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Prevalence of Obesity and Overweight among School Children in Moshi Municipality, Kilimanjaro, Tanzania

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Certification and Declaration

I, Josephine Thadeus Kimario, declare that this report is a result of my original work and has not been presented to any other examination body in here and elsewhere. Acknowledgement for other information sources used in this report has been properly referenced according to methods that are accepted by Ghent University. Only author and promoter of this report deserve the right to give permission for consulting and copying parts of this work for personal use. For any other use is obliged by Copyright laws. Particularly when using results from this master's dissertation it is mandatory to specify the sources after having obtained a written permission.

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Abstract

BACKGROUND: The prevalence of children and adolescent's obesity and overweight is increasing in both developed and developing nations. Its trend is rising with urbanization, changes in lifestyle and social economic transition. In Tanzania, children and adolescent's obesity and overweight is not well known and documented. This study aimed to determine the prevalence of overweight and obesity among school children aged 10-12 years in Moshi Municipal – Kilimanjaro, using Body Mass Index (BMI), Triceps and Subscapular skinfold thickness (SFT).

METHODS: A cross- sectional study was conducted, involving 140 school children aged 10-12 years drawn from two randomly selected public and two private primary schools in Moshi Municipal. BMI was calculated from weight and height, triceps and subscapular SFT was measured with Lange skin calliper. Using BMI, overweight and obesity were defined based on the International Obesity Task Force (IOTF) BMI cut off-points. Using triceps and subscapular SFT, overweight (≥85th percentile) and obesity (≥95th percentile) were defined by the use of the reference curves for triceps and subscapular skinfold thicknesses in United States children and adolescents. Data was analysed using Statistical Package for Social Science (SPSS) version 22.0. The Chi square test was used to determine the relationship between overweight/obesity and socio-demographic characteristics and other variables.

RESULTS: The prevalence of overweight and obesity obtained in this study by the use of BMI, Triceps, and Subscapular SFT were 20%, 24.3% and 22.9% respectively. There was a strong level of correlation between the three methods used in the classification of nutrition status of school children. Using all three methods, the prevalence of overweight/obesity and among children in private schools was significantly higher than those in public schools ($p= 0.032$ for BMI, and $p<0001$ for both Triceps and Subscapular SFT). Additionally, parents' education and means of transport used to go to school were positively associated with overweight/obesity.

CONCLUSION: The study revealed a relatively high prevalence of overweight and obesity in Moshi Municipal with majority of children coming from families with high social economic status. Therefore, there is a need for the public health policy in Tanzania for early detection and intervention in order to prevent overweight/obesity among school going children.

Key Words: Obesity, Overweight, Body Mass Index, Skinfold Thickness, School children

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List of Abbreviations

BIA	Bioelectrical Impedance
BMI	Body Mass Index
HRQoL	Health-related quality of life
IOTF	International Obesity Task Force
YPAQ	Youth Physical Activity Questionnaire
SFT	Skinfold Thickness
SPSS	Statistical Package for Social Science
WHO	World Health Organization

Chapter 1: Introduction

1.1 Background

Childhood obesity and overweight is a health problem that needs effective approaches. Its prevalence is becoming a threat to public health worldwide affecting both developed and developing nations (Y. Wang & Lobstein, 2006). Obesity and overweight represent a rapidly growing risk to the health of the people in an increasing number of countries (WHO, 2000). For many developing countries, obesity and its consequence have become a challenge similar to hunger and under nutrition (Keding et al., 2013). Children and adolescent obesity is progressively being observed with the improved technology which is associated with varying lifestyle of families with increased purchasing power, luxurious living, increasing hours of inactivity due to television, video games, and computers, which seems to substitute the outdoor games and other social activities (Abdul-Rasoul, 2012; Singh & Sharma, 2005). The trend of obesity and overweight is rising with urbanization, changes in lifestyle and social economic transition. Social transition is considered to be among the causes of obesity and overweight in which residing in cities provides more access to more fast foods and the emergence of people with high economic income that can afford the fast foods, that is foods with high glycaemic index (Mosha & S Fungo, 2010; Y. Wang & Lobstein, 2006). In fast growing cities like Moshi-Tanzania, children are more exposed to city culture with sedentary life style and high intake of denser foods, soft drinks and less nutritious foods.

Recently there is an increasing prevalence of childhood obesity (5-19years) due to rapidly changing of dietary practices and a sedentary lifestyle in developing countries (Gupta et al., 2012). Prevalence of childhood overweight and obesity worldwide has increased from 4.2% in 1990 to 6.7% in 2010 (De Onis et al., 2010).The trend is anticipated to reach 9.1% in 2020. The estimated prevalence of childhood overweight and obesity in Africa in 2010 was 8.5% and is expected to reach 12.7% in 2020.

Physical and psychological health of the child is highly affected by overweight and obesity, its mechanism is not well understood and it's believed to be disorder of multiple causes. The prevalence of obesity has risen due to environmental factors, lifestyle preferences and cultural environment. It's assumed to be as result of increasing caloric and fat intake. Overweight and obesity are the result of caloric imbalance, too few calories expended for the amount of calories

consumed (Dehghan et al., 2005). Excessive sugar intake through soft drinks, overconsumption of calories and reduced physical activity play a major role in increasing the rate of obesity all over the world. According to experimental and observational studies, both diet and physical activity have a positive effect on decreasing obesity. The parents have an important role in controlling the diet and physical activity of their children as a means of controlling their weight (Dehghan et al., 2005)

In clinical and epidemiologic studies, BMI and SFT are widely used to measure adiposity. The 85^{th} and 95^{th} percentiles of BMI and SFT are frequently used to define overweight and obesity respectively (Luis B Sardinha, Going, Teixeira, & Lohman, 1999). The BMI has become the standard reliable indicator of overweight and obesity meanwhile yet it is incomplete. BMI relies on body weight alone, and it does not measure fat directly, therefore misclassifies athletic adolescences as obese by using BMI. It is much preferred as it is easy and quick to perform, however, without consideration of the complex factors that influence obesity. World Health Organization (de Onis & Habicht, 1996) recommended body mass index (BMI) and triceps and subscapular SFT as the anthropometric methods to assess the weight status of children and adolescents.

1.2 Rationale of the study

Prevalence of children and adolescent's obesity and overweight in Tanzania is not well known by the health specialist and the policy makers, as there is no enough data that documents the problem. Few studies have been done in a few areas such as Dar es Salaam, Dodoma, Njombe and Morogoro but they cannot be used to generalize the whole country. To develop control strategies, the prevalence and causes of these problems should be well documented. Children are a priority group for intervention strategies for prevention of obesity because more potential interventions strategies for children are available compared to adults. This is due to difficulties in reducing excessive weight in adult once it becomes customary. Furthermore, overweight and obesity in children have significant influence on both physical and psychological health.

In Kilimanjaro there is no study that has been done concerning overweight and obesity among school children. This study aims at determining the prevalence of overweight and obesity among school children aged 10-12 years in Moshi municipal using BMI cut off points for defining child overweight and obesity published by IOTF in 2000 (Cole, Bellizzi, Flegal, & Dietz, 2000). These were obtained from sex-specific curves that document through a BMI of 25 kg/m^2 and 30 kg/m^2 by age 18 years, for overweight and obesity respectively. The study also

used Triceps and Subscapular SFT to determine the nutrition status of the children in the study area. Reference curves for triceps and subscapular skinfold thickness in United States children and adolescents were used to classify children as overweight (≥85th percentile) or obese (≥95th percentile) (Addo & Himes, 2010b). This was developed using the same national samples as those that was included in the reference curves for BMI in the Centres for Disease Control and Prevention 2000 Growth Charts.

1.3 Objectives

1.3.1 Main objective

To determine the prevalence of overweight and obesity among school children aged 10-12 years in Moshi Municipality - Kilimanjaro

1.3.2 Specific objectives

1. To assess nutritional status of school children aged 10-12 years in Moshi-Kilimanjaro using skinfold thickness (SFT) and Body mass index (BMI);
2. To assess how the level of physical activity/sedentary behaviour is linked to overweight and obesity of school children (10-12years) in Moshi-Kilimanjaro;
3. To assess how obesity and overweight differ in public and private primary school children in Moshi Municipal.

1.4 Research Questions

1. Is there a relationship in determination of overweight and obesity in school children by using skinfold thickness (SFT) and Body mass index (BMI)?
2. Is the prevalence of overweight and obesity among private school children different from that of public school children?
3. Does physical activity/sedentary behaviour associate with overweight and obesity?

Chapter 2: Literature Review

2.1 Prevalence of Childhood Overweight and Obesity

The prevalence of childhood overweight/obesity has significantly increased in recent years, this has been documented in developed countries whereas data from the developing coutries are scarce (Muthuri et al., 2014). For the few developing countries where studies have been done the prevalence is also increasing. Prevalence of obesity and overweight for both adult and children has increased significantly in the past three decades. There is a great disparities across countries in the levels and trends with distinct county patterns (Ng et al., 2014). People in all socio-economic groups, in both developed and developing countries, irrespective of age, sex or ethnicity are affected by obesity. Worldwide childhood obesity estimates projected that over 22 million children under the age of 5years are severely overweight, and one in 10 children is obese (Kosti & Panagiotakos, 2006).

Recently there has been an increasing prevalence of childhood obesity (5-19years) due to rapidly changing of dietary practices and a sedentary lifestyle in developing countries: 41.8% in Mexico, 22.1% in Brazil, 22.0% in India, and 19.3% in Argentina. Secular trends indicate increasing prevalence rates in these countries: 4.1 to 13.9% in Brazil during 1974 –1997, 12.2 to 15.6% in Thailand in 1991–1993, and 9.8 to 11.7% in India in 2006 –2009 (Gupta et al., 2012). Prevalence of childhood overweight and obesity worldwide increased from 4.2% in 1990 to 6.7% in 2010. The trend is anticipated to reach 9.1% in 2020. The estimated prevalence of childhood overweight and obesity in Africa in 2010 was 8.5% and is expected to reach 12.7% in 2020 (De Onis et al., 2010).

Globally, in 2013 the prevalence of overweight and obesity in children in developed countries was 23·8% for boys and 22·6% for girls. However in developing counties the prevalence was 12.9% and 13.4% for boys and girls respectively (Ng et al., 2014). A systematic review investigating the evidence of overweight/obesity transition occurring in school-aged children and youth in Sub Saharan Africa found the average of overweight/obesity and obesity to be 10.6% and 2.5% respectively (Muthuri et al., 2014). The prevalence of obesity/overweight was higher in children living in urban and those of higher social economic status compared to those of lower socioeconomic status and living in rural areas.

In European region about 20% of children and adolescents are overweight of which a third of these are obese (Branca et al., 2007). In 2007 the childhood obesity was 10 times higher than that of 1970 in European region, predicting high adult epidemic that will creat future health challenge for the coming generation. The overweight prevalence rate in many of the Eastern Europe countries has increased over the time period of 2002 to 2010 (Ahluwalia et al., 2015).

One of the study done in Tanzania that used the IOTF cut-off points to classified the school children aged 7-14 years as obese or overweight in Kinondoni District, Dar-es-salaam found the prevalence of overweight and obesity to be 10.2% and 4.5% respectively (Mwaikambo, 2012). Another study conducted in 2010 to determine prevalence of overweight and obesity among children aged 6-12 years in Dodoma and Kinondoni municipalities reported prevalence of obesity among children aged 6 - 9 years in Dodoma and Kinondoni to be 5.6% and 6.3% respectively. Likewise, 4.2% of children aged 6-9 years in Dodoma were overweight while 8.6% in Kinondoni municipality were overweight. For children aged 10-12 years, 3.9% in Dodoma were obese compared to 5.8% in Kinondoni whereas 4.9% of the children of the same age in Dodoma were overweight compared to 5.8% in Kinondoni. (Mosha & S Fungo, 2010). The study categorized children as overweight or obese based on WHO cut-offs and body fat mass measurements by using bioelectrical impedance (BIA).

Alwan (2011) found a sharp rise in overweight among infants and young children in lower-middle-income countries but higher prevalence in the upper middle-income (Alwan, 2011). Figure 2-1 below shows the trend of infant and children overweight trend as from 1990 to 2015.

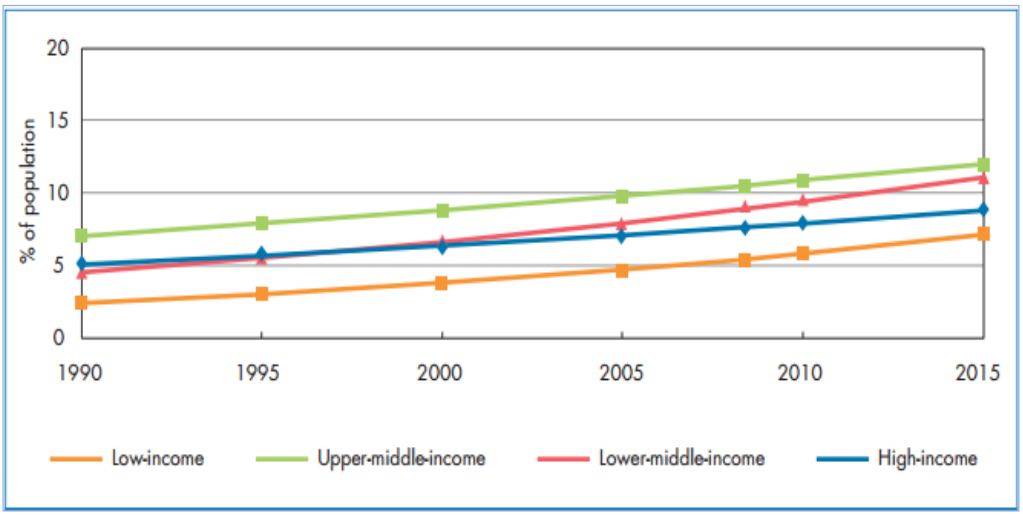

Figure 2-1 Infant and young child overweight trends from 1990 to 2015, by World Bank income group

Source : (Alwan, 2011)

2.2 Factors Contributing to Child Overweight and Obesity

Generally, childhood obesity is believed to be caused by a wide range of interrelating factors operating at multiple levels. This includes; the school environment, sociocultural factors, family and individual behaviour and factors related to macro-level policy influences (Mohammadpour-Ahranjaniet al., 2014).

2.2.1 Behaviour factors

Behaviour is believed to be one of the factor that cause person to become overweight or obese**.** It comprises the following;

2.2.1.1 Dietary behaviour

This include consumption of fast food or drinks, frequency of fast food consumption, taste, quick access and peer influence, large portion size, unhealthy food, eating away from home, and regular drinking of sugar-rich beverages (Patterson et al., 2012). Skipping of breakfast, consumption of less than three meals per day, low intake (low serving per day) of fruits, vegetables, milk and milk products. All these revealed to be predictors of overweight and obesity among school children (Amin et al., 2008; Antonogeorgos et al., 2012). Childhood obesity in countries with limited resources and food availability is favoured by good socio-economic status of their parents while still insufficient nutrition education is available (Kouéta et al., 2010). Eating behaviour of the children is influenced by the availability of food, peers, siblings and parent's behaviour and child-feeding practices. (Birch & Fisher, 1998).

Fruits and vegetables intake has shown to be associated with overweight and obesity in children and adolescents. This indicates that sufficient fruits and vegetables intake can help maintain healthy weight status (Bes-Rastrollo et al, 2006). A recommended levels of fruits and vegetables consumption has suggested to help reduce obesity, this is due to their bulk and low energy density that are believed to reduce energy-dense food consumption as they are low in fat, calories, and added sugar while having high concentrations of nutrients and fibres (Rolls et tal., 2004). Fruits and vegetables have high amount of water and fibre content that may help feel full and increase satiety at a meal while consuming fewer calorie hence being considered as a good substitutes for foods. Children aged 10-12 years that consume breakfast daily was found to be have lower chance of being overweight/obese (Antonogeorgos et al., 2012; Manios et al., 2014). Breakfast, fruits and vegetables are to be emphasized in promoting a healthy diet and weight status.

