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Body Mass Index and Growth Spurts in School Teenagers in Addis Ababa - The Case of A Private School.

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GRADUATE PROGRAMME

This is to certify that the thesis prepared by **Zeritu Abate**, entitled: Body Mass Index and Growth Spurts in School Teenagers in Addis Ababa - The Case of Private Schools. *Ethiopia* and submitted in partial fulfillment of the requirements for the Degree of Master of Science complies with the regulations of the University and meets the accepted standard with respect to originality and quality.

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ACRONYMS

BMI= Body mass index

CDC= Center for Disease Control and Prevention

GHRH= Growth Hormone Releasing Hormone

GHIH=Growth hormone-inhibiting hormone

HGH= Human Growth Hormone

(hGHpb)= Human Growth Hormone Binding Proteins.

(IGF)-I= Insulin-like growth factor

NIH = National Institute of Health

NHLBI= National Heart, Lung and Blood Institute

WHO= World Health Organization

ABSTRACT

The purpose of this study was to assess variation in mean body weight, height and body mass index(BMI) between age and sex cohorts of school teenage children in Deliverance Primary & Secondary School of Addis Ababa in grades 7 to 10 (age 13-17)(Private School).

Lottery sampling method was used in selecting students. Measurement of weight and height were done to determine mean height, mean weight and BMI variations of students based on age and sex. The researcher used quantitative research methods to describe sample students' weight and height. The sample students were from grade 7 to 10 of both sexes, males and females.

The height, weight and MIof students of age 13-17 years were recorded in this study to determine rates of growth and body weight status of school teenagers in Addis Ababa Private School (Deliverance Primary & Secondary School).The results showed that mean height ranged between 1.49m (13 years) and 1.69m (17 years) while the individual height range was 1.23m - 1.86m. Males were taller than females for all age groups. The highest height increment was observed between 13 and 14 age groups (2.67%) and 14-15 age groups (2.6%). The mean weight range was 49.81kg – 77.98kg while the individual weight range was 30kg – 88kg. The highest percentage increment was 15.72% (13-14 years old).

The mean BMI ranged between 22 kg/m^2 and 28.50 kg/m^2while the individual BMI range was 16.90 kg/m^2-32.41kg/m^2. Based on the BMI values almost all age categories of males and females were overweight except 13 year old males who had normal weight.

The results revealed that at age 13 and 14 there were high body and weight growth. Based on the findings and conclusions of the study, it is recommended that the stakeholders in education and sports teachers should put a mechanism that will guide all children at schools to participate in physical activities.

Keywords: Body mass index, growth spurt, school teenagers, height, weight, private school

Introduction

Body mass index **(**BMI) is a measure of weight adjusted for height, calculated as weight in kilograms divided by the square of height in meters (kg/m^2) (https://www.cdc.gov/obesity/downloads/bmiforpactitioners.pdf). Although BMI is often considered an indicator of body fatness, it is a substitute measure of body fat because it measures excess weight rather than excess fat. BMI is a reasonable indicator of body fat for both adults and children. Because BMI does not measure body fat directly, it should not be used as a diagnostic tool. Instead, BMI should be used as a measure to track weight status in populations and as a screening tool to identify potential weight problems in individuals (CDC, 2009).

BMI is an attempt to quantify the amount of tissue mass (muscle, fat, and bone) in an individual, and then categorize that person as underweight, normal weight, overweight, or obese based on that value. That categorization is the subject of some debate about where on the BMI scale the dividing lines between categories should be put (Kendrick, 2015).

BMI is a simple, inexpensive, and noninvasive substitute measure of body fat. In contrast to other methods, BMI relies solely on height and weight and with access to the proper equipment, individuals can have their BMI routinely measured and calculated with reasonable accuracy. Furthermore, studies have shown that BMI levels correlate with body fat and with future health risks. High BMI predicts future morbidity and death. Therefore, BMI is an appropriate measure for screening for obesity and its health risks. Lastly, the widespread and longstanding application of BMI contributes to its utility at the population level. Its use has resulted in an increased availability of published population data that allows public health professionals to make comparisons across time, regions, and population subgroups. For adults 20 years and older, BMI is interpreted by using standard weight status categories that are the same for all ages and for both men and women. However, for individuals younger than age 20 (Freedman*et al*., 2009).

The best index was the ratio of the weight in kilograms divided by the square of the height in meters, or the Quetelet Index described in 1832.

Quetelet (1796-1874) was a Belgian mathematician, astronomer and statistician, who developed a passionate interest in probability calculus that he applied to study human physical characteristics and social aptitudes. It aims to estimate whether a person has a healthy weight. The Quetelet Index was termed the body Mass Index in 1972 by Ancel Keys (1904-2004), which measured obesity by dividing a person's weight (in kilograms) by the square of his or her height (in inches) (Eknoyan, 2008).

According to Quetelet (1842) for a person of weight M (kilograms) and height H (meters), BMI is defined as BMI = M/H^2(https://www.aps.org/units/fps/newsletters/201201/apell.cfm). The Centers for Disease Control cautions that while the correlation between BMI and body fat is fairly strong, there are variations by race, sex, and age. For adults, CDC guidelines classify a person with a BMI of < 18.5 as underweight, 18.5 to 24.9 as normal weight, 25 to 29.9 as overweight, and > 30 as obese.

BMI, however, is one of the tools that are used to calculate healthy risk. Other factors such as blood pressure, cholesterol level, blood sugar level, family history of heart disease, age, gender, waist circumference, level of physical activity, menopause status, smoking status etc. are also taken into consideration while assessing health risks. For most people, BMI can be used to provide a good measure of obesity. But BMI fails to provide actual information on body composition like amount of muscle, bone, fat, and other tissues. In some persons BMI is a more accurate measure of body fat than others. For example, persons who are very muscular may fall into the “overweight” category when they are actually healthy and very fit. These persons with a very low body fat percentage could have the same BMI score as someone who is overweight. Similarly, an elderly and frail individual person may be in the normal weight category when they have little muscle mass and a high percentage of body fat. BMI, when used for children and adolescents who are still growing, those with large body frames or petite builds, pregnant women and highly muscled individuals thus need to be assessed and interpreted carefully (Mandal,2017).

Relatively few studies have scrutinized the BMI in Ethiopia. As a result, there is limited data on body mass index for children in Ethiopia. Therefore, this study attempted to fill some of the data gap.

2. Objectives of the study

2.1. General objective

The general aim of this study was to generate data on BMI and growth spurts of teenage students between age 13-17 at Deliverance Primary and Secondary School.

2.2. Specific objectives

- To determine the rate of chronological increase in height and weight.
- To identify sex-specific chronological variation in height and weight.
- To analyze the difference in mean body mass and height between boys and girls.
- To compare the age-specific mean body weight, mean height and mean BMI of sampled student populations of private and government school.

3. Literature Review

3.1. Historical aspects of BMI

BMI is derived from a simple mathematics formula. The best index was the ratio of the weight in kilograms divided by the square of the height in meters. It was devised in the 1830s by Lambert Adolphe Jacques Quetelet, a Belgian who was also known as the "founder of social physics". Quetelet did not intend his index to be used to characterize obesity or general health status, but rather to help him define a "normal man" (Nordqvist, 2017). Through a comparative study of obesity indices, Ancel Keys of the University of Minnesota and his collaborators introduced in 1972 the notion of body mass index as the best performing such measurements (Keys *et al.*, 1972). This was a renaming of the Quetelet index proposed in 1832 by AdolpheQuetelet (Eknoyan, 2008).

BMI has been used for over 100 years to help health professionals decide whether a patient is overweight or underweight. It is used in population studies, by doctors, personal trainers, and others. However, BMI has some important flaws. For example, it does not measure overall fat or lean tissue (muscle) content. The BMI is not the only index of general health and weight status. Several alternative and complementary indices such as the Pondera Index, Body Volume Index, Skin Fold Method, Waist-to-Hip Ratio, and Sagittal Abdominal Diameter have been developed (Huxley *et al*., 2010).

Before 1980, doctors generally used weight-for-height tables, one for men and one for women- that included ranges of body weights for each centimeter of height. These tables were limited because they were based on weight alone, rather than body composition. BMI became an international standard for obesity measurement in the 1980s. The public learned about BMI in the late 1990s, when the USA government launched an initiative to encourage healthy eating and exercise (Wilson, 2018).

In 1998, the National Institutes of Health lowered the overweight threshold range for BMI 25 to 27.8 match international guidelines. The move added 30 million Americans who were previously in the "healthy weight" category to the "overweight" category. The NIH advises doctors and their patients to include BMI in a complete assessment of a person's body size and overall health (Wilson, 2018).

In 2013, Prof. Nick Trefethen, a mathematician from Oxford University in the United Kingdom (U.K.) wrote a letter to the *Economist*, in which he questioned the usefulness of the current BMI formula, calling it a "bizarre measure." Trefethen argued that the formula leads to confusion and misinformation. The height term, he says, divides the weight by too much when people are short and by too little when they are tall. The result is that short people being told they are thinner than they really are, while tall people are made to think that they are fatter than they are. Trefethen recommends a "new BMI calculator," which: multiplies the weight by 1.3 for metric measures (kilograms), or by 5,734 for imperial measures (pounds) divides the weight by height to the power of 2.5, instead of 2, or squared (Garn and Clark, 1997).

3.2. Physiology of growth

3.2.1. Growth hormone

With the recognition of its multiple and complex effects in the early 1960s, the physiology and regulation of GH has become a major area of research interest in the field of endocrinology. The human GH gene is located on chromosome 17q22 and comprises of five genes. It encodes two distinct GH molecules (22 kDa and 20 kDa) of which 90% in the circulation constitute the 22kDa molecule. Growth hormone (GH), also known as somatotropin, stimulates growth, cell reproduction, and cell regeneration in humans and other animals. Growth hormone is a 191-amino acid, single-chain polypeptide that is synthesized, stored and secreted by somatotropic cells within the lateral wings of the anterior pituitary gland.(Herrington, 2001).

GH is a dynamic hormone, which like most other hormones in the human body, varies in concentration and action under the influence of numerous factors such as age, physical fitness and body composition play a major role in the level and action of GH in humans. It is well recognized for its vital role in glucose and lipid homeostasis and muscle mass function. Its secretion is regulated by several factors including growth hormone releasing hormone (GHRH), somatostatin, ghrelin and IGF-1. Ghrelin the "hunger hormone", also known as lenomorelin (INN) is secreted from the stomach and circulates in the blood stream under fasting conditions, indicating that it transmits a hunger signal from the periphery to the central nervous system.Besides regulating appetite, ghrelin also plays important roles for maintaining growth hormone release and energy homeostasis in vertebrates (Kojima and Kangawa, 2008).

GH acts both directly through its own receptors and indirectly through the induced production of Insulin-like Growth Factor I (IGF-I). IGF-I is a 70 amino-acid peptide, found in the circulation, 99% bound to transport proteins. It is synthesized both in the liver and in the peripheral tissue, and is an important mediator of GH action. Following the initial discovery of IGF-I in the late 1950s, Salmon and Daughaday hypothesized, that GH governs somatic growth by IGF-I secreted by the liver. However, in the 1980s this hypothesis was modified by the identification of IGF-I production in most tissues including bone, myoblasts in muscle, erythroid precursors, ovary, kidney and central nervous system. Nevertheless, the liver produces approximately 75% of IGF-I and is mainly under the regulation of GH while the peripheral production of IGF-I is regulated by GH as well as tissue dependent paracrine factors. IGF-I is known as a global and tissue-specific growth factor as well as an endocrine factor. In some tissues IGF-I acts as a potent inhibitor of cellular apoptosis (Gunawardane, 2015).

GH and IGF-I are the main stimulators of longitudinal bone growth. They are also important for the acquisition of bone mass during the pre-pubertal period and maintenance of bone homeostasis throughout life. Longitudinal bone growth is mediated by GH, circulating IGF-I, and more importantly, local IGF-I in the growth plate.

For differentiation, proliferation, and hypertrophy of chondrocytes; the production of extracellular matrix; and ossification in the growth plate, IGF-I produced from chondrocytes of the epiphyseal plate is important (Giustina*et al*., 2008).

There is a close interplay between estrogen and GH in the regulation of growth and development in puberty. During puberty, there can be a 1.5- to 3-fold increase in the pulsatile secretion of GH and a more than 3-fold increase in the concentration of serum IGF-I. During the pubertal growth spurt, proliferation and differentiation of chondrocytes, secretion of extracellular matrix, calcification of the hypertrophic zone, invasion and differentiation of osteoblast, and formation of blood vessel repeat continuously in the growth plate. Secretion of GH in the pituitary is regulated by the neurosecretory nuclei of the hypothalamus. These cells release the peptides Growth hormone-releasing hormone (GHRH or somatocrinin) and Growth hormone-inhibiting hormone (GHIH or somatostatin) into the hypophyseal portal venous blood surrounding the pituitary. GH release in the pituitary is primarily determined by the balance of these two peptides, which in turn is affected by many physiological stimulators (e.g., exercise, nutrition, sleep) and inhibitors (e.g., free fatty acids) of GH secretion *(*Bartholomew *et al*., 2009).

