ADDIS ABABA UNIVERSITY
COLLEGE OF HEALTH SCIENCE
SCHOOL OF PUBLIC HEALTH

MID-UPPER ARM CIRCUMFERENCE AS A SCREENING TOOL FOR IDENTIFYING OVERWEIGHT AND OBESITY AMONG ADOLESCENTS IN ADDIS ABABA

BY: BINYAM GIRMA (BSc.)

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BY: BINYAM GIRMA (BSc.)

ADVISORS: Dr. SEIFU HAGOS (BSc., MSc, MPH, PhD.)
Mr. DEMEWOZ HAILE (BSc., MSc, PhD candidate)

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APPROVED BY THE BOARD OF EXAMINERS

This thesis, by Binyam Girma, entitled "Mid-upper arm circumference as a screening tool for identifying overweight and obesity among adolescents in Addis Ababa, Ethiopia" is accepted in its present form by the board of examiners as fulfilling for the degree of masters in public health nutrition.

Advisor

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Full name Rank Signature Date

Advisor

_____ _____ _____ _____

Full name Rank Signature Date

External Examiner

_____ _____ _____ _____

Full name Rank Signature Date

Internal Examiner

_____ _____ _____ _____

Full name Rank Signature Date

Chairman, Department Graduate committee

_____ _____ _____ _____

Full name Rank Signature Date

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LIST OF ABBREVIATIONS AND ACRONYMS

AACAEB	Addis Abab City Administration Education Bureau
AUC	Area Under The Curve
BMI	Body Mass Index
CI	Confidence Interval
DEXA	Dual Energy X-Ray Absorptiometry
MUAC	Mid-Upper Arm Circumference
NLR	Negative likelihood ratio
NNP	National nutritional program
NPV	Negative predictive value
PLR	Positive likelihood ratio
PPV	Positive predictive value
ROC	Recever operating caractarstics curve
SE	Standard error
TEM	Technical Error Measurement
WHO	World Health Organization

ABSTRACT

Background- Adolescent overweight and obesity is a global public health problem and associated with increased risk of metabolic syndrome. Recently, mid-upper arm circumference has been suggested as a screening tool for overweight and obesity among school age children and early adolescent. However, little is known about the potential use of mid-upper arm circumference in late adolescents (15-19 years).

Objective- The aim of the study was to evaluate the ability of mid-upper arm circumference to correctly identify BMI-for-age z-score defined overweight and obesity among adolescents in selected high schools of Addis Ababa, Ethiopia, 2019.

Methods- A school-based cross-sectional study was conducted among 851 late adolescents in Addis Ababa. A stratified multi-stage sampling procedure was followed. A pre-tested interviewer-administered questionnaire was used. Anthropometric measurements including weight, height, and mid-upper arm circumference were measured. Receiver operating characteristic curve analysis was done to determine the ability of MUAC to detect overweight and obesity. Sensitivity, specificity, predictive values and likelihood ratio of MUAC were calculated for the optimal cutoff points.

Result - MUAC had strong positive correlation with BMI-for-age z-score (r = 0.84). The diagnostic performance of MUAC as assessed by area under the curve (AUC) for identifying overweight and obesity was 0.96 for both genders. The optimal mid upper arm circumference cut off point was ≥ 27.9 cm with sensitivity of 90.28%, specificity of 90.71%, positive likelihood ratio of 9.72 and negative likelihood ratio of 0.11 for girls. Similarly, for boys optimal mid upper arm circumference cut off point was ≥ 27.75 cm with sensitivity of 94.1%, specificity of 89.1%, positive likelihood ratio of 8.7 and negative likelihood ratio of 0.07.

Conclusion - This study provide evidence that MUAC have high specificity and sensitivity to identify overweight/obese among late adolescences as evaluated against body mass index for age z-score. The optimal mid upper arm circumference cut off point for girls was ≥ 27.9 cm and for boys was ≥ 27.75 cm. MUAC have potential for screening and surveillance applications as simple and widely available indicator of overweight/obesity in late adolescents.

1. INTRODUCTION

1.1 Background

World Health Organization (WHO) define overweight and obesity as an abnormal or excessive fat accumulation that may impair health (1). Overweight and obesity is a disorder of positive energy balance due to excess calorie intake and inadequate caloric expenditure, combined with a genetic predisposition for weight gain (2, 3).

Adolescents defined by the United Nations as those between the ages of 10 and 19 (4). There are 1.2 billion adolescents in the world today, making up 16 % of the world's population. Majority of them are living in developing countries (5). Adolescence drive for individualization and peer influence contributes for unhealthy food choices, increasing trends in fast food , eating outside and sedentary behavior. So that all these changes put adolescents at greater risk for overweight and obesity (6).

In the last four-decade global prevalence of obesity in children and adolescents increased by tenfold from 11 million in 1975 to 124 million in 2016. An additional 216 million children and adolescents were overweight. If current trends continue by the year 2022, child and adolescent obesity is expected to exceed moderate and severe underweight (7). There is also rising prevalence of childhood and adolescent obesity in low- and middle-income countries recently (8). In Africa, even with a high prevalence of undernutrition, the magnitude of overweight and obesity is increasing at a rapid rate. In Middle East, North Africa, Sub-Saharan countries prevalence of overweight and obesity in children and adolescents were 25.6% and 34.8% among males and 20.8% and 20.5% among females respectively (9, 10).

Adolescent overweight and obesity can be measured using direct and indirect measurements (Anthropometric measurements) (11). Anthropometric measurements are well recognized and extensively used indicators of nutritional status in both children and adolescents (12). Among anthropometric measurements body mass index for age z-score is one of the extensively used and recommended measure of overweight and obesity among children and adolescents (13). BMI-for-age z-score is closely correlated with body fat and long-term health risks in children and adolescents. Thus international gender- and age-specific cut-offs are recommended (14).

Alternatives to BMI-for-age z-score mid upper arm circumference has been a suggested measurement of overweight and obesity among children and adolescents (15, 16). Mid upper arm circumference (MUAC) is the circumference of the non-dominant upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromion) (17). Mid upper arm circumference measures the arm muscle and fat area (18). MUAC is most commonly used for identification of severe acute malnutrition in young children (6–60 months of age) in resource-limited settings (19). MUAC has also been used for numerous years as an another index of nutritional status in conditions, such as famines or refugee crises, where height and weight measurements is difficult (20). In low-resource settings, pregnant mothers nutritional status both under nutrition and obesity could reliably be assessed using MUAC (21).

Although, much is not known on the potential use of MUAC as a screening tool for overweight and obesity in children; recent studies have suggested that MUAC can accurately identify overweight and obesity in children and early adolescents (16, 17, 22-27). The accuracy level of MUAC for identifying obesity was high in both sexes among children and early adolescents (16, 17, 22, 25-27). However, little is known about the ability of MUAC as measure of overweight and obesity among late adolescents (15 – 19 years).

1.2 Statement of the Problem

Adolescent overweight and obesity is one of the major public health challenges of the 21st century with far-reaching and long-term adverse health outcomes (28). According to meta-analysis done in Ethiopia a combined pooled prevalence of 11.30 % of overweight and obesity among adolescents was reported (29). Studies done in other major cities of Ethiopia also reported a high prevalence of adolescents overweight/obesity range from 9.9% - 14.7% (30-32). In Addis Ababa a high prevalence of overweight and obesity has been reported with range from 9.4 - 13.9% (33-36).

Adolescent overweight and obesity have been linked to numerous medical conditions. These conditions include, but are not limited to high blood pressure, type 2 diabetes, high cholesterol, fatty liver disease (hepatic steatosis), sleep apnea, asthma, cardiovascular disease and cholelithiasis (gallstones) (37). Overweight and obese adolescents are more likely to stay obese into adulthood and to develop noncommunicable diseases including diabetes and cardiovascular. The risk of morbidity from colorectal cancer, hypertension, type 2 diabetes, gout, abnormal kidney function, polycystic ovary syndrome, asthma, and obstructive sleep apnea was increased among adults who had been overweight in adolescence (38, 39).

Without early intervention, 80% of adolescent obesity persists into adulthood and increase the risk of non-communicable diseases (40). Findings from studies showed that the effective ways to prevent the adverse consequences of overweight and obesity is to identify and manage overweight and obesity, especially during childhood and adolescence (41, 42). Even though precise methods to determine body fat exist, these methods are not practical for surveillance and routine clinical practice; because most of this method are laboratory based, expensive and require highly trained professional. Due to this, anthropometric measurements are used to screen overweight and obesity (11). An important strategy to control overweight and obesity would be to develop a practical, low cost, simple and reliable method of screening for identifying adolescents overweight and obesity, especially in primary health care, at school and community level (43).

Among anthropometric measurements Body mass index for age z-score is recommended for screening overweight and obesity in children and adolescents in both public health and clinical

practice (44). Even with its popularity and easiness to use, it has a number of drawbacks. BMI-for-age z-score is less preferred by minimally trained health workers; also measuring equipment are expensive to buy, maintain and require regular calibration. Additionally, its time consuming to measure weight, height and interpret the value with reference chart. It may be improper to use MUAC in settings where measuring weight is deemed inappropriate because of concerns of creating body image issues (17, 45).

Several studies have suggested other anthropometric measures alternative to BMI including waist circumference and waist-to-hip ratio (22, 46, 47). In spite of their benefits, each has its own limitations. For example, measuring waist circumference may be time-consuming and difficult in terms of cultures where exposing the body for measurement is discouraged. Additionally, after consuming food, waist circumference is affected by abdominal distention (48).

Due to limitations stated in the above paragraphs, another anthropometric measurement is required to screen overweight and obesity (49). Potential alternative that can overcome these limitations is MUAC. MUAC is considered as potential alternative because it doesn't require extensive training, supervision, or expensive materials. MUAC is relatively easy to use and simple to understand for both community health workers and health care professionals (17). MUAC measurement can be done at any time of the day and in any situation: standing, siting or laying on their back (50). Errors of measurement associated with MUAC are no more frequent than error occurred with either weight or height measurement. Study have shown that even for minimally trained health workers, intra- and inter-observer reliability of MUAC measurements are at least as good as other anthropometric measurements (15). MUAC can offer considerable cost advantages; MUAC tapes are cheaper than height and weight measuring equipment.

A number of studies were done on the potential use of mid-upper arm circumference as a screening tool for overweight and obesity among school age children and early adolescents (17, 24, 26, 27). Most of this study showed that MUAC can accurately identify overweight and obesity among early adolescents (17, 22, 23). However, none of this study have explored the ability of MUAC to identify overweight and obesity among late adolescents. Hence, this study aims to fill the gap on existing literature and evaluate the ability of MUAC to correctly identify BMI-for-age z-score defined overweigh and obesity in late adolescents (15 – 19 years).

1.3 Significance of the Study

Findings of this study might be used as a base line for further study on ability of mid upper arm circumference to detect overweight and obesity among late adolescents. The results could be used by policy makers and relevant stakeholders to develop cost-effective screening and surveillance for overweight and obesity by providing simple cheap and easy screening tool. The finding of this study could be used by national nutritional program II to develop simple, inexpensive and easy screening tool to detect overweight and obesity among adolescents. It might also be used to promote use of mid upper arm circumference at community level and by health extension worker to screen overweight and obesity among late adolescents.

2. LITERATURE REVIEW

2.1 Magnitude of Overweight and Obesity

Since 1975 childhood and adolescent obesity has risen from 11 million to 124 million in 2016. Global prevalence of childhood and adolescent overweight and obesity has reached 213 million in 2016. Among girls obesity has increased from 5 million in 1975 to 50 million in 2016 in boys it has increased from 6 million in 1974 to 74 million in 2016 (7).

There is also a rising prevalence of childhood and adolescent obesity in low and middle-income countries recently: 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 low and middle-income countries (8). In Africa, in spite of a high prevalence of undernutrition, there is a rapid rise in overweight and obesity. In the Middle East and North Africa region prevalence of overweight and obesity in children and adolescents were 25.6% and 34.8% among males and 20.8% and 20.5% among females respectively (9). In Sub-Saharan countries, the prevalence of overweight and obesity among school-aged children and adolescents were 10.6% and 2.5% respectively (10).

Meta-analysis done based on studies done in Ethiopia show a combined pooled prevalence of 11.30 % of overweight and obesity among adolescents (29). More than a few studies done in Addis Ababa showed a high prevalence of overweight and obesity ranges from 13.9% - 9.4% and 4.2-0.8% respectively (33-36). The overall Prevalence of overweight and/or obesity among school-age children in Bole sub-city was 9.8% and obesity accounted for the rest 1.8% (35). Studies done in other cities including Adama, Babile district, Hawassa, Wolaita Sodo, Gondar, Dire dawa and Jimma showed a prevalence of overweight and obesity ranging from 14.7%-4.8% and 5.8%-0.5%, respectively (31, 32, 51-55). The overall prevalence of obesity and overweight among preschool and school-age children was 3.4% -3.1% and 7.3% -8.8% reactively (56, 57).