2.2.1.2 Physical activity

Obesity is mainly explained by a prolonged positive energy imbalance due to increased energy intake and decreased spending. Physical activity determine number of calories that are spent or stored in the body as fat. It maintain healthy weight status because of its potentially major impact on body composition, metabolism, and increasing energy expenditure (Nowicka & Flodmark, 2007). Physical activity not only has benefits that are associated with obesity but also reduces risk for cardiovascular diseases and diabetes, reduces blood pressure, depression and osteoporosis, improves the level of high density lipoprotein cholesterol and control of blood glucose in overweight people. It further reduces systemic inflammation and blood coagulation, reduces the risk for colon cancer and breast cancer among women, and promote autonomic tone and improve cardiac and endothelial function (Warburton et al., 2006; Nowicka & Flodmark, 2007).This reveal that effective physical activity prevents both primary and secondary chronic diseases and premature death.

Sports has been considered as the lowest physical activity practiced by children. Outdoor play and sports in children has been substituted by video games, televisions, computers, and mobile devices which make a child to be physically inactive thereby increasing the risk of becoming overweight/obese (Kelishadi et al., 2003). Shortage of safe spaces for children to play and perform sports, lack of parents' time and family low income are the factors that influence childhood obesity (Yamamoto-Kimura et al., 2012).

It has been noticed that the diet and the level of physical activity of children is highly affected by what they do at school, home, as well as in the community. In helping obese child or adolescent in weight management it is not required to suggest structured exercise programs, more emphasis will be on how to live an active lifestyle such as reducing sedentary behaviour, encouraging everyday activities and sports, emphasizing the importance of physical education class at school, increasing the variety of activities and encouraging spontaneous play and hobbies (Nowicka & Flodmark, 2007). Physical activity of children and adolescents varies with age, type of exercise and setting. In order to maintain or improve children's and adolescent's health (5-17 years old), a minimum of 60 minutes of regular, moderate-intensity physical activity is recommended by World Health Organization recommends (WHO, 2010). Physical activities should be done on daily basis at family and school settings and it also include the community activities, which includes play, games, sports, physical education, and recreation.

In a systematic review of the evidence base for health and physical activity in school-age children by Strong and colleagues recommended 60 minutes or more of physical activity, which can be achieved collectively in school during physical education class, as well as before and after school hours (Strong et al., 2005), this suggested that unsupervised activities can be the best option in making the children more active. A greater amount of physical activity would be necessary to attain health benefits effects and behaviour outcome in daily environments.

Unstructured play proved positive effects on child development, through improving physical fitness, for optimal development of all tissues and organs (Nowicka & Flodmark, 2007). Children develop movement skills and feel safer through playing which can improves their self-esteem. They learn social skills when playing with others, thereby expanding their cognitive skills. On the other hand a planned, structured, and repetitive exercise (aerobic, strength training or both), has been found to reduce the body fat percentage in overweight and obese children and adolescents (Kelley & Kelley, 2013).

2.2.1.3 Sedentary behaviour

Any activity which is measured by an energy expenditure ≤ 1.5 metabolic equivalents and a sitting or reclining posture is termed as sedentary activity. It include TV viewing, playing video game, computer use collectively called "screen time", driving automobiles, and reading, excessive sitting–lying down, or a combination of both (Cart, 2012). All these indicate lack of physical activity**.** It has been evidenced by various studies that decreasing sedentary time is associated with lower health risk in children and youth. To overcome this, screening time should be restricted to not more than 2 hours per day, more than 2 hours is associated with reduced physical and psychosocial health, and can lead to higher BMI. Also sedentary time can be reduced by limiting motorized transport, time spent indoors and prolonged sitting time (Tremblay et al., 2011).

Significant association between screen time and obesity in children aged 6- 12 years has been observed, where children who spent less than two hours per day on screen time were at less risk of becoming overweight or obese, compared with those who spent more than three hours per day (Li et al., 2015). This association was also observed in the study which was assessing the prevalence and risk factors of overweight among 5- to 11 year old schoolchildren in Narbonne, France. (Padilla et al., 2011). High level of sedentary activities more than four hours per day

together with a limited exercises has also found to lead to overweight and obesity among school children in urban cities in Bangladesh (Bhuiyan et al., 2013).

Sleep deprivation plays a main part in obesity in children. Sleeping less than 10 hours per night (short sleep duration) are the risk factors for overweight and obesity in children. (Padilla et al., 2011); (Owens et al., 2014). Short sleep duration is associated with television viewing, computer use and late bedtime (de Jong et al., 2012) and increased food intake (Chaput & Tremblay, 2012). To attain optimal health, school aged children should sleep at least ten hours per day. In order to attain high demand of physical, emotional and sexual development, the sleeping time of children and adolescents should be increased (Koss et al., 2015).

The physical activity and walking to school duration are significantly correlated with body mass index. Rural children have high prevalence of obesity and overweight than the urban children because of lower physical activity and less time spent walking to school (Itoi et al., 2012). Frequently walking or cycling to school makes children more active than the using school buses or private cars (van Sluijs et al., 2009). Participating in home and school chore is another way that makes a child/adolescent active (Laxmaiah et al., 2007). The prevalence of overweight and obesity was found significantly lower to those children who participate in household chores for more than three hours per day.

2.2.1.4 Parenting style and Family socio-demographic characteristics

Parenting style and family socio-demographic characteristics has an effect on the children's healthy behaviour (Berge et al., 2010; Berge et al., 2010; Chen & Kennedy, 2004; Halliday et al., 2013). Poor family functioning is linked with increased risk of overweight and obesity in children and adolescents (Halliday et al., 2013). This includes poor communication, poor behaviour control, and high levels of family conflicts, low family hierarchy values and unstructured parenting. Children spend long hours away from home hence learning some of their behaviour outside home. Directives from the parents may boost or limit children's consumption of several food which may affects the development of food preference together with the modification of energy intake (Birch & Fisher, 1998). A study of Verloigne et al., (2012) found that lenient parenting style was associated with the risk factors for children overweight and obesity, such as less breakfast and more soft drink consumption.

Relationship between cultural and socio-economic characteristics of the parents and the children's obesity and overweight has been shown by some studies. Some showed that the

children with parents with higher education level (university degrees and high school diplomas) and with more highly qualified occupations had a lower likelihood of being overweight/obese than of children with lower education and less qualified occupation (Albertini et al., 2008; Posso et al., 2014). Contrary one of the systematic review which was reviewing the evidence of overweight/obesity transition among school-aged children and youth in Sub Saharan Africa (Laxmaiah et al., 2007; Muthuri et al., 2014) found the higher prevalence of overweight and obesity in children of higher social economic status compared to those of lower socioeconomic status. Another study in the United States, revealed that adults with low and medium income and less qualified occupation were more at risk of obesity and overweight, where this led to a large risk to their children due to their influence on the family diet and lifestyle (Drewnowski & Darmon, 2005). This is because the lower cost of refined grains, added sugars, and added fats compared to that of more nutrient dense, fish, lean meats, fresh vegetables, and fruit whereby the people with low income and less qualified occupation cannot afford.

Rising income in low income countries, is connected with increasing rates of overweight among infants and young children whereas in high-income countries, higher prevalence is found more among people with lower socioeconomic status (Alkali et al., 2015; De Silva et al., 2015; Y. Wang, 2001).

Family size seemed to have an association with children's overweight and obesity. It was observed that children with higher children BMI was related with small family size (Gulliford et al., 2001).

2.2.2 Environmental factors

Children are the vulnerable group highly influenced by surrounding environment and by other children. The current environment in homes, schools, and neighbourhoods tend to discourage a healthy lifestyle (Penney et al., 2014). The external food environments and access to fast food restaurants, food stores, supermarkets, in schools, or recreation and sports sites, are characterized by energy dense, nutrient-poor food items which may play a part in increasing weight status of an individual (Bodor et al., 2010). The consumption of food rich in fat, sugar and energy may be influenced by the environment where the food are present and consumed by peer and the family (Birch & Fisher, 1998; Penney et al., 2014).

World health organization (WHO, 2008) reported that several environmental factors including low air quality, pollution, and high density traffic, lack of parks, sidewalks, violence and

absence of recreational facilities due to increased urbanization might discourage participation in physical activity in both adult and children thus increasing the rate obesity and overweight.

2.2.3 Genetic factors

Genetic predisposition is linked to several genes that make a given individual or a family of given individuals more exposed to obesity. This may lead an individual to face more difficulties in maintaining a healthy weight when confronted with a high calorie diet. (Kouéta et al., 2010). It has been noted that the family history of obesity multiplied the risk of overweight among children. The risk of a child to become overweight/obese is high if one or both parents are overweight, suggesting that children of obese parents are at higher risk of developing obesity than children of non-obese parents (Birch & Fisher, 1998). The obesity rate is increasing due to the interaction between genetic susceptibility to obesity and recent several environmental factors that have changed because of global nutrition and health transitions (Demerath, 2012)

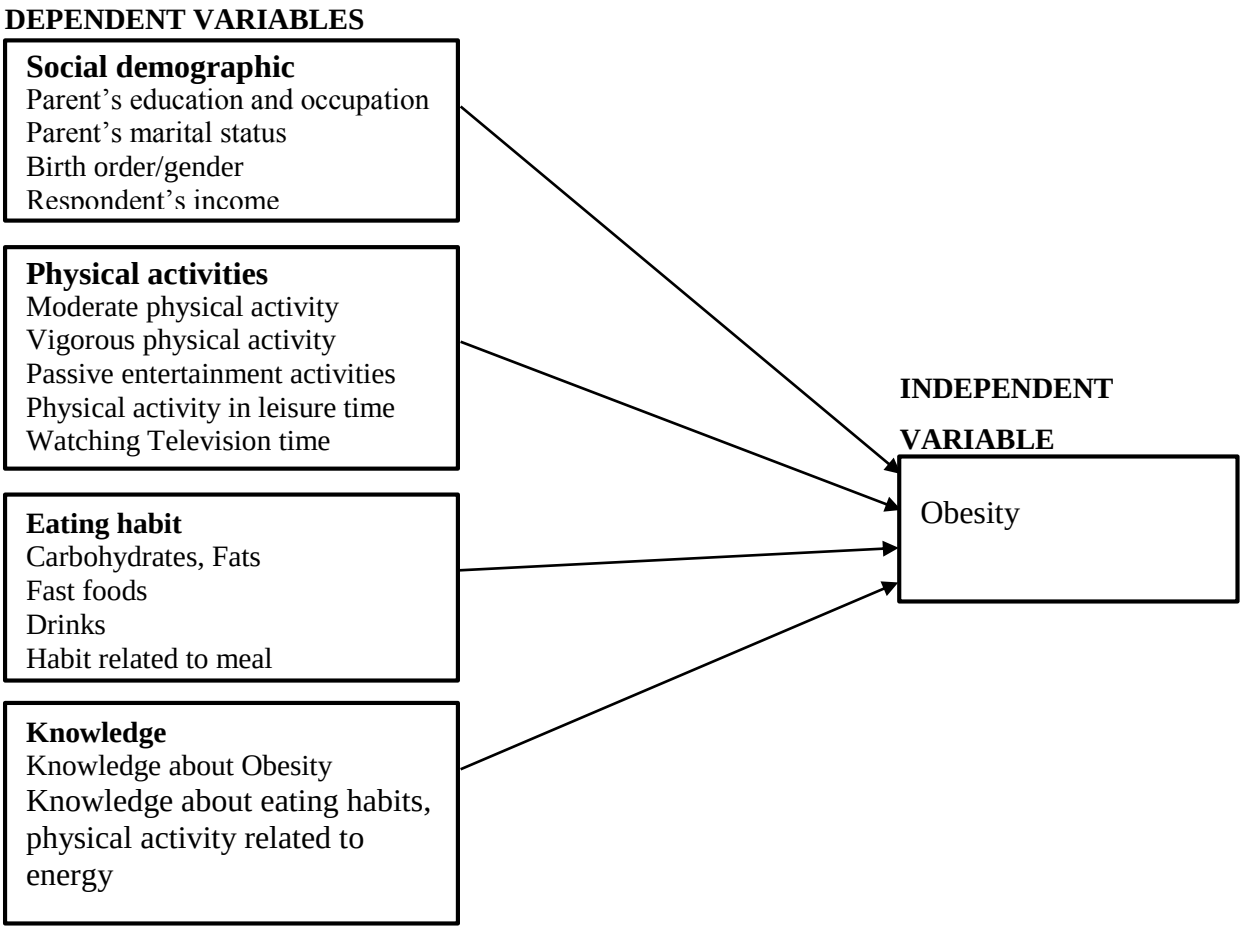

Figure 2-2 Conceptual Framework

Source:(Thanh, 2008)

2.3 Assessment of Adult and Childhood Obesity

Obesity and overweight in adult are often determined using the BMI. Adults are classified as obese or overweight by a variety of cut-off values. The World Health Organization has published specific BMI criteria for overweight and obesity in adults. A BMI value of 25-29.9 kg/m² indicates overweight whereas a BMI value of 30 kg/m² and above indicates obesity. The classes of obesity is further classified into class I (BMI 30-34.9 kg/m²), class II (BMI 35-39.9 kg/m²) and BMI > 40 kg/m² as class III (WHO, 2000) The intra-abdominal fat is estimated through waist circumference and the waist hip circumference ratio, these are regularly used to predict the health risk of obesity in adults.

It is difficult to measure obesity in children and adolescents by using only BMI. This is largely because they are growing as there is an increase in weight for height, sexual maturation and the changing body composition. BMI in children changes consequently with age as it rises during infancy, falls during the preschool years and rises again during adolescences and early adulthood (WHO, 2000). If the child has a high weight before the age of six, the child has all the risks of being obese in adulthood (Kramoh et al., 2012). Also BMI changes in children differs between boys and girls, in this case Age- and sex specific reference curves are used to assess fatness in children and adolescents (Cole et al., 2000). IOTF cut-off points for classifying children as obese or overweight were obtained from sex-specific curves that determined that a BMI of 25kg/m2 and 30kg/m2 by age 18years, for overweight and obesity, respectively

BMI measures excess weight instead of excess body fat (Freedman et al., 2007). Its pattern reflect actual changes in body weight and early in life it is an indicator of later development (Rolland-Cachera, 1993). Various methods have been a to assess adiposity in children including absolute weight, weight for height percentiles, percent of ideal body weight, body mass index and skinfold thickness (Sarria et al., 1998). World Health Organization (de Onis & Habicht, 1996) recommended BMI and Triceps and Subscapular SFT as the anthropometric methods to assess the weight status of adolescents.

The best estimators of body density in the children and adolescents studied were a combination of BMI and SFT. SFT are used as a good predator of total body fat (adiposity) in children and adolescences which provides a good estimate of obesity and body fat distribution, (Nooyens et al., 2007);Ahmad et al., 2013; Rolland-Cachera, 1993).

The most common sites that are used are subscapular and triceps SFT measurements. The triceps SFT measures percentage fat while subscapular SFT determines the internal body fat (Rolland-Cachera, 1993). BMI during adolescence is predictive of BMI at adult age but it cannot differentiate between lean and fat body mass, in this case SFT is suggested to be a better predictor of body fatness and obesity (Himes et al., 1980; Nooyens et al., 2007). BMI is more recommended measure for accessing overweight and obesity status, but the percentiles and z scores of subscapular and of SFT will allow better assessment of adiposity (Addo & Himes, 2010a; Ahmad et al., 2013). It has been suggested that in monitoring the school children growth skinfold measurements should be preferred in addition to BMI (Lobstein et al., 2015). SFT measurements are fast, non-invasive, easy and requires simple training so that a precision can be attained.

2.4 Consequences of Obesity

2.4.1 Social effects

Obesity and overweight are substituting more traditional complications such as under nutrition and infectious diseases as the utmost significant causes of ill-health (WHO, 2000). Obese children and adolescents are highly socially and psychologically affected. They experience discrimination and poor self-esteem, which can continue into adulthood. Obese children are seen to be taller and viewed more matured compared to non-overweight peers thus affecting their socialization (Dietz, 1998). Additionally, physical, emotional, social and school functioning of children and adolescents is affected by obesity (Riazi et al., 2010). This revealed that obese children and adolescents have inferior health-related quality of life (HRQoL) scores on all dimensions compared to the healthy controls. This was also witnessed in adult where HRQoL was found to be low in obese and overweight adult (Döring et al., 2015). Likewise recently study of Finistrella et al., (2015) determined that obese preadolescence and adolescence were found to be at higher risk of developing eating disorders and social problems as compared to normal weight peers.