Effects of growth hormone on the tissues of the body can generally be described as building up. Like most other protein hormones, GH acts by interacting with a specific receptor on the surface of cells. Increased height during childhood is the most widely known effect of GH. Height appears to be stimulated by at least two mechanisms: Becausepolypeptide hormones are not fat-soluble, they cannot penetrate cell membranes. Thus, GH exerts some of its effects by binding to receptors on target cells, where it activates the MAPK/ERK pathway.Through this mechanism GH directly stimulates division and multiplication ofchondrocytes of cartilage(*Binder et al.,2007*).

GH also stimulates, through the pathway the production of IGF-1, formerly known as somatomedin C, a hormone homologous to proinsulin. The liver is a major target organ of GH for this process and is the principal site of IGF-1 production. IGF-1 has growth-stimulating effects on a wide variety of tissues.

Additional IGF-1 is generated within target tissues, making it what appear to be both an endocrine and an autocrine/paracrine hormone. IGF-1 also has stimulatory effects onosteoblast and chondrocyte activity to promote bone growth (*Binder et al., 2007*).

In order to facilitate this behavior as a hormone GH binds to two receptors on the outside of a cell known as Human Growth Hormone Binding Proteins (hGHpb). Once the Human Growth hormone binds on both receptors. It causes a shift in the receptor protein, which in turn causes an internal signaling cascade. This cascade is how somatotropin is able to effect cell growth and function. In addition it can cause the release of other growth factors, like IGF-1.The body's primary mechanism of regulating GH is to release somatostatin, also known as growth hormone inhibitory hormone (GHIH). Somatostatin is produced in the hypothalamus and released by the anterior pituitary gland, pancreas, and GI tract (Somatostatin, 2011). This hormone works together with growth hormone releasing hormone (GHRH) to properly regulate the secretion of GH from the pituitary gland. Somatostatin levels are directly affected by levels of circulating GH. Specifically, levels of somatostatin are high when GH concentrations are high and low when GH is low (Harel*et al.,* 2017).

3.2.2. The growth process

The metaphysis of the long bones are present only at birth. Meanwhile, on the other end of the growing long bones grow primarily by elongation at an epiphysis, surprisingly the long bone of the leg embraces nearly half of adult height. Femurs, tibias and fibulas of the lower limb, the humeri, radii, and ulnas of the upper limb (arm + forearm), and the phalanges of the fingers and toes are included under long bones. Spine and skull are the other primary skeletal component of height. A child bones "growth plates" contain growing zone both ends that include special cells responsible for the bone's growth in length, these plates are easy to spot on an x-ray because they are softer and contain less minerals (Uvaze, 2013).

During child grows the epiphyses, carpal and tarsal bones of the hands and feet becomes calcified and appear on the x-rays. The bone maturation accelerated during puberty as sex steroid levels rise.

The bones get the size and shape of adult as growth nears conclusion and attainment of adult height. The remaining cartilaginous portions of the epiphyses become thinner. Obliteration of cartilaginous results the close and no further lengthening of the bones. According to Michael *et al., (*2008) small amount of spinal growth concludes an adolescent's growth.

Hart 2007, studied on puberty and its change on body growth. He discussed his study as follow. Puberty is a dynamic period of development marked by the rapid changes in body size, shape, and composition all of which are sexually dimorphic. Puberty characterized by the greatest sexual differentiation and rapid rate of linear growth. With the onset of puberty hormonal regulation of growth becomes increasingly complex, the age this occurs varies among sex, for girls age 11 and age 13 for boys considered as the onset of puberty. Adequate levels of thyroid hormone and cortisol continue to be prerequisites for normal growth, but the gonadal steroid hormones now play a major role. In addition, there is a dramatic activation of the GH/IGF-1 axis.During adolescence, the gonadal steroid hormones and the GH/IGF-1 axis continue to exert independent effects on growth, but of greater importance is the interaction between them, which sub serves the dramatic alterations in linear growth and body composition during puberty. During puberty, the GH/IGF-1 axis undergoes a dramatic activation by the time adolescent development is complete, the levels of GH and IGF-1 decrease to pre-pubertal values in both gender.

Justin, 2018, also studied on the factors that determine growth of human being and he said,Human beings are known to grow in height right from birth to around 20 to 22 years. Although growth of human beings is dependent on many factors like gene, weather conditions, food and health conditions, biologically men grow taller than women. There are certain reasons for the difference in height. Women stop growing in height after 15 to 16 years because after puberty the long bones stop growing in height due to closing of epiphyseal plates. Besides the effect of endocrine glands have function in respect of determining of height of human beings.

Sometimes over-secretion or under-secretion can lead to gigantism or dwarfism. Again the mean heights of different races all over the world differ. Asians don't grow as tall as the Europeans. So part of the reasoning relating to growth in height is dependent on the gene of the parents. Whenever human beings sleep, the growth hormones help them to grow more than when they are awake. But the growth actually takes place through the growth plates.

Justin, 2018, also explained when boy's growth stops and how it stops. The lower body stops growing in height before the upper body because they have solid bones which don't allow growth once fused. Whereas the upper part of the body is formed of cartilages and bones so the growth stops later. Generally the age where women stop growing in height is 15 to 16 years, while in case of men it is 20 to 22 years. But there is no strict age as such. Sometimes stretching exercises like swimming and cycling enhance growth, but that too during the growth age, definitely not after 25 years of age.

Sometimes people who are unsatisfied with their height go on to have surgical operations to enhance height after 22 years. They undergo breaking of the legs and pulling them apart and bolts are drilled into the bones which take time to get set inside the body. The entire procedure is very painful and problematic. These are very difficult and require the supervision of medical experts. With these exercise human beings can add half or one inch to their original height even after attaining 25 years of age. Instead of doing all these human beings should be satisfied with the height they attain genetically till 22 years of age.

3.2.3. Growth spurts

A rapid rise in height and weight – are most visible in the first year of life and around puberty, both periods when a tremendous amount of growth takes place in a short time. There is a very broad range of time in which kids hit puberty-related growth spurts: Most girls start their sexual development between the ages of 8 and 13 (the average age is 12), and have a growth spurt between the ages of 10 and 14. Most boys start developing sexually between the ages of 10 and 13, and continue to grow until they're around 16 (Mary and Gavin, 2015).

Growth and changes during puberty or sexual development is a time of dramatic change for both boys and girls. Hormone-driven changes are accompanied by growth spurts that transform kids into physically mature teens as their bodies develop. It is important for them to have healthy eating habits, a well-balanced diet, and some physical activity each day to ensure continued growth and proper development during these years.

Once girls start to menstruate, they usually grow about five cm reaching their final adult height by about age 14 or 15 years (younger or older depending on when puberty began.
Boys tend to grow most quickly between ages 12 and 15. The growth spurt of boys is, on average, about two years later than that of girls. Compared to girls' early growth spurt, growth accelerates more slowly in boys and lasts longer, resulting in a taller adult stature among males than females (on average about 10 cm) (Hussaini, 2016).

The difference is attributed to the much greater potency of estradiol compared to testosterone in promoting bone growth, maturation, and epiphyseal closure. In boys, growth begins to accelerate about nine months after the first signs of testicular enlargement and the peak year of the growth spurt occurs about two years after the onset of puberty, reaching a peak velocity of about 8.5–12 cm per year. The feet and hands experience their growth spurt first, followed by the limbs, and finally ending in the trunk (Starr and McMillan, 2001).

3.2.4. Other physiological changes during puberty

Although sexual maturation and the height spurt are the main pubertal events, many other physiological changes take place during puberty. The central nervous system grows, and lymphoid tissue regresses significantly. The heart, lungs, and viscera all increase in size and mass. Blood pressure gradually increases, and essential hypertension can begin to appear in susceptible individuals. Gender-specific changes in body composition occur. Although muscle mass and strength increase in males and females, males become relatively leaner and females become relatively less lean (Kaiming, 1998).

Physiologic development also is reflected in age-specific laboratory values. Rapid bone growth generates transient elevations in alkaline phosphatase. Sensitive assays can demonstrate. The red blood “supernormal” but nevertheless age-appropriate levels of GH and sex steroids cell mass increases in both males and females, with boys establishing norms of hemoglobin and hematocrit that are slightly higher than those of girls. Cholesterol levels begin to rise. Serum creatinine levels also rise to reach adult standards (Kaiming, 1998).

3.3. Factors Affecting Growth

3.3.1. Genetic factors

Heredity is a biological process through which the transmission of physical and social characteristics takes place from parents to off-springs. It greatly influences the different aspects of growth and development i.e. height, weight and structure of the body, color of hair and eye, intelligence, aptitudes and instincts. However , environment equally influences the above aspects in many cases. Biologically speaking heredity is the sum total of traits potentially present in the fertilized ovum by which off-springs resemblance to their parents are determined (Prakash, 2011).

It is well known that the parents' height has an influence on the stature of their children. However, the relationship between the height of the baby and that of the parents is not apparel at birth but becomes more evident toward the age of two years, and thereafter the correlation becomes greater with increasing age (Smith *et al.*,1976).

The Louisville Twin Study examined height data longitudinally from birth to maturity in twin families, and from this it was estimated that heredity accounted for 90% or more of the factors that determined height from the age of six years and after (Philips and Matheny, 1990).

These investigators observed a substantial and constant correlation between the height of the children and their parents from the age of three years and onwards. Monozygotic twins, with identical genetic composition, had a greater difference in final height when reared apart than when reared together. However, this difference was less than the difference between dizygotic twins. The difference in height of monozygotic twins is probably caused by environmental factors (Shields, 1962)

3.3.2. Environmental factors and disease condition

The fetus does not develop optimally in poor environmental conditions. Weight gain is the first parameter to be inhibited, but after prolonged inadequacy height is also negatively affected (Usher and McLean, 1974). Environmental conditions account for about 60% of the variability of birth weight and genetic factors for the remaining 40% (Polani, 1974). Such environmental factors, among others, include maternal age, order of birth, and crowding within the uterus (Giovannelli*et al.*, 1989).

The growth process is inhibited by chronic diseases, and in cases of unexplained growth failure, long-term observation may reveal underlying chronic conditions such as "asymptomatic" coeliac disease (Groll*et al*., 1980). Total recovery from chronic disease allows catch-up growth to occur, and this has two components: the first is a rapidly achieved complete restoration of growth rate to normal values, and the second is a slow recovery of growth rate to increased values, which is not as marked as the first component but is more prolonged (Prader*et al.*, 1963). An alternative outcome is an extended growing period allowing normal final height to be reached but at a later time (Tanner, 1981).

3.3.3. Socioeconomic status

A higher socioeconomic status includes higher income associated with better education, resulting in better nutrition, better child care, and better medical and social services. These factors may induce a change in size, rate of growth, and timing of pubertal development, the so-called secular change (Eveleth and Tanner, 1990).

In Europe during the last 100 years, people have become taller, the onset of puberty has commenced at a younger age, and the full-grown state has been reached at an earlier age. However, during situations of deprivation, a decrease in growth can be detected (Douglas and Simpson, 1964).

The British National Child Development Survey showed a height difference of 3.3 cm in 7-year-old boys from professional and managerial classes compared to the unskilled manual working class (Goldstein, 1971), and this gap still remains in spite of the secular trend. Developing countries also show taller stature and greater weight attained by children from the higher socioeconomic classes (Eveleth and Tanner, 1990).

3.3.4. Season, physical activity and sex

During the year, there are periods of more rapid growth when growth rate is three times greater than the time of slowest growth. These periods of growth rate are synchronized with the seasons, and most rapid growth occurs in spring (Marshall, 1971).

In the tropics, lower food supply during the rainy season may be responsible for the changes in growth rate. Climate is also affected by high altitude, where people exposed to lower oxygen saturation in the air have a shorter stature. Seasonal food scarcities may be one of the causative factors (Leonard, 1989).

There are many contradictory reports about the effects of physical activity on height, puberty, and skeletal maturation and a clear positive or negative effect on final height has never been confirmed. The effect on puberty may depend on the type of physical activity. A retarded menarche is found in girls actively involved in running or dancing. The onset of puberty, in addition to the rate of maturation, appears to be dependent on heredity and the environment. The age at menarche of identical twin sisters is within 1-2 months of each other, whereas in dizygotic twins there is about a year's difference (Fischbein, 1977).

Sex acts as an important factor of growth and development. There is difference in growth and development of boys and girls. Boys in general are taller, courageous than girls but girls show rapid physical growth in adolescence and excel boys. In general the body constitution and structural growth of girls are different from boys. The functions of boys and girls are also different in nature (Dutta, 2016).

3.3.5. Nutritional factors affecting growth

Quantity of food consumed is a major determinant of growth. In populations where food shortages are present, growth delays occur, and children are shorter and lighter than in populations with adequate or abundant supplies of food. This is due to the fact that the process of the multiplication of cells and their enlargement in size requires an adequate supply of energy, amino acids, water, lipids, vitamins and minerals (Bogin, 1999).