2.2 Measurements of Overweight and Obesity

Measurement of obesity and overweight can be done using direct measurement methods or anthropometric measurements. Direct measurement of adiposity includes computed

tomography, densitometry and dual-energy x-ray absorptiometry(DXEA) (58). These methods are expensive and often time-consuming but superior to anthropometric measurements such as BMI. Anthropometric measurements including BMI, Waist Circumference (47), neck circumference (46), MUAC (23, 27) are more accessible, easy to use and cheaper but not as accurate as direct measurement methods. BMI and circumferences, have been used as proxies for overweight and obesity (59).

2.2.1 Anthropometric measurements

Anthropometric measurements and indices describe body size, shape, and composition. Changes in body proportions reflect the overall health and wellbeing of individuals and populations. Anthropometry is used to assess health and survival of individuals and reflect the economic and social wellbeing of populations. It is a widely used, inexpensive and non-invasive measure of the general nutritional status of an individual or a population group (60).

Anthropometric measurement are convenient, cheap, noninvasive method and commonly applicable (61) and involves the external measurement of body composition of human beings (62). It reveals both health and nutritional status of individuals and populations, such that they can be selected for intervention programs as well as for screening of nutrition status (61).

2.2.1.1 Body mass index

Body mass index is a measure of weight adjusted for height. It is calculated as weight in kilograms divided by the square of height in meters. Although BMI is an imperfect tool; it does not distinguish overweight due to excess fat mass from overweight due to excess lean mass – it is the most commonly used measure for assessing obesity in adults. Other methods of determining adiposity are more accurate,(63) but have limited applicability to screening or studying large populations. The BMI is well correlated with these more direct fatness measures (64).

Body mass index *z*-scores, also called BMI standard deviation scores, are measures of relative weight adjusted for child age and sex. Given a child's age, sex, BMI, and an appropriate reference standard, a BMI *z*-score (or its equivalent BMI-for-age percentile) can be determined.

BMI-for-age z-score is the most commonly used measure of body adiposity in both children and adolescents worldwide (65).

BMI for age z- score has high specificity but low sensitivity to detect excess adiposity and fails to identify over a quarter of children with excess body fat percentage. Pooled sensitivity to detect high adiposity of 73 % and a pooled specificity of 93 % In males, BMI for age z- score showed a pooled sensitivity of 67 % and a pooled specificity of 94 % As for females, BMI for age z- score showed a pooled sensitivity of 71 %, pooled specificity of 95 % (58).

Regardless of BMI for age widespread use and advantage number of authors have detailed its limitation. BMI is it varies by gender, age, and level of maturity. BMIs for age tend to be similar in both genders during childhood however in adolescence females have higher BMI for age. With regard to age, BMI for age increases from birth to about one year, then declines to around age six, then rises through the rest of childhood and adolescence (66). Such variations mean that among children and adolescents the significance of any particular BMI for age is more difficult to determine than within adult populations (58).

BMI for age measures both fat and fat-free mass. However, populations differ in respect of both percentage fat mass and fat distribution, and in the relation between body composition and morbidity. This means, again, that the significance of any particular BMI for age well varies. Thus, among children with the same BMI, fat measurements are higher for whites than for blacks (67). Further, recent studies have suggested that increases in overall BMI for age have been accompanied by larger increases in the percentage as fat mass and concomitant decreases in fat-free mass (attributed to reduced activity levels). Importantly, this suggests that recent increases in adiposity are even greater than those suggested by increases in BMI for age (68).

BMI for age is may not be feasible in a resource-poor area where weight, height measuring equipment, and trained personnel are scarce. It’s difficult to use BMI at a community level and studies with large sample size because it requires carrying Stadiometer and weight scale (24).

2.2.1.2 Mid-upper arm circumference

MUAC is the circumference of the left upper arm, measured at the mid-point between the tip of the shoulder and the tip of the elbow (olecranon process and the acromion) (17). Mid-upper arm circumference (MUAC) is a valuable anthropometric measurement used for screening malnourished children. MUAC is easy, practical and reliable tool measuring tapes are affordable and portable (69). Even though it is imperative to give workers training in how to take the measurement in order to reduce inter- and intra- observer error, the technique can be readily taught to minimally trained health workers (15).

MUAC is commonly used in developing countries to diagnose and monitor underweight in children aged 6–60 months with a single cut-off point (70). MUAC has also been used to identify chronic energy deficiency among adults in developing countries (50). Additionally MUAC has been used to screen adolescent under nutrition and showed 28.57% sensitivity and 96.46% specificity (18). In low-resource settings, the simpler MUAC measurement could reliably replace BMI to assess nutritional status of pregnant women. The MUAC cut-offs among pregnant women for obesity (BMI >30) and underweight (BMI <18.5) were 30.57 cm and 22.8 cm, respectively (21).

In recent years MUAC has been proposed as an important tool in detecting overweight and obesity in children and adolescent. MUAC as a measure of overweight and obesity is age and gender-specific. As expected, MUAC varies between gender and increase with age (17). MUAC shows a strong positive correlation with BMI-for-age z-score in both genders (24, 26, 71). MUAC had strongly positive correlation with percent body fat (measured by bioelectrical impendency) in both genders (24). MUAC also had strong positive correlation with age, height and weight in both genders (23, 71). However, study done on children age 7-12 and 6-12-year report MUAC has a moderate positive correlation with age in both genders (16, 26).

Most studies conducted on the ability of MUAC to correctly detect overweight and obesity was done by comparing MUAC to BMI-for-age z-score (as golden standard). All studies evaluate the diagnostic ability of MUAC by plotting ROC curve and calculating area under curve separately for boys and girls (16, 17, 22-24, 26, 27). A study conducted Dutch shows MUAC has an excellent and good area under the curve (AUC) (0.88–0.94); With sensitivity ranges from 51.8% to 95.3% and specificity from 71.4% to 93.8% across age groups. Across age and

gender groups, 65.1% to 89.0% participants are classified by both MUAC and BMI as normal weight, overweight or obese (27). A similar study done in 12 countries (24) and study done in Thailand show MUAC has excellent AUC with an overall sensitivity of ≥90% and specificity of ≥ 85% (22).

The sensitivity of MUAC compared with BMI-for-age z-score is low in 5-9 years old children, resulting in a considerable number of false positives (23, 25, 27). A study done in Pakistani children aged 5–14 years shows relatively lower sensitivity and specificity range from 56% to 58% but higher specificity range from 76%-94% (23).

Only single study done among children and early adolescents evaluate the ability of MUAC to measure overweight and obesity by comparing it to total body fat percentage measured by bioelectrical impendency (golden standard). In general, sensitivity and specificity were relatively high for all age and gender groups. The exceptions were among children 5-9 year that MUAC has low sensitivity (25-63%) and modestly high specificity (85-60 %). However, among early adolescent girls MUAC have excellent sensitivity (100%) and moderately low specificity (77%). Among early adolescent boys MUAC has good sensitivity (95%) and specificity (95%) in detecting obesity (17).

The ability of MUAC to identify overweight and obesity is affected by gender and age of participants. The ability of MUAC to detect overweight and obesity is low among children 2-5 and 5-9 year children (23, 25, 27). In addition, the ability of MUAC to measure overweight and obesity low among girls 7-12 year (26). However, MUAC shows higher accuracy among early adolescents (16, 17, 22, 27).

3. OBJECTIVES

3.1 General Objective

The general objective of the study was to evaluate the ability of mid-upper arm circumference to correctly identify body mass index for age z-score defined overweight and obesity among adolescents in selected high schools of Addis Ababa, Ethiopia, 2019.

3.2 Specific Objective

The study has the following specific objectives

- To evaluate the diagnostic capacity of mid-upper arm circumference compared to body mass index for age z-score for identifying overweight and obesity among adolescents in selected high schools of Addis Ababa, Ethiopia,2019.

- To determine the sensitivity and specificity of mid-upper arm circumference in identifying body mass index for age z-score defined overweight and obesity among adolescents in selected high schools of Addis Ababa, Ethiopia, 2019.

4. Method and Materials

4.1 Study Area and Period

The study was conducted in Addis Ababa, the capital city of Ethiopia which lies 9°1′48″N latitude and 38°44′24″E longitude with a total area of 540Km^2.with subtropical highland climate. Addis Ababa is a city with a great diversity and homes of almost all ethnicities. The city contains 10 administrative sub cities namely: Arada, Yeka, Gulele, Addis Ketema, AkakiKality, NefassilkLafto, Lideta, Bole, KolfeKeranio, and Kirkos. Based on the 2007 Census, Addis Ababa had a total population of 3,384,569, adolescents constitute 635,903 which is 23.2% of the total population & those from 15-19 years are 385,713 that is 14.1% (72).

According to 2018 Addis Ababa City Administration Education Bureau (AACAEB) report, there are 1,014 primary and secondary schools in all sub-cities. Out of total schools 795 are primary, 219 secondary and preparatory (9-12). From those schools 297 are governmental, 717 are non-governmental (73).

4.2 Study Period

The study was conducted in Addis Ababa from March to May 2019.

4.3 Study Design

A school-based cross-sectional study was conducted among high school adolescent students in both private and government schools of Addis Ababa.

4.4 Population

4.4.1. Source population

The source population for the study were all regular high school adolescent students in Addis Ababa who were attending high school in the academic year 2011/2019.

4.4.2. Study population

The study population included all regular high school adolescent students in selected private and government schools of Addis Ababa who were attending school in the academic year 2011/2019.

4.4.3 Inclusion criteria

All late adolescent (15-19 years) students who were attending classes in selected private and governmental high schools of Addis Ababa.

4.4.4 Exclusion criteria

Adolescents with a physical deformity that affect height and weight measurement were excluded from the study.

4.5 Sample Size Determination

The sample size for this study objectives was calculated by using the diagnostic accuracy test study sample size calculation formula (74).

Sample Size Required for Sensitivity

$$\mathrm{N1} = \frac{z^2_{1-\alpha/2} \times \mathrm{SN} \times (1 - \mathrm{SN})}{\mathrm{L}^2 \times \mathrm{P}}$$

Sample Size Required for Specificity

$$\mathrm{N2} = \frac{z^2_{1-\alpha/2} \times \mathrm{SP} \times (1 - \mathrm{SP})}{\mathrm{L}^2 \times (1 - \mathrm{P})}$$

Where n = the larger Sample size between N1 and N2

Z = Z value corresponding to a 95% level of significance = 1.96

P= Assuming prevalence

SN= Expected sensitivity

SP= Expected specificity

L= maximum clinically acceptable width or precision of the 95% Confidence level.

Hence assuming an anticipated sensitivity of 95.2% specificity of 89.9% (17) and a prevalence of overweight among adolescent students in Addis Ababa shows 13.9% (33), W of 5%, the maximum feasible sample size of 526 was required. Sampling procedure for the study is stratified three-stage sampling, to adjust the variability taking design effect of 1.5.

N= 526×1.5 = 789 participants. The final sample size after adding 10% non-respondent the final sample for the study was **877** adolescents.

4.5 Sampling Procedure

Figure 1 one shows the sampling procedure employed in this study. A stratified three-stage sampling technique was used to obtain a representative sample of study participants. The total sample schools were all private and government schools with secondary and preparatory education (9-12) who were 219.

Among the total high schools, 73 are governmental and 146 are non-governmental high schools (73). A total of 15 schools, 10 non-governmental and 5 governmental schools was selected randomly. A sample of students was distributed proportionally between governmental and non-governmental schools by considering the size of students in each school. Four sections from each selected school at which one section from each grade level (grade 9 – 12) were selected randomly. Students were allocated proportionally to the size of students in each selected section. Finally, students list was obtained and used to randomly select study participants from each section.