2.4.2 Health effects

Overweight and obese children can possibly become obese during adulthood (Samuelson, 2004). Overweight and obesity in children and adolescents may lead to intermediate and long term health risks (Must, 1996). Obesity could also lead to various co-morbidities comprising coronary heart disease, hypertension and stroke, certain types of cancer, type 2 diabetes

mellitus, gallbladder disease, dyslipidaemia, osteoarthritis and gout, and pulmonary diseases, including sleep apnoea, hyperlipidaemia and abnormal glucose tolerance (WHO, 2000; Samuelson, 2004; Dietz, 1998).

The risk of adult overweight in adult was shown to be two times higher for those who were overweight during childhood stage compared to those who were not overweight, this has been demonstrated in a long term follow-up studies that included children and adolescents (Guo et al., 2002; Must, 1996) In a study of Kesztyüs et al., (2014) meant at studying the associations between HRQoL, frequency of illness, and weight in primary school children in southern German reported that the obese children especially the central obese had extra sick days and numbers of visiting a physician than non-obese.

2.4.3 Economic effects

Obesity-related health problem adversely impacts health outcomes including quality of life, disability and mortality which end up by increasing healthcare utilization (Lehnert et al., 2013). Being overweight or obese has economic significances (Branca et al., 2007). It includes the costs of health services, these includes higher medical costs associated with obesity related diseases including hospitalization, drugs, radiological or laboratory tests, and long term care including nursing homes. The economic costs from the excess morbidity and mortality due to obesity-related diseases is not only on the health-care costs alone but also through decreases in workforce productivity (Y. C. Wang et al., 2011).

There are indirect costs that are associated with obesity. Obesity has a negative effect on workforce productivity and costs, it includes absenteeism and disability days. The missing working days for obese workers seems to be more as compared to non-obese workers (Trogdon et al., 2008). Employers pay higher life insurance for workers' compensation for employees who are obese than for employees who are not obese. Studies done in WHO European Region shows that, the health care costs of obesity account for 2–4% of national health expenditure, this included the significant indirect costs that are earned from lost productivity due to work absences as a result of health problems and premature death (Branca et al., 2007). The evidence has shown that obesity has a negative impacts on individuals, healthcare systems, employers, and the economy in general (Lehnert et al., 2013).

2.5 Strategies towards School Children Obesity Prevention

Children are considered as the priority group for intervention strategies for prevention of obesity because more potential interventions strategies are available compared to adults. It would be more advantageous to initiate prevention and treatment of obesity in early stage of life as a successful prevention and treatment of obesity in childhood could reduce the adult incidence of various disease (Dehghan et al., 2005). There seems to be no easy-going solution to combat school children overweight and obesity, to maximize its success a range of strategies has to be considered. Both school and home environment has to be well-thought-out when planning interventions to prevent children's overweight and obesity. This is because these settings has an influences on eating and physical behaviour of children (Control & Prevention, 2011; Golan, 2006). Interventions directing build environment, physical activity and diet may combat obesity/overweight. The following were found to be promising policies and strategies by various studies;

- Incorporating nutrition education lessons (healthy eating), physical activity into school curriculum as the best way of preventing and treating school children obesity (Waters et al., 2011; Katz et al., 2008). Randomized controlled trials studies that concentrated on physical activity or nutrition in school seemed to produce promising results (Hung et al., 2015). On the other hand, changed school food environments and cultural practices, through improving nutritional quality of the food supply in schools, examples reducing higher denser foods/snacks/drinks in vending machines and increasing availability of fruits and vegetables proved positive. (Kaphingst & French, 2006; Waters et al., 2011).

- Parent support through promoting healthy eating by encouraging children to eat more nutritious food, promoting physical activity through training their children to participate in various home activities and spend less time in screen based activities (Koplan et al., 2005; Verloigne et al., 2012; Waters et al., 2011).

- Encouraging sleep and fighting against sedentary lifestyle can be of great advantages in lessen the prevalence of overweight and obesity to children (Padilla et al. 2011; de Jong et al. 2012). This can be done successfully by the parents through improving their parenting skills and providing knowledge and structural timetable to their children

Obesity is a complex condition that covers many factors, including environmental, behavioural, psychosocial, inherited, and metabolic factors, thereby making it difficult to be resolved (Waters et al., 2011). Long term sustainable impacts must be attained by the Childhood obesity prevention research through incorporate effective interventions within health, education and care systems.

Chapter 3: Methodology

3.1 Study Area

The study was conducted in Moshi Municipal, in Kilimanjaro region located in the North Eastern part of Tanzania Mainland. Kilimanjaro rsegion is divided into seven administrative districts: - Moshi Municipal Council, others are the district council including Moshi, Hai, Siha, Rombo, Mwanga and Same. The region covers an area of 13,209 km^{-2} or 1.4% of the area of the entire Tanzania Mainland. Moshi Municipal Council **(**study area**)** has a population of 184,292 according to the 2012 census. It is among the fast growing urban centres of the country and most populated among others. The municipal has a total of 48 Primary schools, whereby 35 of them are public owned and the rest 13 are private schools (Moshi Municipal Investment Profile, 2013).

3.2 Study Design

A cross sectional study was carried out in two public and two private primary schools in Moshi municipal, Kilimanjaro using multiple methods of data collection.

3.3 Study Population

Study population were the children aged 10-12 years who attended public and private primary schools in Moshi municipal, Kilimanjaro. This age group was selected because they are more likely to be able to understand and respond accurately to questions than younger children (for a better communication).

3.4 Sampling Technique

A stratified random sampling was used to select two public schools (St Anne and Moshi Airport primary school) and two private schools (Kiboriloni and Soweto primary school) as the representatives of other schools in the municipal. The school children aged 10-12 years in each school selected were stratified according to gender then simple random sampling was applied to get 140 children to participate in the study. This approach is of benefit as it improves the representativeness of the sample by reducing sampling errors.

3.5 Data Collection

3.5.1 Anthropometric Measurements

Body height was measured to the nearest 0.1cm, using stadiometer and weight to the nearest 0.1 kilogram using a standard weighing scale with child wearing light clothes and with no shoes. Also children's triceps and subscapular SFT was measured to the nearest 0.5 mm using a Lange skin calliper. Three measurements were taken at each site and recorded. Both measurements were taken on subjects' right side in accordance with standard procedures (Lohman et al., 1988). BMI was calculated as 'body weight in kilograms divided by height in meters squared (kg/m^2). The cut-off points recommended in identifying the age and gender-specific cut-off points for the BMI with the age ranging from 1 to 18 years for the diagnosis of overweight and obesity was used (Cole et al., 2000). Cut offs to define thinness in children and adolescents, based on body mass index at age 18 years was also used (Cole et al., 2007). Reference curves for triceps and subscapular skinfold thicknesses in the United States children and adolescents was used to classify children as overweight (≥85th percentile) or obese (≥95th percentile)(Addo & Himes, 2010b). The children whose skinfold thickness was above the upper limit of normal were considered to be obese, however children that corresponded to ≤10th percentile were identified as underweight (Schneider et al., 2007).

3.5.2 Questionnaires

Structured questionnaire was used for data collection. Social demographic information such as age, sex, type of school, parent's education and occupation, number of people in the household were collected. Anthropometric measurements were included in this questionnaire and all the measurements were done as explained above in section 3.5.1. Information regarding physical activity and sedentary behaviour and some questions regarding dietary behaviour were collected using the same questionnaire. Some questions from the Youth Physical Activity Questionnaire (YPAQ) were included in this questionnaire. This questionnaire (YPAQ) has been validated (Crocker et al., 1997) where the PAQ-C has been supported as a cost efficient method of evaluating general levels of children's physical activity during the school age. The physical activities that are accustomed and match with the objectives of this study were included in this questionnaire.

3.6 Data Analysis

A number of statistical tests were conducted to analyse the results of this study, using Statistical Package for Social Science (SPSS) version 22.0. Data was entered in Microsoft Excel spreadsheet (Microsoft Office Excel) where BMI was calculated from the height and weight measurements of each school children. The data was then imported into a Statistical spreadsheet (Statistical data analysis software system, version 22.0) and analysed. Descriptive analyses were conducted in reporting distributions of study variables of interest.

Normality of distribution of each continuous variables was checked using Kolmogorov-Smirnov testing, histogram, box plot and QQ plots. Variables were expressed as mean ± standard deviation for normal distributed data whereas for non-normally distributed data the median, 1st, 3rd quartile were recorded. To compare the means and median differences as a function of socio-demographic variables, Independent Student t-tests and Mann-Whitney U-tests were used respectively.

Chi square (χ^2) test was used to determine if there were differences in prevalence of overweight and obesity as a function of socio-demographic variables and other variables. For all statistical tests, the level of significance was set at $p = 0.05$.

All the association of the variables was done by comparing two groups. The overweight children were combined with obese children (overweight/ obese) and those of normal weight were combined with the underweight ones (normal weight/underweight). The underweight children were combined with normal weight ones because they were not seen to be malnourished/ skinned as they were not far from the normal weight borderline.

For the control of the confounders a step wise logistic regression analysis was conducted assigning BMI, Triceps and Subscapular SFT as the dependent variables. While the type of school as an independent variable of interest, together with other factors that had statistical significant association (considered as confounders) with school children overweight/ obesity were included in the model (father's education, mother's education and mode of transport used to go to school).The odd ratios, p-values and 95% confidence intervals were recorded.

3.7 Ethical Considerations

Permission to conduct the study was obtained from the Municipal Director of Moshi Municipality. The list of primary schools present in Moshi used for sampling was obtained from the District Education Officer.

A written informed consent to take anthropometric measurements and interview children was given to school head teachers. Each respondent gave verbal consent before participating in the study. All the respondents were aware of their rights to refuse to answer any question, ask questions at any point, confidentiality and anonymity, know how the data will be used as well as being clear about data ownership and copyright issues.

Chapter 4: Results

4.1 Demographic characteristics of study participants

Participants and parents demographic information is provided table 4-1. A total of 140 school children participated, where (n=68; 48.6%) were boys and (n=72; 51.6%) were girls. All of them were included in the analysis of all variables. Two private schools and two public primary schools were involved, (n= 69; 49.3%) children from a private school and (n=71; 50.7%) from public school. Majority of the school children were from the families with more than 6 people (n=62; 44.3%). All children knew their parent's education and occupation.

Table 4-1 Demographic characteristics of study participants

Characteristics	Number	Percentage
Sex		
Boys	68	48.6
Girls	72	51.6
Type of school		
Private	69	49.3
Public	71	50.7
Number of people living in a household		
2 -3	17	12.2
4	24	17.1
5	37	26.4
+6	62	44.3
Father's education		
Primary education	58	41.4
Secondary education	32	22.9
Post-secondary/college	50	35.7
Mother's education		
Primary education	73	52.1
Secondary education	27	19.3
Post-secondary/college	40	28.6
Father's occupation		
Formally employed	55	39.3
Self-employed	67	47.9
Unemployed	18	12.9
Mother's education		
Formally employed	43	30.7
Self-employed	69	49.3
House wife	28	20.0

Table 4-2 shows the age, height, weight, BMI, average triceps SFT and average subscapular SFT of the school children. The age range was 10-12 years, with a mean of 11.1 ± 0.8 years. The mean weight and height were 37.6 ± 9.1 kilograms and 1.4 ± 0.9 meters respectively. The

mean BMI was 17.9 ± 3.1 kg/m² while the mean Triceps and Subscapular SFT was 13.8 ± 7.3 millimetres and 9.7 ± 35.4 millimetres respectively.

Table 4-2 Descriptive statistics of age and anthropometric measurements of the school children

Variable	Range	Min**	Max ***	Mean ± SD
Age in years	2.0	11.0	12.0	11.1 ± 0.8
Weight in kilograms	46.0	21.5	67.5	37.6 ± 9.1
Height in meters	0.4	1.2	1.6	1.4 ± 0.9
Body mass index kg/m²)	16.1	13.2	29.4	17.9 ± 3.1
Average Triceps SFT in mm*	31.1	3.8	35.0	13.8 ± 7.3
Average Subscapular SFT in mm*	25.3	4.00	29.3	9.7 ± 35.4

* Mean of three measurements, **Minimum, ***Maximum

Mann Whitney test was used to compare the median of BMI, Triceps SFT and Subscapular SFT between girls and boys. The median BMI for the girls (17.3 kg/m²) was higher than that of the boys (16.7kg/m²), however this difference was not statistically significant.

The medium triceps values were 14.08 mm for girls and 10.5 mm for boys, whereas the medium subscapular values were 9.17 mm for girls and 7.0 mm for boys. There was statistical significant different in triceps SFT (p=0.009) and subscapular SFT (p=0.001) between boys and girls, where girls showed higher Triceps and Subscapular SFT values as shown in table 4-3 below.

The median BMI, Triceps and Subscapular SFT according to type of schools (Table 4-4**)** were found to be significantly (p< 0.001) higher for the sample of private school children compared to their public school counterpart.

Table 4-3 Comparison of BMI, Triceps SFT and Subscapular SFT between girls and boys

Variables	Gender						p-value*
	Girls (n=72)			Boys (n=68)			
	Min ***	Max ****	Median (1st,3rd quartile)	Min ***	Max ****	Median (1st,3rd quartile)	
BMI (kg/m^2)	13.3	29.4	17.3 (15.8,20.3)	13.6	26.5	16.8 (15.5,18.9)	0.186
Average Triceps SFT (mm)**	4.0	31.0	14.1(9.5,20.5)	3.8	35.0	10.5 (6.7,15.8)	0.009
Average Subscapular SFT(mm)**	4.0	29.3	9.2(6.7,14.1)	4.0	22.5	7.0 (5.3,9.1)	0.001

* Mann Whitney test, ** Means of three measurements, ***Minimum, ****Maximum

Table 4-4 Medium BMI, Triceps and Subscapular SFT according to type of school

Variables	Type of school		
	Private	**Public**	**p value****
	Median (1st, 3rd quartile)	Median (1st, 3rd quartile)	
BMI (kg/m²)	18.4 (16.5, 20.7)	16.1 (15.3, 18.2)	<0.001
Average Triceps SFT (mm)*	15.2 (11.6, 22.9)	9.5 (6.0, 13.0)	<0.001
Average Subscapular SFT(mm)*	9.7 (7.5, 15.0)	6.3 (5.2,8.3)	<0.001

* Means of three measurements ** Mann Whitney test

4.2 Prevalence of overweight and obesity among school children

BMI, Triceps and Subscapular SFT were used to access the prevalence of overweight and obesity among school children as shown in table 4-5. Based on BMI, the prevalence of obesity was (n=4; 2.9%) while that of overweight was (n=24; 17.1%). With triceps SFT method the prevalence of obesity was (n=16; 11.4%) and that of overweight was (n=18; 12.9%). Subscapular gave a prevalence of obesity of (n=14; 10.0%) while that of overweight was (n=18; 12.9%). The prevalence of overweight and obesity using all BMI, Triceps and Subscapular SFT cut-offs was not found to be significantly different between girls and boys. Higher obesity prevalence was detected with the use of Triceps SFT (n=16; 11.4%) followed by Subscapular (n=14; 10.0%) and lower with the use of BMI (n=4; 2.9%). On the other hand, high prevalence of overweight were recorded using BMI (n=24; 17.1%) however both Triceps and Subscapular SFT detected the same number of school children (n=18; 12.9%) as overweight. There was no great variation in number of school children that was identified as obese using Triceps SFT and Subscapular SFT.

Using all methods used (BMI, Triceps and Subscapular SFT), the prevalence of overweight and obesity among children attending private primary school was found to be significantly higher than those who attended public primary school (BMI p=0.032, Triceps SFT p= <0.001 and subscapular SFT p=0.001).