The good model for this was famines of the World Wars. During the World War II and some years after the mean stature of children decreased especially on the children between the age of birth and 12 years. The post-war recovery in height and weight occurred after the improvement in diet (Markowitz, 1955; Murata, Hibi, 1992). Yet, agricultural societies are still experiencing periodic food shortages due to variation in rainfall, temperature. Shortage of some necessary for growth nutrients can be filled by means of food supplement. The appearance of animal food, vegetable/fruit and milk in complementary feeding improve the child growth in the past decade in China (Chang *et al.*, 2007). Milk contains several essential nutrients, protein and calcium which associated with the increased of height growth.

Too little and too much food has its own consequences, inadequate amounts of food results growth failure and excess diet causes obesity. At different stages of human development environmental factors in a different degree influence growth. First of all, the nutrition status of mother influences growth of the fetus. In early intra-uterine life, under nutrition tends to produce small but normally proportioned baby, whereas at later stages of development it leads to selective organ damage. Malnutrition in pregnancy leads to low birth weight infants who are at risk of neonatal mortality (Scott and Duncan, 2002).

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Growth can be slowed when a healthy diet is not maintained therefore health diet is important for both muscle and bone development. However, lack of proteins and nutrition in the food would result slow or limited growth. Food also affects body height increase, thus improving the supplement of proteins and vitamins in human diet are essential for healthy growth

3.3.6. List of foods that increase height

Vitamin D: An essential vitamin required for height is vitamin D rich food. For the proper absorption of calcium, bone development and healthy immune functioning, include vitamin D rich foods such as fish, cereals, eggs, soy milk, soy beans, mushrooms, sausages and almonds.

Protein: This is another natural way to increase height. Protein rich foods are healthy and effective in height gain as it repairs body tissues and promotes building new tissues. Amino acids in protein rich foods are crucial for proper growth and function of the human body. Protein rich foods such as milk, cheese, green beans, seeds (pumpkin, watermelon and squash), fish (tuna, salmon), lean meat, lean beef, peanuts, lentils, chicken, soy beans and pulses are nutritious. Include these foods in human diet to enhance height gain.

Vitamin A: For healthy and proper functioning of the body organs, have vitamin A rich food. Vitamin A preserves calcium in the bones and keeps it strong and healthy.. Include food such as spinach, beetroot, carrots, chicken, cantaloupe, papaya, peach, milk, tomatoes, peas and apricot.

Calcium: It is important to keep the bones strong. Calcium rich foods improve the bone growth and development. Have dairy products such as milk, cheese, yogurt and eggs every day to increase height.

Minerals: Minerals build bone tissues, increase bone growth and improves blood flow in the body. To increase height naturally, have mineral rich foods such as green beans, legumes, broccoli, spinach, cabbage, pumpkin, carrot, lentils, peanuts, bananas, prunes, grapes and peaches.

The single most important cause of growth retardation worldwide is poverty related malnutrition. When suboptimal nutrition is continued for prolonged periods of time, growth stunting occurs (Amrisha, 2011).

3.4. Social implications of overweight and obesity in children's learning

Overweight children are prone to low self-esteem which results from being rejected by peers (Janssen *et al.,* 2006). They are likely to develop unhealthy dieting habits and eating disorders, such as anorexia (eating disorder due to prolonged loss of appetite) and bulimia nervosa (too much eating). They are also prone to depression and substance abuse. Gavin (2005) cautioned that "...obese children have to contend with discrimination from peers..." Of no less importance than health, is the effect that obesity has in psychological and physical appearance of one's body image. Wessel and Macintyre (1997) argued that desires for participation in pleasurable activities such as sport, is influenced by weight. Obese children may be rejected by peers because they are perceived as lazy, dirty, stupid, ugly and cheats (Janssen *et al.,* 2006).

Overweight and obesity are said to affect children's psychosocial outcomes, leading to low self-esteem and depression which all together affect other aspects of children's lives, such as academic performance with even more serious adverse social outcomes in the long term (Swan, 2002). Datar*et al*.,(2004) report that lower educational achievements among adults are associated with obesity and obese adolescents consider themselves worse students than normal weight students.

Swan (2002) revealed that teachers had negative impressions over obese children. In due regards, they were paying little attention to overweight and obese children during teaching and learning process. Swan (2002) added that both pre-service and in-service teachers perceived obese children more negatively than average weight children. Rejections from teachers and peers cause majority of overweight and obese children to be underperformers in academic and fail to complete their studies.

4. Materials and Methods

This shows the research methodology. It comprises of research design, study area and target population. Also there are sampling techniques, data collection methods, and data analysis procedures.

4.1. Research design

A research design is a plan that specifies and states clearly the population studied, method and procedure(s) used for processing information obtained from the field (Kothari, 2004). This study used mainly a quantitative research approach. comparative design was chosen to investigate chronological variation of weight, height and body mass between boys and girls.

4.2. Study area

The study was conducted in Deliverance Primary & Secondary school which is located at Bole Sub-city, Wereda 9, in Addis Ababa, Ethiopia. Ten private schools were identified which are found in Addis Ababa for selection purposes. The Deliverance Primary & Secondary school was chosen for the study by using the lottery method not to be biased. The school was established in 2002 G.C. When the school started, there were 2 administrators, 11 teachers and 36 students. Currently the school has 3 administrators, 75 teachers and 1190 students. The number of students from grade 7-10 is 628, of which 330 are females and 298 are males.

4.3. Target population, sample size and sampling techniques

The target population for this study included the students in Deliverance Primary & Secondary School Addis Ababa, Ethiopia. The sample size taken for this study was 477 students (228 males and 249 females) out of 628 students from grade 7-10. All children who participated in this study were aged between 13 and 17 years.

A lottery method of random sampling was used in the selection of participants from each group. Slips of similar pieces of paper with number equal to the total number of students needed for the study were made. The papers were rolled, mixed thoroughly and displayed on table where every student could pick one of the slips blindly. Once the piece of paper was picked it was not replaced (Kothari, 2004).

Each student who picked a piece of paper with number was to consider himself/herself selected for participation in the study. For ensuring equal representation of males and females, pieces of papers for boys and girls were displayed separately. The sample size is categorized as shown in Table 1.

Table 1. Number and age distribution of students included in the study

Age	No Students		
	Female	Male	Total
13	48	40	88
14	58	46	104
15	47	53	100
16	71	64	135
17	25	25	50
Total	249	228	477

4.4. Methodology

Body weight and height measurements were conducted on both male and female students between ages of 13-17. Selection of participating students was conducted using lottery method. Consent was obtained from each participating student.

The place of measurements was in Deliverance Private School compound in the Science Department room. Measurement of height and weight was completed in May, 2018,

Measurement of students' weight and height was used to determine BMI. The data were collected by using a Digital Weighing Scale (Model CR 2032) which maximum weight that can hold 150 Kg and Measuring Tape and the length of Measuring Tape meter was 3 meter long (Figure 1).

Figure 1. Measuring tape (Top) and Digital weight scale (Bottom) used in the study

4.5. Focus Group Discussion with sample students

Focus group discussion was used to get information from the school children. All sample children attended each focus group discussion. Challenges, critics and objections were observed during the discussions especially when a child attempted to provide false information. The students were informed that the measurement of BMI is important for them.

4.6. Ethical considerations

Before the research was done, Deliverance Primary and Secondary School was asked if it is possible to get sample students for this study and measure their height and weight, as the main data for this research. The school management gave permission to conduct the study. The school prepared the permission letter and forwarded it and it is attached as Appendix 5.

4.7. Data analysis

Calculated BMI values were converted to body weight categories using the age-specific percentile growth charts developed by the US Center for Disease Control. The World Health Organization Expert Committees' recommendations are to classify BMI-for-age at or above the 95^{th} percentile as overweight and between the 85^{th} -95^{th}percentile as at risk of overweight (Himes and Dietz, 1994).

" Overweight " rather than obesity is the term preferred for describing children and adolescents with a BMI-for-age equal to or greater than 95^{th} percentile. The 85^{th} -95^{th} percentile is included on the BMI-for-age and the weight-for-stature charts to identify those at risk of overweight. Normal is the term preferred for describing children and adolescents with a BMI-for-age between the 5^{th} - 85^{th}percentile. The cutoff for underweight of less than the 5^{th} percentile is based on recommendations by the World Health Organization Expert Committee on Physical Status (World Health Organization, 1996).

The World Health Organization (WHO) subsequently recommended these normalized charts for international applications. These normalized charts are sometimes referred to as the NCHS/WHO, CDC/WHO, or NCHS/ CDC/WHO growth charts (World Health Organization, 1978).

BMI $\geq$ 95^{th} percentile = Overweight

$85^{th} \leq$ BMI < 95^{th} percentile = Risk of Overweight

$5^{th} \leq$ BMI< 85^{th} percentile = Normal

BMI < 5^{th} percentile = Underweight

4.8. Statistical analysis

Variations in percentage increment of height, weight and BMI for both males and females were statistically tested using the parametric chi-square test. One way ANOVA was used to compare the mean height, weight and BMI of students in the present study and those from similar studies in government and rural schools using SPSS software version 17. The 95% confidence interval was used to determine statistical significant.

5. Results and Discussion

5.1. Overall height

As given in Table 2 female students had shorter height compared to the males in each age group. The combined mean was also greater than the corresponding age groups of females and lower than the males. There are certain reasons for the difference in height. Women stop growing in height after 15 to 16 years because after puberty the long bones stop growing in height due to closing of epiphyseal plates. Although growth of human beings is dependent on many factors like gene, weather conditions, and food and health conditions, biologically men grow taller than women (Justin, 2018).

Table 2. Mean + standard deviation of height (m) for females, males, and both sexes combined

Age	Combined (females and males)	Females	Males (M)
13	1.50 +0.085	1.49 +0.07	1.50 +0.09
14	1.54 +0.075	1.52 +0.06	1.56 +0.09
15	1.58 +0.08	1.54 + 0.07	1.61 + 0.09
16	1.60 +0.075	1.56 + 0.06	1.65 + 0.09
17	1.64 +0.08	1.58 + 0.07	1.69 + 0.08

Height ranged between 1.23m and 1.86m. The shortest student was a 13 year old male and the tallest was a 17 year old male. The shortest height for females was 1.34m (13 years old) while the tallest was 1.75 (16 and 17 year groups) (Table 3).

Table 3. Height range (m) for each age category of females, males and both sexes combined

Age	Combined height range	Female height range	Male height range
13	1.23-1.69	1.34-1.62	1.23-1.69
14	1.34-1.71	1.37-1.66	1.34-1.71
15	1.40-1.80	1.40-170	1.42-1.80
16	1.41-1.82	1.41-1.75	1.50-1.82
17	1.45-1.86	1.45-1.75	1.56-1.86

The highest increment of height between consecutive age groups for the combined mean of males and females was observed between 13 and 14 and 14 and 15 age cohorts (2.6%) while the lowest percentage increment was observed in the transition from 15 to 16 years. The variation in percentage increment was not statistically significant (p=0.748) (Fig. 2).

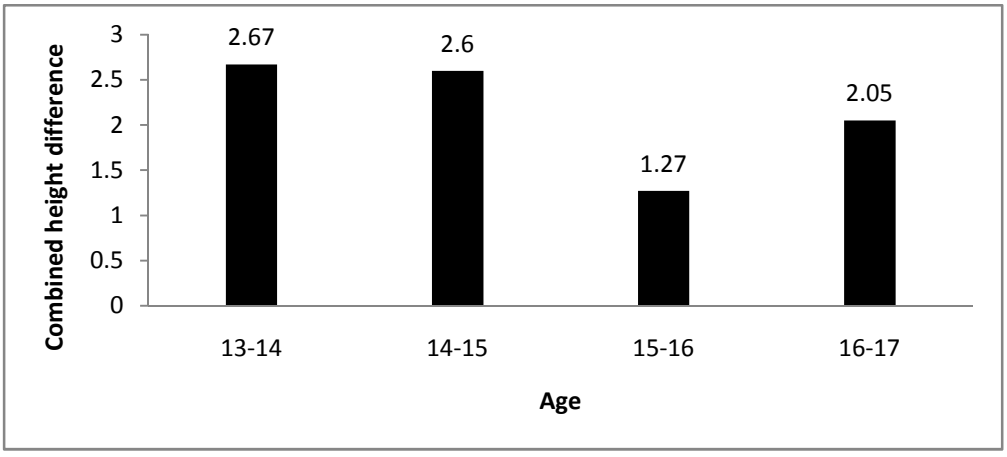

Figure 2. Percentage increment of height between consecutive age cohorts for the combined mean of males and females

When data was considered for females alone, the highest percentage increment was observed during the transition from 13 to 14 years (2%) while in the remaining age categories, the increment was almost the same (1.28-1.32%). This might be due to the fact that most girls start their sexual development between the ages of 8 and 13 (the average age is 12), and have a growth spurt between the ages of 10 and 14 (Mary and Gavin, 2015). And the lowest was 1.28 % (16-17 years). The possible reason is once females attain puberty between ages 15 and 16, they do not grow any more (James, 2018). The variation was not statistically significant (p=0.896) (Fig 3).