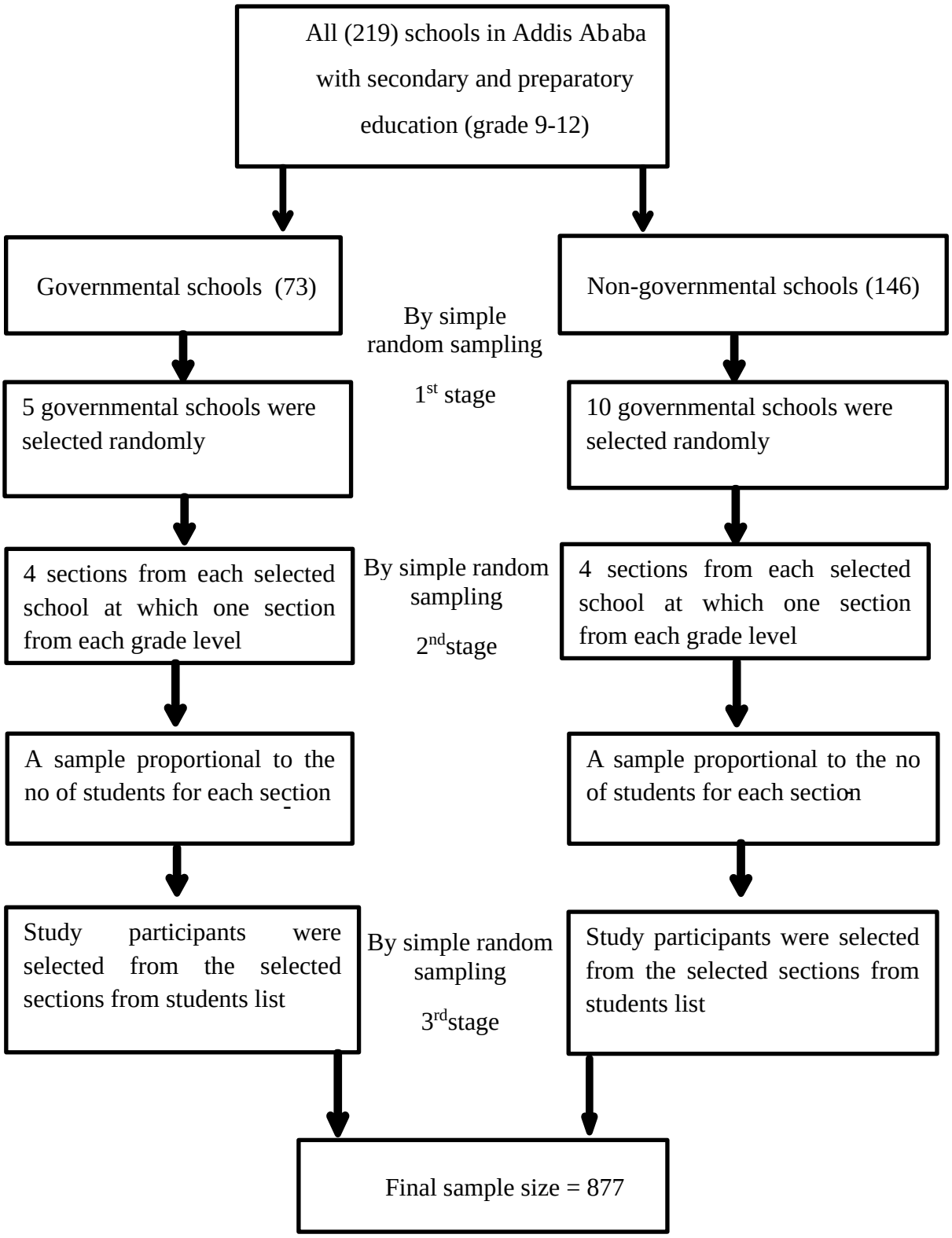

Figure 1: Schematic Presentation of Sampling Procedure

4.6 Study Variable

Mid upper arm circumference: as measured in centimetres to the nearest 0.1 cm.

Overweight and obesity was measured using the World Health Organization (WHO) BMI-for-age Z-score; overweight z score >1 and ≤ 2 and obesity z score >2.

Demographic and Socio-Economic characteristics

Socio-demographic characteristics such as age, religion, grade level, school type, parents educational level, parents occupation, family size, living arrangements and socio economic status were included. Age is measured to nearest day, month and years. Education levels of their fathers and mothers using scales range from: 1) illiterate, 2) read and write, 3) primary education 4) secondary education 5) some college and technical school 6) college graduate and above were assessed. Occupation of their fathers were assessed using choices: 1) Government or private employee 2) Merchant 3) Daily laborer 4) Unemployed. Occupation of their mother were assessed using choices: 1) Government or private employee 2) Merchant 3) Daily laborer 4) House wife. The study participants school types were categorized into two groups 1) Private /Missionary /International /Community 2) Government /Public.

4.7 Data Collection Procedure

Interviewer administered structured questionnaires

Interviewer administered questionnaire was used to collect data. The questionnaire consists of information on socio-demographic and economic status adapted from EDHS (75).

Anthropometry measurement

Weight

Weight was measured using Seca digital weight scale with precision of 0.1 kg. To measure weight, the weight scale was placed on a smooth flat surface shoes and heavy clothing were removed. The surface of the scale was pressed gently to switch on the display until it shows zero. The study participants were asked to step onto the scale; feet slightly apart and in the middle of the platform of the scale. Measurement of weight was recorded to the nearest 0.1 kg.

Height

Height was measured using portable stadiometer with a precision of 0.1 cm. The portable stadiometer has measuring rod with reading scale along both sides. Measuring rod can be assembled on spot with measuring range of 20 – 205 cm. It has sliding horizontal headpiece that can be adjusted to rest on top head. In addition, it has stable floor plate which provide the necessary stability.

To measure height stadiometer was placed on a flat surface, with the back supported by a wall. Study participants shoes were removed. Study participants was measured with the head, buttocks, back, and heels touching the board. The head positioned to the line of vision at right angles to the body and the arms hang freely by the sides. The movable headboard was lowered until it touches the upper part of the subject head firmly. Measurements was recorded to the nearest 0.1 cm.

Mid-upper arm circumference

Mid upper arm circumference was measured using non stretchable adult MUAC tape. The study participant non-dominant arm is flexed to 90 degrees at the elbow. The midpoint of the arm between the lateral acromion and distal olecranon was identified and marked. The measurement was recorded to the nearest 0.1 cm.

The measurements and readings for each subject was taken twice and the average is used for analysis. For height and MUAC, two more measurements were obtained if the first two measurements are greater than 1.0 cm and 0.5 cm apart respectively the measurement were repeated. For weight, two measurements were obtained if the first two measurements are greater than 0.5 kg apart then the measurements was be repeated.

Data was collected by five trained nurses. The data collection was supervised by trained supervisor and principal investigator. A three-day theoretical and practical training were given for five data collectors and supervisor. The training included the objective and methodology of the study, data collection and interviewing approach, how to take anthropometric measurements, data recording and ethics during data collection.

4.8 Data Quality Management

Data quality assurance was done before, during and after data collection. Before data collection, a three-day training was given for the data collectors and supervisor on purpose of the study, Anthropometric measurement including standardization protocol data collection tool and procedures. The training was given by the principal investigator. The questionnaire was first prepared in English and then translated to Amharic and back to English to keep the consistency of the questions. Pre-testing of the questionnaire was made on 48 adolescents that were not included in the actual data collection.

All measurers participated in standardization exercise in which they took repeated measurements of ten adolescents. Each measurer took two height, weight and MUAC measurements for ten adolescents. The Technical error of measurement (TEM) was calculated and it was found that the Intra observer technical error of measurements for height, weight and MUAC were found to be 0.2 ,0.12 and 0.1 respectively. Inter observer technical error of measurement for height, weight and MUAC were found to be 0.21, 0.21 and 0.12 respectively; which were all within the acceptable range. In addition, the coefficient of reliability was calculated for height, weight and MUAC which were all within acceptable range (≥ 96%) (76).

During data collection, the principal investigator and supervisor were overseeing all activities. Measuring equipment were calibrated regularly during data collection. Measurement scale were carefully handled and calibrated every morning with a 5kg iron bars and checked for 000.0 reading before each measurement. Data completeness and consistency was checked on spot questionnaires with missing variables were turned back to the data collectors for correction by revisit. Non-respondents were reconnected twice.

After data collection, data was entered in Epi data v 4.4.2.0 by the principal investigator and cleaned using Stata version 15.1.

4.9 Data Management and Analysis

Data were coded, entered to Epi Data version 4.4.1.0 and cleaned using Stata version 15.1. All statistical tests were performed using STATA version 15.1. The dataset on WHO Anthro plus software has been merged with Stata dataset using unique variable (identification number).

The World Health Organization (WHO) 2007 growth reference was used as a standard reference for classifying adolescents based on BMI-for-age z-score. using WHO Anthro plus software version 1.0.4. BMI-for-age z-score (BAZ) < -3 were classified as severely thin, ≥ -3 and < -2 as thin, ≥ -2 and < +1 as normal weight, ≥ +1 and < +2 as overweight and ≥ + 2 as obese (77). Stunting was classified as height-for-age z-score ≤ -2 (78). However due to small number of observations in obese and severe thinness categories, the BMI-for-age z-score is regrouped as "underweight", "normal weight" and "overweight".

Wealth index

Household's wealth index was determined using Principal Component Analysis (PCA) by considering the household assets, including ownership of house and housing condition and ownership of various durable goods (radio/tape, television, car, refrigerator, sofa, bicycle, motorcycle, car, mobile/telephone and others). First, variables were coded between 0 and 1. Then, principal component analysis was used to generate wealth index from fixed assets. Finally, A relative socio-economic status was constructed by dividing the resulting scores into 5 quantiles to give poorest, poor, medium, wealthy and wealthiest status.

Comparison of MUAC, BMI-for-age z-score and nutritional status by gender

Differences between boys and girls mean MUAC and BMI-for-age z-score were determined using two sample t-tests. We compare nutritional status (obese, overweight, normal weight and underweight) of study participants according to gender using chi-squared test. A *p*-value <0.05 was considered as statistically significant.

Relationship between MUAC and other anthropometric variables

Pearson correlation was used to examine relationship between MUAC, BMI for age z-score and age in year. Pearson's correlation was interpreted using coefficient of determination (r^2) value along with r. Square of correlation coefficient (r^2), known as coefficient of determination, represents the proportion of variation in one variable that is accounted for by the variation in the other variable. For example, if height and weight of a group of persons have a correlation coefficient of 0.80, one can estimate that 64% ($0.80 \times 0.80 = 0.64$) of variation in their weights is accounted for by the variation in their heights (79).

The test retest reliability of MUAC among adolescents

Test–retest reliability was assessed by paired t-test, for the 1st mid upper arm circumference measurement and 2nd mid upper arm circumference measurement.

The performance of MUAC in identifying overweight/obesity

The ability of MUAC to correctly identify overweight and obesity was evaluated by comparing MUAC to BMI-for-age z-score separately for boys and girls. Receiver operating characteristic curve (ROC) was plotted for sensitivity and 1 – specificity for various cutoffs of MUAC. Receiver operating characteristics curve show how well MUAC can separate participants into groups with overweight/obesity and without overweight/obesity. The area under the ROC curve (AUC) determines the overall level of accuracy, with a value of 0.50 indicating purely random performance and 1.00 indicating the maximal value possible. The categories used to summarize accuracy of AUC in ROC analysis were as follows: excellent (0.9–1), good (0.8–0.9), fair (0.7–0.8), poor (0.6–0.7) and fail (0.5–0.6) (80). A test with an AUC $\geq$ 0.85 was generally considered an accurate test (81) .

The best MUAC cutoff point for each gender were chosen as a value with the highest Youden index (J= Sensitivity + Specificity-1). For test with poor diagnostic performance Youden index equals to 0 and a perfect test will have 1 (82).

Sensitivity, specificity, positive and negative predictive value of MUAC were calculated for the proposed cutoff point for both genders. Likelihood ratios for MUAC that are predictive of overweight and obesity were computed for each gender.

The performance of MUAC in identifying underweight

The ability of MUAC to correctly identify underweight was evaluated by comparing MUAC to BMI-for-age z-score separately for boys and girls. Receiver operating characteristics curve show how well MUAC can separate participants into groups with underweight and without underweight.

The best MUAC cutoff point for each gender were chosen as a value with the highest Youden index.

Sensitivity, specificity, predictive value and likelihood ratios of MUAC were calculated for the proposed cutoff point for both genders.

ROC regression

ROC regression is more than determining the basic accuracy of a test, rather it determines factors that affect its accuracy. In doing so, it is possible to identify populations and settings where a test is more or less accurate, which can be useful in determining how best to use a test. This is accomplished using regression analysis of test accuracy or Roc regression analysis (83). We fitted the model for status variable overweight and obesity and classifier MUAC with the following covariate; gender, age in years and height.

To determine specifically where the MUAC performed the best we used ROC regression postestimation to calculate Receiver Operating Curve summary statistics for covariate-specific ROC curves.

4.10 Ethical Consideration

First, ethical clearance was obtained from the School of Public Health College of Health Science Addis Ababa University Institutional Review Board. Permission were obtained from Education Departments of Sub-cities and Directors of Schools to be studied. After getting permission from the schools, both written and verbal informed consent was obtained from adolescents greater than 18 years old and from parents/guardians of those under 18 years by sending them information sheet and consent form through their corresponding study adolescent.

Respondents were informed that they could refuse or discontinue participation at any time and they are informed that Information is recorded without their name being mentioned. Only codes were used to keep it anonymous and maintain confidentiality and privacy of respondent.

4.11 Dissemination of Results

The final report of the study will be disseminated to Addis Ababa University, School of Public Health, Ministry of Health, Addis Ababa City Health Bureau and the Addis Ababa Administration Education Bureau. In addition, great efforts will be made to disseminate the result through presentation in different seminars, workshops, scientific conferences. Attempts will be made to publish the findings on reputable peer-reviewed journal.

5. RESULT

5.1 Socio Demographic & Economic Characteristic

A total of 877 high school adolescents was approached, 851 had participated resulting 97.0 % respondent rate. Twenty-six students were not included in the study for the following reasons: twenty-one students were absent on the scheduled day, five adolescents refused to remove their shoes and heavy clothes for measurement.