Table 4-5 Nutritional status classification of school children aged 10-12 years using BMI, Triceps SFT and Subscapular SFT

Method used	All (N=140)	Sex			Type of school		
		Girls (N=72) n (%)	Boys (N=68) n (%)	p-value*	Private (N=69) n (%)	Public (N=71) n (%)	p-value*
BMI category							
Obesity	4 (2.9)	2 (2.8)	2 (2.9)		3 (4.3)	1 (1.4)	
Overweight	24 (17.1)	16 (22.2)	16 (11.8)		17 (24.6)	7 (9.9)	**0.032**
Normal weight	100 (71.4)	48 (66.7)	52 (76.5)	**0.438**	46 (66.7)	54 (76.1)	
Underweight	12 (8.6)	6 (8.3)	6 (8.8)		3 (4.3)	9 (12.7)	
TRICEPS SFT category							
Obesity	16 (11.4)	9 (12.5)	7 (10.3)		13 (18.8)	3 (4.2)	
Overweight	18 (12.9)	10 (13.9)	8 (11.8)		13 (18.8)	5 (7.0)	
Normal weight	9 (64.3)	44 (61.1)	46 (67.6)	**0.884**	41 (59.4)	49 (69.0)	**<0.001**
Underweight	16 (11.4)	9 (12.5)	7 (10.3)		2 (2.9)	14 (19.7)	
SUBSCAPULAR SFT category							
Obesity	14 (10.0)	6 (8.3)	8 (11.8)		13 (18.8)	1(1.4)	
Overweight	18 (12.9)	12 (16.7)	6 (8.8)		12 (17.4)	6(8.5)	
Normal weight	106 (75.7)	52 (72.2)	54 (79.4)	**0.239**	44 (63.8)	62 (87.3)	**0.001**
Underweight	2 (1.4)	2 (2.8)	0 (0.0)		0 (0.0)	2 (2.8)	

* Chi square (χ^2) test

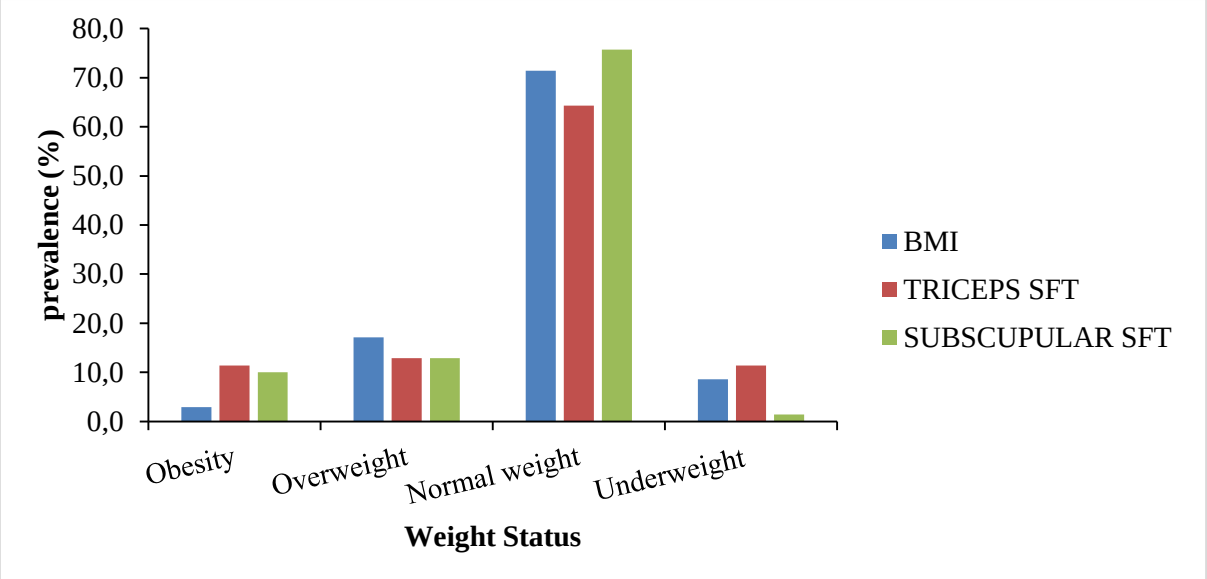

Figure 4-1 Weight status using BMI, Triceps SFT and Subscapular SFT

4.3 Correlation between BMI and skinfold thickness measures in assessing Obesity and overweight

Pearson correlation (r) shows a positive relationship between BMI and both SFT measurements (Triceps and Subscapular) in the assessment of overweight and obesity among school children. As shown in table 4-6 below, the relationship between BMI and triceps SFT showed high level of correlation ($p \leq 0.001$; $r=0.853$), the association between BMI and subscapular SFT was weaker than that of BMI and Triceps SFT ($p \leq 0.001$; $r=0.55$). Stronger correlation was also detected between Triceps SFT and Subscapular SFT ($p \leq 0.001$; $r=0.893$).

Table 4-6 Correlation between BMI and skinfold thickness

Method used	BMI r (p-value)	Triceps SFT r (p-value)
BMI	-	-
Triceps SFT	0.853(≤0.001)	-
Subscapular SFT	0.55 (≤0.001)	0.893 (≤0.001)

r correlation coefficient, Correlation is significant at the 0.05 level

There was an overlap in the classification of school children as overweight /obese between the methods as shown in figure 4-2 below. A total of 43 school children were classified as overweight/obese using combination of either three, two or by using only one method. Combination of BMI, Triceps SFT and Subscapular SFT) classified (n=23; 57.5%) as overweight /obese. BMI and Triceps SFT classified (n=3; 7.5%) school children as overweight /obese. Triceps and subscapular found (n=5; 12.5%), while none of the school children that was

classified as overweight or obese using a combination of BMI and Subscapular SFT. The school children that were classified as overweight/obese by only one method were; (n=2; 5%) using BMI, (n=4; 10%) using Triceps SFT and (n=3; 7.5%) by subscapular SFT.

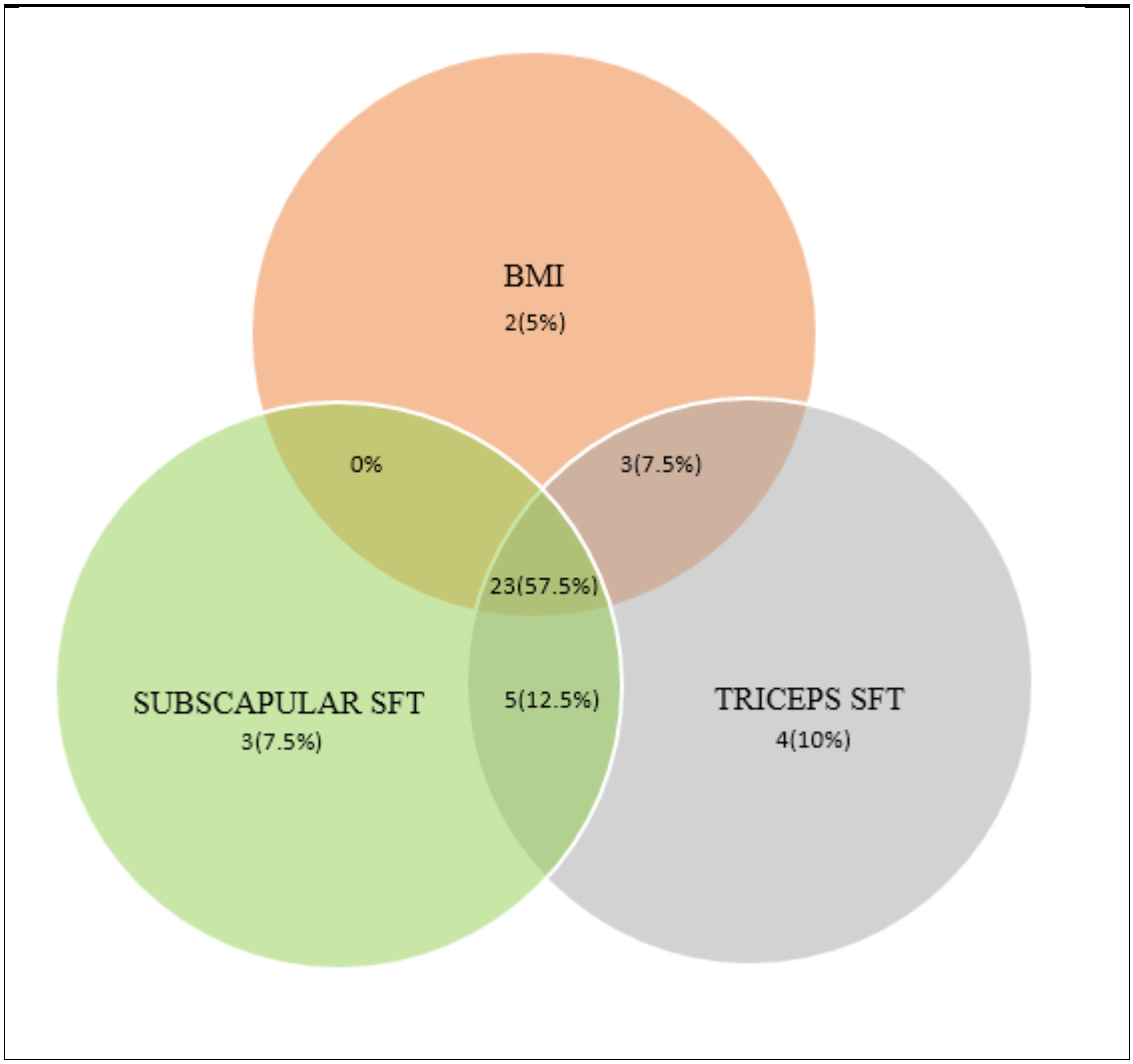

Figure 4-2 Relationship between BMI, Triceps and Subscapular SFT in assessing overweight/obesity

4.4 Relationship between social demographic factors and weight status of school children

Using all the assessment methods (BMI and SFT) as shown in Table 4-7 below, no significant relationship was found between overweight /obesity and gender (p=0.128 for BMI, p=0.550 for Triceps SFT and p= 0.534 for Subscapular SFT). Although the percentage of overweight /obese girls was greater than that of the overweight/obese boys, this difference was not significant. However, children who attended private schools showed higher prevalence of overweight /obesity than children in public schools. This relationship was found to be statistically

significant using all the methods used in classifying overweight and obesity (BMI, p=0.009, p<0.001 for both Triceps and Subscapular SFT). Children belonging to educated parents show higher rates of overweight and obesity, this was statistically significant using both triceps and subscapular SFT. Parents' occupation shows no significant differences between the two groups. The children from household of less than six people showed higher prevalence rate of overweight/obesity than those from households with six or more people. This relationship was not found to be statistically significant using BMI and Triceps SFT but was statistically significant using Subscapular SFT (p=0.036).

There were differences in parent's education and occupation between private and public primary school (p<0.001) as shown in table 4- 8. A higher number of the children whose father (78.3%) and mother (72.5%) has secondary/post-secondary/college education were in private primary schools compared to those who were in public primary school. There was a significant difference between overweight/obese and normal/underweight children with respect to their father's education (except for those children that were assessed using BMI), where the prevalence of overweight/obesity was highest among children whose father had higher level of education. The significant difference was likewise observed in mother's education where the prevalence of overweight /obesity was higher in children whose mother had higher level of education. There was no significant difference in overweight /obesity prevalence rates based on both parent's occupation as shown in table 4-7. A higher percentage of children (56.5%) whose father are formally employed in private or government sectors were in private schools. Whereas high percentage (63.8%) of those whose mother are either self-employed business/or unemployed were in private primary schools. Therefore, father's and mother's education has a relationship with obesity/overweigh status but mother's/father's occupation has no relationship.

Table 4-7 Relationship between obesity status and social demographic characteristics

Variables	BMI		Triceps SFT		Subscapular SFT	
	Overweight /Obese n (%)	Normal /Underweight n (%)	Overweight/ Obese n (%)	Normal /Underweight n (%)	Overweight /Obese n (%)	Normal /Underweight n (%)
Gender						
Girls	18 (25)	54 (75)	19 (26.4)	53 (77.6)	18 (25)	54 (75)
Boys	10(14.5)	58 (85.3)	15 (22.1)	53 (77.6)	14 (20.6)	54 (79.4)
p –value*	**0.128**		**0.550**		**0.534**	
Type of school						
Private	20 (29)	49(71)	26 (37.7)	43 (62.3)	25 (36.2)	44 (63.8)
Public	8 (11.3)	63(88.7)	8 (11.3)	63 (88.7)	7 (9.9)	64 (90.1)
p –value*	**0.009**		**<0.001**		**<0.001**	
Father's education						
Primary education	8(13.8)	50 (86.2)	9 (15.5)	49 (84.5)	7 (12.1)	51 (87.9)
Secondary/post-secondary/college	20 (24.4)	62(75.6)	25 (30.5)	57 (69.5)	25 (30.5)	57 (69.5)
p-value*	**0.123**		**0.042**		**0.011**	
Fathers occupation						
Formally employed-private or government employee	13 (23.6)	42(76.4)	16 (29.1)	39 (70.9)	16 (29.1)	39 (70.9)
Self -employed/casual work/petty business/unemployed	15 (17.6)	70 (82.4)	18 (21.2)	67 (78.8)	16 (18.8)	69 (81.2)
p-value*	**0.387**		**0.286**		**0.158**	
Mother's education						
Primary education	10 (13.7)	63(86.3)	11 (15.1)	62 (84.9)	10 (13.7)	63 (86.3)
Secondary/post-secondary/college	18 (26.9)	49(73.1)	23 (34.3)	44 (65.7)	22 (32.8)	45 (67.2)
p –value*	**0.052**		**0.008**		**0.007**	
Mother's occupation						
Formally employed-private or government employee	10 (23.3)	33 (76.6)	13(30.2)	30 (78.4)	14 (32.6)	29 (67.4)
Self -employed/casual work/petty business/unemployed	18 (18.6)	79 (81.4)	21 (21.6)	76 (69.8)	18 (18.6)	79 (81.4)
p-value*	**0.521**		**0.275**		**0.065**	
Number of people living in a household						
≥ 6	9 (14.5)	52 (85.5)	13 (21)	49 (79)	9 (14.5)	53 (85.5)
<6	13(24.4)	59 (75.6)	21 (26.9)	57 (73.1)	23 (29.5)	55 (70.5)
p-value*	**0.148**		**0.414**		**0.036**	

* Chi square (χ^2) test

Table 4-8 Comparison of Parent's education and occupation between private and public primary school

Variables	Type of school		
	Private (n=69) n (%)	**Public (n=71) n (%)**	**p-value***
Father's education			
Primary education	15 (21.7)	43 (60.6)	**<0.001**
Secondary/post-secondary/college	54 (78.3)	28 (39.4)	
Mother's education			
Primary education	19 (27.5)	54 (76.1)	**<0.001**
Secondary/post-secondary/college	50 (72.5)	17 (23.7)	
Fathers occupation			
Formally employed-private or government employee	39 (56.5)	16 (22.5)	**<0.001**
Self -employed/casual work/petty business/unemployed	30 (43.4)	55 (77.1)	
Mother's occupation			
Formally employed-private or government employee	31 (44.9)	37 (52.1)	**<0.001**
Self -employed/casual work/petty business/unemployed	38 (63.8)	34 (47.9)	

* Chi square (χ^2) test

4.5 Physical activity and means of transport used to go to school

Table 4-9 shows the physical activity of the school children and the mode of transport used to go to school. More than half of the school children (61.4%) are actively participating in sport activity which was rated as high to vigorous physical activity for at least 30 minutes and below per day. And only (1.4%) achieves more than 90 minutes per day. The mean number of time that they participate in sport activity was 2.7 ± 1.4 times per week and this was performed 1-3 times per week by three quarter of the school children (75%). Sport activity in the study area were football, cycling, running, swimming, and volleyball. About 67.9% of the school children walk to and from school. The time used in walking was estimated by most of them to be 30 minutes and below. Other mode of transport used were school bus, private cars and public transport.

Means of transport used were statistically significant difference between private and public primary schools ($p<0.001$) as shown in table 4-10. About (80.4%) of the school children from private school used private/public car /school bus while more than half (66%) of the school children in public school walk.

Table 4-9 School children physical activity and means of transport used to go to school

Characteristics	Mean ± SD	Number	(%)
Average number of times participating in sport activity per week	2.7 ±1.4		
Average number of times participating in sport activity per week			
1-3 times		105	75
4-5 times		35	25
Average time spent(hours) in sport activity per day			
30 minutes and below		86	61.4
31-60 minutes		50	37.5
61-90 minutes		2	1.4
Above 90 minutes		2	1.4
Means of transport used to and from school			
Private/public car /school bus		46	32.9
Walking		94	67.9

Table 4-10 Relationship between type of school and means of transport used to go to school

Type of school	Mode of transport		
	Private/public car /school bus n (%)	Walk n (%)	p-value*
Private	37 (80.4)	32 (34)	<0.001
Public	9 (19.6)	62 (66)	

* Chi square (χ^2) test

4.6 Relationship between obesity status of school children and physical activity and means of transport used to and from school

According to the result in table 4-11, children who participating in sport activity on average of 4-5 times per week showed lower prevalence of overweight/obesity compared to those who participate 1-3 times per week however it was not statistically significant. The children that reported playing for 30 minutes and less indicated higher prevalence of overweight/obesity than those playing more than 30 minutes per day though the relationship was also not statistically significant. The children who walk to and from school showed a low prevalence of overweight/obesity than those who use private/public car /school bus going to school, this relationship was found to be statistically significant (Triceps SFT, p=0.043 and Subscapular SFT, p=0.019) but not by using BMI.