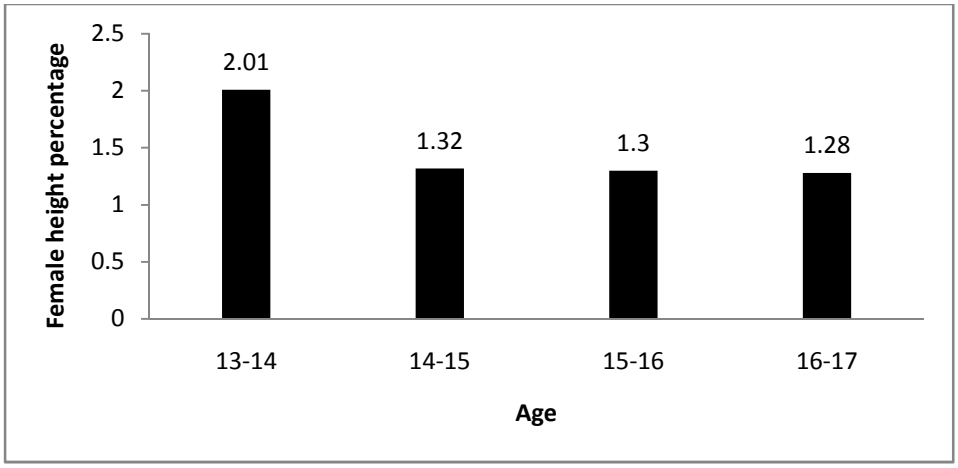

Figure 3. Percentage increment of height between consecutive age cohorts in females

For males too, the highest percentage increment of height was between 13-14 years (4%) .This was followed by the 14-15 age groups (3.21%). These growths were seen in all age groups and it increases when age increases. Due to most boys start developing sexually between the ages of 10 and 13 (Mary and Gavin, 2015). And boys tend to grow most quickly between ages 12 and 15 (Hussaini, 2016). However, the variation in percentage increment was not statistically significant (p=0.881) (Fig. 4).

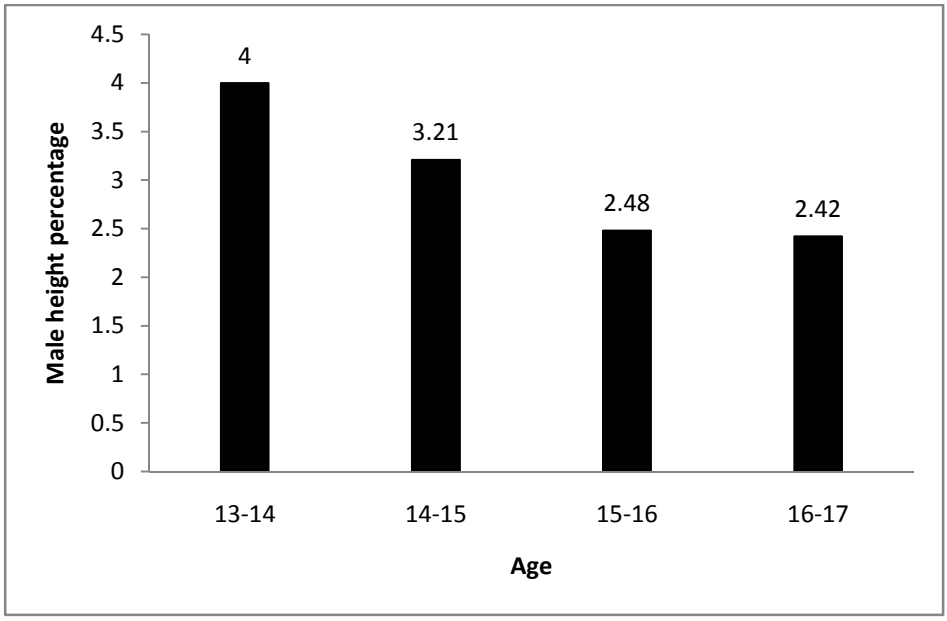

Figure 4. Percentage increment of height between consecutive age cohorts in males

5.2. Overall weight

Females were heavier than males among 13 year olds (51.11 vs. 49.81) while the males had higher body weight in the age group of 15 and above. Both sexes had similar mean body weight at age 14. After about eight years of age, girls begin gaining fat mass at a greater rate than boys. During the adolescent growth spurt, the rate of fat increase in girls almost doubles than that of boys. Fat cells are mostly seen in the gluteal-femoral areas such as pelvis, buttocks, and thigh and to a lesser extent in the breasts because of changes in female hormone levels. After adolescence, the accumulation of sex-specific fat more or less stops, or decreases dramatically and there is usually no further increase in the number of fat cells (Patrick, 2002). (Table 4).

Table 4. Mean + standard deviation of weight (m) for females, males, and both sexes combined

Age	Combined mean weight(Kg)	Female mean weight(Kg)	Male mean weight (Kg)
13	50.46 +9.34	51.11 +8.58	49.81 +10.05
14	58.39 +10.24	58.11 + 10.15	58.73 +10.33
15	64.54 +10.69	62.07 + 9.62	67.28 + 11.76
16	69.64 +9.03	66.80 + 10.70	73.65 + 7.36
17	74.61 +6.60	71.23 + 9.30	77.98 + 3.89

The lowest weight was recorded among 13 year old males (30kg) and the highest was among 17 year old males (88kg). The highest and lowest weight among females was 81kg (17 years) and 34kg (13 and 14 years) respectively (Table 5).

Table 5. Weight range (m) for each age category of females, males and both sexes combined

Age	Combined weight range (Kg)	Female weight range (Kg)	Male weight range (Kg)
13	30-70	34-66	30-70
14	34-77.5	34-72	38-77.5
15	35-81	35-75	42-81
16	40.7-82	40.7-79	43-82
17	39-88	39-81	70-88

The percentage increment of body weight between consecutive age groups for the combined data was highest for 13 to 14 years (15.72%) followed by 14 to15 years (10.54%). The difference in percentage increment observed for the age groups was not statistically significant (p=0.98) (Fig. 5)

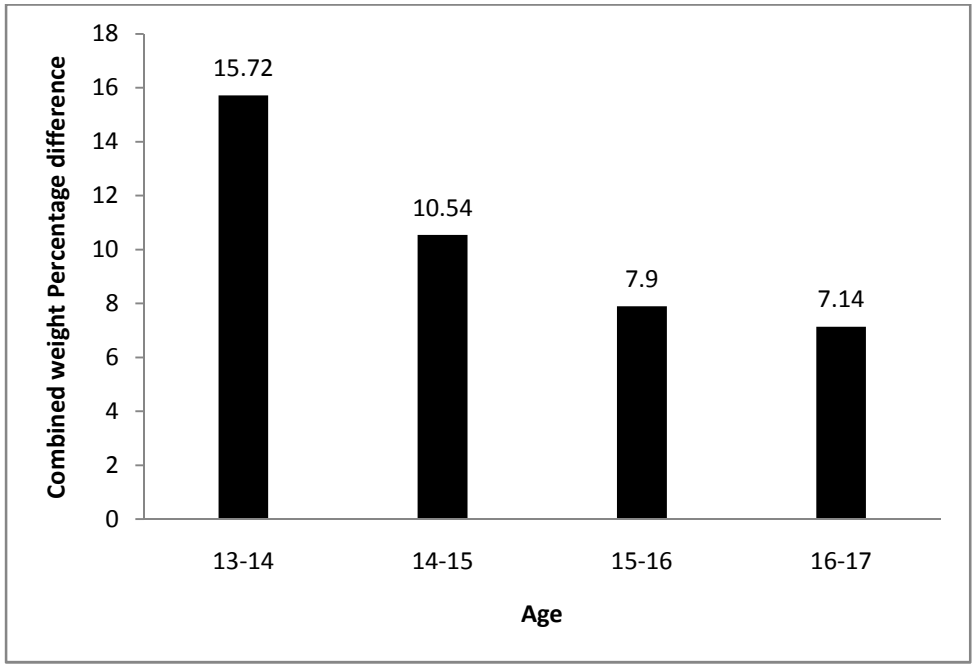

Figure 5. Percentage increment of weight between consecutive age cohorts for the combined mean of males and females

Among females, the highest percentage increment of body weight for consecutive age groups was recorded for 13 -14 years(13.7 %). And the lowest percentage increment of body weight for consecutive age groups was recorded for 16 -17 years (6.63%) apparently due to fat increment during the adolescent growth spurt. After adolescence, the accumulation of sex-specific fat more or less stops, or decreases dramatically and there is usually no further increase in the number of fat cells (Patrick, 2002). The values were nearly the same for the remaining age groups. The difference in percentage increment of body weight between the consecutive age groups was not statistically significant (p=0.286) (Fig.6).

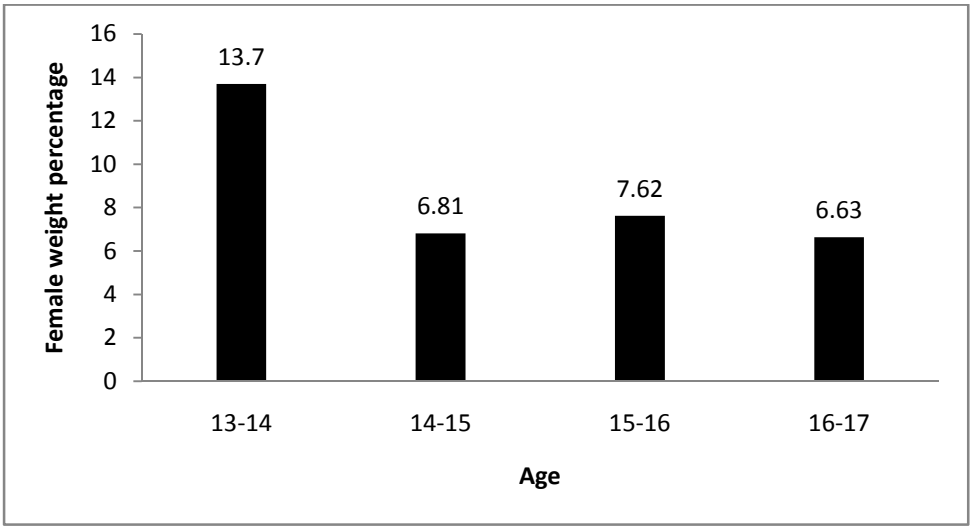

Figure 6. Percentage increment of weight between consecutive age cohorts of females

Similarly, the highest weight percentage increment was observed in the 13-14 age group (17.91%) followed by the 14-15 age group (14.56%) for males. The lowest increment was observed for 16-17 years (5.88 %). The average weight of a teenager can fluctuate quite a bit from one year to the next, finally stabilizing around 18-20 years of age. (Jennifer, 2017). The variation in the precentage incerement was not statistically significant (p=0.075) (Fig. 7)

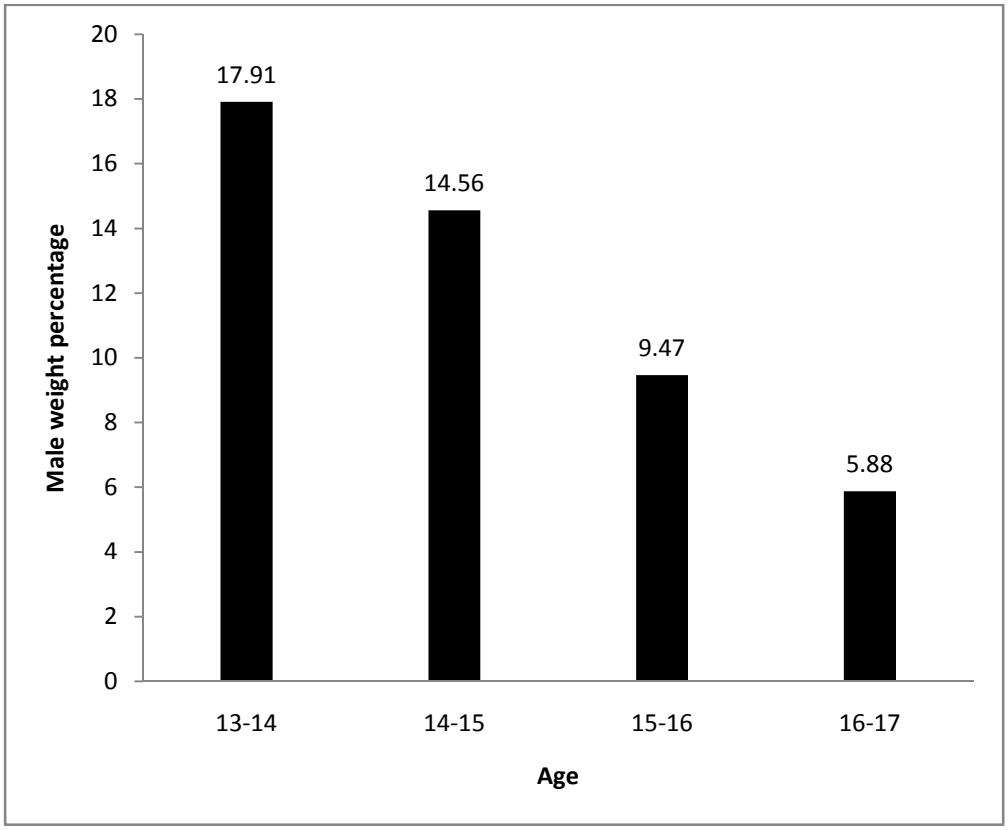

Figure 7. Percentage increment of weight between consecutive age cohorts of males

5.3. Percentage difference between males and females on mean height

The highest percentage difference in mean height between males and females was obtained for 17 years (6.96%) followed by 16 years (5.77%) .The lowest percentage difference was 0.67% in age group of 13 years. Girls usually start and finish puberty sooner than boys and most girls have reached their adult height by the time they are 15 years old (Barrell, 2018) (Table 6).

