferred foot			
			5. Takes off and lands three consecutive times on nonpreferred foot			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Leap	A minimum of 20 feet of clear space, a beanbag and tape	Place a beanbag on the floor. Attach a piece of tape on the floor so it is parallel to and 10 feet away from the beanbag. Have the child stand on the tape and run up and leap over the beanbag. Repeat a second trial.	1. Take off on one foot and land on the opposite foot			
			2. A period where both feet are off the ground longer than running			
			3. Forward reach with the arm opposite the lead foot			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Horizontal jump	A minimum of 10 feet of clear space and tape	Mark off a starting line on the floor. Have the child start behind the line. Tell the child to jump as far as he/she can. Repeat a second trial.	1. Preparatory movement includes flexion of both knees with arms extended behind body			
			2. Arms extend forcefully forward and upward reaching full extension above the head			
			3. Take off and land on both feet simultaneously			
			4. Arms are thrust downward during landing			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Slide	A minimum of 25 feet of clear space, a straight line and two cones	Place the cones 25 feet apart on top of a line on the floor. Tell the child to slide from one cone to the other and back. Repeat a second trial.	5. Body turned sideways so shoulders are aligned with the line on the floor			
			6. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot			
			7. A minimum of four continuous step-slide cycles to the right			
			8. A minimum of four continuous step-slide cycles to the left			
Skill Score						
Locomotor Subtest Raw Score (sum of the 6 skill scores)						

Appendix G: Object Control Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Striking a stationary ball	A 4-inch lightweight ball, a plastic bat and a batting tee	Place the ball on the batting tee at the child's belt level. Tell the child to hit the ball. Repeat a second trial.	1. Dominant hand grips bat above nondominant hand			
			2. Nonpreferred side of body faces the imaginary tosser with feet parallel			
			3. Hip and shoulder rotation during swing			
			4. Transfers body weight to front foot			
			5. Bat contacts ball			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Stationary dribble	An 8 to 10-inch playground ball for children ages 3 to 5; a basketball for children ages 6 to 10; and a flat hard surface	Tell the child to dribble the ball four times without moving his/her feet, using one hand, and then stop by catching the ball. Repeat a second trial.	6. Contacts ball with one hand at about belt level			
			7. Pushes ball with fingertips (not a slap)			
			8. Ball contacts surface in front of or to the outside of foot on the preferred side			
			9. Maintains control of ball for four consecutive bounces without having to move the feet to retrieve it			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Catch	A 4-inch plastic ball, 15 feet of clear space and tape	Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. Toss the ball underhand directly to the child with a slight arc aiming for his/her chest. Tell the child to catch the ball with both hands. Only count those tosses that are between the child's shoulders and belt. Repeat a second trial.	1. Preparation phase where hands are in front of the body and elbows are flexed			
			2. Arms extend while reaching for the ball as it arrives			
			3. Ball is caught by hands only			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Kick	An 8 to 10-inch plastic, playground or soccer ball; a beanbag; 30 feet of clear space and tape	Mark off one line 30 feet away from a wall and another line 20 feet from the wall. Place the ball on top of the beanbag on the line nearest the wall. Tell the child to stand on the other line. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	4. Rapid continuous approach to the ball			
			5. An elongated stride or leap immediately prior to ball contact			
			6. Nonkicking foot placed even with or slightly in back of the ball			
			7. Kicks ball with instep of preferred foot (shoe laces) or toe			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Overhand throw	A tennis ball, a wall, tape and 20 feet of clear space	Attach a piece of tape on the floor 20 feet from a wall. Have the child stand behind the 20-foot line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.	8. Windup is initiated with downward movement of hand/arm			
			9. Rotates hip and shoulders to a point where the nonthrowing side faces the wall			
			10. Weight is transferred by stepping with the foot opposite the throwing hand			
			10. Follow-through beyond ball release diagonally across the body toward the nonpreferred side			
Skill Score						
Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
Underhand roll	A tennis ball for children ages 3 to 6; a softball for children ages 7 to 10; two cones; tape; and 25 feet of clear space	Place thetwo cones against a wall so they are 4 feet apart. Attach a piece of tape on the floor 20 feet from the wall. Tell the child to roll the ball hard so that it goes between the cones. Repeat a second trial.	1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones			
			2. Strides forward with foot opposite the preferred hand toward the cones			
			3. Bends knees to lower body			
			4. Releases ball close to the floor so ball does not bounce more than 4 inches high			
Skill Score						

Appendix H: Ethical Clearance Certificate

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ETHICAL CLEARANCE CERTIFICATE
REC-270710-028-RA Level 01

Certificate Reference Number:	LY0021 SIDA01
Project title:	Physiological, anthropometric, growth pattern and motor development of rural children in Nkonkobe Municipality, Eastern Cape Province, South Africa.
Nature of Project:	Masters
Principal Researcher:	Mere Idamokoro
Supervisor:	Prof P Lyoka
Co-supervisor:	N/A

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

Special conditions: Research that includes children as per the official regulations of the act must take the following into account:

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
    - Any unethical principal or practices are revealed or suspected
    - Relevant information has been withheld or misrepresented
    - Regulatory changes of whatsoever nature so require
    - The conditions contained in the Certificate have not been adhered to

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office

The Ethics Committee wished you well in your research.

Yours sincerely

Professor Wilson Akpan

Acting Dean of Research

20 September 2016