Table 1 shows the socio-demographic and economic characteristics of high school adolescents. The proportion of boy study participants were relatively higher than girl study participants (53.5% Vs 46.4%). More than half of study participants (56.64%) were from government schools and the rest (43.4%) were from private schools. The median age of study participants was 17 years with interquartile range of 2 years.

Table 1: Socio-demographic & economic characteristics of high school adolescents in Addis Ababa, Ethiopia, 2019

Variables	Frequency	percent
Gender		
Boy	456	53.5
Girl	395	46.4
Religion		
Orthodox	621	73.1
Muslim	108	12.8
Protestant	104	12.2
Catholic	12	1.4
Other	5	0.6
Father's educational status		
No formal education	104	12.3
Primary school	130	15.3

Secondary school	271	31.9
Technical school and above	344	40.5
Mother's educational status		
No formal education	145	17.1
Primary school	180	21.2
Secondary school	307	36.2
Technical school and above	217	25.6
Fathers occupation		
Government or private employee	447	52.6
Merchant	260	30.6
Daily laborer	11	1.3
Unemployed	44	5.2
Other	88	10.4
Mothers occupation		
Government or private employee	290	34.2
Merchant	182	21.4
Daily laborer	7	0.8
Housewife/unemployed	357	42.1
Other	13	1.5
Student grade level		
9^{th} grade	228	26.8
10^{th} grade	226	26.6
11^{th} grade	196	23.0
12^{th} grade	201	23.6
School type /owner		
Non-governmental	369	43.4
Governmental	482	56.6

Living with		
With both parents	580	68.3
With mother/ father only	127	15.0
With brothers/sisters	20	2.4
With relatives	84	9.9
Other	38	4.5
Family size		
< 5	453	53.2
≥ 5	398	46.8
Wealth quintile		
Poorest	171	20.1
Poor	170	20.0
Medium	170	20.0
Wealthy	170	20.0
Wealthiest	170	20.0

5.2 Nutritional Status of Adolescents

Figure 2 shows BMI-for-age z-score categories of high school adolescents. The overall prevalence of overweight and obesity was 14.5% (95% CI; 12.2% - 17.0 %), with 11.2 % (95% CI; 9.2-13.5%) overweight and 3.3% (95% CI; 2.3 – 4.7) obese. The prevalence of underweight was 9.5 % (95% CI; 7.7% - 11.7%).

Prevalence of stunting among adolescents was 7.9% (95% CI; 6.2% - 9.9 %). About 8.6% (95% CI; 6.3 – 11.5) of boys and 7.1 % (95% CI; 4.9 – 10.1) of girls were stunted.

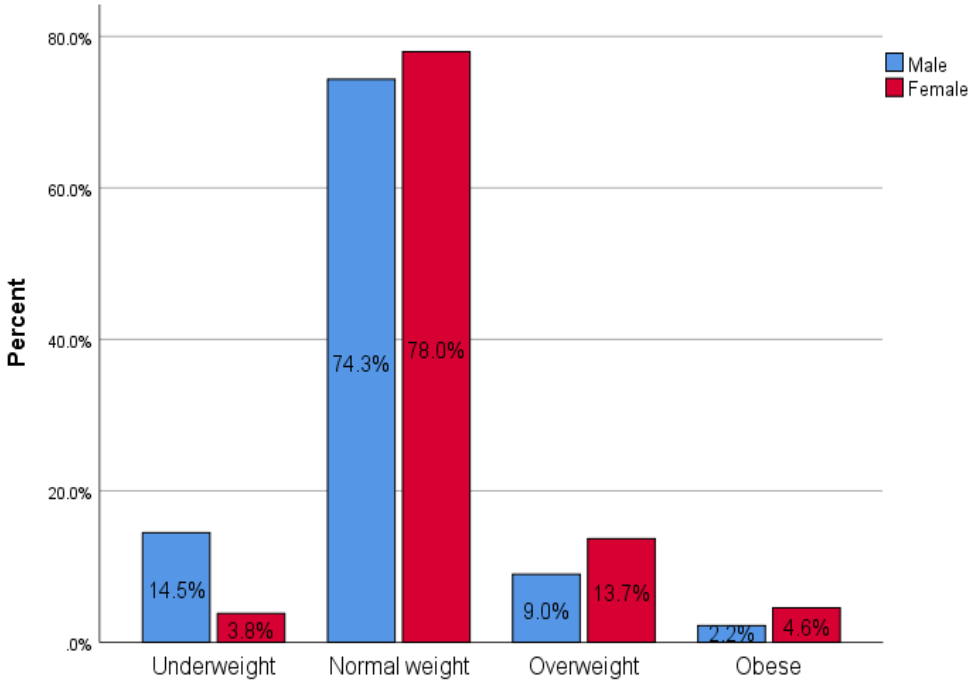

Figure 2: BMI-for-age z-score categories of high school adolescents in Addis Ababa, Ethiopia, 2019

5.3 BMI-for-age z-score and MUAC Compared by Gender

Table 2 Shows comparison of BMI-for-age z-score and MUAC of high school study participants compared by gender. The mean of MUAC and BMI-for-age z-score were significantly different between boy and girl study participants.

Table 2: Comparison of BMI-for-age z-score and MUAC of high school adolescents according to gender, Addis Ababa, 2019

	Boy (n =456)	**Girl (n = 395)**		
Variables	**Mean (**± [1]SD**)**	**Mean (**±SD**)**	***P*-values**	**t -values**
BMI z-score	- 0.8 (1.2)	-0.05 (1.1)	<0.001	-8.86
MUAC (cm)	25.3 (3.2)	25.7 (3.4)	0.038	-2.09

[1]SD: Standard deviation

Table 3 Shows comparison of obesity, overweight, normal weight, thinness and severe thinness compared by gender. The prevalence of underweight and overweight were significantly different between boys and girls.

Table 3: Comparison of obesity, overweight, normal weight and underweight of high school adolescents by gender, Addis Ababa, 2019

	Boy (n =456)	**Girl (n = 395)**	
Nutritional status	**Frequency (%)**	**Frequency (%)**	***P*-values**
Obesity	10 (2.2)	18 (4.5)	0.054
Overweight	41 (9.0)	54 (13.7)	0.031
Normal weight	339 (74.3)	308 (77.8)	0.216
Underweight	66 (7.76)	15 (1.76)	< 0.001

Comparison of nutritional status by genders was done using chi squared test

5.4 Test-retest reliability of MUAC

Table 4 shows the test-retest reliability of mid upper arm circumference among adolescents as assessed by paired t test. No significant mean difference was found between the first MUAC measurement and second MUAC measurement ($p = 0.78$).

Table 4: The Test-retest reliability of mid upper arm circumference among high school adolescents, Addis Ababa,2019

Age	MUAC 1st Mean (± [1]SD)	MUAC 2nd Mean (±SD)	P-values	t -values
15	24.7 (3.4)	24.7 (3.5)	0.872	-0.16
16	25.1 (3.3)	25.2 (3.3)	0.919	-0.10
17	25.3 (2.9)	25.4 (2.9)	0.853	-0.1851
18	25.9 (3.2)	25.9 (3.2)	0.922	-0.0980
19	26.1(3.2)	26.2 (3.1)	0.925	-0.0935
Total	25.4 (3.2)	25.4 (3.2)	0.78	-0.27

5. 5 Relationship between MUAC and Other Anthropometric Characteristics

Table 4 shows the correlation between MUAC, age in years and BMI z-score. Seventy percent of variation in BMI z-score is accounted for by the variation in their mid-upper arm circumference. However, only 1.44 % variation in mid upper arm circumference is accounted by variation in age in year.

Table 5: Correlation between MUAC, age in year and BMI for age z-score among high school adolescents, Addis Ababa,2019

	Mid upper arm circumference	
Characteristic	**r**	**95 % CI**
Age in years	0.12 *	(0.06,0.19)
[2]BMI z-score	0.84 *	(0.82,0.86)

[1]BMI: body mass index [2] BMI z-score: body mass index for age z-score *$P < 0.05$

5.6 Ability of MUAC to Classify Overweight Including Obesity Defined by BMI- for-age z-score

Table 5 shows area under the curve (AUC) of mid upper arm circumference for identifying overweight/obesity among adolescents. MUAC has excellent ability in identifying BMI-for-age z-score defined overweight and obesity for both genders (AUC = 0.96).

Table 6: Area under the curve (AUC) of mid-upper arm circumference for identifying overweight/obesity among high school adolescents, Addis Ababa,2019.

Gender	Observation	[1]AUC	[2]SE	95% [3]CI
Boy	456	0.96	0.01	(0.93, 0.98)
Girl	395	0.96	0.01	(0.94, 0.98)
Total	851	0.96	0.01	(0.94, 0.97)

[1]AUC: Area Under Roc Curve [2]SE: Standard error [3] CI: Confidence interval

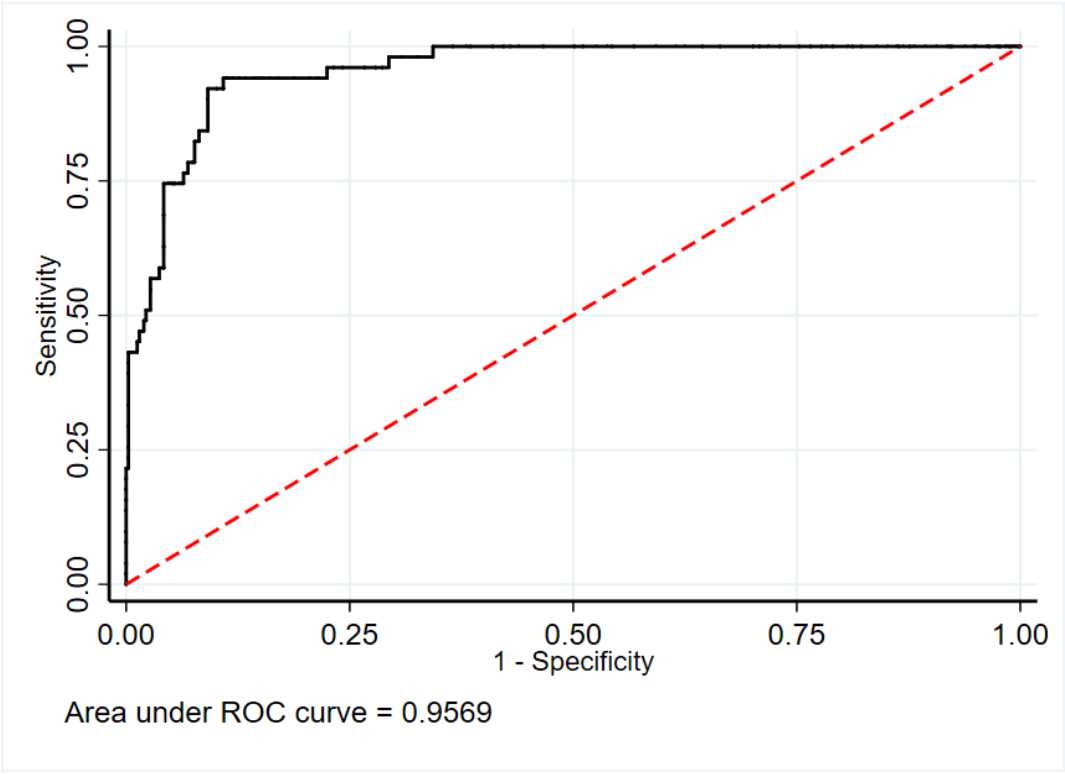

Figure 3: ROC curve showing ability of MUAC to classify overweight including obesity in high school adolescent boys, Addis Ababa,2019

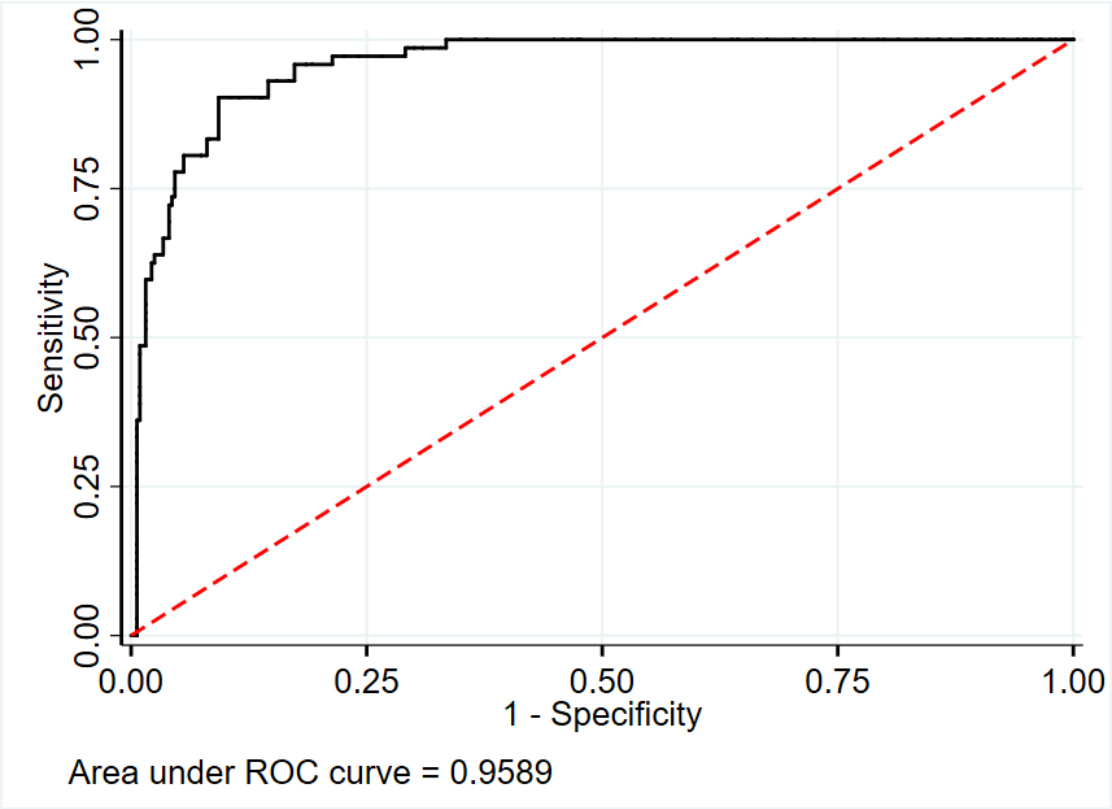

Figure 4: ROC curve showing ability of MUAC to classify overweight including obesity in high school adolescent boys, Addis Ababa,2019

Table 6 shows the sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, correctly classified, Youden index and cutoff points of mid upper arm circumference for identifying overweight and obesity among adolescents. The cut-off values of MUAC to identify overweight and obesity among boys and girls were nearly similar (27.75 cm Vs 27.9 cm). Based on the proposed cutoff points high sensitivity, specificity and negative predictive value were found for both genders. However, low positive predictive value has been found for both genders (52.2% ,68.4%).