Table 4-11 Relationship between obesity status of school children and physical activity and mode of transport used to go to school

Variables	BMI		Triceps SFT		Subscapular SFT	
	Overweight/ Obese n (%)	Normal /Underweight n (%)	Overweight/ Obese n (%)	Normal /Underweight n (%)	Overweight/ Obese n (%)	Normal /Underweight n (%)
Average number of times participating in sport activity per week						
1-3 times	23 (21.9)	82 (78.1)	28 (26.7)	77 (73.3)	26 (24.8)	30 (65.20
4-5 times	5 (14.3)	30 (85.7)	6 (17.1)	29 (82.9)	6 (17.1)	78 (83)
p –value*	**0.329**		**0.255**		**0.353**	
Average time spent in physical activity						
30 minutes and below	20 (23)	66 (76.7)	24 (27.9)	62 (72.1)	23 (26.7)	63 (73.3)
31-60 minutes	8 (16)	42 (84.4)	9 (18)	41 (82)	8 (16)	42 (84)
61-90 minutes	0 (0)	2 (100)	1 (50)	1 (50)	1 (50)	1 (50)
Above 90 minutes	0 (0)	2 (100)	0 (0)	2 (100)	0 (0)	2 (100)
p –value*	**0.558**		**0.384**		**0.321**	
Mode of transport used to go to school						
Private/public car /school bus	11 (23.3)	35 (76.1)	16 (34.8)	30 (65.2)	16 (34.8)	30 (65.2)
Walk	17 (18.1)	77(81.9)	18(19.1)	76 (80.9)	16 (17)	78 (830
p–value*	**0.418**		**0.043**		**0.019**	

* Chi square (χ^2) test

4.7 School children sedentary behaviour and home/school chores activities

Table 4-12 below shows that the average sleeping time was found to be 9.5 ± 0.8 hours, where 62.9% school children slept for less than 10 hours per day. About 66.4% of the school children were involved in sedentary activities for more than four hours per day with average time of about 5.3± 2.5 hours. Sedentary activities in this group included doing arts and crafts, listening to music, playing indoors with toys/card/computer games, reading, sitting, talking, talk on the phone, using computer and watching television. Screen time includes the cumulative hours spent watching television and video/computer game, this was found to be 1.7 ± 1.23 hours per day however 69.3% used ≤2 hours per day. About 70% of school children use average of < 3 hours per day doing home /school chores which includes house cleaning, laundry, preparing/cooking food, gardening, farm work or talking care of siblings.

Table 4-12 School children sedentary behaviour and home/school chores activities

Characteristics	Range	Mean ± SD	Number (%)
Average sleeping time per day	4.0	9.5 ± 0.8	
Sleeping hours per day			
More than 10 hours			52 (37.1)
Less than 10 hours/day			88 (62.9)
Average time take for sedentary activities(in hours)	14.7	5.3 ± 2.5	
Average time take for sedentary activities			
>4 hours per day			93 (66.4)
≤4hours per day			49 (33.6)
Average screening time per day(hours)	6	1.7 ± 1.2	
Average screening time per day(hours)			
>2 hours per day			43 (30.7)
≤2 hours per day			97 (69.3)
Average time in home /school chores per day(hours)	10	2.2 ± 1.2	
Average time in home /school chores per day(hours)			
< 3hours per day			98 (70)
≥3 hours per day			42 (30)

Mann Whitney test was used to compare the median of the time spent for physical activity, sedentary activity, screening and home/house chores as shown in Table 4-13. There were no significance differences between overweight/obesity and normal/overweight children.

Table 4-13 Comparison length of time spend for physical activity, sedentary activity, screening and home/house chores between Overweight/Obese and Normal/Underweight children

Variables	BMI		Triceps STF		Subscapular SFT	
	Overweight/Obese median(1st,3rd quantile)	Normal /Underweight median(1st,3rd quantile	Overweight/Obese median(1st,3rd quantile	Normal /Underweight Median(1st,3rd quantile	Overweight/Obese median(1st,3rd quantile	Normal /Underweight median(1st,3rd quantile
Sleeping time in hours/day	9.5 (9.0,10.5)	9.5 (9.0,10)	10.0 (9.0,10.5)	9.5 (9.0,10.0)	9.75 (9.0,10.5)	9.5 (9.0,10.5)
p-value*	**0.235**		**0.028**		**0.079**	
Times in Physical activity per week	3.0 (1.0,3.0)	2.0 (1.0,4.0)	3.0 (1.0,4.0)	3.0 (1.0,3.0)	3.0 (1.0,3.0)	3.0 (1.0,4.0)
p-value*	**0.647**		**0.721**		**0.781**	
Sedentary activity in hours/day	5.09 (3,7,6.2)	4.81 (3.6,6.6)	4.75 (3.7,6.0)	4.91 (3.6,6.7)	4.75 (3.6,6.1)	4.89 (3.6,6.6
p-value*	**0.813**		**0.478**		**0.665**	
Screening time in hours/day	1.35 (0.9,2.2)	1.28 (0.7,2.2)	1.35 (0.9,2.0)	1.28 (0.8,2.3)	1.43 (1.0,2.3)	1.28 (0.8,2.3)
p-value*	**0.633**		**0.926**		**0.445**	
Home/house chores in hours/day	1.75 (0.5,3.1)	1.58 (0.8,3.0)	1.41 (0.7,3.0)	1.66 (0.7,3.0)	1.12 (0.5,3.0)	1.87 (0.9,3.0)
p-value*	**0.977**		**0.920**		**0.354**	

* Mann Whitney test

4.8 Relationship between sedentary activity and home/school chores activities and obesity status of the school children

The results in Table 4-14 shows that children sleeping more than ten hours per day seem to have high prevalence of overweight/obesity than those who sleep less than ten hours. This was not statistically significant for those children that were identified to be overweight/obesity by the use of BMI and subscapular SFT, but it was significant to those observed by the use of Triceps SFT ($p=0.048$), this was found to be similar to the average time taken by the children for the sedentary activities. The proportion of overweight/obesity was higher in children that use ≤4 hours per day for sedentary activities than the one used >4 hours per day.

The school children using ≤2 hours per day for watching television and video/computer game (screening time) had high rate of overweight/obesity than ones with screen time of >2 hours per day though it was not statistically significant. Those children that use ≥3 hours per day for home /school chores per day showed higher prevalence of overweight/obesity compared to those who used <3 hours and more per day. However, the association was not found to be statistically significant for both groups that were identified by all three methods.

Table 4-14 Relationship between sedentary activity and home/school chores activities and obesity status of school children

Variables	BMI		Triceps SFT		Subscapular SFT	
	Overweight/ Obese n (%)	Normal /Underweight n (%)	Overweight/ Obese n (%)	Normal/ Underweight n (%)	Overweight/ Obese n (%)	Normal /Underweight n (%)
Sleeping hours per day						
More than 10 hours	12 (24.4)	37 (75.5)	17 (34.7)	32 (65.3)	15 (30.6)	34 (69.4)
Less than 10 hours/day	15 (18.1)	68 (81.9)	16 (19.3)	67 980.7)	16 (19.3)	67 (80.7)
p –value *	**0.377**		**0.048**		**0.138**	
Average time take for sedentary activities						
>4 hours per day	18 (19.4)	74 (80.4)	21 (22.8)	71 (77.2)	19 (20.7)	73 (79.3)
≤4hours per day	9 (22.5)	31 (77.5)	12 (30)	28 (70)	12 (30)	28 (70)
p-value*	**0.701**		**0.048**		**0.244**	
Average screening time per day(hours)						
>2 hours per day	8 (18.6)	35 (81.4)	8 (18.6)	35 (81.4)	9 (20.9)	34 (79.1)
≤2 hours per day	19 (21.3)	70 (78.7)	25 (28.1)	64 (71.9)	22 (24.7)	67 (75.3)
p-value*	**0.714**		**0.238**		**0.630**	
Average time in home /school chores per day(hours)						
< 3hours per day	17 (18.7)	76 (81.7)	20 (21.5)	73 (78.5)	20 (21.5)	73 (21.5)
≥3 hours per day	11 (26.2)	31 (73.8)	13 (31)	29 (69)	11 (26.2)	31 (73.8)
p-value*	**0.294**		**0.237**		**0.549**	

***** Chi square (χ^2) test

4.9 School children dietary practices and behaviour

Table 4-15 shows dietary practices assessed in this study. All the school children were given food at school. The foods given were stiff porridge/rice /maize with beans/meat. This was the same in both private and public primary schools. Less than half (46.6%) of the school children were given money (mean=321.5 -Tanzanian shillings) to buy food at school. About (87.5%) took breakfast more than five times per week. High percent of school children consume fruits and vegetables 3-4 days per week (42.9% for fruits and 46.4% for vegetables).

Table 4-15 School children dietary practices and behaviour

Characteristics	Mean ± SD	Number	Percentage
Given any money for buying foods or drinks while at school or outside home			
Yes		65	46.6
No		75	53.6
Average amount of money given per day? (Tsh)*	321.53+281.45		
Number of times buying food at school per week			
Once		3	2.1
2-4 times		48	34.3
5-6 times		14	10
Number of days per week taken breakfast			
1-2 days		5	3.6
3-4 days		15	10.7
More than5 days		120	85.7
Number of days per week taken fruits			
1-2 days		39	27.9
3-4 days		60	42.9
More than5 days		37	26.4
Number of days per week taken vegetables			
1-2 days		17	2.1
3-4 days		65	46.4
More than5 days		58	41.5

*1 Tsh (Tanzanian shiling) = 2000 euro

4.10 Relationship between dietary practices and behaviour and obesity status of school children

The result in in table 4-16 showed that there was no relationship between giving children money for buying foods or drinks while at school or away from home and overweight/obesity. There was a statistical significant differences (p=0.002 for BMI, and p=0.007 for triceps SFT) in number of times that children buy food at school per week between the two groups. Taking breakfast, fruits and vegetables showed no relationship with overweight/obesity in school children. However the prevalence was high to those school children who take/eat fruits and vegetables more than five days in a week and also to the school children that take breakfast 3-4 days in a week.

Table 4-16 Relationship between dietary practices and behaviour and obesity status of school children

Variables	BMI		Triceps SFT		Subscapular SFT	
	Overweight/ Obese n (%)	Normal/ Underweight n (%)	Overweight/ Obese n (%)	Normal/ Underweight n (%)	Overweight/ Obese n (%)	Normal/ Underweight n (%)
Given any money for buying foods or drinks while at school or outside home						
Yes	13 (20)	52 (80)	16 (24.6)	49 (75.4)	12 (18.5)	53 (81.5)
No	15 (20)	60 (80)	18 (24)	57 (76)	20 (26.7)	55 (73.3)
p –value*	**1.000**		**0.933**		**0.249**	
Number of times buying food at school per week						
Once	3(100)	0	3 (100)	0	1 (33.3)	2 (66.7)
2-4 time	8 (16.7)	40 (83.3)	11 (22.9)	37 (77.1)	9 (18.8)	39 (81.3)
5-6 times	2 (14.3)	12(85.7)	2 (14.5)	12 (85.7)	2 (14.3)	12 (87.7)
p-value *	**0.002**		**0.007**		**0.739**	
Number of days per week taken breakfast						
1-2 days	1 (20)	4 (80)	1 (20)	4 (80)	1 (20	4 (80)
3-4 days	5 (33.3)	10 (66.7)	5 (33.3)	10 (66.7)	4 (26.7)	11 (73.3)
More than 5 days	22 (18.5)	98 (81.7)	28 (32.3)	92 (76.7)	27 (22.5)	93 (77.5)
p-value*	**0.392**		**0.678**		**0.925**	
Number of days per week taken fruits						
1-2 days	7 (17.9)	32 (82.1)	8 (20.5)	31 (75.5)	7 (17.9)	32 (82.1)
3-4 days	13 (21.6)	47 (78.4)	16 9(26.7)	44 (73.3)	12 (20)	48 (80)
More than 5 days	8 (21.7)	29 (78.3)	10 (27)	27 (73)	13 (35.1)	24 (64.9)
p–value*	**0.890**		**0.743**		**0.145**	
Number of days per week taken vegetables						
1-2 days	3 (17.6)	14 (82.4)	4 (23.5)	13 (76.5)	2 (11.5)	15 (88.2)
3-4 days	11 (16.9)	54 (83.1)	12 (18.5)	53 (81.5)	13 (20)	52 (80)
More than 5 days	14 (24.1)	44 (75.9)	18 (31)	40 (69)	17 (29.3)	41 (70.3)
p –value*	**0.587**		**0.267**		**0.240**	

***** Chi square (χ^2) test

Before controlling for the confounders, type of school was statistically significantly associated with overweight/obesity to those children that were identified as overweight/obese using all the methods (BMI-Odd ratio=0.31, CI=0.13-0.77, p=0.009, Triceps SFT-Odd ratio=0.21, CI=0.09-0.51, p<0.001 and Subscapular SFT-Odd ratio=0.19, CI=0.08-0.48, p<0.001). After adjusting for father's education, mother's education and mode of transport used to school ,type of school was statistically significantly associated with overweight/obesity to those children that were identified as overweight/obesity using Triceps SFT-Odd ratio=0.28, CI=0.1-0.79, p=017) and Subscapular SFT-Odd ratio=0.29, CI=0.09-0.48, p=0.024) but not by using BMI -Odd ratio=0.35, CI=0.12-1.02, p=0.053) as shown table 4-17.

The odd ratio of being overweight/obesity measured using BMI, Triceps SFT and Subscapular SFT was 0.35, 0.28, and 0.29 respectively in children attending private schools.

Table 4-17 Adjusted relationship between type of school and school children overweight/ Obesity

Method used	**Type of school[a]**					
	Unadjusted			**Adjusted**		
	Odd ratio	**95% CI**	**p-value**	**Odd ratio**	**95% CI**	**p-value**
BMI	0.31	0.13-0.77	0.009	0.35	0.12-1.02	0.053
Triceps SFT	0.21	0.09-0.51	<0.001	0.28	0.1-0.79	0.017
Subscapular SFT	0.19	0.08-0.48	<0.001	0.29	0.09-0.48	0.024

a categorized as private school and public school

CI confidence interval

Chapter 5: Discussion

5.1 Prevalence of obesity and overweight among school children

The study investigated the prevalence of overweight and obesity among school children aged 10-12 years in Moshi Municipal–Kilimanjaro using BMI, Triceps and subscapular SFT. The prevalence of overweight and obesity obtained using BMI, Triceps, and Subscapular SFT were 20%, 24.3% and 22.9% respectively. In this study, overweight and obesity prevalence using BMI criteria was 2.9% and 17.1% respectively. There was no significant difference in overweight/ obesity prevalence by gender. The combined prevalence of both overweight and obesity is slightly higher than the figures obtained in similar previous studies (using IOTF cut-off points) in Dar es salaam, Tanzania, where the combined prevalence of overweight and obesity (7-14years) was 14.7% (Mwaikambo, 2012). However, other studies using WHO criteria reported obesity prevalence of 5.2% among school children aged 6-17 years from Dar es Salaam (Muhihi et al., 2013). For children aged 10-12 years in Dodoma, the prevalence was 3.9% and 4.9% for obesity and overweight respectively, whereas 5.8% obesity and 5.8% overweight were detected in Kinondoni -Dar es salaam (Mosha & S Fungo, 2010).