Table 6. Percentage difference between males and female on mean height

Age	Female mean height	Male mean height	Percentage difference
13	1.49	1.50	0.67
14	1.52	1.56	2.63
15	1.54	1.61	4.55
16	1.56	1.65	5.77
17	1.58	1.69	6.96

5.4. Mean weight percentage difference

The mean weight of females was higher than males for 13 years old (2.61%). For age groups 14-17 years, males had higher mean body weight. In females similar to height, 17 years old were heavier than 16 years old (71.23 kg vs 66.80kg). For the remaining age groups, males were heavier than females, with the highest percentage difference observed among 16 years old. After about eight years of age, girls begin gaining fat mass at a greater rate than boys. During the adolescent growth spurt, the rate of fat increase in girls almost doubles than that of boys. Fat cells are mostly seen in the gluteal-femoral areas such as pelvis, buttocks, and thigh and to a lesser extent in the breasts because of changes in female hormone levels (Jennifer, 2017) (Table 7).

Table 7. Percentage difference between males and females on mean weight

Age	Female mean weight	Male mean weight	Percentage difference
13	51.11	49.81	2.61
14	58.11	58.73	1.07
15	62.07	67.28	8.39
16	66.80	73.65	10.25
17	71.23	77.98	9.48

5.5. Body Mass Index

Females had higher mean BMI than males for all age groups. This is because there may be an increase in the weight of females due to hormonal influence during puberty. Similar result was reported by Oyewale et al., (2010) (Table 8).

Table 8. Mean + standard deviation of BMI for females, males, and both sexes combined

Age	Combined mean BMI	Female mean BMI	Male mean BMI
13	22.60 +3.19	23.00 +2.88	22.00 +3.49
14	24.57 +3.67	25.00 +3.74	24.00 +3.60
15	25.99 +3.78	26.21 +3.92	25.79 +3.64
16	27.20 +3.56	27.25 +4.30	27.14 +2.81
17	27.77 +2.52	28.50 +3.18	27.30 +1.86

The mean BMI ranged between 16.9 (observed among 15 years old females) to 32.41 observed in 17 years old females. The narrowest range was observed in 17 years old males (24.39-30.15) while the widest range (17.72-32.14) was in 15 years old males (Table 9).

Table 9. BMI range for each age category of females, males and both sexes combined

Age	Combined BMI range	Female BMI range	Male BMI range
13	17.12-30.10	17.12-26.13	17.28-30.10
14	17.37-31.07	17.37-31.05	17.52-31.07
15	16.90-32.14	16.90-31.92	17.72-32.14
16	17.42-32.25	17.42-32.25	17.48-31.11
17	17.81-32.41	17.81-32.41	24.39-30.15

For the combined mean BMI data of males and females, the highest percentage increment between consecutive ages was 8.72% observed between age 13 and 14 cohorts while the lowest increment was observed during the transition from age 16 to 17 (2.1%). This variation was not statistically significant (p=0.208). (Fig. 8).

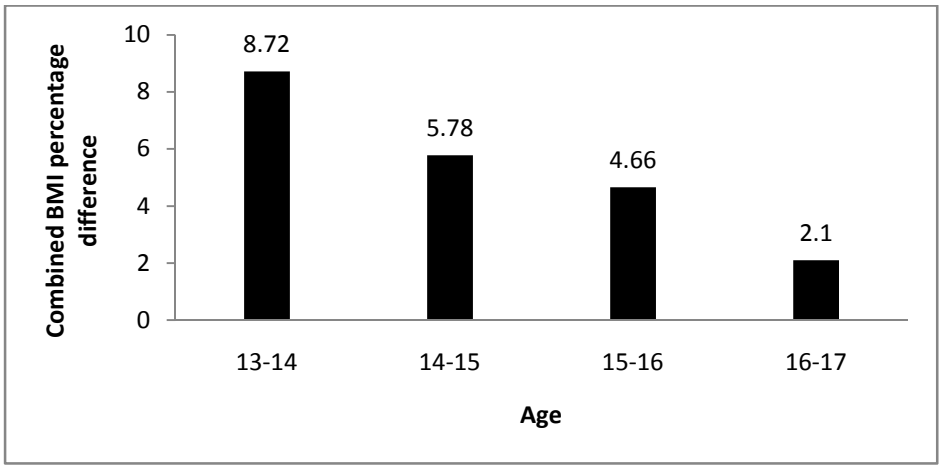

Figure 8. Percentage increment of BMI between consecutive age cohorts for the combined mean of males and females

When the mean BMI data of females was considered separately, the highest percentage increment (8.7%) between consecutive age groups was observed between 13 and 14 age cohorts. The increment between the remaining age groups was nearly the same (4.03% – 4.84%). This research revealed again there was high increment of BMI percentages at 13-14 age groups of females while the lowest BMI percentage increase was at age 15-16. Females BMI percentage increments were greater than males in all age groups. Usually, BMI values of girls are slightly higher than boys (from age 16 to 17) (Halls, 2018). The difference in the percentage increment was not statistically significant (p=0.327) (Fig. 9)

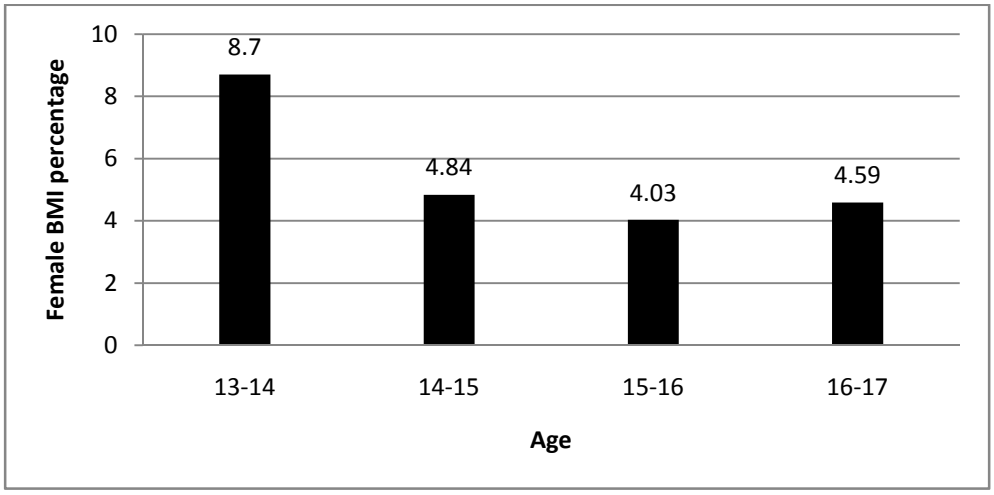

Figure 9. Percentage increment of BMI between consecutive age cohorts for females

Similar to females, percentage increment was the highest during the transition from age 13 to 14 (9%). However, there was also some variation in the remaining age categories. The percentage increment between age 16 and 17 was very small (0.59%) compared to the rest. As long as men and women are not overweight, BMI values of men are also slightly higher than for women (after age 18) (Halls, 2018). In males, the highest BMI percentage increases were seen at age of 13-14 and the lowest were seen at age of 16-17. The BMI percentage decreases when age increases. However, the overall variation in percentage increment observed at the consecutive age groups was not statistically significant (p=0.081) (Fig.10)

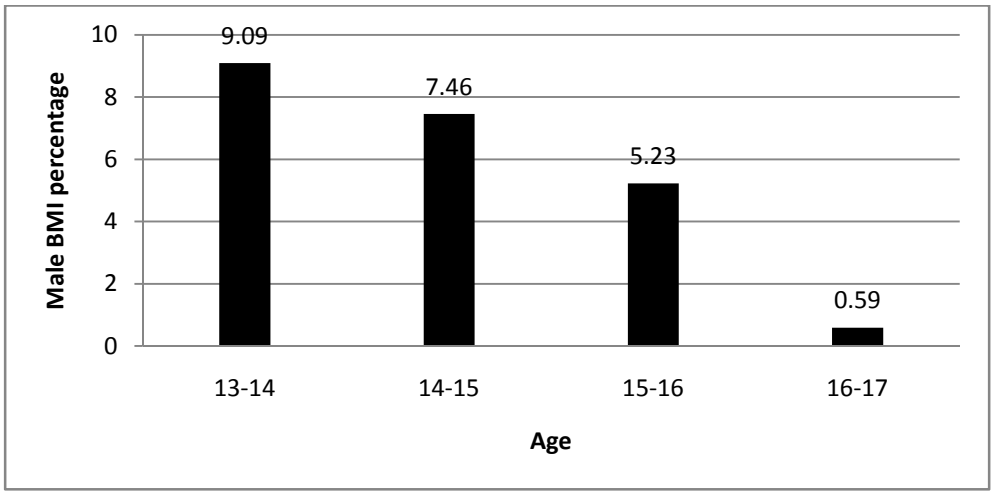

Figure 10. Percentage increment of BMI between consecutive age cohorts for males

5.6. Mean BMI difference

Female students had higher BMI for all age groups. However, the difference between males and females was the high at age 13, 14, and 17 while it is negligible for 16 years old (Table 10).

Table 10. Percentage difference of BMI between females and males

Age	Female mean BMI	Male mean BMI	Percentage difference
13	23+2.88	22+3.49	4.55
14	25+3.74	24+3.60	4.17
15	26.21+3.92	25.79+3.64	1.75
16	27.25+4.30	27.14+2.81	0.4
17	28.50+ 3.18	27.30+1.86	4.40

5.7. Weight categorization of BMI values

Based on the mean BMI values all female age groups were categorized as overweight (Table 11).

Table11. Mean BMI (Kgs/m^2) with standard deviation and corresponding weight categories of females.

Age	Female mean BMI	Weight category
13	23+ 2.88	Risk of Overweight
14	25+ 3.74	Risk of Overweight
15	26.21+ 3.92	Risk of Overweight
16	27.25+ 4.30	Risk of Overweight
17	28.50+ 3.18	Risk of Overweight

Similar to females, all age groups of males were categorized as overweight. Studies conducted in many parts of the world have shown physical inactivity including lack of participation in sports activities at school or at home, and less active mode of transport to and from school to be associated with increased risk of overweight and obesity among children (Pabayo et al., 2010). Diets high in saturated fats, sugars and refined starch have also been shown to contribute to the increasing overweight and obesity among children and adults (Huang, 2015). Furthermore, the increase in time spent watching television and playing electronic games partially contributes to the increasing rates of obesity among children (Futton et al, 2009). (Table 11 & 12)

Table 12. Mean BMI (Kgs/m^2) with standard deviation and corresponding weight categories of males

Age	Male mean BMI	Status of BMI
13	22+ 3.49	Normal
14	24+ 3.60	Risk of Overweight
15	25.791+ 3.64	Risk of Overweight
16	27.14+ 2.81	Risk of Overweight
17	27.30+ 1.86	Risk of Overweight

5.8. Comparison of results of this study with other government school

5.8.1. Height

The mean height of females obtained in the present study was compared with one other similar studies. The comparisons show that mean height was nearly similar for all groups in the two studies. However, students in the present study were slightly taller for the age groups 15 and above but this difference in height observed in the two studies was not statistically significant (p=0.717) (Table 13)

Table13. Female mean height in this study compared with similar study in government school in Addis Ababa (2018).

Age	Female mean height Sample from Deliverance private School (Present study)	Female mean height Sample from Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababa
13	1.49+ 0.07	1.48 + 0.04
14	1.52+ 0.06	1.52 + 0.05
15	1.54+ 0.07	1.53 + 0.06
16	1.56+ 0.06	1.54 + 0.06
17	1.58+ 0.07	1.57 + 0.06

Males had slightly higher height measurement for most age groups than the other study. But this difference was not statistically significant (p=0.954) (Table 14).