Table 7: Sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, correctly classified, Youden index and Cutoff points of mid-upper-arm circumference for detecting overweight including obesity among high school adolescents, Addis Ababa,2019

Gender	Sensitivity (%) 95% CI[1]	Specificity (%) 95% CI	PPV[2] (%) 95% CI	NPV[3] (%) 95% CI	PLR[4] 95% CI	NLR[5] 95% CI	Correctly classified (%)	Youden index	Cut off point (cm)
Boys	94.1 (83.8,98.8)	89.1 (85.7,92)	52.2 (45,59.3)	99.2 (97.6, 99.7)	8.7 (6.5,11.5)	0.07 (0.0,0.2)	89.7	0.83	≥ 27.75
Girls	90.28 (81,96)	90.71 (87 ,93.6)	68.4 (60.4,75.4)	97.7 (95.4, 98.8)	9.7 (6.9,13.8)	0.11 (0.1,0.2)	90.6	0.81	≥ 27.9
Total	91.06 (84.6 ,95.5)	90.25 (87.9,92.3)	61.7 (56.2,66.9)	98.3 (97.1, 99)	9.3 (7.4,11.7)	0.10 (0.1,0.2)	90.4	0.81	≥ 27.95

[1] CI: Confidence interval

[2] PPV: Positive predictive value

[3] NLR: Negative predictive value

[4] PLR: Positive likelihood ratio

[5] NLR: Negative likelihood ratio

5.7 ROC Regression

Table 7 shows ROC regression results factors that affect the ability of MUAC to identify overweight including obesity among adolescents. In the ROC regression analysis, age significantly affect the ability of MUAC to detect overweight and obesity among adolescents (β= 0.461 *P* <0.001). In addition, gender of respondent has significant effect on the ability of MUAC to detect overweight and obesity among adolescents. MUAC is a more accurate screening tool for detecting overweight/obesity in girls than in boys (β= -0.74, *P* <0.001).

Table 8: ROC regression showing factors that affect the ability of MUAC to identify overweight and obesity among high school adolescent, Addis Ababa,2019

variable	**Coefficient (β)**	**Robust SE[1]**	**[2]t**	***P* value**	**95% CI[3]**
Age in Years	0.46	0.08	5.51	0.000	(0.30,0.63)
Gender (ref = male)	-0.74	0.24	-3.05	0.002	(-1.21, -0.26)
Height	0.05	0.01	3.35	0.001	(0.02,0.07)
Constant	9.63	2.37	4.06	0.000	(4.97, 14.29)

Gender (girls = 0, boys = 1)

[1]SE: Standard error adjusted for complex design

[2] t: t-statistics

[3]CI: Confidence intervals

*p < 0.05

5.8 ROC Regression Postestimation

Table 9 and 10 shows the result of ROC regression post estimation: Covariate specific area under curve for boys and girls. The ability of MUAC to identify overweight and obesity was highest for 15 and 19 years old girls. However, the ability of MUAC to identify overweight and obesity was relatively low for 16 years old girls.

Table 9: ROC Regression Postestimation: Covariate-specific Area Under Curves (AUC) showing ability of MUAC to classify overweight and obesity among high school adolescent boys, Addis Ababa,2019

Covariates	**AUC[1]**	**SE[2]**	**95% CI[3]**
Age in Years			
15	0.99	0.1	(0.97, 1.00)
16	0.97	0.01	(0.94, 1.00)
17	0.95	0.04	(0.88, 1.00)
18	0.94	0.02	(0.90, 0.98)
19	0.94	0.06	(0.83, 1.00)

[1]SE: Standard error [2]AUC: Area Under Roc Curve [3] CI: Confidence interval

Table 10: ROC Regression Postestimation: Covariate-specific Area Under Curves (AUC) showing ability of MUAC to classify overweight and obesity among high school adolescent girls, Addis Ababa,2019

Covariates	**AUC[1]**	**SE[2]**	**95% CI[3]**
Age in Years			
15	1.00	0.00	(0.99, 1.00)
16	0.93	0.02	(0.88, 0.99)
17	0.94	0.03	(0.89, 0.99)
18	0.96	0.02	(0.92, 1.00)
19	1.00	0.00	(1.00, 1.00)

[1]SE: Standard error [2]AUC: Area Under Roc Curve [3] CI: Confidence interval

5.9 Ability of MUAC to Classify Underweight Defined by BMI- for-age z-score

Table 11 shows area under the curve (AUC) of mid upper arm circumference for identifying underweight among adolescents. MUAC has excellent ability in identifying BMI-for-age z-score defined underweight for both genders (AUC = 0.96).

Table 11: Area under the curve (AUC) of mid-upper arm circumference for identifying underweight among high school adolescents, Addis Ababa,2019.

Gender	Observation	[1]AUC	[2]SE	95% [3]CI
Boy	456	0.90	0.02	(0.86, 0.93)
Girl	395	0.97	0.01	(0.95, 0.99)
Total	851	0.91	0.01	(0.88, 0.9)

[1]AUC: Area Under Roc Curve [2]SE: Standard error [3] CI: Confidence interval

Table 12 shows the sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, correctly classified, Youden index and cutoff points of mid upper arm circumference for identifying underweight among adolescents. Based on the proposed cutoff points high sensitivity, specificity and negative predictive value were found for both genders.

Table 12: Sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, correctly classified, Youden index and Cutoff points of mid-upper-arm circumference for detecting underweight among high school adolescents, Addis Ababa,2019

Gender	Sensitivity (%) 95% CI[1]	Specificity (%) 95% CI	PPV[2] (%) 95% CI	NPV[3] (%) 95% CI	PLR[4] 95% CI	NLR[5] 95% CI	Correctly classified (%)	Youden index	Cut off point (cm)
Boys	87.9 (77.5,94.6)	75.9 (71.3, 80.1)	38 (33.5, 42.8	97.4 (95.1, 98.6)	3.65 (2.99, 4.44)	0.16 (0.0832,0.307)	87.1	0.638	< 23.65
Girls	100 (78.2, 100)	88.2 (84.5, 91.2)	25.1 (20.3, 30.6)	100 (0,0)	8.44 (6.42, 11.1)	0 (0,0)	89.6	0.882	< 22.55
Total	84 (74.1, 91.2)	81.6 (78.6, 84.2)	32.4 (28.6, 36.4)	98 (96.7, 98.8)	4.55 (3.82, 5.43)	0.197 (0.119,0.324)	82.1	0.655	< 23.25

[1] CI: Confidence interval

[2] PPV: Positive predictive value

[3] NLR: Negative predictive value

[4] PLR: Positive likelihood ratio

[5] NLR: Negative likelihood ratio

6. DISCUSSION

The aim of this study was to evaluate the ability of MUAC to detect BMI-for-age z-score defined overweigh and obesity in late adolescents. Findings from this study revealed that MUAC has high discriminatory ability in detecting overweight and obesity (BMI-for-age Z-score defined) in adolescents age 15 – 19 years. Area under the curve of 0.96 is consistent with robust diagnostic performance. The other major finding of the study was MUAC ≥ 27.9 cm was optimal cutoff point to detect overweight and obesity among girls, with sensitivity of 90.28% and specificity of 90.71%. Similarly, MUAC ≥ 27.75 cm was optimal cutoff point to detect overweight and obesity among boys, with sensitivity of 94.1%, specificity of 89.1%.

This study shows that, the prevalence of overweight among adolescents was 11.1 % and that of obesity was 3.3% based on BMI for age Z score classification. This finding was nearly similar with the result of a study conducted in Addis Ababa found 9.7 % and 4.2 % prevalence of overweight and obesity among high school adolescents (33). However, it was lower than that of developed countries (7, 84). One of the possible reasons for the difference in prevalence of overweight and obesity could be cultural difference in dietary intake, physical activity level and difference in socioeconomic status. Sex specific prevalence of overweight and obesity shows 5.99 % and 8.46 % of boy and girls respectively. Girl participants were 4.6 % and 3.7 % overweight and obese respectively. High prevalence of overweight is recorded in girls. This can be attributed to hormonal changes at puberty leading to fat accumulation, as well as negative attitudes toward girls participation in outdoor activities due to certain cultural restrictions (85).

The major finding of this study was MUAC have excellent diagnostic accuracy. The areas under curve 0.957 and 0.959 for boys and girls respectively are consistent with robust diagnostic performance and indicated that measurement of MUAC has an excellent ability to identify adolescents with or without elevated BMI-for-age z-score. Results of this study are consistent with previous studies done in Thailand reported an area under the curve of 0.98 and 0.98 for boys and girls respectively (22). Studies done in china also have area under the curve values range between 0.93 and 0.98 for MUAC predicting overweight/obesity (26). Similar study done among black South African children and adolescents showed area under the curve values between 0.97 and 0.98 for MUAC predicting overweight/obesity (17). However, studies done in Pakistan showed fair ability (AUC= 0.88) to identify adolescents with or without

elevated BMI-for-age Z-score. This difference may be due to the difference in age groups included this study. Another possible explanation might be because of the difference in body size body fat distribution according to race (86).

The other major finding of this study is MUAC with optimal cut off point has high sensitivity and specificity for both boys and girls. This finding is consistent with studies done including early adolescents shows sensitivity 90 % – 100 % and specificity 89.9 % - 100 % (17, 22, 27). The relative importance of sensitivity and specificity will depend on the particular application (87), for example, a clinical diagnostic tool has to have high specificity in order to avoid diagnosing the non-overweight/obese as overweight/obese and offering treatment unnecessarily. However, when the results are to be used for a public health application such as prevalence estimation arguably a high sensitivity is more important, to avoid underestimation of prevalence (88). The percentages of correctly classified adolescents using the proposed cut of points range from 91.01% and 90.63% for boys and girles respectively. This finding is in line with similar studies done among early adolescents 80.3% - 98.6 % (17, 22).

MUAC has a positive likelihood ratio 9.3 for a total sample; this means that an adolescent with overweight/obesity is 9.3 times more likely to have MUAC ≥ 27.95 cm than an adolescent without overweight/obesity (BMI-for-age z-score defined). MUAC has negative likelihood ratio of 0.10 for a total sample; this implies that an adolescent without overweight/obesity is about 10 folds more likely to have MUAC less than 27.95 cm than an adolescent without overweight /obesity (BMI-for-age z-score defined). This indicates that MUAC is good indicator for ruling in and ruling out overweight and obesity among adolescents. These findings are consistent to studies done among early adolescents (16, 17, 22). However, study done in India has found much higher positive likelihood ratio (PLR = 36) (22). This might be due to the difference in magnitude of obese adolescents since likelihood ratio is greatly depend on spectrum of disease or condition in this case the degree of obesity.

MUAC has negative predictive value of 98.3 % for the total sample; this means that among adolescent with MUAC < 27.95 cm the probability for being non-overweight/obese (BMI-for-age z-score defined) was 0.98. MUAC has positive predictive value of 61.7% for a total sample; this indicates that among adolescent with MUAC ≥ 27.95 the probability of being overweight/obese (BMI-for-age z-score defined) was 0.61. Similar findings have been reported by study done on 6-8 years children (89). High negative predictive value might not tell the

accuracy of the test. It is more important for expert to estimate what is the probability of not being overweight/obese if an adolescent that MUAC value below optimal cutoff point. This low positive predictive value and high negative predictive values might be due to the relatively low prevalence of overweight and obesity among adolescents. Predictive values are largely dependent on the prevalence of condition in the population. Positive predictive tends to decrease, while negative predictive value increases with the decrease in the prevalence of the disease/condition in a population (90). Therefore, predictive values from one study should not be transferred to some other setting with a different prevalence of the disease in the population (91).