This indicates an increased prevalence of overweight and obesity, worsening future trends of childhood obesity, making it an important public health issue in Tanzania. In Kenya, the neighbouring country a study of Kyallo et al., (2013) involved school children aged 9-14 years found 19.0%, as the prevalence of combined overweight and obesity which is comparable to our study. Nevertheless, the prevalence of overweight and obesity in this study was closer to that of the systematic review that was done to investigate the evidence of overweight/obesity transition occurring in school-aged children and youth in Sub Saharan Africa which found the prevalence of overweight/obesity and obesity to be 10.6% and 2.5% respectively (Muthuri et al., 2014). On the other hand, the prevalence of overweight and obesity in this study was lower compared to recent studies in developed countires. These include Oklohama where a combined prevalence of overweight and obesity of children aged 7-13 years was 63% (Dennison et al., 2015). A systematic review in Republic of Ireland between 2002 and 2012 found a combined prevalence of overweight and obesity of primary school aged children ranged from 20-34% within the studies (Keane et al., 2014). In the United States in the year 2011-2012, 16% of the children 2-19 years were obese

(Ogden et al., 2014). Similarly in Brazil, 41% of children aged 6-10 year were overweight/obese (Passos et al., 2015). Factors such as demography, lifestyle and socioeconomic differences may be responsible for the lower figures seen in our subjects compared to the western children. Our study did not find a significant gender difference in the prevalence of children obesity and overweight, although absolute values were higher in girls. Others studies found similar results (Dennison et al., 2015; Keane et al., 2014; Mwaikambo, 2012; Ogden et al., 2014; Passos et al., 2015; Van Stralen et al., 2012)**.**

Using SFT, the prevalence of obesity was higher than that obtained using BMI and for overweight the prevalence was lower. Triceps SFT found a prevalence of obesity and overweight of 11.4% and 12.9% respectively, while Subscapular SFT determined 10% and 12.9% of obesity and overweight respectively. There is no study in Tanzania that has used a combination of BMI and SFT to assess the prevalence of obesity/overweight. The actual prevalence of school children overweight/obesity can be obtained by the use of the combined methods of assessment.

The prevalence of the combined result of overweight and obesity obtained using BMI, Triceps, and Subscapular SFT shows lower prevalence as compared to a study in Portugal. the study compared BMI, SFT, and Waist circumferences that acquired a high prevalence of overweight/obesity of 31.6%, 61.4%, and 41.1% by the use of BMI, skinfold thickness, as well as waist circumference respectively (Minghelli et al., 2013). Studies conducted in Nigeria found less prevalence of school children overweight and obesity using Triceps SFT, BMI and BIA compared to this study. A study involving adolescents aged 10-18 years, triceps SFT found a prevalence of obesity and overweight to be 0.8% and 2.5% respectively whereas BIA gave a prevalence of obesity and overweight of 2.5% and 1.7% respectively (Ahmad et al., 2013). Other study including school children aged 5–18 years, found obesity prevalence of 4.5% and 3.5% using Triceps SFT and BMI respectively (Izuora et al., 2013). In both studies SFT seem to be more sensitive as it identifies more obese school children than BMI.

The prevalence of overweight and obesity among children using all the three method of assessment was significantly higher in children who attended private primary schools than those who attended public primary schools. This finding agrees with findings of other studies that assessed children and adolescent's overweight and obesity using BMI in Tanzania, Kenya, Puerto Rica, India, Andhra Pradesh; (Bhardwaj et al., 2008; Elías-Boneta et al., 2015; Kyallo et al., 2013;

Mwaikambo, 2012; Prasad et al., 2015). In Tanzania the public primary schools are funded by the government whereas private primary schools charge considerable high tuition fees, which means only parents who can afford the fees charged choose to enrol their children in private schools. This is supported by the fact that children who attend private primary schools come from families with higher social economic characteristics including higher incomes compared to those who go to public schools. There was significant difference in parent's education and occupation between private and public primary school. A higher number of the children whose father and mother has secondary/post-secondary/college education were in private primary schools compared to those who were in public primary schools. Most probably parent's education level reflects the socio-economic status of families. A higher prevalence of overweight/obesity was observed in children with parents that has secondary/post-secondary/college education. Father and mother's education had a relationship with overweight/obesity, and has been demonstrated by other studies (Anuradha et al., 2015; De Silva et al., 2015; Karimi & Ghorbani, 2015; Kyallo et al., 2013; Meko et al., 2015; Thanh, 2008).This has been observed in many developing countries where overweight/obesity rates are higher among groups with higher socioeconomic status and education level. This might be caused by the fact that these families can more easily manage motorized transport, sedentary recreations and have high purchasing power that lead to an increased calorie accessibility, mostly from fat, high sugar and refined grains foods. In Africa body weight perception is furthermore influenced by social cultural factors, large body size is considered to be desirable as it reflects good health and higher social economic status (Holdsworth et al., 2004; Muhihi et al., 2012). The HIV pandemic has also been associated with body weight perception. People associate thinness with illness especially HIV and AIDS and Tuberculosis therefore overweight/Obesity is preferred so that to overcome this suspicion (Ezekiel et al., 2009; Puoaneet al., 2010)**.**

5.2 Correlation between BMI and skinfold thickness measures in assessing Obesity and overweight

The high level of correlation between the three anthropometric methods used in the classification of weight status (BMI, Triceps and Subscapular SFT), indicate their applicability in assessing weight status of children and adolescents. This study concurs with similar studies (Boeke et al., 2013; Minghelli et al., 2013; Mohammed & Vuvor, 2012). These studies found that, SFT showed the highest prevalence of overweight and obesity as compared to BMI. Various studies have

suggested that the best estimators of body density in the children and adolescents studied were a combination of BMI and skinfold thickness. SFT is used as a good predictor of total body fat (adiposity) in children and adolescents which provides a good estimate of obesity and body fat distribution, (Ahmad et al., 2013; Nooyens et al., 2007; Rolland-Cachera, 1993). BMI is recommended as method that provides a first-rate sign of overweight and obesity for surveillance ,screening and clinical purposes while the other should be importantly used when assessing the risk factors for cardiovascular diseases (Himes, 2009). However then, it is known that obesity is a great risk factor for many co-morbidities such as coronary heart disease, hypertension and stroke, certain types of cancer, type 2 diabetes mellitus, gallbladder disease, dyslipidemia, osteoarthritis and gout, and pulmonary diseases, including sleep apnea (WHO, 2000; Samuelson, 2004). Therefore all these methods that assess adiposity should be used simultaneously in order to set preventive measures in early stage.

5.3 Physical activity/sedentary activity and Obesity/overweight of school children

In this study a high percentage of the school children spend approximately 30 minutes and less for sport activity, and majority did it 1-3 times per week. Only 2.8 % met the recommended time (60 minutes or more for 5 days per week) for physical activity by WHO (WHO, 2010). However, our study found no significant relationship between physical activity and overweight/obesity this concur with a finding of Masuet-Aumatell et al., (2012). The probable explanation may be that the recommended time for sport to have effect on weight management is not met or the eating habit may negate the benefit achieved through sports.

Various studies have demonstrated the relationship between physical activity and overweight /obesity, that insufficient physical activity increased the risk of overweight and obesity (Abril et al., 2013; Kapil & Bhadoria, 2014; Rahman et al., 2015).

A recent review indicated that exercise was effective in reducing percent body fat in overweight and obese children and adolescents (Kelley & Kelley, 2013). It has been shown that great number of children and adolescents do not meet current recommendations of physical activity (Guthold et al., 2008; Kalman et al., 2015). To reduce related future health problems children and adolescents should be encouraged to participate in physical activity as recommended, this should be made simple and enjoyable for children and adolescents to participate.

Walking to and from school is a factor of being physically active. The study found significant differences between means of transport and overweight/obesity. The children walked to and from school showed a low prevalence of obesity/overweight than those who use private/public car /school bus, this agrees with other studies (Alkali et al., 2015; Duncan et al., 2011; Itoi et al., 2012). Means of transport used was significantly different between private and public primary schools. This is probably because of the fact that parents with children in private schools can meet the expenses to take their children to school using private cars or school buses. Nowadays children are unlikely to walk to school and prefer using vehicles to go to school especially in big cities possibly because of changes in the built environment.

Other studies found that sleeping less than ten hours per night is a risk factor for overweight and obesity in children (Owens et al., 2014; Padilla et al., 2011), but this was not found in this study. High demand of physical, emotional and sexual development is attained when the sleeping time of an adolescents is increased (Koss et al., 2015) and its recommended that school children should sleep at least for 10 hours per day.

High percentage of school children in the study (66.4%) were involved in sedentary activities for more than four hours per day with average time of about 5.3 hours which is a risk factor for overweight and obesity as found by another study (Bhuiyan et al., 2013). Our study found no relationship between sedentary activity, screening time and house/school chores and school children overweight/obesity, that has been supported by certain studies (Al-Haifi et al., 2013; Collings et al., 2015). Although other studies have found evidence of the relationship between sedentary activities (Bhuiyan et al., 2013), screening time/computer usage (Giammattei et al., 2003; Karimi & Ghorbani, 2015; Li et al., 2015; Padilla et al., 2011), home/school chores (Laxmaiah et al., 2007) and overweight/obesity.

5.4 Dietary practices and school children obesity/overweight.

This study did not find a significant relationship between breakfast, fruits and vegetables consumption and the risk of obesity in school children. For the positive effects the number of saving and the portion size of fruits and vegetables recommended per day should be taken, in our study this information was not collected, therefore, this might be the cause of this finding. This finding appears to diverge from other studies which reported an inverse relationship between fruits and

vegetables consumption and overweight/obesity among children (Mocanu, 2013; Te Velde et al., 2007; Vilchis-Gil et al., 2015).

Other studies (Antonogeorgos et al., 2012; Manios et al., 2014) found that children that consume breakfast daily were found to be having lower chances of being overweight/obese. About 85.7% of the school children in our study took breakfast more than five days in a week, but its relationship with overweight/obesity was not observed, this might be caused by the consumption of poor breakfast.

5.5 Strengths and Limitations of the study

The study used BMI, and SFT (Triceps and Subscapular), to assess the prevalence of weight status of children and adolescents. The strong correlation obtained between these methods indicated their applicability in assessing the nutrition status and gave the actual prevalence of overweight and obesity among the school children. Many studies have applied one method (BMI) which emphasizes the overweight than the excess body fat, which might be more crucial in the children. Therefore, the combination of the three methods do not only provide information on excess weight but also excess fat deposits. Furthermore, the combination of these methods has not been used in Tanzania before.

However, this study is a cross-sectional and describes the situation of a small sample which may not reflect the whole population. To study nutrition status of people a large sample size is required, but in this study, only 140 participants were included, therefore the results of this study may have some bias. Only associations can be reported and not causal effects. This is because of lack of time and man power. In this study not all factors that influence school children's weight status were addressed; hence, the study assessed only some of the variable risk behaviour associated with overweight and obesity.

Chapter 6: Conclusion and Recommendations

This study has revealed a relatively high prevalence of overweight and obesity in a representative sample of 140 school children in Moshi municipality in Kilimanjaro, Tanzania using three anthropometric measurements: BMI, Triceps and Subscapular SFT. The results demonstrate that prevalence of overweight and obesity is higher in school children attending private school, children with parents that have high level of education and those who use private car/school buses to go to school. There is a great need for the public health policy in Tanzania to act attentively so that early detection and intervention can be made in order to prevent obesity and overweight in school children. Preventive measures of obesity during childhood could reduce the adult incidence of diseases. Both schools and home environment have an important role to play in preventing children's obesity and overweight directing on eating and physical activity behaviour. There is a need to provide nutrition education to the parents as well as to school children in order to prevent overweight and obesity as it has been shown that the prevalence is higher among school children that belongs to parents with high level of education. This indicated that the people that are highly educated may not necessarily have a nutrition education.

There was high correlation between the three methods (BMI, Triceps and Subscapular SFT) in the classification of nutrition status of school children in this study. Therefore, all of these methods should be used simultaneously in order to identify all subjects and to set preventive measures in early stage. It's obviously known that each method of assessing children and adolescent's overweight and obesity has advantages and disadvantages, as each method depends on convenience, time, equipment and possibly a trained personnel. It will be more appropriate if all these are taken into consideration when conducting the study that involved all the assessment methods.

The study findings recommend the following; first, the assessment of overweight and obesity should be conducted in other cities in Tanzania on a large scale and focus on more factors influencing overweight and obesity among children and adolescents. This will facilitate the creation of the preventive measures of overweight and obesity in Tanzania.

Second; to reduce the future health problems, children and adolescents should be encouraged to participate in physical activity as recommended, this should be simple and enjoyable that all the children and adolescents will actively participate. Integrating physical activity and nutrition education in school curriculum at all levels will play a great part in decreasing the prevalence of obesity and overweight in Tanzania. This will produce a healthy generation that will consequently lower the health costs associated with overweight and obesity.

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Appendices

Appendix 1 Demographic data and Physical Activity questionnaire

Questionnaire No…….

Date: …….

Name of School: …….…….…….…….…….

School Location: …….…….…….

Part A: Demographic characteristics

1. Pupil's Age (Years): …….
2. Sex: Male…….Female: …….
3. Residence: …….…….…….…….

4. Father's education

a) No formal education
b) Primary education
c) Secondary education
d) Post-secondary education / college
e) Not applicable

5. Mother's education

a) No formal education
b) Primary education
c) Secondary education
d) Post-secondary education / college
e) Not applicable

6. Father's occupation

a) Self-employed/Casual work/petty business
b) Formally employed-private or government employee
c) Unemployed

7. Mother's occupation
    a) Self-employed/Casual work/petty business
    b) Formally employed-private or government employee
    c) Unemployed
    d) House wife
8. Who is the head of the household where you live?

a) Male head HH (Father)
b) Female head HH (Mother)
c) Child headed HH
d) Grandparent head HH
e) Other adult living in H

9. What is the total number of individuals living in your household

a) 2
b) 3
c) 4
d) 5
e) 6+

Part B: Anthropometric measurements

1. Height (cm): …….
2. Weight (kg): ……. BMI_____
3. Skinfold thickness

Number of times	Triceps (back of mid-upper arm) (mm)	Subscapular (below the shoulder blade) (mm)
Average		

Part C: Physical Activity

C1: Personal fitness

1. Please put a time in each box

	Average over the past year	
	At what time do you normally get up?	At what time do you normally go to bed?
On a weekday		
On a weekend day		

2. Which form of transport do you use most often when going to school?

Please tick (✓) one box **ONLY** per line

Distance of journeys (Approximate time in minutes)	Usual mode of transport				
	Car	Walk	Public transport	Cycle	School bus
Less than 30minutes					
30minutes to 1 hour					
More than 1hour					

C2: School Physical Education

3. Do you usually participate in sports activities (by playing)?

Yes: ☐ No: ☐

4. If yes, what types of sports do you usually play? Please tick (✓)

Football	Cycling	Running	Swimming	Volleyball	Aerobics	Others (specify)
☐	☐	☐	☐	☐	☐	☐

5. For how long (in minutes) do you play the sports above?

Football	Cycling	Running	Swimming	Volleyball	Aerobics	Others

6. How many times per week do you participate in sports activities during physical education lesson……

7. For how long in a day? ……hours/minutes

C3: Home Activities

8. Did you do the following activities during **your free time** in the **past 7 days?**

					Weekdays **Total** hours/minutes	Weekend **Total** hours/minutes
Art & craft (e.g. pottery, sewing, drawing, painting)	No		Yes			
Doing homework	No		Yes			
Listen to music	No		Yes			
Play indoors with toys	No		Yes			
Playing board games / cards	No		Yes			
Playing computer games (e.g. PlayStation / Gameboy)	No		Yes			
Playing musical instrument	No		Yes			
Reading	No		Yes			
Sitting talking	No		Yes			
Talk on the phone	No		Yes			
Using computer / internet	No		Yes			
Watching TV / videos	No		Yes			

C4: House Activities

9. What other activities (house chores), do you usually perform while at home? Please tick (✓) and indicate number of hours

Activity		Approximate Number of hours/minutes in a day for each activity	
a) House cleaning			hours/minutes
b) Laundry and Ironing			hours/minutes
c) Preparing food, cooking			hours/minutes
d) Taking care of siblings			hours/minutes
e) I don't do anything			hours/minutes
f) Others (specify)			
			hours/minutes

10. What other activities do you usually perform while at home or school? Please tick (✓) and indicate number of hours

Activity		Approximate Number of hours in a day for each activity	
a) Farm work			hours/minutes
b) Gardening			Hours/minutes
c) I don't do anything			hours/minutes
d) Others (specify)			
			hours/minutes

Part D. Questions related to dietary habits

1. Are you given any money for buying food or drinks while at school or outside home?
    a) Yes
    b) No
2. If yes, on average how much money are you given per day? _____
3. How many times per week do you buy foods/ drinks sold in school or away from home?
    a) Once
    b) 2-4times
    c) 5-6 times
4. What type of food do you usually buy at school or away from home? _____
5. Are you given lunch at school?
    a) Yes
    b) No
6. If yes, what type of food are you usually given at school? _____
7. Are you given any food at home to take to school?
    a) Yes
    b) No
8. If yes, what type of food do you usually take to school? _____
9. How many times per week do you take food to school?
    a) Once
    b) 2-4times
    c) 5-6 times
10. Do you usually eat breakfast before going to school?
    a) Yes
    b) No
11. If yes, on average how many times per week do you take breakfast?
    a) Once
    b) 2-4times
    c) 5-6 times

12. Do you usually eat fruits?

a) Yes

b) No

13. If yes on average how many times per weeks do you eat fruits? .....days per week

a) 1-2 days

b) 3-4days

c) More than 4 times

13. Do you usually eat vegetables?

a) Yes

b) No

14. If yes, on average how many times per week do you eat vegetables?

.....days per week

a) 1-2 days

b) 3-4days

c) More than 5 days

Appendix 2 Permission to conduct a study

MOSHI MUNICIPAL COUNCIL

(All correspondence be addressed to the Municipal director)

MUNICIPAL DIRECTOR: **+ 255-027-2752344**
ALL OFFICE: **+255-027-2752906**
E-MAIL: director.moshi@gmail.com
WEBSITE: www.moshimc.go.tz
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TELEGRAPHIC ADDRESS: **MANISPAA**

MUNICIPAL HALL
P.O BOX 318
MOSHI.