Table 14. In this study male mean height were compared with the government school in Addis Ababa (2018)

Age	Male mean height Sample from Deliverance private School (Present study)	Male mean height Sample from Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababa
13	1.50+ 0.09	1.46 + 0.06
14	1.56+ 0.09	1.53 + 0.06
15	1.61+ 0.09	1.60 + 0.07
16	1.65+ 0.09	1.64 + 0.06
17	1.69+ 0.08	1.66 + 0.05

5.8.2. Weight

Females in this study had notably higher mean weight than those sampled in the other one studies in Addis Hiwot Elementary school and Ewketlefre Secondary School in Addis Ababa. The highest weight in the present study was 71.23kg compared to 50kg for the government school from Addis Ababa. On the other hand, the lowest mean weight was 51.11kg in the present study which is higher than the highest weight in the government school. This difference was statistically significant (p=0.001) (Table 15).

Table 15. In this study females' mean weights were compared with the selected government school in Addis Ababa (2018).

Age	Female mean weight Sample from Deliverance private School (Present study)	Female mean weight Sample from Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababa
13	51.11+ 8.58	41.2 + 2.87
14	58.11+ 10.15	44+ 7.53
15	62.07+ 9.62	47 + 5.28
16	66.80+ 10.70	47.2+ 5.61
17	71.23+ 9.30	50.1+ 7.19

Similar to females, males from this study were notably heavier than those female students in the government school. The highest mean weight in this study was 77.98kg and while it was only 52 kg for the government school from Addis Ababa. The lowest mean weight recorded in this study (49.81kg; age 13) was comparable to the weight of those of age 16 in the government school studies. This difference in weight of males between these two studies was statistically significant (p=0.003) (Table 16).

This study revealed that both males and females were heavier (in most cases increase on weight can cause health risk on individual, but it needs more study weather to say that the students that were found in my study were healthy or unhealthy) and taller in current study compared with government school children in Ethiopia (EtagegnAschalew, 2018). This may be explained by the fact that the private school students are from economically better families compared to the government schools. Their exposure to walk from home to school and vice versa is rare or almost none since most have access to personal vehicles of their families or contracted transport services. Besides this, they are more likely to spend their spare time watching television, and playing video games due to the ease of access resulting from their better economic status. These would makethem sedentary and as a result they burn less and less calorie and easily gain weight. This has also been reported in previous studies.

Table 16. In the present study male mean weight compared with the government school in Addis Ababa (2018).

Age	Male mean weight Sample from Deliverance private School (Present study)	Male mean weight Sample from Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababa
13	49.81+ 10.05	37.8+ 4.91
14	58.73+ 10.33	42.8+ 7.44
15	67.28+ 11.76	48 + 5.76
16	73.65+ 7.36	49.7+ 5.79
17	77.98+ 3.89	52+ 6.06

5.8.3. Body Mass Index

In females BMI was also highest in the present study compared with one government school study. The maximum for the current study was 28.5 compared to 20.38 in the government school at Addis Ababa. The minimum BMI recorded in this study (23, age 13) was higher than the BMI in all age categories in the government school study. The difference in BMI between this two studies was statistically significant (p=0.00) (Table 17)

Table 17. In the present study female mean BMI were compared with one government school study in Addis Ababa (2018).

Age	Female mean BMI Sample from Deliverance private School (Present study)	Female mean BMI Sample from Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababa
13	23+ 2.88	18.64+ 1.22
14	25+ 3.74	19.07+ 3.28
15	26.21+ 3.92	20.11+ 2.24
16	27.25+ 4.30	19.93+ 2.36
17	28.50+ 3.18	20.38+ 2.99

The difference in BMI for males in this study and the selected government school study showed a similar pattern with the females. Males of this study had higher mean BMI than the other study. The highest BMI in this study was 27.3kg/m^2 compared to 20.45kg/m^2 (Government School in Addis Ababa). Similarly, the lowest mean BMI in this study (22kg/m^2) was higher than the highest BMI obtained in the government school study compared here. The difference in BMI between the two studies was statistically significant (p=0.00) (Table 18).

Table 18. In this study male mean BMI were compared with study done in government school in Addis Ababa (2018).

Age	Male mean BMI Sample from Deliverance private School (Present study)	Male mean BMI Sample from Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababa
13	22+ 3.49	17.61+ 2.38
14	24+ 3.60	18.22+ 2.74
15	25.79+ 3.64	18.6+ 1.59
16	27.14+ 2.81	18.32+ 1.79
17	27.30+ 1.86	18.82+ 1.76

All of the females from the current study were overweight while those from the governmentalschool at Addis Ababa are within the Normal body weight range (Table 19).

Table 1. Comparisons of females' meanBMI (Kgs/m^2) with standard deviationand corresponding weight categoriesbetween Private and Governmental Schools

Age	Deliverance private School females mean BMI with SD (Present study)	Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababafemales mean BMI with SD
13	23 ± 2.88 (Overweight)	18.64 ± 1.22 (Normal)
14	25 ± 3.74 (Overweight)	19.07 ± 3.28 (Normal)
15	26.21 ± 3.92(Overweight)	20.11 ± 2.24 (Normal)
16	27.25 ± 4.30 (Overweight)	19.93 ± 2.36 (Normal)
17	28.5 ± 3.18 (Overweight)	20.38 ± 2.99 (Normal)
18	Not available	20.28 ± 2.54 (Normal)

Similar to females, males from the current study were all overweight except 13 age groups of males while those from theGovernmentalschool at Addis Ababa are within the Normal body weight range (Table20). All males and females from the current study all were overweight except 13 age groups of males while those from theGovernmentalschool at Addis Ababa were within normal body weight(Etagegne, 2010). These variations might be related to the factors that are affected by economic status of private and government students.

In the case of the former, students have access to high fat diet and junk food more frequently. In addition they are more likely to be less physically active due to access to family vehicle reducing their chances of walking to and from school. In Portuguese from 742 school children 31% boys and 18% girls were overweight with many factors contributing for the weight of school children such as genetics, family, environment, food habits, physically active or sedentary life styles (television, computers, mobile phones etc) (Guine*et al*., 2016) (Table 19 and 20)

Table 20. Comparisons of males' mean BMI (Kgs/m^2) with standard deviationand corresponding weight categoriesbetween Private and Governmental Schools

Age	Deliverance private School males mean BMI with SD	Addis Hiwot Elementary School and Ewketlefre Secondary School in Addis Ababamean BMI with SD
13	22 ± 3.49 (Normal)	17.61 ± 2.38 (Normal)
14	24 ± 3.60 (Overweight)	18.22±2.74 (Normal)
15	25.79 ± 3.64 (Overweight)	18.6 ± 1.59 (Normal)
16	27.14 ± 2.84 (Overweight)	18.32 ± 1.79 (Normal)
17	27.30 ±1.86 (Overweight)	18.82 ± 1.76 (Normal)

6. Conclusions and Recommendations

6.1. Conclusions

The current study shows that weight and height increases with increasing age in school children aged between 13-17. Males were slightly taller than females. The height range for the females was 1.34m-1.75m and that of the males was 1.23m – 1.8m. Maximum growth was observed between 13-14 years and 14-15 years. Also males were heavier than females for age group 15-17 while females were heavier for age 13 years. The weight of females ranged between 34kg to 81kg and that of males 30kg to 80kg. The highest percentage increment of weight for the combined data that is males and females was seen in 13 and 14 ages. Females had higher BMI for all age groups than males.

6.2. Recommendations

Based on the results in this study, stakeholders in education, sport teachers should put mechanisms that will guide all children in schools to participate in physical activities. Such activities may include sports activities that will prevent excessive body fat deposits that lead students to be overweight and obese. This will help in improving body health conditions and academic performance.

Parents and teachers should encourage children to be physically active for example, encouraging them to walk to school partly or fully when they are coming to and returning from school. Also students can be advised to engage more on physical activities rather than spending most of their free time on watching TV and playing video games at home. Education should be given to students and parents on the essence and impacts of overweight and obesity to children to raise awareness on the negative impacts of excess fat accumulation. There is also a need to raise awareness among parents on healthy diet provided to their children in order to avoid risks of overweight and obesity.

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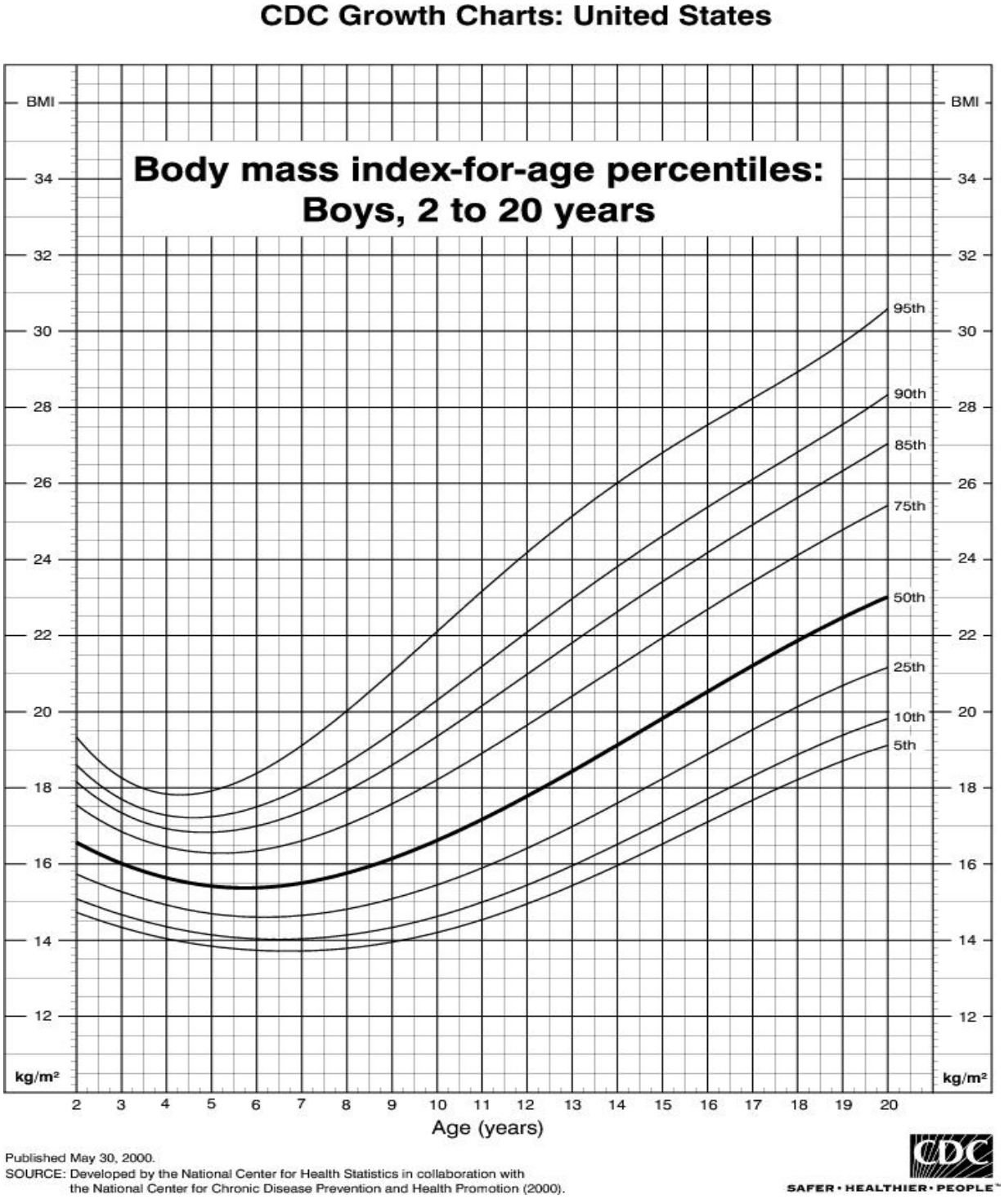
8. List of Appendix