In this study a MUAC of ≥ 27.75cm, ≥ 27.9 cm for boys and girls respectively was found to be the optimum cutoff point to identify late adolescents with overweight and obesity. The potentially optimal MUAC cut-offs to identify overweight are proposed: at ages 10–14 years, 22.5 cm/22.8 cm and 22.2 cm/23.2 cm for girls and boys, respectively (17). The potential optimum cutoff point for identifying obesity by study done in Thailand report 25.5 cm for boys and 25.4 cm for girls (16). However, cutoff points determined by this study are higher than previous studies determine among early adolescents (10-14 years) (22, 23). This might be due to difference in age group of adolescents included in previous studies (17, 22, 23, 26). Since mid-upper arm circumference increase with the age; late adolescent's MUAC is expected to be higher than that of early adolescent's, this might result higher cutoff point in late adolescents.

Studies done on school age children and early adolescents have proposed age and gender specific cutoff point due to moderate to strong positive correlation between MUAC with age (23, 26). In this study MUAC had weak positive correlation with age. In addition, age of adolescents and gender significantly affect the ability of MUAC to identify overweight and obesity. Therefore, this study proposes age and sex specific cutoff points. However due to relatively small samples size it's was not possible determine age and sex specific cutoff points and calculate measures of diagnostic measure of accuracy.

An ideal screening method for adolescent overweight and obesity should be simple, inexpensive, easy to use, and acceptable to the participants (26). While evaluating the overweight and obesity index, MUAC has several key advantages: it is easy to use, less expensive, only a measuring tape is required, the measurements can be easily done in community and health facilities and can be easily understood by clinicians and families.

7. STRENGTH AND LIMITATION OF THE STUDY

7.1 Strength

The strengths of this study were; First, this research study tried to address an important public health concern of adolescents. Second, weight scale and stadiometer were regularly calibrated this helps to minimize measurement errors. In addition, data collectors were trained on anthropometric measurement and technical error measurements (TEM) were performed and ensured its within acceptable range. This will help to minimize measurement errors and ensure the validity and precision of measurements.

7.2 Limitation

The following limitation need to be considered while interpreting the above findings. The first limitation of this study is the lack of available superior standard (bioelectrical impendency, dual energy x-ray absorptiometry or underwater body weighing) for percentage body fat to compare with, besides BMI-for-age z-score. BMI z-score may not perfectly identify adolescents with overweight and obesity. The second limitation of the study is due to relatively small sample size we didn't determine age and sex specific cutoff points and measure of diagnostic accuracy. The third limitation of the study is that, it's done in specific population with specific geographic area. Since body fat distribution and body size varies significantly throughout different geographic locations. The finding from study done in single geographic location may not apply to other settings.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

In conclusion, MUAC has excellent ability in detecting overweight and obesity in late adolescents. MUAC have high specificity and sensitivity to identify overweight/obese among late adolescences as evaluated against body mass index z-score. The optimal mid upper arm circumference cut off points to identify overweight/obesity were: ≥ 27.9 cm for girls and ≥ 27.75 cm for boys.

7.2 Recommendations

For policy makers and programmers

Policy makers and programmers shall consider to use MUAC for public health surveillance of overweight and obesity among adolescent. In addition, MUAC might be used to perform school-based screening of overweight and obesity in adolescents to address adolescents who benefit from nutritional education and obesity management programs.

The Ethiopian National nutritional II program (NNP) plan periodic nutritional screening and counseling of students for early identification of obesity and overweight at school. Even though NNP doesn't specify with what method nutritional screening is performed. The NNP II should consider to use MUAC as screening tool among adolescents to detect overweight/obesity to utilize for school-based screening and counseling program.

For researchers

Further nationwide study assessing the diagnostic performance of MUAC in identify overweight/obesity using skinfold, waist circumference measurement in addition to BMI for age, with adequate sample size for each specific age and sex group.

Further study should also relate MUAC to functional outcome, i.e. the developments of comorbidity associate with overweight and obesity such as type 2 diabetes and cardiovascular disease presence of their risk factor.

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10. ANNEX

Annex 1 Study Informed Sheet in English

Addis Ababa University, School of public health

Subject Information Sheet

Hello,

My name is_____ I am here on behalf of Binyam Girma, a student in Addis Ababa University School of public health nutrition unit. He is conducting a research on "Mid-upper arm circumference as a screening tool for identifying overweight and obesity among adolescents in Addis Ababa, Ethiopia". He has received permission from Addis Ababa university school of public health and the respected sub city education bureau to conduct this study.

You are selected randomly to participate in this study because you are currently attending in one of those selected high schools for the study purpose. Your participation in this study will only be on based on your -willingness. You have the right to choose not to take part in this study. If you choose to take part, you have the right to stop at any time. If you are willing to participate or refuse or decide to withdraw later, you will not be subjected to any ill-treatment.

If you agree to participate in the study, your weight, height and mid-upper arm circumference will be measured. Only light closes will be wearing during weight measurement and height will be measured with barefoot. You will also be interviewed about background information. You can stop at any time if you don't feel comfortable during an interview and measurement process. The measurement and filling the questionnaire will take about 20 minutes.

The study will provide evidence on ability of mid upper arm circumference as measure of overweight and obesity. That can be used to inform governmental, non-governmental organizations and clinical practitioners to adopt mid-upper arm circumference as a measure of overweight and obesity among adolescents. The information that you provide will be kept confidential by using only code numbers and locking the data. Your name will not be written on the questionnaire. No one will have access to the non-coded data except the principal investigator and the data will not be used for purposes other than the study. Your willingness and active participation is very important for the success of this study.

Annex 2 Informed Consent and/or Ascent Form

Based on the understanding of the above information, are you willing to participate in this study?

A) Yes

B) No

If yes, I will continue and

If no, I will skip to next participant after writing the reasons of refusal ——————————

_____

Respondent (For both under and above 18 years old)

Signature _____Date_____

Respondents Parent (for those under 18 years old)

Signature _____Date_____

Name of the person obtaining parental permission ——————————————

Data collector

Name_____ Signature_____

Questionnaires ID number_____

Date of data collected_____

Result of data collected

A) Completed

B) Not completed

C) Partially completed

D) Refused

Checked by Supervisor: Name _____Signature_____

For further explanation, use the Principal Investigator's Address;

Name: Binyam Girma Sisay

Email: Binyamgirma3@gmail.com Cell phone: +251 912845957

Annex 3 English Version Questionnaire

Addis Ababa University School of Public Health

Survey Questionnaire to assess Mid-upper arm circumference as a screening tool for identifying overweight and obesity in adolescents Addis Ababa, Ethiopia

Name of school_____

Respondent's grade/ no _____

Date of data collection ____/_____/_____

Data collector Name ———————— Signature ————————

Checked by Supervisor Name ———————— Signature ————————

Part1. Sociodemographic information

Instruction: Now I am going ask you questions regarding sociodemographic characteristics.

No.	Questions	Responses	Skip
101	Age of respondent	☐☐ Years	
102	Birth day of respondent?	Date ☐☐ Don't know the Date …...99 Month ☐☐ Don't know the Month…99 Year ☐☐☐☐ Don't know the Year…...9999	
103	Sex of respondent?	Female……1 Male …….....2	
104	What grade are you now?	☐☐	
105	What is your school type?	Government/public ……..1 Private/community/ missionary …..2	
106	What is your religion?	Orthodox……..1 Catholic……...2 Protestant…….……3 Muslim……4 Other (Specify)_____99	
107	How much is your household family size including you?	☐☐	
108	What is your father's educational Status?	Illiterate (can't read and write) ….……1 Read and write only…….……2 Primary school (grade 1-8) …….3 Secondary school (grade 9-12) ……4 Some college or technical school……5 College graduate or above……6 I don't know……7 Father is not alive……...8 → 110	
109	What is your father's / guardian occupation?	Government/private employee……..1 Merchant……...2 Daily laborer……..... 3 Unemployed……..... 4 I don't know……..5 Other (specify)……..99	

110	What is your mother's educational Status?	Illiterate (can't read and write) ……..…….1 Read and write only……2 Primary school (grade 1-8) …….3 Secondary school (grade 9-12) ……...4 Some college or technical school……5 College graduate or above……..6 I don't know……7 Mother is not alive……...….8	→ 112
111	What is your mother's / guardian occupation?	Government/private employee……..1 Merchant…….....2 Daily laborer…….....3 Housewife/unemployed …….....4 I don't know……5 Other (specify)_____99	
112	With whom do you live now?	With both of my parents……1 With my mother only…….2 With my father only……...3 With brothers/sisters…….....4 With grandparents……..5 With cousins……..6 With mother/father and a Stepfather/stepmother……7 With my friends……8 Others (specify) _____.99	

Part2. Household socio-economic status (Wealth Index)

Instruction: Now I am going to ask you about your household assets, services and housing conditions. please circle your possible answer within the response box.

No.	Questions	**Responses**	**Skip**
1. Housing Condition – please answer the following questions thinking about the housing condition of your household and circle your possible answer. S			
201	Home ownership	Private……..……1 Government……..……2 Rent……..…3 Other (specify) ——……99	
202	Number of rooms	☐☐	
203	Number of sleeping room	☐☐	

204	Main construction material used for the roof: CIRCLE ALL THAT APPLY	**Natural roof** Thatch/mud…..…….....……1 **Rudimentary roof** Rustic mat/ plastic sheet…….……..……2 Reed/bamboo ...……...…….……..……...3 Wood planks...……...4 Cardboard ...…….……...…….……5 **Finished roof** Metal/corrugated iron...……..…….……6 Wood ...…….…….....7 Cement ...…….…….....8 Ceramic tiles ...……..……...9 Other(specify): _____99	
205	Main construction material used for the floor: CIRCLE ALL THAT APPLY	**Natural floor** Earth/sand……1 Dung…….……2 **Rudimentary floor** Wood planks…….……...3 Palm/bamboo…….....4 **Finished floor** parquet or polished wood……5 vinyl or asphalt strips/plastic tile…….....6 Ceramic Tiles……..7 Cement……...……..……8 Carpet…….…….…….……..9 Other(specify):_____99	
206	Main construction material used for exterior walls: CIRCLE ALL THAT APPLY	**Natural walls** No walls .....1 Cane/Trunks/Bamboo/Reed .....2 **Rudimentary walls** Wood with Mud ..... 3 Stone with mud .....……...4 **Finished walls** Cement…….……5 Stone with lime/cement ..... 6 Bricks .....7 Cement blocks……..8 Wood planks/shingles ..... .9 Other(specify)_____99	
207	What kind of toilet facility does your household have? [INTERVIEWER: LIMIT TO ONE RESPONSE; IF TWO TYPES ARE	Pour flush toilet…….....……..1 Ventilated improved pit latrine...…….…..2 Pit latrine with slab…….……..….....3 Pit latrine without slab…….…….……...4 No latrine…….....0 Other (specify): _____99	

	MENTIONED, RECORD THE TYPE CLOSEST TO THE TOP OF THE LIST]		
208	Does the household have its own water source within the compound? (Multiple Response is possible)	Yes, unprotected well……....……1 Yes, protected well…….……2 Yes, pipe water …….……..3 No …….....0	
209	What is the main source of drinking water for members of your household? (Do not read the options, just ask and circle what they told you)	Piped water .....1 Protected well .....2 Unprotected well .....3 Protected spring ..... 4 Unprotected spring ..... 5 Surface water (River/stream/ Pond/lake//Dam) ..... 6 Tanker .....7 Bottled water ..... 8 Other (specify) _____9	
2. Household assets & services – In answering the questions below please think of assets & services available in your household			
210	Does your house hold have?		
	Electricity	Yes……..……1 No…….2	
	Radio	Yes……..……1 No…….2	
	television	Yes……..……1 No…….2	
	non-mobile telephone	Yes……..……1 No…….2	
	computer	Yes……..……1 No…….2	
	refrigerator	Yes……..……1 No…….2	
	Table	Yes……..……1 No…….2	
	Chair	Yes……..……1 No…….2	
	A bed with cotton/ Sponge/ spring mattres	Yes……..……1 No…….2	
	Electric mitad	Yes……..……1 No…….2	
	A kerosene lamp/pressure lamp	Yes……..……1 No…….2	
	Solar	Yes……..……1 No…….2	

	Sofa	Yes……..…….1 No…….2	
211	Do any members of this household own?		
	A watch?	Yes……..…….1 No…….2	
	A mobile phone?	Yes……..…….1 No…….2	
	A bicycle?	Yes……..…….1 No…….2	
	A motorcycle?	Yes……..…….1 No…….2	
	A car or truck?	Yes……..…….1 No…….2	
	A bajaj	Yes……..…….1 No…….2	
212	What type of fuel does your household mainly use for cooking? (Multiple Response is possible)	Electricity……..…….1 Biogas…….2 Kerosene…….3 Wood……..4 Charcoal……..5 Straw/shrubs/grass……..6 Animal Dung……..7 Agricultural crop……8 Other (specify): _____99	
213	Does any members of this household have a bank/microfinance account?	Yes……..…….1 No…….2	

Part 3. Anthropometric measurements

Instruction: Now I am going to measure your weight, height and mid upper arm circumference. Can you please remove your shoes and heavy cloths for height and weight measurement?