17.7.2014

Ref. No. MMC/A.40/13/1/130

Ms. Josephine Thadeus Kimario,
Researcher,
Gent University,
Faculty of Bioscience Engineering,
Belgium.

RE: PERMISSION TO CONDUCT A RESEARCH

Refer to the above heading and your letter dated 24th June, 2014 from Gent University, Faculty of Bioscience engineering regarding the permission to conduct the study with the title Prevalence of Obesity and Overweight among School Children in Moshi Municipality, Kilimanjaro, Tanzania. With this letter, the permission has been granted to you to conduct the study in our Municipality starting from 17th July to 25th July 2014.

Best regards
Gloria S. Haule
For; **MUNICIPAL DIRECTOR, MOSHI**

C.C: HOD-Education Primary**,**
MOSHI MUNICIPALITY

Appendix 3 Informed Consent Form

To Head Teacher

Title of the study: Prevalence of Obesity and Overweight among School Children in Moshi Municipality, Kilimanjaro, Tanzania.

I am a student at Ghent University pursuing masters in Nutrition and rural Development, main subject Human Nutrition.

Your school has been selected to participate in the study. The purpose of the study is to identify the prevalence of Obesity and Overweight among school children aged 10-12 years in Moshi Municipality – Kilimanjaro, Results that will be obtained from this study will be used to propose school based intervention methods for prevention of overweight and obesity among primary school children. The study results will be disseminated through a publication and in a thesis for academic purpose. In this study children will be interviewed on questions related to potential risk factors for the development of overweight and obesity, demographical data will also be taken.

There are no straight benefits for participating in the study. But the study will obtain the information on risk factors for overweight and obesity. The study will recommend preventive measures that can be adopted by schools or parents to prevent children from becoming overweight or obese.

Please note that your school's participation in this study is voluntary and you have a right to refuse to consent. If you consent for your school to participate you have the right to withdraw your school from the study at any time if you wish to do so.

There are no risks or discomforts involved in this study. Children will be asked questions and their height, weight, triceps and subscapular skinfold thicknesses measurements will be taken in a non-invasive ways.

Names of interviewed children will not appear on the questionnaire and no record of their participation as individuals will be kept.

I confirm that I have read carefully and understood the information provided and consent for my school to participate in the study. I am aware that I can freely withdraw my school from this study any time I wish to do so.

Signature of the participant (Head Teacher) _____

Date: _____

Signature of Researcher _____

Date _____

Appendix 4 Internation cutoff points for body mass index for overweight and obesity by Sex between 2 and 18 years,defined to pass through the BMI of 25 and 30kg/m^2 at age of 18 years

	Body mass index 25 kg/m^2		Body mass index 30 kg/m^2	
Age (years)	Males	Females	Males	Females
2	18.41	18.02	20.09	19.81
2.5	18.13	17.76	19.80	19.55
3	17.89	17.56	19.57	19.36
3.5	17.69	17.40	19.39	19.23
4	17.55	17.28	19.29	19.15
4.5	17.47	17.19	19.26	19.12
5	17.42	17.15	19.30	19.17
5.5	17.45	17.20	19.47	19.34
6	17.55	17.34	19.78	19.65
6.5	17.71	17.53	20.23	20.08
7	17.92	17.75	20.63	20.51
7.5	18.16	18.03	21.09	21.01
8	18.44	18.35	21.60	21.57
8.5	18.76	18.69	22.17	22.18
9	19.10	19.07	22.77	22.81
9.5	19.46	19.45	23.39	23.46
10	19.84	19.86	24.00	24.11
10.5	20.20	20.29	24.57	24.77
11	20.55	20.74	25.10	25.42
11.5	20.89	21.20	25.58	26.05
12	21.22	21.68	26.02	26.67
12.5	21.56	22.14	26.43	27.24
13	21.91	22.58	26.84	27.76
13.5	22.27	22.98	27.25	28.20
14	22.62	23.34	27.63	28.57
14.5	22.96	23.66	27.98	28.87
15	23.29	23.94	28.30	29.11
15.5	23.60	24.17	28.60	29.29
16	23.90	24.37	28.88	29.43
16.5	24.19	24.54	29.14	29.56
17	24.46	24.70	29.41	29.69
17.5	24.73	24.85	29.70	29.84
18	25	25	30	30

Source: (Cole et al., 2000)

Appendix 5 Internation cutoff points for body mass index for thinness grades 1,2 and 3 by sex for exact age between 2 and 18 years,defined to pass through the BMI of 16, 17, and 18.5 at age of 18 years

	Boys			Girls		
Age (years)	16	17	18.5	16	17	18.5
2.0	13.37	14.12	15.14	13.24	13.90	14.83
2.5	13.22	13.94	14.92	13.10	13.74	14.63
3.0	13.09	13.79	14.74	12.98	13.60	14.47
3.5	12.97	13.64	14.57	12.86	13.47	14.32
4.0	12.86	13.52	14.43	12.73	13.34	14.19
4.5	12.76	13.41	14.31	12.61	13.21	14.06
5.0	12.66	13.31	14.21	12.50	13.09	13.94
5.5	12.58	13.22	14.13	12.40	12.99	13.86
6.0	12.50	13.15	14.07	12.32	12.93	13.82
6.5	12.45	13.10	14.04	12.28	12.90	13.82
7.0	12.42	13.08	14.04	12.26	12.91	13.86
7.5	12.41	13.09	14.08	12.27	12.95	13.93
8.0	12.42	13.11	14.15	12.31	13.00	14.02
8.5	12.45	13.17	14.24	12.37	13.08	14.14
9.0	12.50	13.24	14.35	12.44	13.18	14.28
9.5	12.57	13.34	14.49	12.53	13.29	14.43
10.0	12.66	13.45	14.64	12.64	13.43	14.61
10.5	12.77	13.58	14.80	12.78	13.59	14.81
11.0	12.89	13.72	14.97	12.95	13.79	15.05
11.5	13.03	13.87	15.16	13.15	14.01	15.32
12.0	13.18	14.05	15.35	13.39	14.28	15.62
12.5	13.37	14.25	15.58	13.65	14.56	15.93
13.0	13.59	14.48	15.84	13.92	14.85	16.26
13.5	13.83	14.74	16.12	14.20	15.14	16.57
14.0	14.09	15.01	16.41	14.48	15.43	16.88
14.5	14.35	15.28	16.69	14.75	15.72	17.18
15.0	14.60	15.55	16.98	15.01	15.98	17.45
15.5	14.86	15.82	17.26	15.25	16.22	17.69
16.0	15.12	16.08	17.54	15.46	16.44	17.91
16.5	15.36	16.34	17.80	15.63	16.62	18.09
17.0	15.60	16.58	18.05	15.78	16.77	18.25
17.5	15.81	16.80	18.28	15.90	16.89	18.38
18.0	16.00	17.00	18.50	16.00	17.00	18.50

Source: (Cole et al., 2000)

Appendix 6 Smoothed percentiles for Subscapular skinfold for age (mm): boys aged 1.50 – 19.99years

				Percentile									
Age	*L*	*M*	*S*	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
1.50–1.99 y	−0.3827	5.8414	0.2767	3.63	3.84	4.19	4.88	5.84	7.09	7.92	8.55	9.63	10.44
2.00–2.49 y	−0.4078	5.7779	0.2748	3.61	3.82	4.16	4.83	5.78	7.01	7.82	8.45	9.52	10.32
2.50–2.99 y	−0.4582	5.6469	0.2711	3.57	3.76	4.09	4.74	5.65	6.83	7.63	8.24	9.30	10.09
3.00–3.49 y	−0.5086	5.5132	0.2677	3.52	3.71	4.02	4.64	5.51	6.66	7.44	8.04	9.08	9.86
3.50–3.99 y	−0.5591	5.3813	0.2651	3.47	3.64	3.94	4.54	5.38	6.50	7.25	7.84	8.87	9.66
4.00–4.49 y	−0.6095	5.2551	0.2638	3.41	3.58	3.86	4.44	5.26	6.34	7.09	7.67	8.70	9.49
4.50–4.99 y	−0.6597	5.1370	0.2638	3.34	3.51	3.79	4.34	5.14	6.21	6.94	7.53	8.56	9.37
5.00–5.49 y	−0.7094	5.0215	0.2654	3.28	3.43	3.70	4.24	5.02	6.08	6.82	7.41	8.47	9.30
5.50–5.99 y	−0.7579	4.9017	0.2689	3.19	3.35	3.61	4.14	4.90	5.96	6.70	7.31	8.40	9.27
6.00–6.49 y	−0.8040	4.7885	0.2743	3.11	3.26	3.51	4.03	4.79	5.85	6.61	7.24	8.39	9.32
6.50–6.99 y	−0.8466	4.7139	0.2817	3.04	3.19	3.44	3.95	4.71	5.80	6.59	7.25	8.49	9.52
7.00–7.49 y	−0.8844	4.7007	0.2910	3.01	3.15	3.41	3.92	4.70	5.83	6.68	7.39	8.76	9.93
7.50–7.99 y	−0.9163	4.7407	0.3018	3.00	3.15	3.40	3.93	4.74	5.94	6.85	7.64	9.19	10.56
8.00–8.49 y	−0.9416	4.8172	0.3139	3.01	3.16	3.42	3.97	4.82	6.10	7.10	7.99	9.77	11.41
8.50–8.99 y	−0.9603	4.9274	0.3268	3.04	3.19	3.47	4.03	4.93	6.31	7.42	8.42	10.50	12.48
9.00–9.49 y	−0.9729	5.0737	0.3402	3.09	3.25	3.53	4.12	5.07	6.58	7.81	8.95	11.38	13.81
9.50–9.99 y	−0.9802	5.2439	0.3535	3.14	3.31	3.60	4.23	5.24	6.88	8.26	9.55	12.41	15.38
10.00–10.49 y	−0.9832	5.4157	0.3662	3.20	3.37	3.68	4.34	5.42	7.19	8.71	10.16	13.48	17.10
10.50–10.99 y	−0.9828	5.5760	0.3776	3.25	3.43	3.75	4.44	5.58	7.48	9.14	10.75	14.55	18.85
11.00–11.49 y	−0.9797	5.7219	0.3874	3.30	3.49	3.82	4.53	5.72	7.74	9.53	11.29	15.54	20.51
11.50–11.99 y	−0.9745	5.8541	0.3952	3.35	3.54	3.88	4.62	5.85	7.97	9.87	11.77	16.40	21.96
12.00–12.49 y	−0.9670	5.9749	0.4010	3.39	3.59	3.94	4.70	5.97	8.17	10.17	12.16	17.08	23.07
12.50–12.99 y	−0.9572	6.0965	0.4047	3.44	3.64	4.00	4.78	6.10	8.37	10.42	12.48	17.58	23.81
13.00–13.49 y	−0.9453	6.2330	0.4065	3.51	3.71	4.08	4.88	6.23	8.56	10.67	12.77	17.95	24.21
13.50–13.99 y	−0.9318	6.3961	0.4066	3.59	3.80	4.18	5.01	6.40	8.78	10.92	13.05	18.23	24.38
14.00–14.49 y	−0.9167	6.5929	0.4054	3.70	3.92	4.31	5.17	6.59	9.03	11.21	13.35	18.48	24.42
14.50–14.99 y	−0.9001	6.8202	0.4032	3.83	4.05	4.46	5.35	6.82	9.32	11.52	13.67	18.71	24.40
15.00–15.49 y	−0.8817	7.0694	0.4006	3.97	4.21	4.63	5.55	7.07	9.63	11.85	14.00	18.96	24.38
15.50–15.99 y	−0.8609	7.3362	0.3981	4.12	4.36	4.81	5.76	7.34	9.96	12.21	14.36	19.23	24.39
16.00–16.49 y	−0.8376	7.6251	0.3961	4.27	4.53	5.00	5.99	7.63	10.32	12.61	14.77	19.56	24.51
16.50–16.99 y	−0.8110	7.9385	0.3948	4.44	4.71	5.20	6.24	7.94	10.72	13.05	15.23	19.96	24.74
17.00–17.49 y	−0.7809	8.2763	0.3944	4.61	4.90	5.41	6.50	8.28	11.15	13.54	15.74	20.45	25.08
17.50–17.99 y	−0.7475	8.6462	0.3948	4.79	5.09	5.63	6.78	8.65	11.64	14.09	16.33	21.03	25.54
18.00–18.49 y	−0.7111	9.0550	0.3960	4.98	5.30	5.87	7.09	9.06	12.18	14.71	16.99	21.72	26.15
18.50–18.99 y	−0.6723	9.4930	0.3978	5.18	5.52	6.12	7.42	9.49	12.76	15.38	17.72	22.48	26.85
19.00–19.49 y	−0.6314	9.9431	0.4000	5.37	5.74	6.38	7.75	9.94	13.36	16.08	18.47	23.27	27.58
19.50–19.99 y	−0.5892	10.3940	0.4025	5.56	5.94	6.63	8.08	10.39	13.97	16.78	19.22	24.05	28.32

Source : Addo & Himes, 2010b

Appendix 7 Smoothed percentiles for Triceps skinfold for age (mm): boys aged 1.50 – 19.99years