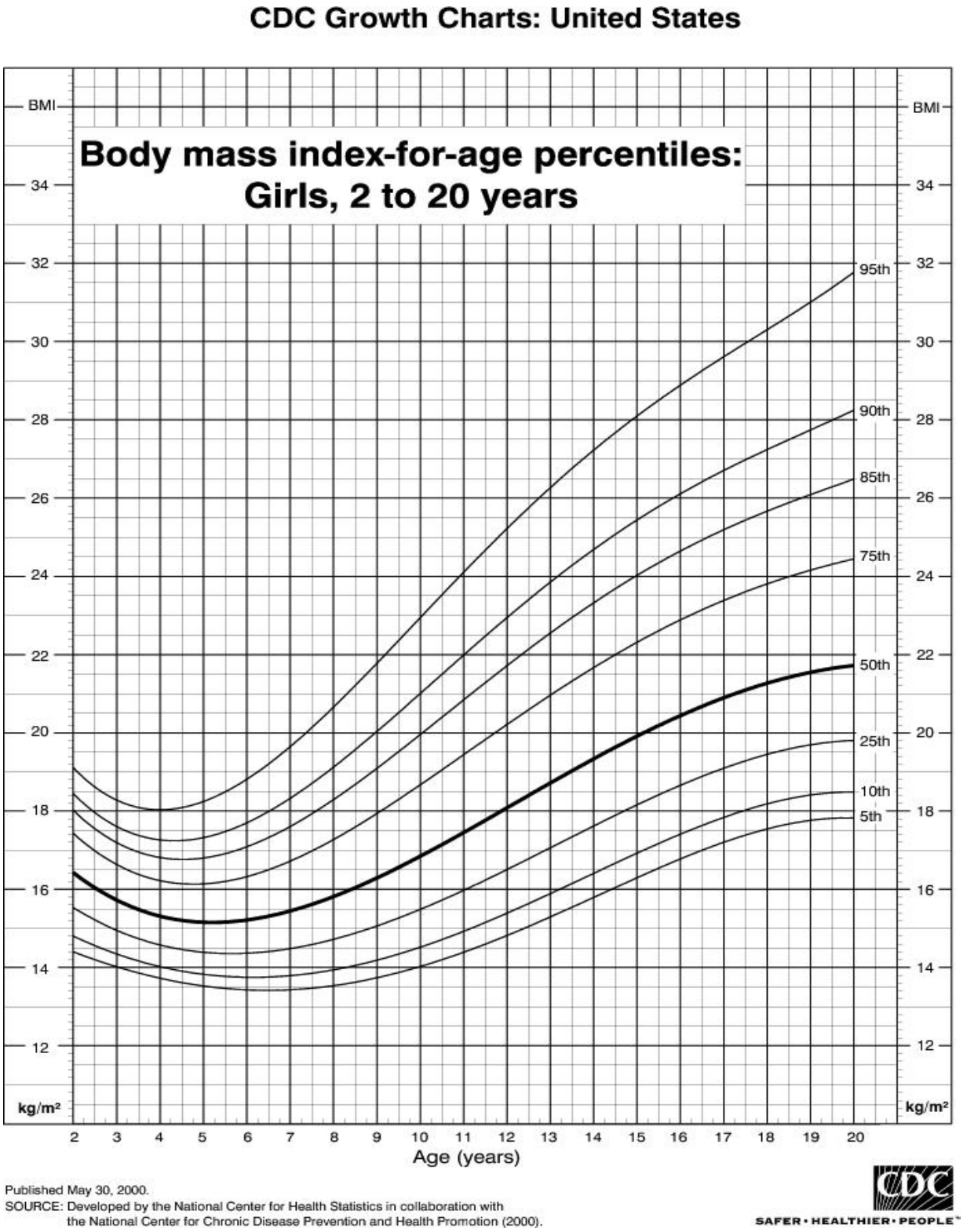
Appendix 1

BMI Chart for children at age 2-20 (males)



Appendix 2

BMI Chart for children at age 2-20 (Females)



Appendix 3

Deliverance Primary & Secondary School 2010/2018

Raw data for females (Age 13)

No	Height	Weight	Grade	H^2	BMI
1	1.55	61	7	2.4	25.42
2	1.57	62.5	7	2.46	25.41
3	1.56	61	7	2.43	25.10
4	1.61	66	7	2.59	25.48
5	1.50	48	7	2.25	21.33
6	1.58	64	7	2.5	25.6
7	1.51	58	7	2.28	25.44
8	1.45	45	7	2.1	21.43
9	1.50	45	7	2.25	20
10	1.45	40	7	2.1	19.05
11	1.46	42	7	2.13	19.72
12	1.46	40	7	2.13	18.78
13	1.51	51	7	2.28	22.37
14	1.62	44	7	2.28	19.30
15	1.55	58	7	2.62	22.14
16	1.62	61	7	2.4	25.42
17	1.50	57	10	2.25	25.33
18	1.54	45	10	2.37	18.99
19	1.54	47	7	2.37	19.83
20	1.49	38	7	2.22	17.12
21	1.48	56	7	2.19	25.57
22	1.42	52	7	2.02	25.74
23	1.40	49	7	1.96	25
24	1.49	56	7	2.22	25.23
25	1.45	53	7	2.10	25.24
26	1.56	50	8	2.43	20.58
27	1.56	62	8	2.43	25.51
28	1.58	61.5	8	2.50	24.6
29	1.61	53	8	2.59	20.46
30	1.59	63.8	8	2.53	25.22
31	1.48	56	8	2.19	25.57
32	1.49	58	7	2.22	26.13
33	1.50	57	7	2.25	25.33
34	1.51	57	7	2.28	25
35	1.55	60	7	2.40	25.
36	1.45	53	7	2.1	25.24
37	1.47	51	7	2.16	23.61
38	1.39	49	7	1.93	25.39
39	1.35	47	7	1.82	25.82
40	1.40	50	7	1.96	25.51

Continued …

No	Height	Weight	Grade	H^2	BMI
41	1.50	53	**7**	2.25	23.56
42	1.46	37	**7**	2.13	17.37
43	1.4	40	**7**	1.96	20.41
44	1.35	44	**7**	1.82	24.18
45	1.34	43.5	**7**	1.8	24.17
46	1.40	35	**7**	1.96	17.86
47	1.36	34	**7**	1.85	18.38
48	1.41	39	**7**	1.99	19.60

Raw data for females (Age 14)

No	Height	Weight	Grade	H^2	BMI
1	1.66	57	7	2.76	20.65
2	1.46	51	7	2.13	23.94
3	1.60	62	7	2.56	24.22
4	1.54	57	9	2.37	24.05
5	1.58	62.5	9	2.5	25
6	1.54	59	9	2.37	24.89
7	1.56	63	9	2.43	25.93
8	1.49	53	9	2.22	23.87
9	1.54	61	9	2.37	25.74
10	1.59	60.5	9	2.53	23.91
11	1.47	50	8	2.16	23.15
12	1.57	60	8	2.46	24.39
13	1.48	61	8	2.19	27.85
14	1.53	63	8	2.34	26.92
15	1.57	64	8	2.46	26.02
16	1.54	64.5	8	2.37	27.22
17	1.48	56	8	2.19	25.57
18	1.60	69	8	2.56	26.95
19	1.47	63	8	2.16	29.17
20	1.51	66	8	2.28	28.95
21	1.61	69.5	8	2.59	26.83
22	1.52	65.6	8	2.31	28.40
23	1.62	71	8	2.62	27.10
24	1.52	44	8	2.31	19.05
25	1.57	69	8	2.46	28.05
26	1.59	69.7	8	2.53	27.55
27	1.56	68.5	8	2.43	28.19
28	1.53	67	8	2.34	28.63
29	1.50	63	7	2.25	28
30	1.50	61.5	7	2.25	27.33
31	1.47	64	7	2.16	29.63
32	1.49	67	8	2.22	30.18
33	1.48	65	8	2.19	29.68
34	1.43	62	8	2.04	30.39
35	1.48	68	8	2.19	31.05
36	1.44	40	8	2.07	19.32
37	1.47	62	8	2.16	28.70
38	1.48	64.6	8	2.19	29.50
39	1.63	72	8	2.66	27.07
40	1.42	38	8	2.02	18.81

Continued …….

No	Height	Weight	Grade	H^2	BMI
41	1.37	34	8	1.88	18.09
42	1.57	58	8	2.46	23.58
43	1.47	45	8	2.16	20.83
44	1.45	43	8	2.1	20.48
45	1.46	37	8	2.13	17.37
46	1.46	53	8	2.13	24.88
47	1.52	41	8	2.31	17.75
48	1.50	55	8	2.25	24.44
49	1.65	61	8	2.72	22.43
50	1.48	39	8	2.19	17.81
51	1.42	46	9	2.02	22.77
52	1.49	48	9	2.22	21.62
53	1.59	59	7	2.53	23.32
54	1.59	60	7	2.53	23.72
55	1.47	38	7	2.16	17.59
56	1.58	62	7	2.5	24.8
57	1.59	72	7	2.53	28.46
58	1.50	65.5	10	2.25	29.11

Raw data for females (Age 15)

No	height	Weight	Grade	H^2	BMI
1	1.44	50	7	2.07	24.15
2	1.46	68	7	2.13	31.92
3	1.45	52	7	2.10	24.76
4	1.56	60	9	2.43	24.69
5	1.40	48	9	1.96	24.49
6	1.54	59	9	2.37	24.89
7	1.55	72	9	2.4	30
8	1.41	63	9	1.99	31.66
9	1.53	67	9	2.34	28.63
10	1.50	67	9	2.25	29.78
11	1.50	55.9	9	2.25	24.84
12	1.49	63	9	2.22	28.38
13	1.50	54.6	9	2.25	24.27
14	1.52	64.9	9	2.31	28.10
15	1.56	60	9	2.43	24.69
16	1.51	67.7	9	2.28	29.69
17	1.49	64.6	9	2.22	29.10
18	1.53	69.5	9	2.34	29.70
19	1.53	68.5	9	2.34	29.27
20	1.55	70.5	9	2.4	29.38
21	1.52	67.5	9	2.31	29.22
22	1.53	68.7	9	2.34	29.36
23	1.60	73	9	2.56	28.52
24	1.57	73	9	2.46	29.67
25	1.56	72.8	9	2.43	29.96
26	1.61	75	9	2.59	28.96
27	1.57	72	8	2.46	29.27
28	1.55	71	8	2.4	29.58
29	1.62	74	8	2.62	28.24
30	1.52	68	8	2.31	29.44
31	1.55	59	8	2.40	24.58
32	1.52	54	8	2.31	23.38
33	1.50	52	8	2.25	23.11
34	1.48	35	8	2.19	29.22
35	1.46	36	8	2.13	16.90
36	1.47	38	8	2.16	17.59
37	1.61	60	8	2.59	23.17
38	1.50	65	8	2.25	28.89
39	1.53	57	7	2.34	24.36
40	1.64	66	7	2.69	24.53

Continued…

No	Height	Weight	Grade	H^2	BMI
41	1.64	66	10	2.69	24.53
42	1.63	65	10	2.66	24.44
43	1.70	71	10	2.89	24.57
44	1.62	65	10	2.62	24.81
45	1.64	48	10	2.69	17.84
46	1.65	46	10	2.59	17.76
47	1.59	45	10	2.53	17.79

Raw data for females (Age 16)

No	Height	Weight	Grade	H^2	BMI
1	1.56	72	8	2.43	29.63
2	1.52	70	8	2.31	30.30
3	1.68	79	8	2.82	28.01
4	1.50	70	8	2.25	31.11
5	1.48	67	8	2.19	30.59
6	1.50	68	7	2.25	30.22
7	1.58	74	8	2.50	29.6
8	1.60	75	8	2.56	29.30
9	1.54	71	9	2.37	29.96
10	1.53	69	9	2.34	29.49
11	1.51	56	9	2.28	24.56
12	1.50	66	9	2.25	29.33
13	1.56	71	9	2.43	29.22
14	1.46	63	9	2.13	29.58
15	1.41	60	9	1.99	30.15
16	1.57	74	9	2.46	30.08
17	1.64	79	9	2.69	29.37
18	1.56	77	9	2.43	31.69
19	1.52	71	9	2.31	30.74
20	1.54	75	9	2.37	31.65
21	1.55	72	9	2.4	30
22	1.53	74	9	2.34	31.62
23	1.57	76	9	2.46	30.89
24	1.62	78	9	2.62	29.77
25	1.54	74.6	9	2.37	31.48
26	1.63	75	9	2.66	28.20
27	1.57	75.8	9	2.46	30.81
28	1.49	65	9	2.22	29.28
29	1.57	73	9	2.46	29.67
30	1.54	68.5	9	2.37	28.90
31	1.75	76	9	2.06	36.89
32	1.53	69	9	2.34	29.49
33	1.58	62	9	2.5	24.8
34	1.60	74	10	2.56	28.91
35	1.56	70.6	10	2.43	29.05
36	1.56	60	10	2.43	24.69
37	1.55	66	10	2.4	27.75
38	1.66	67	10	2.76	24.28
39	1.66	68	10	2.76	24.64
40	1.70	71	10	2.89	24.57

Continued…..