NO	Anthropometric measurement	1st measurement	2nd measurement
301	Weight in kilograms	☐☐☐.☐	☐☐☐.☐
302	Height in centimeters	☐☐☐.☐	☐☐☐.☐
303	MUAC in centimeters	☐☐☐.☐	☐☐☐ ☐

Thank you very much

Annex 4 Study Information Sheet in Amharic

አዲስ አበባ ዩኒቨርስቲ ጤና ሣይንስ ኮሌጅ የህብረተሰብ ጤና አጠባበቅ ትምህርት ክፍል

የተጠያቂው / የመላሾች የመረጃ ቅፅ

ጤና ይስጥልኝ እንደምን ነዎት ስሜ_____ይባላል፡፡ የመጣሁት ከአዲስ አበባ ዩኒቨርስቲ የህብረተሰብ ጤና አጠባበቅ የስነምግብ ትምህርት ክፍል ተማሪ የሆነውን ቢንይም ግርማ ወክዬ ነው፡፡በጉርምስና ወቅት የሚያጋጥም ከመጠን ያለፈ ውፍረትን የላይኛው የክንድ ዙሪያን በመለካት ማወቅ የሚቻልበት መንገድን ለማጥናት በአዲስ አበባ በሚገኙ የግልና የመንግስት ት/ቤቶች ላይ ጥናት እያደረገ ሲሆን ከአዲስ አበባ ዩኒቨርሲቲ እና አዲስ አበባ ት/ቢሮ እንዲሁም ከተመረጡት ትምህርት/ቤቶችም ፈቃድ አግኝቶል፡፡

እርስዎ በዚህ ጥናት ላይ እንዲሳተፉ የተመረጡት በተደጋጋሚ በተደረገ የአጋጣሚ የናሙና አወሳሰድ ስልት መሰረት ሲሆን ለዚህ ጥናት አላማ ከተመረጡት ትምህርት/ቤቶች በአንዱ ውስጥ ስለሚማሩ ነው ፡፡ በጥናቱ ላይ ያለመሳተፍ ሙሉ መብት አለዎት፡፡ የእርስዎ ተሳትፎ ሙሉ በሙሉ በእርስዎ ሙሉ ፈቃደኝነት ላይ የተመሰረተ ነው፡፡

ለመሳተፍ ፍቃደኛ ከሆኑ በኋላም በፈለጉት ጊዜ ማቋረጥ ይችላሉ፡፡ በጥናቱ ባለመሳተፎ የሚደርስቦት ምንም አይነት ችግር አይኖርም በጥናቱ ለመሳተፍ ከተስማሙ ክብደት ቁመትዎን እና የላይኛው ክንድ ዙሪያን በመሳሪያዎች እንለካለን፡፡ ክብደት እና ቁመት በሚለካበት ጊዜ ቀለል ያለ ልብሶች በመልበስ እና በባዶ እግር ይሆናሉ፡፡ በተጨማሪም የተወሰኑ ጥያቄዎችን እንጠይቆታለን፡፡ በመጠይቁ ጊዜ ጥሩ ስሜት ካልተሰማዎት በማንኛውም ጊዜ አቋርጠው መሄድ ይችላሉ፡፡ መጠይቁና የሰውነት ልኬቱ 15 ደቂቃ ይህል ይፈጃል።

ይህ ጥናት ፖሉሲ አውጪዎችና የሚመለከታቸው አካላት በጉርምስና ወቅት የሚያጋጥም ከመጠን ያለፈ ውፍረትን የላይኛው የክንድ ዙሪያን በመለካት ማወቅ የማውቂያ መንገድን እንዲጠቅሙ መነሻ ይሆናሌ የሚሌ ፅኑ እምነት አለን፡፡

በመጨረሻም ከእርስዎ የምንሰበስበው መረጃ ከስምዎ ጋር እንደማይያያዝ ስምዎ እንደማይጠቀስና ለማንም አካል ተላልፎ እንደማይሰጥ ልናረጋግጥልዎት እንወዳለን፡፡ የዚህ ጥናት ውጤት ግን ተጠርዞ እና ተዘጋጅቶ ጉዳዩ ለሚመለከታቸው የጤና ድርጅቶች ወይም ባላድርሻ አካላት ሊሰጥ ይችላል ፡፡

Annex 5 Informed Consent and/or Ascent Form

የስምምነት መጠየቂያ/ማረጋገጫ ቅፅ

ከላይ በሰጠንዎት መረጃ መሰረት በጥናቱ ላይ ለመሳተፍ ፈቃደኛነዎት?

1. አዎ

2. አይደለሁም

ፈቃደኛ ካልሆኑ ምክንያቱን ፅፈው ወደ ሚቀጥለው ተሳታፊ

እለፍ_____

የተሳታፊ ፊርማ (ከ18 አመት በላይ ለሆኑ ልጆች) ፉርማ_____ቀን_____

የተሳታፊ ቤተሰብ ፊርማ (ከ18 አመት በታች ለሆኑ ልጆች)

ፉርማ_____ ቀን_____

የቤተሰብ ፈቃድ ያገኘው ልጅ ስም_____

የመረጃ ሰብሳቢ ስም_____ ፉርማ_____

የመጠይቅ ቁጥር _____

መጠይቁ የተካሄደበት ቀን_____

የመጠይቁ ውጤት

1. ሙሉ በሙሉ የተሞላ

2. በከፊል የተሞላ

3. ምንም ያልተሞላ

በተቆጣጣሪ ተረጋግጧል ፡ ስም_____ፉርማ_____

ለተጨማሪ ማብራሪያ የዋና አጥኚውን አድራሻ ይጠቀሙ

ስም፡ቢኒያም ግርማ

ኢሜይል፡binyamgirma3@gmail.com

ስልክ፡+251 912845957

Annex 6 Amharic Version Questionnaire

የመጠይቁ መለያ ቁጥር_____

በአዲስ አበባ ዩኒቨርስቲ ጤና ሣይንስ ኮሎጅ የህብረተሰብ ጤና አጠባበቅ ትምህርት ክፍል በጉርምስና ወቅት የሚያጋጥም ከልክ ያለፈ ውፍረትን አጋማሽ በላይኛው ክንድ ዙሪያ በመለካት ማወቅ በሚል ርእስ ለሚከናወነው የጥናታዊ ፅሁፍ መረጃ መሰብሰቢያ መጠይቅ፡፡

የት/ቤቱ ስም _____

የተጠያቂው ክፍል/ቁጥር _____/_____

መጠይቁ የተማላበት ቀን____/____/2011

መጠይቁን ያስሞላው (ሰም) ———————— ፊርማ ————————ያረጋገጠው ተቆጣጣሪ ስም ———————— ፊርማ ————————

ክፍል1. የማህበራዊ እና የስነህዝብ የተመለከቱ ጥያቄዎች

መመሪያ **፡** አሁን የማህበራዊ እና የስነህዝብ የተመለከቱ ጥያቄዎችን እጠይቅዎታለሁ ፡፡

ተ.ቁ	ጥያቄ	መልስ	ዝለል
101	እድሜህ/ሽ ስንት ነው ?	☐☐ አመት	
102	የተወለድክበት/ሽበት ቀን ወር እና አመት?	ቀን ☐☐ ቀኑን አላውቅም ….....00 ወር ☐☐ ወሩን አላውቅም……00 አመት ☐☐☐☐ አመቱን አላውቅም……00	
103	የተሳታፊው/ዋ ጸታ ?	ወንድ……1 ሴት……..2	
104	ስንተኛ ክፍል ነህ/ሽ?	☐☐	
105	የት/ቤት አይነት	የግል/የሚሲዮን/የሀይማኖት ተቋም…….…..1 የመንግስት/የህዝብ……...2	
106	ሀይማኖትህ/ሽ ምንድን ነዉ?	አርቶዶክስ ክርስትና……...1 ካቶሊክ…….…….2 ፕሮቴስታንት…….…….…3 እስልምና…….……4 ሌላ (ይገለፅ) _____99	

107	በምትኖሩበት ቤት ውስጥ አንቺን/ተን ጨምሮ የቤተሰብ ብዛት ስንት ነው?	☐☐	
108	የወላጅ አባት/ጠባቂህ/ሽ የደረሱበት ከፍተኛ የትመህርት ደረጃ ምንድን ነው?	ማንበብና መፃፍ የማይችል ……..1 ማንበብና መፃፍ የሚችል…….2 አንደኛ ደረጃ (1-8) ……...3 ሁለተኛ ደረጃ (9-12) ……..……..4 ኮሌጅ/ቴክኒክ……5 ዩኒቨርስቲ……6 አላውቅም……..……..7 አባቴ በህይወት የለም……..…..…8 → 110	
109	የአባትዎ / ጠባቂህ/ሽ ሙያ ምንድን ነው?	የመንግስት/የግል ተቀጣሪ…….....1 ነጋዴ……...……..2 የቀን ሰራተኛ……...……3 ስራ የሌለው…….……4 ሌላ ጥቀስ_____....99	
110	የእናትዎ / ጠባቂህ/ሽ የደረሱበት ከፈተኛ የትመህርት ደረጃ ምንድን ነው?	ማንበብና መፃፍ የማትችል……..…1 ማንበብና መፃፍ የምትችል……..……..2 አንደኛ ደረጃ (1-8) ……...……...3 ሁለተኛ ደረጃ (9-12) …….....……4 ኮሌጅ/ቴክኒክ…….....5 ዩኒቨርስቲ…….....6 አላውቅም……..……7 እናቴ በህይወት የለችም……..……..……..……8 → 112	
111	የእናትዎ / ጠባቂህ/ሽ ሙያ ምንድን ነው?	የመንግስት/የግል ተቀጣሪ……1 ነጋዴ……2 የቀን ሰራተኛ……3 የቤት እመቤት……..4 ሌላ ጥቀስ_____.....99	
112	ከማን ጋር ነው የምትኖረው/ሪው?	ከእናትና ከአባቴ ጋር……..……1 ከእናቴ ጋር ብቻ……...……2 ከአባቴ ጋር ብቻ……3 ከእህቶቼ/ወንድሞቼ ጋር…….……4 ከአያቶቼ ጋር……5	

		ከአክስቴ/አጎቴ ሌጆች ጋር……6 ከእናቴና ከእንጀራ አባቴ ወይም ከጓደኞቼ ጋር……...…8 ከአባቴ እና ከእንጀራ እናቴ……..7 ሌላ ካለ ይገለፅ _____.....99	

ክፊሌ2. የቤተሰብን የሀብት ደረጃ የተመለከቱ ጥያቄዎች

ማሳሰቢያ፡ የሚቀጥሉት ጥያቄዎች የሚኖሩበት ቤት ውስጥ ስለሚገኙ ንብረቶችና የቤት አሰራር ሁኔታ ይመለከታል፡፡

1. የቤት አሰራር ሁኔታ፡- እባክዎ የሚቀጥሉትን ጥያቄዎች ስለሚኖሩበት ቤት አሰራርና ሁኔታ እያሰቡ ይመልሱ			
ተ.ቁ	ጥያቄ	መልስ	ዝለል
201	የሚኖሩበት ቤት ባለቤትነቱ የማን ነው?	የግል……1 የመንግስት (የቀበሌ)…..……..…….2 ከግለሰብ ኪራይ…..……..…….....3 ሌላ ካለ ይገለፅ_____99	
202	የሚኖሩበት ቤት ስንት ክፍል አለው ?	☐☐	
203	በቤትዎ ውስጥ ስንት የመኝታ ክፍል አለ ?	☐☐	
204	የሚኖሩበት ቤት ጣሪያው ምንድን ነው?	**<u>ተፈጥሮ ጣሪያ</u>** ሳር/ጭቃ……..1 **<u>በቅጡ ያልተጠናቀቀ ጣሪያ</u>** ፕላስቲክ/ሸራ …….....2 ቀርከሃ/ሸምበቆ…….....3 የእንጨት ሳንቃ/ጣዉላ…….……4 ካርቶን……....5 **<u>የተጠናቀቀ ጣሪያ</u>** ቆርቆሮ….....6 ዉብ የጣሪያ ጣዉላ…….….....7 ሲሚንቶ……..…..8 ሴራሚክ ጣሪያ…….....9 ሌላ (ይገለፅ)_____.....99	
205	የሚኖሩበት ቤት ወለሉ ምንድን ነው?	**<u>የተፈጥሮ ወለል</u>** አፈር/አሸዋ…….…….…1 **<u>በቅጡ ያልተጠናቀቀ ወለል</u>** ፍግ…….....2 የእንጨት ሳንቃ/ጣዉላ…….……3 ሸምበቆ ……..……..4 የተጠላለፈ ዉብ የወለል ጣዉላ…….....5 **<u>የተጠናቀቀ ወለል</u>** ፕላስቲክ ንጣፍ……..…….……6 በሴራሚክ ንጣፍ ……..……7 ሲሚንቶ……..……8	