				Percentile									
Age	*L*	*M*	*S*	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
1.50–1.99 y	−0.0982	9.7466	0.2464	6.20	6.55	7.14	8.27	9.75	11.52	12.62	13.43	14.74	15.66
2.00–2.49 y	−0.1065	9.6551	0.2495	6.11	6.46	7.05	8.17	9.66	11.44	12.55	13.37	14.69	15.63
2.50–2.99 y	−0.1229	9.4769	0.2559	5.94	6.29	6.87	7.99	9.48	11.28	12.41	13.25	14.60	15.57
3.00–3.49 y	−0.1392	9.3113	0.2626	5.77	6.12	6.70	7.82	9.31	11.14	12.29	13.14	14.54	15.53
3.50–3.99 y	−0.1555	9.1537	0.2698	5.62	5.96	6.54	7.65	9.15	11.01	12.18	13.06	14.50	15.53
4.00–4.49 y	−0.1715	8.9913	0.2778	5.45	5.79	6.36	7.48	8.99	10.88	12.08	12.98	14.47	15.54
4.50–4.99 y	−0.1871	8.8176	0.2866	5.28	5.61	6.18	7.29	8.82	10.74	11.97	12.90	14.44	15.56
5.00–5.49 y	−0.2021	8.6349	0.2963	5.09	5.42	5.99	7.10	8.63	10.59	11.86	12.82	14.42	15.60
5.50–5.99 y	−0.2164	8.4553	0.3071	4.91	5.23	5.80	6.90	8.46	10.45	11.76	12.76	14.44	15.67
6.00–6.49 y	−0.2298	8.2999	0.3189	4.73	5.06	5.62	6.73	8.30	10.35	11.70	12.75	14.51	15.82
6.50–6.99 y	−0.2423	8.1976	0.3314	4.59	4.91	5.47	6.59	8.20	10.32	11.73	12.83	14.71	16.11
7.00–7.49 y	−0.2540	8.1739	0.3445	4.49	4.81	5.38	6.52	8.17	10.39	11.88	13.06	15.07	16.59
7.50–7.99 y	−0.2648	8.2395	0.3578	4.44	4.77	5.35	6.52	8.24	10.57	12.17	13.43	15.62	17.29
8.00–8.49 y	−0.2748	8.3857	0.3712	4.43	4.77	5.36	6.58	8.39	10.87	12.59	13.96	16.36	18.20
8.50–8.99 y	−0.2841	8.5913	0.3844	4.45	4.80	5.42	6.69	8.59	11.25	13.11	14.61	17.25	19.30
9.00–9.49 y	−0.2926	8.8356	0.3974	4.49	4.86	5.50	6.83	8.84	11.68	13.70	15.34	18.25	20.54
9.50–9.99 y	−0.3006	9.0972	0.4099	4.55	4.92	5.59	6.98	9.10	12.14	14.33	16.12	19.33	21.87
10.00–10.49 y	−0.3082	9.3464	0.4217	4.60	4.98	5.67	7.12	9.35	12.59	14.95	16.88	20.40	23.21
10.50–10.99 y	−0.3153	9.5503	0.4328	4.63	5.02	5.73	7.22	9.55	12.97	15.49	17.57	21.39	24.46
11.00–11.49 y	−0.3222	9.6840	0.4429	4.63	5.03	5.75	7.28	9.68	13.26	15.91	18.12	22.21	25.54
11.50–11.99 y	−0.3286	9.7329	0.4520	4.60	5.00	5.73	7.28	9.73	13.42	16.19	18.51	22.83	26.38
12.00–12.49 y	−0.3347	9.6954	0.4600	4.53	4.94	5.66	7.22	9.70	13.45	16.30	18.70	23.20	26.93
12.50–12.99 y	−0.3405	9.5778	0.4669	4.44	4.84	5.56	7.10	9.58	13.36	16.25	18.70	23.33	27.19
13.00–13.49 y	−0.3460	9.3915	0.4728	4.33	4.72	5.42	6.94	9.39	13.17	16.07	18.54	23.24	27.18
13.50–13.99 y	−0.3512	9.1601	0.4777	4.20	4.58	5.26	6.75	9.16	12.89	15.78	18.25	22.97	26.96
14.00–14.49 y	−0.3559	8.9122	0.4816	4.06	4.43	5.10	6.55	8.91	12.59	15.44	17.89	22.60	26.60
14.50–14.99 y	−0.3601	8.6733	0.4848	3.94	4.30	4.95	6.37	8.67	12.28	15.10	17.52	22.20	26.19
15.00–15.49 y	−0.3635	8.4643	0.4872	3.84	4.19	4.82	6.21	8.46	12.01	14.79	17.19	21.83	25.80
15.50–15.99 y	−0.3660	8.2983	0.4892	3.75	4.10	4.72	6.08	8.30	11.80	14.54	16.92	21.53	25.48
16.00–16.49 y	−0.3673	8.1842	0.4909	3.70	4.04	4.65	5.99	8.18	11.65	14.37	16.73	21.33	25.27
16.50–16.99 y	−0.3673	8.1258	0.4923	3.66	4.00	4.61	5.94	8.13	11.58	14.30	16.66	21.25	25.20
17.00–17.49 y	−0.3663	8.1247	0.4936	3.65	3.99	4.60	5.93	8.12	11.59	14.32	16.69	21.30	25.27
17.50–17.99 y	−0.3642	8.1877	0.4949	3.67	4.01	4.63	5.98	8.19	11.69	14.45	16.84	21.50	25.52
18.00–18.49 y	−0.3615	8.3189	0.4961	3.72	4.07	4.69	6.07	8.32	11.88	14.69	17.13	21.88	25.96
18.50–18.99 y	−0.3582	8.5027	0.4973	3.80	4.15	4.79	6.19	8.50	12.15	15.03	17.53	22.38	26.56
19.00–19.49 y	−0.3546	8.7141	0.4984	3.88	4.24	4.90	6.34	8.71	12.46	15.42	17.98	22.95	27.23
19.50–19.99 y	−0.3509	8.9348	0.4994	3.97	4.34	5.02	6.50	8.93	12.79	15.82	18.45	23.55	27.93

Source : Addo & Himes, 2010b

Appendix 8 Smoothed percentiles for Subscapular Skinfolds for age (mm): girls aged 1.50-19.99years

				Percentile									
Age	*L*	*M*	*S*	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
1.50–1.99 y	−0.3964	6.0797	0.2903	3.71	3.93	4.30	5.03	6.08	7.45	8.38	9.09	10.32	11.25
2.00–2.49 y	−0.4191	6.0672	0.2901	3.71	3.93	4.29	5.03	6.07	7.44	8.37	9.09	10.33	11.27
2.50–2.99 y	−0.4644	6.0349	0.2900	3.71	3.92	4.28	5.00	6.03	7.41	8.34	9.08	10.35	11.32
3.00–3.49 y	−0.5086	5.9881	0.2907	3.70	3.90	4.26	4.97	5.99	7.36	8.31	9.05	10.36	11.36
3.50–3.99 y	−0.5508	5.9274	0.2928	3.66	3.87	4.21	4.91	5.93	7.31	8.26	9.02	10.37	11.43
4.00–4.49 y	−0.5904	5.8579	0.2968	3.62	3.81	4.16	4.85	5.86	7.25	8.23	9.01	10.42	11.53
4.50–4.99 y	−0.6267	5.7831	0.3029	3.55	3.75	4.09	4.77	5.78	7.20	8.20	9.02	10.51	11.70
5.00–5.49 y	−0.6588	5.7054	0.3109	3.48	3.67	4.01	4.69	5.71	7.15	8.20	9.06	10.64	11.94
5.50–5.99 y	−0.6862	5.6263	0.3205	3.40	3.59	3.92	4.60	5.63	7.11	8.20	9.12	10.83	12.25
6.00–6.49 y	−0.7085	5.5517	0.3317	3.31	3.50	3.83	4.51	5.55	7.08	8.23	9.21	11.07	12.65
6.50–6.99 y	−0.7258	5.5058	0.3443	3.24	3.43	3.75	4.44	5.51	7.10	8.32	9.37	11.42	13.20
7.00–7.49 y	−0.7385	5.5156	0.3579	3.19	3.38	3.72	4.42	5.52	7.20	8.51	9.66	11.94	13.99
7.50–7.99 y	−0.7468	5.5937	0.3723	3.18	3.38	3.72	4.44	5.59	7.39	8.82	10.09	12.68	15.07
8.00–8.49 y	−0.7507	5.7454	0.3870	3.21	3.41	3.77	4.53	5.75	7.68	9.26	10.69	13.66	16.47
8.50–8.99 y	−0.7501	5.9649	0.4015	3.28	3.49	3.86	4.66	5.96	8.07	9.82	11.43	14.84	18.17
9.00–9.49 y	−0.7447	6.2339	0.4154	3.37	3.59	3.98	4.83	6.23	8.54	10.48	12.28	16.20	20.10
9.50–9.99 y	−0.7346	6.5311	0.4287	3.47	3.70	4.12	5.02	6.53	9.04	11.18	13.20	17.64	22.15
10.00–10.49 y	−0.7199	6.8411	0.4410	3.57	3.82	4.26	5.22	6.84	9.56	11.91	14.13	19.08	24.18
10.50–10.99 y	−0.7012	7.1598	0.4519	3.68	3.94	4.40	5.43	7.16	10.09	12.63	15.05	20.46	26.07
11.00–11.49 y	−0.6794	7.4882	0.4612	3.79	4.06	4.56	5.65	7.49	10.62	13.35	15.94	21.75	27.75
11.50–11.99 y	−0.6559	7.8240	0.4687	3.90	4.19	4.72	5.87	7.82	11.15	14.04	16.79	22.91	29.18
12.00–12.49 y	−0.6318	8.1690	0.4743	4.03	4.33	4.88	6.10	8.17	11.68	14.72	17.59	23.93	30.35
12.50–12.99 y	−0.6082	8.5264	0.4779	4.16	4.48	5.07	6.35	8.53	12.21	15.37	18.34	24.84	31.31
13.00–13.49 y	−0.5856	8.8932	0.4796	4.31	4.65	5.26	6.61	8.89	12.73	16.00	19.05	25.63	32.07
13.50–13.99 y	−0.5644	9.2649	0.4794	4.47	4.83	5.47	6.88	9.26	13.24	16.60	19.70	26.30	32.66
14.00–14.49 y	−0.5450	9.6395	0.4775	4.64	5.01	5.68	7.16	9.64	13.74	17.16	20.29	26.87	33.09
14.50–14.99 y	−0.5272	10.0125	0.4743	4.82	5.21	5.91	7.45	10.01	14.21	17.69	20.83	27.35	33.41
15.00–15.49 y	−0.5105	10.3772	0.4708	5.00	5.40	6.13	7.73	10.38	14.67	18.19	21.35	27.80	33.72
15.50–15.99 y	−0.4939	10.7312	0.4682	5.17	5.59	6.34	8.00	10.73	15.13	18.69	21.86	28.28	34.09
16.00–16.49 y	−0.4767	11.0737	0.4671	5.32	5.75	6.54	8.26	11.07	15.58	19.20	22.41	28.83	34.57
16.50–16.99 y	−0.4585	11.4021	0.4677	5.45	5.90	6.71	8.49	11.40	16.03	19.73	22.98	29.44	35.16
17.00–17.49 y	−0.4391	11.7132	0.4696	5.55	6.02	6.87	8.71	11.71	16.47	20.25	23.56	30.09	35.81
17.50–17.99 y	−0.4189	12.0085	0.4721	5.64	6.13	7.00	8.91	12.01	16.90	20.76	24.13	30.72	36.46
18.00–18.49 y	−0.3980	12.2922	0.4750	5.72	6.23	7.13	9.09	12.29	17.32	21.26	24.68	31.34	37.08
18.50–18.99 y	−0.3765	12.5686	0.4783	5.79	6.31	7.24	9.27	12.57	17.73	21.76	25.23	31.95	37.69
19.00–19.49 y	−0.3545	12.8429	0.4820	5.85	6.39	7.35	9.44	12.84	18.14	22.25	25.79	32.57	38.33
19.50–19.99 y	−0.3323	13.1192	0.4859	5.91	6.46	7.45	9.61	13.12	18.56	22.76	26.36	33.21	38.99

Source: Addo & Himes, 2010b

Appendix 9 Smoothed percentiles for Triceps skinfolds for age (mm): girls aged 1.50 – 19.99 years

				Percentiles									
Age	*L*	*M*	*S*	3rd	5th	10th	25th	50th	75th	85th	90th	95th	97th
1.50–1.99 y	0.0360	9.9142	0.2451	6.23	6.61	7.23	8.40	9.91	11.69	12.77	13.55	14.79	15.67
2.00–2.49 y	0.0302	9.9121	0.2491	6.18	6.56	7.19	8.38	9.91	11.72	12.82	13.62	14.89	15.78
2.50–2.99 y	0.0187	9.9069	0.2572	6.09	6.48	7.12	8.33	9.91	11.78	12.92	13.76	15.10	16.03
3.00–3.49 y	0.0073	9.8997	0.2654	6.00	6.39	7.04	8.28	9.90	11.84	13.03	13.90	15.31	16.29
3.50–3.99 y	−0.0038	9.8896	0.2739	5.91	6.30	6.96	8.22	9.89	11.90	13.14	14.05	15.53	16.56
4.00–4.49 y	−0.0145	9.8783	0.2828	5.82	6.21	6.88	8.17	9.88	11.96	13.25	14.21	15.75	16.85
4.50–4.99 y	−0.0245	9.8683	0.2921	5.72	6.12	6.80	8.11	9.87	12.02	13.37	14.37	16.00	17.16
5.00–5.49 y	−0.0338	9.8612	0.3017	5.62	6.03	6.72	8.05	9.86	12.10	13.50	14.55	16.27	17.49
5.50–5.99 y	−0.0420	9.8656	0.3118	5.53	5.94	6.64	8.00	9.87	12.19	13.66	14.76	16.57	17.86
6.00–6.49 y	−0.0492	9.8987	0.3220	5.45	5.87	6.58	7.98	9.90	12.31	13.86	15.02	16.93	18.30
6.50–6.99 y	−0.0553	9.9820	0.3322	5.40	5.83	6.55	7.99	9.98	12.51	14.13	15.36	17.39	18.85
7.00–7.49 y	−0.0603	10.1312	0.3424	5.39	5.82	6.57	8.05	10.13	12.78	14.50	15.81	17.97	19.54
7.50–7.99 y	−0.0643	10.3502	0.3524	5.41	5.86	6.63	8.18	10.35	13.15	14.98	16.37	18.69	20.38
8.00–8.49 y	−0.0671	10.6312	0.3620	5.46	5.93	6.73	8.34	10.63	13.60	15.55	17.03	19.52	21.34
8.50–8.99 y	−0.0687	10.9571	0.3712	5.54	6.03	6.86	8.55	10.96	14.10	16.18	17.77	20.44	22.41
9.00–9.49 y	−0.0689	11.3030	0.3797	5.63	6.13	7.00	8.77	11.30	14.64	16.84	18.54	21.40	23.51
9.50–9.99 y	−0.0674	11.6449	0.3876	5.72	6.24	7.14	8.99	11.64	15.16	17.50	19.30	22.34	24.59
10.00–10.49 y	−0.0643	11.9683	0.3947	5.80	6.34	7.28	9.19	11.97	15.65	18.12	20.02	23.23	25.61
10.50–10.99 y	−0.0596	12.2721	0.4010	5.87	6.43	7.40	9.38	12.27	16.12	18.69	20.68	24.05	26.55
11.00–11.49 y	−0.0533	12.5632	0.4065	5.94	6.51	7.52	9.57	12.56	16.56	19.24	21.31	24.82	27.42
11.50–11.99 y	−0.0458	12.8489	0.4110	6.01	6.60	7.64	9.76	12.85	16.98	19.76	21.90	25.53	28.23
12.00–12.49 y	−0.0373	13.1392	0.4146	6.09	6.70	7.76	9.95	13.14	17.40	20.26	22.47	26.22	28.99
12.50–12.99 y	−0.0281	13.4475	0.4171	6.19	6.82	7.91	10.16	13.45	17.84	20.78	23.04	26.89	29.73
13.00–13.49 y	−0.0186	13.7811	0.4186	6.31	6.95	8.08	10.40	13.78	18.29	21.30	23.63	27.56	30.46
13.50–13.99 y	−0.0088	14.1399	0.4190	6.45	7.11	8.28	10.66	14.14	18.76	21.85	24.22	28.23	31.18
14.00–14.49 y	0.0010	14.5203	0.4183	6.61	7.30	8.49	10.95	14.52	19.25	22.40	24.81	28.88	31.88
14.50–14.99 y	0.0109	14.9146	0.4166	6.79	7.50	8.73	11.26	14.91	19.75	22.95	25.40	29.52	32.54
15.00–15.49 y	0.0209	15.3149	0.4141	6.98	7.71	8.98	11.57	15.31	20.23	23.48	25.96	30.12	33.16
15.50–15.99 y	0.0311	15.7180	0.4110	7.19	7.94	9.24	11.90	15.72	20.71	24.00	26.50	30.69	33.74
16.00–16.49 y	0.0413	16.1220	0.4075	7.40	8.17	9.51	12.23	16.12	21.19	24.51	27.03	31.23	34.29
16.50–16.99 y	0.0518	16.5208	0.4038	7.61	8.40	9.78	12.56	16.52	21.65	24.99	27.53	31.74	34.80
17.00–17.49 y	0.0625	16.9078	0.4000	7.82	8.64	10.04	12.88	16.91	22.09	25.46	28.00	32.22	35.26
17.50–17.99 y	0.0737	17.2818	0.3961	8.03	8.86	10.30	13.19	17.28	22.52	25.90	28.45	32.66	35.69
18.00–18.49 y	0.0853	17.6471	0.3923	8.24	9.09	10.56	13.50	17.65	22.93	26.32	28.87	33.07	36.09
18.50–18.99 y	0.0975	18.0086	0.3885	8.44	9.31	10.81	13.81	18.01	23.33	26.73	29.28	33.48	36.48
19.00–19.49 y	0.1101	18.3699	0.3848	8.64	9.53	11.06	14.12	18.37	23.73	27.14	29.69	33.87	36.86
19.50–19.99 y	0.1228	18.7333	0.3812	8.84	9.76	11.32	14.43	18.73	24.13	27.55	30.11	34.27	37.24

Source: Addo & Himes, 2010b