No	Height	weight	Grade	H^2	BMI
41	1.52	74.5	10	2.31	32.25
42	1.61	78	10	2.59	30.12
43	1.56	74	10	2.43	30.45
44	1.59	73	10	2.53	28.85
45	1.58	71	10	2.5	28.4
46	1.54	69	10	2.37	29.11
47	1.59	72	10	2.53	28.46
48	1.68	79	10	2.82	28
49	1.53	75.5	10	2.34	32.26
50	1.65	77	10	2.72	28.31
51	1.53	72.8	10	2.34	31.11
52	1.62	76	10	2.62	29
53	1.51	56	10	2.28	24.56
54	1.41	48	10	1.99	24.12
55	1.52	40.7	10	2.31	17.62
56	1.52	43	10	2.31	18.61
57	1.54	41.5	10	2.37	17.51
58	1.56	43	10	2.43	17.7
59	1.56	42.6	10	2.43	17.53
60	1.63	48	10	2.66	18.05
61	1.64	47	10	2.69	17.42
62	1.48	53	10	2.19	24.2
63	1.49	44	10	2.22	19.82
64	1.58	61	10	2.5	24.4
65	1.58	59	10	2.5	23.6
66	1.55	57	10	2.4	23.75
67	1.54	58	10	2.37	24.47
68	1.60	62	10	2.56	24.22
69	1.55	57	10	2.4	23.75
70	1.56	56	10	2.43	23.05
71	1.54	57	10	2.37	24.05

Raw data for females (Age 17)

No	Height	Weight	Grade	H^2	BMI
1	1.60	79	10	2.56	30.86
2	1.47	70	10	2.16	32.41
3	1.63	77.7	10	2.66	29.21
4	1.68	81	10	2.82	28.72
5	1.54	74	10	2.37	31.22
6	1.66	79	10	2.76	28.62
7	1.65	78.5	10	2.72	28.86
8	1.57	77	10	2.46	31.3
9	1.54	70.6	10	2.37	29.79
10	1.62	76.6	10	2.62	29.24
11	1.50	69.5	10	2.25	30.89
12	1.60	80	10	2.56	31.25
13	1.63	77.9	10	2.66	29.29
14	1.55	72.9	10	2.4	30.37
15	1.53	69.5	10	2.34	29.7
16	1.59	73.5	9	2.53	29.05
17	1.48	39	10	2.19	17.81
18	1.62	64	10	2.62	24.43
19	1.75	74	10	3.06	24.18
20	1.58	73	10	2.5	29
21	1.57	72	10	2.46	29.27
22	1.71	71	10	2.92	24.32
23	1.47	53	10	2.16	24.54
24	1.52	67	10	2.31	29
25	1.45	61	10	2.10	29.05

Raw data for males (Age 13)

No	Height	Weight	Grade	H^2	BMI
1	1.58	63	8	2.50	25
2	1.56	48	8	2.43	19.75
3	1.57	62	7	2.46	25.20
4	1.66	70	8	2.76	25.36
5	1.60	64	8	2.56	25
6	1.62	67	8	2.62	25.57
7	1.44	53	7	2.07	25.60
8	1.46	54	7	2.13	25.35
9	1.69	54	7	2.86	18.88
10	1.46	54	7	2.13	25.35
11	1.42	51	7	2.02	25.25
12	1.52	59	7	2.31	25.54
13	1.51	58	7	2.28	25.44
14	1.40	59	7	1.96	30.10
15	1.50	57.6	7	2.25	25.6
16	1.48	42	7	2.19	19.18
17	1.54	60	7	2.37	25.32
18	1.42	51	7	2.02	25.25
19	1.47	46	7	2.16	21.30
20	1.46	54	7	2.13	25.35
21	1.42	38	7	2.02	18.81
22	1.61	49	7	2.59	18.92
23	1.46	40	7	2.13	18.78
24	1.42	51	7	2.02	25.25
25	1.61	50	7	2.59	19.31
26	1.63	67	7	2.66	25.19
27	1.46	44	7	2.13	19.25
28	1.45	53	7	2.10	25.24
29	1.45	42	7	2.10	20
30	1.37	35	7	1.88	18.62
31	1.58	44	7	2.50	17.6
32	1.42	36	7	2.02	17.82
33	1.56	42	8	2.43	17.28
34	1.42	39	8	2.02	19.31
35	1.42	36	7	2.02	17.82
36	1.60	49	7	2.56	19.14
37	1.50	44.9	7	2.25	19.96
38	1.40	37	7	1.96	18.88
39	1.23	30	7	1.51	19.87
40	1.48	39	7	2.19	17.81

Raw data for males (Age 14)

No	Height	Weight	Grade	H^2	BMI
1	1.60	50	9	2.56	19.53
2	1.45	53.5	9	2.1	25.48
3	1.56	62	9	2.43	25.51
4	1.34	54	7	1.80	30
5	1.49	56	7	2.22	25.23
6	1.63	67	7	2.66	25.19
7	1.68	55	7	2.82	19.50
8	1.56	75.5	7	2.43	31.07
9	1.60	50	7	2.56	19.53
10	1.57	48	7	2.46	19.51
11	1.69	67	7	2.86	23.43
12	1.68	77.5	7	2.82	27.48
13	1.52	62	7	2.31	26.84
14	1.60	68	7	2.56	26.56
15	1.44	55	7	2.07	26.57
16	1.65	72.5	7	2.72	26.65
17	1.68	76.9	7	2.82	27.27
18	1.57	67.5	7	2.46	27.44
19	1.46	58.6	7	2.13	27.51
20	1.34	48	7	1.80	26.67
21	1.71	73	9	2.92	25
22	1.62	71.9	9	2.62	27.44
23	1.55	67	9	2.4	27.92
24	1.48	56.9	9	2.19	25.98
25	1.40	53.5	8	1.96	27.3
26	1.47	59	8	2.16	27.31
27	1.50	40	8	2.25	17.78
28	1.50	40.5	8	2.25	18
29	1.63	60	8	2.66	22.56
30	1.53	42	8	2.34	17.95
31	1.53	41	8	2.34	17.52
32	1.43	50	8	2.04	24.51
33	1.59	63	8	2.53	24.9
34	1.68	70	8	2.82	24.82
35	1.46	38	8	2.13	17.84
36	1.64	56	8	2.69	20.82
37	1.56	43	8	2.43	17.7
38	1.64	58	8	2.69	21.56
39	1.64	56	8	2.69	20.82
40	1.66	58	8	2.76	21

Continued….

No	height	weight	Grade	H^2	BMI
41	1.56	60	8	2.43	24.69
42	1.58	62	8	2.50	24.8
43	1.59	63	8	2.53	24.9
44	1.58	61	8	2.50	24.4
45	1.66	68	8	2.76	24.64
46	1.64	67	8	2.69	24.91

Raw data for males (Age 15)

No	Height	Weight	Grade	H^2	BMI

1	1.68	77	9	2.82	27.30
2	1.66	78	9	2.76	28.26
3	1.65	75	9	2.72	27.57
4	1.70	81	9	2.89	28.03
5	1.62	76.9	9	2.62	29.35
6	1.63	76	9	2.66	28.57
7	1.60	63	9	2.56	24.61
8	1.60	62	9	2.56	24.22
9	1.55	59	9	2.4	24.58
10	1.64	72	9	2.69	26.77
11	1.75	74	9	3.06	24.18
12	1.54	70	9	2.37	29.54
13	1.79	79	9	3.2	24.69
14	1.65	65	9	2.72	23.90
15	1.56	75	9	2.43	30.86
16	1.62	63	9	2.62	24.05
17	1.68	77	9	2.82	27.30
18	1.64	75	9	2.69	27.88
19	1.57	78	7	2.46	31.71
20	1.62	79	7	2.62	30.15
21	1.64	75	9	2.69	27.88
22	1.71	76	9	2.92	26.03
23	1.73	74	9	2.99	24.75
24	1.74	70	9	3.03	23.10
25	1.65	75	9	2.72	27.57
26	1.72	73	9	2.99	24.41
27	1.66	77	9	2.76	27.90
28	1.68	76.5	9	2.82	27.13
29	1.68	79	9	2.82	28.01
30	1.55	43	9	2.4	17.92
31	1.72	72	9	2.99	24.08
32	1.80	79	10	3.24	24.38
33	1.64	67	10	2.69	24.91
34	1.53	42	8	2.34	17.95
35	1.60	63.5	8	2.56	24.80
36	1.59	45	8	2.53	17.79
37	1.68	70	8	2.82	24.82
38	1.54	42	8	2.37	17.72
39	1.46	66	8	2.13	30.99
40	1.45	67.5	8	2.10	32.14

Continued…..

No	Height	Weight	Grade	H^2	BMI
41	1.51	64	8	2.28	28.07
42	1.55	70	8	2.40	29.17
43	1.50	63.5	8	2.25	28.22
44	1.49	46	8	2.22	20.72
45	1.50	64	7	2.25	28.44
46	1.56	69	7	2.43	28.40
47	1.63	75	8	2.66	28.20
48	1.42	42	8	2.02	20.79
49	1.64	74	8	2.69	27.51
50	1.54	49	8	2.37	20.68
51	1.51	47	8	2.28	20.61
52	1.62	72	8	2.62	27.48
53	1.44	43	8	2.07	20.77

Raw data for males (Age 16)

No	Height	Weight	Grade	H^2	BMI
1	1.61	72	10	2.59	27.80
2	1.56	71	10	2.43	29.22
3	1.68	78	10	2.82	27.66
4	1.69	77	10	2.86	26.92
5	1.60	74	10	2.56	28.91
6	1.60	76	10	2.56	29.69
7	1.55	70	10	2.4	29.17
8	1.60	75	10	2.56	29.30
9	1.67	79	10	2.79	28.32
10	1.63	73	10	2.66	27.44
11	1.69	79.5	10	2.86	27.80
12	1.65	77	10	2.72	28.31
13	1.72	76.5	10	2.96	25.84
14	1.65	75	10	2.72	27.57
15	1.73	78	10	2.99	26.09
16	1.63	72	10	2.66	27.07
17	1.73	80	10	2.99	26.76
18	1.73	78.5	10	2.99	26.25
19	1.82	80	10	3.31	24.17
20	1.81	82	10	3.28	25
21	1.68	78	10	2.82	27.66
22	1.62	76	8	2.62	29.01
23	1.73	79	9	2.99	26.42
24	1.71	75.7	9	2.92	25.92
25	1.68	76.8	9	2.82	27.23
26	1.58	76	9	2.5	30.4
27	1.61	77	9	2.59	29.73
28	1.59	74	9	2.53	29.25
29	1.73	79	9	2.99	26.42
30	1.58	73	9	2.5	29.2
31	1.56	75	9	2.43	30.86
32	1.63	79	9	2.66	29.70
33	1.68	78	8	2.82	27.66
34	1.63	77	8	2.66	28.95
35	1.63	79.5	8	2.66	29.89
36	1.70	78	8	2.89	26.99
37	1.65	76	8	2.72	27.94
38	1.55	70	8	2.4	29.17
39	1.50	67	8	2.25	29.78
40	1.77	79	8	3.13	25.24

Continued…...

No	Height	Weight	Grade	H^2	BMI
41	1.59	74.5	9	2.53	29.45
42	1.61	75	9	2.59	28.96
43	1.60	73	9	2.56	28.52
44	1.60	78	9	2.56	30.47
45	1.64	76	9	2.69	28.25
46	1.69	77	9	2.86	26.92
47	1.50	70	9	2.25	31.11
48	1.60	74	9	2.56	28.91
49	1.61	75	9	2.59	28.96
50	1.61	75.6	9	2.59	29.19
51	1.63	76	9	2.66	28.57
52	1.71	76.9	9	2.92	26.34
53	1.82	80	9	3.31	24.17
54	1.73	74	9	2.99	24.75
55	1.70	72	9	2.89	24.91
56	1.66	49	9	2.76	17.75
57	1.57	43	9	2.46	17.48
58	1.71	71.6	10	2.92	24.52
59	1.60	46	10	2.56	17.97
60	1.58	61.5	10	2.5	24.60
61	1.67	69	10	2.79	24.73
62	1.62	65	10	2.62	24.81
63	1.67	68	10	2.79	24.37
64	1.65	67	10	2.72	24.63

Raw data for males (Age 17)

No	Height	Weight	Grade	H^2	BMI
1	1.63	78	10	2.66	29.32
2	1.76	84	10	3.10	27.10
3	1.61	74	10	2.59	28.57
4	1.75	83	10	3.06	27.12
5	1.67	79	10	2.79	28.32
6	1.66	78	10	2.75	28.36
7	1.71	81	10	2.92	27.74
8	1.64	79	10	2.69	29.37
9	1.74	79	9	3.03	26.07
10	1.63	75	9	2.66	28.20
11	1.73	81	10	2.99	27.09
12	1.74	79.5	10	3.03	26.24
13	1.56	70	10	2.43	28.81
14	1.60	72	10	2.56	28.13
15	1.75	76	10	3.06	24.84
16	1.76	76.9	10	3.09	24.89
17	1.81	80	10	3.28	24.39
18	1.62	75	10	2.62	28.63
19	1.73	74	10	2.99	24.75
20	1.60	76	10	2.56	29.69
21	1.76	77	10	3.1	24.84
22	1.80	80	10	3.24	24.69
23	1.59	75	10	2.53	29.64
24	1.62	79	10	2.62	30.15
25	1.86	88	8	3.46	25.43

Appendix 4

One director (W/roFrehiwotGizaw) and four teachers (W/roMeseretGirma, W/roFantaneshTenaw, W/ro Aster Abebe and W/roElzabethTumelisan) from science department participated in facilitating the measurement of the students' height and weight when the researcher measures the students' height and weight.

The director was acted as a coordinator to choose the measurements place and assigned one teacher for each day to help the researcher. When the researcher measured the students' height and weight, the assigned teacher was managing the students who came to the measurement place. Those four teachers who participated for four days were came from different grade levels