		ስጋጃ ምንጣፍ……..……..9 ሌላ (ይገለፅ)_____99	
206	የቤቱ የዉጨኛዉ ግድግዳ በዋነኛነት ከምንድነው የተሰራው?	**<u>የተፈጥሮ ግድግዳ</u>** የሌለዉ……..1 አገዳ/ግንድ/ሸምበቆ…….....2 **<u>በቅጡ ያልተጠናቀቀ ግድግዳ</u>** እንጨትና ጭቃ……3 ድንጋይና ጭቃ…….....4 **<u>የተጠናቀቀ ግድግዳ</u>** ሲሚንቶ……..…....5 ድንጋይና ሲሚንቶ……..….....6 የሸክላ ጡብ……..…….…7 ብሎኬት……....8 የእንጨት ሳንቃ/ጣዉላ…..…….....9 ሌላ (ይገለፅ)_____99	
207	ቤቱ ምን ዓይነት የመፀዳጃ ቤት አለዉ? (**ከአንድ በላይ መልስ ከተሰጠ ትንሽ ቁጥር የተሰጠውን ይመዝግቡ)**	በዉሀ የሚወርድ ሽንት ቤት…….....1 የአየር ማስወጫ ቱቦ ያለዉ ሽንት ቤት…….....2 ርብራብ ያለዉ ሽንት ቤት……...3 ርብራብ የሌለዉ ሽንት ቤት……....4 መፀዳጃ ቤት የለዉም…….....5 ሌላ (ይገለፅ)_____99	
208	በግቢያችሁ ዉስጥ የራሳችሁ የመጠጥ ዉሃ አለ? **(ከአንድ በላይ መመለስ ይቻላል)**	አዎ፤ያልተጠበቀ የጉድጓድ……1 አዎ፤የተጠበቀ የጉድጓድ…….……..2 አዎ፤የቧንቧ ዉሃ……....3 የለም…….....4	
209	ቤተሰቡ በዋነኛነት የመጠጥ ዉሃ የሚያገኘዉ ከምንድን ነዉ?	የቧንቧዉሃ…….....1 የተጠበቀ ጉድጓድ…….....2 ያልተጠበቀ ጉድጓድ……3 ምንጭ የተጠበቀ……4 ምንጭ ያልተጠበቀ……..5 ታንከር……7 የታሸገ ዉሃ……..……8 ሌላ(ይገለፅ)_____...99	
2. የቤት ንብረት እና አገልግልቶች ፡- እባክዎ የሚቀጥለትን ጥያቄዎች ቤትዎ ውስጥ ስለሚገኙ ንብረቶችና አገልግልቶች እያሰቡ ይመልሱ			
210	ቤተሰቡ የሚከተሉት ቁሳቁሶች አሉት?		
	የኤሌክትሪክ መብራት	አዎ……1 የለም……2	
	ሬድዮ	አዎ……1 የለም……2	

	ቴሌቪዝን	አዎ……1 የለም……2	
	የቤት ስልክ	አዎ……1 የለም……2	
	ኮምፒዉተር	አዎ……1	
	ፍሪጅ	አዎ……1 የለም……2	
	ጠረንፔዛ	አዎ……1 የለም……2	
	ወንበር	አዎ……1 የለም……2	
	አልጋ ከነፍራሹ	አዎ……1 የለም……2	
	የኤሌክትሪክ ምጣድ	አዎ……1 የለም……2	
	የኩራዝ መብራት	አዎ……1 የለም……2	
	ሶላር	አዎ……1 የለም……2	
	ሶፋ	አዎ……1 የለም……2	
211	ከቤተሰቡ አባላት ዉስጥ የሚከተሉት ቁሳቁሶች ያለዉ አለ?		
	ሰዓት	አዎ……1 የለም……2	
	የስልክ ቀፎ	አዎ……1 የለም……2	
	ብስክሌት	አዎ……1 የለም……2	
	ሞተር	አዎ……1 የለም……2	
	መኪና	አዎ……1 የለም……2	
	ባጃጅ	አዎ……1 የለም……2	
212	ቤቱ ባብዛኛዉ ለምግብ ማብሰያነት የሚጠቀመዉ ምንድን ነዉ?	የኤሌክትሪክ ኃይል……1 ባዮጋዝ……2 ናፍጣ……..3	

		እንጨት……4 ከሰል……5 ሳር……..……6 የከብት ተረፈ ምርት (ኩበት)……7 የሰብል ተረፈ ምርት (ገለባ)……..8	
213	ከቤተሰቡ አባላት ዉስጥ የቁጠባ ደብተር (የባንክ ወ.ዘ.ተ) ያለዉ አለ?	አዎ……..……...1 የለም…….....2	

ክፍል3. የሰውነት መጠን ልኬት

መመሪያ **፡** አሁን ቁመትዎ ፣ ክብደትዎ እና የላይኛው የክንድ ዙሪያ የምንለካ ይሆናል ፡፡ ስለዚህ የለበሱትን ከባድ ልብሶች እና ያደረጉትን ጫማ እንዲያወልቁ እጠይቃለሁ ፡፡

ተ.ቁ	የሰውነት መጠን ልኬት	የመጀመሪያ ልኬት	ሁለተኛ ልኬት
301	ክብደት በኪሎግራም	☐☐☐.☐	☐☐☐.☐
302	ቁመት በሴንቲሜትር	☐☐☐.☐	☐☐☐.☐
303	አጋማሽ በላይኛው ክንድ ዙሪያ በሴንቲሜትር	☐☐.☐	☐☐☐

ስለ ትብብርዎ በጣም አመሰግናለሁ

Annex 7 Technical Error of Measurement for Weight, Height and MUAC

Intra observer TEM of height data in cm (N=10)								
	Measurer: 1				Measurer: 2			
subject number	1st measurement	2nd measurement	Difference(D)	D^2	1st measurement	2nd measurement	Difference(D)	D^2
1	166.5	166.2	0.3	0.09	166.6	166.3	0.3	0.09
2	169.8	169.6	0.2	0.04	169.7	169.4	0.3	0.09
3	156.9	157.3	-0.4	0.16	157.5	157.2	0.3	0.09
4	173.5	173.2	0.3	0.09	173.6	173.2	0.4	0.16
5	154.6	154.3	0.3	0.09	153.9	154.2	-0.3	0.09
6	158.3	158	0.3	0.09	158.2	158.1	0.1	0.01
7	167.4	167.2	0.2	0.04	167.1	167.2	-0.1	0.01
8	164.8	164.6	0.2	0.04	164.9	164.7	0.2	0.04
9	160	160.3	-0.3	0.09	159.8	160.1	-0.3	0.09
10	158.8	158.5	0.3	0.09	158.7	158.4	0.3	0.09
Absolute Intra Observer TEM = 0.025 cm					Absolute Intra Observer TEM = 0.1949 cm			
Intra observer TEM [∑ ∑(mi1-mi2) sq / 2*K*Nj] = 0.198746069 Standard deviation = 1.4753 Inter observer TEM = 0.2156 cm Coefficient of reliability = 97.9 %								

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TEM of Weight data in kg (N=10)								
Measurer: 1					Measurer: 2			
subject number	1st measurement	2nd measurement	Difference(D)	D^2	1st measurement	2nd measurement	Difference(D)	D^2
1	47	47.2	-0.2	0.04	47	47.1	-0.1	0.01
2	50.5	50.4	0.1	0.01	50.6	50.4	0.2	0.04
3	40	40.2	-0.2	0.04	40	40.1	-0.1	0.01
4	49.5	49.4	0.1	0.01	49.5	49.7	-0.2	0.04
5	50.3	50.1	0.2	0.04	50	50.2	-0.2	0.04
6	59.2	59.4	-0.2	0.04	59.3	59.4	-0.1	0.01
7	53.4	53	0.4	0.16	53.4	53.3	0.1	0.01
8	60.1	59.8	0.3	0.09	60.1	60.2	-0.1	0.01
9	56.1	56.2	-0.1	0.01	56	55.9	0.1	0.01
10	48.3	48.4	-0.1	0.01	48.3	48.3	0	0
Absolute Intra Observer TEM = 0.15 kg					Absolute Intra Observer TEM = 0.095 kg			
Intra observer TEM [$\sum \sum$(mi1-mi2) sq / 2*K*Nj] = 0.1255 Standard deviation = 1.3401 Inter observer TEM = 0.2155 kg Coefficient of reliability = 97.81 %								

TEM of MUAC data in cm (N=10)								
Measurer: 1					Measurer: 2			
subject number	1st measurement	2nd measurement	Difference(D)	D^2	1st measurement	2nd measurement	Difference(D)	D^2
1	25.5	25.3	0.2	0.04	25.4	25.5	-0.1	0.01
2	27	27.2	-0.2	0.04	27.1	27	0.1	0.01
3	26.2	26	0.2	0.04	26.1	26	0.1	0.01
4	22.5	22.4	0.1	0.01	22.3	22.4	-0.1	0.01
5	22.3	22.4	-0.1	0.01	22.3	22.4	-0.1	0.01
6	26.4	26.3	0.1	0.01	26.5	26.4	0.1	0.01
7	29	29.1	-0.1	0.01	29	29.2	-0.2	0.04
8	26.1	26	0.1	0.01	26.1	26	0.1	0.01
9	23.5	23.4	0.1	0.01	23.3	23.4	-0.1	0.01
10	20.1	20.2	-0.1	0.01	20.1	20.3	-0.2	0.04
Absolute Intra Observer TEM = 0.097 cm					Absolute Intra Observer TEM = 0.089 cm			
Intra observer TEM [∑ ∑(mi1-mi2) sq / 2*K*Nj] = 0.0935 Standard deviation = 0.6094 Inter observer TEM = 0.1194 cm Coefficient of reliability = 96.1%								

Curriculum Vitae of primary investigator

Last updated: 10/26/19

Personal Information

First name: Binyam Middle name: Girma Last name: Sisay

Age: 26 years Sex: Male Marital status: Single

Date of Birth: 14 December, 1992

Nationality: Ethiopian

Language: Amharic and English: Speak, Read and Write

Email: binyamgirma3@gmail.com

Phone number (mobile): +2519-12-84-59-57

Home Address

Yeka sub-city, Kebele 01

House number 1174/4, Addis Ababa, Ethiopia

Tel: +251-111-144-345

I. Academic Qualification

1. **Degree of Public Health:**
   Period of study: March 2012-July 2015 G.C
   Program: public health
   Institution: Ambo University, School of public Health, Ethiopia

2. **Ethiopian Higher Education Entrance Certificate:**
   Period of study: September 2010-July 2011 G.C
   Program: Preparatory Program
   Institution: Debre Haile Saint Raguel church school, Addis Ababa, Ethiopia

3. **Ethiopian General Secondary Education Certificate:**
   Period of study: September 2008-July 2009 G.C
   Program: High School
   Institution: Debre Haile Saint Raguel church school, Addis Ababa, Ethiopia

II. Short courses

1. Nutrition and lifestyle in pregnancy
   Program: Online course
   Institution: Ludwing-Maximilians-Universiitate Munichen

2. Essentials of Global Health
   Program: Online course
   Institution: Yale university

3. Introduction to the principles and practice of clinical research
Program: Online course
Institution: The national institute of health clinical center

4. Writing in the Sciences
Program: Online course
Institution: Stanford University

5. Programming for Infant and Young Child Feeding
Program: Online course
Institution: Cornell University and UNICEF

6. Introduction to systematic review and meta-analysis
Program: Online course
Institution: Johns Hopkins University

III. Training

Title: Health regulatory training package
By: Addis Ababa city administration Food, Medicine and Health Care Administration and control Authority
From: February, 13/2017 to February, 17/2017

IV. Work Experience

1. Health care organizations Licensing and control officer

Duration of employment:

- May 26, 2016- June 14, 2018.

Institution:

- Kolfe Keranyo Wereda 10 Sub-City Food Medicine and Health Care Administration and Control Office from May 26, 2016- May 9,2017
- Arada Sub-City Wereda 3 Food Medicine and Health Care Administration and Control Office from May 9, 2017 – June 14, 2018.

Professional Associations

Memberships

- Ethiopian Public Health Association (EPHA)

Skills, interests and hobbies

- Know how on statistical software packages (SPSS, Stata, EPI INFO, WHO-Anthro)
- Team leadership
- Good communication skills
- IT know how

Future Plans and Interests

- To upgrade my level of education to the next higher level
- Giving voluntary health services

References:

- Mr. Mulugeta Mekuria e-mail: mule201160@yahoo.com
- Dr. Mohammed Abseno e-mail: merihmoh@gmail.