DECLARATION

This thesis is my original work and has not been presented for a Degree or any other award in this or any other University.

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DEDICATION

This work is dedicated to my dear husband, Peter and children, Joylyne, Clara and Leon for their love and moral support throughout my study.
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<tr>
<td>BAZ</td>
<td>BMI-for-age z-scores</td>
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<td>BMI</td>
<td>Body Mass Index</td>
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<td>CDC</td>
<td>Centre for Disease Control</td>
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<td>DDS</td>
<td>Dietary Diversity Score</td>
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<td>DEXA</td>
<td>Dual Energy X-ray Absorptiometry</td>
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<td>ERs</td>
<td>Energy Requirements</td>
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<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<td>FFM</td>
<td>Fat Free Mass</td>
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<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
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<tr>
<td>FGDs</td>
<td>Focus Group Discussion</td>
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<tr>
<td>FM</td>
<td>Fat Mass</td>
</tr>
<tr>
<td>FTIR</td>
<td>Fourier Transform Infrared Spectrometry</td>
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<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
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<tr>
<td>MUAC</td>
<td>Mid Upper Arm Circumference</td>
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<tr>
<td>NACOSTI</td>
<td>National Commission for Science, Technology and Innovation</td>
</tr>
<tr>
<td>NCD</td>
<td>Non-Communicable Disease</td>
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<tr>
<td>NGOs</td>
<td>Non-Governmental Organizations</td>
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<td>NMR</td>
<td>Nuclear Magnetic Resonance</td>
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<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
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<td>PAQ-C</td>
<td>Physical Activity Questionnaire for Children</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>SIDT</td>
<td>Stable Isotope Dilution Technique</td>
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<td>SOPs</td>
<td>Standard Operational Procedures</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
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<tr>
<td>TBW</td>
<td>Total Body Water</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WtHR</td>
<td>Waist-to-Height Ratio</td>
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OPERATIONAL DEFINITION OF TERMS

**Anthropometric measurements:** Height (cm), weight (kg), waist circumference (cm), BMI-for-age z-scores and waist to height ratio (WtHR).

**Central obesity:** Waist to height ratio above 0.5 cm.

**Dietary practices:** Frequency of consumption of various foods, diet diversity and total energy intake.

**Nutritional status:** Overweight and obesity as measured and inferred by dietary intake, physical activity, anthropometric measurements and body composition.

**Nutritional status assessment methods:** Anthropometric measurements (BMI-for-age z score; WtHR); dietary intake which influence body weight and composition through energy intake and physical activity level which influence energy expenditure hence influencing body weight and composition (Fat mass and Fat free Mass).

**Obesity:** BMI-for-age z-score greater than +2SD and excess body fat as given by percent body fat >25% for boys and >30% for girls.

**Over-nutrition:** Overweight and obesity.

**Overweight:** BMI-for-age z-score greater than +1SD and excess body fat as given by percent body fat >20% for boys and >25% for girls.

**Percent body fat:** Body fat calculated as percentage of the total body weight.

**Physical activity level:** Activity score as calculated from physical activity questionnaire for children (PAQ-C) and the time (minutes) spent in physical activity as assessed by accelerometers.
Stable isotope dilution technique: A technique used to assess body composition (fat mass and fat free mass) by two compartment model.

Validation: The process of testing the performance of selected test method with a gold standard method.
Methods used to assess overweight and obesity generate information that can be used to design interventions and policies which can address over-nutrition. Dietary practices, physical activity and anthropometry are the commonly used methods for assessing overweight and obesity. However, studies have cited their limitations since these methods do not indicate fat mass which is the factor that predisposes individuals to weight-related health risks. This study aimed to validate anthropometry, dietary practices and physical activity as commonly used methods for assessing overweight and obesity using stable isotope dilution technique (SIDT) as the gold standard for measuring body fat (BF). The study further aimed to model prediction equations for estimation of body fat among Kenyan children. A cross-sectional analytical study design was used to collect both qualitative and quantitative data from 202 randomly selected children aged 8-11 years in four randomly selected schools in Kasarani sub-county, Nairobi. Data were collected on demographic characteristics of the children, dietary practices, physical activity, anthropometric measurements, and body composition measurements. Anthropometric data were analyzed using WHO anthroplus software. The distribution of body mass index (BMI)-for-age z-scores and waist to height ratio (WtHR) were categorized according to WHO guidelines. Saliva samples for determination of body composition were analyzed using Fourier Transform Infrared Spectrometry. Physical activity score was calculated from the total score of nine questions in physical activity questionnaire for children and accelerometer data was analyzed using Acti-life computer software. Nutrient intake was analyzed using Nutri-Survey software. Relationships between variables were established using Pearson correlation, odds ratio and chi-square while differences were established using t-test and Wilcoxon test. Validation was done using Cohen’s Kappa coefficient and Bland-Altman analysis. Multiple regression was used to model equations. The mean percent body fat was 27.52±6.4 for girls and 19.65±5.9 for boys with 24.0% of children having excess fat. The mean BMI-for-age was 16.0±2.4 with 5.0% being overweight and 3.0% obese. Central obesity using WtHR was 6.9%. Children with excess energy intake above 120% of RDAs were 29.7%. Energy intake significantly correlated with body fat (r = 0.621, P<0.001). The mean physical activity score was 2.9±0.6. The physical activity significantly correlated with body fat (r = -0.396, P<0.001). There was low concordance between nutritional status assessed by BMI-for-age z-score (κ = 0.129) and WtHR (κ = 0.357), compared to SIDT. Similarly, low concordance was noted among children with high energy intake (κ = 0.119) and low physical activity (κ = 0.241) in respect to body fat. The prediction equations that provided reliable estimates of body fat modeled using weight (wt), height (ht), waist circumference (wc) and BMI-for-age were; BF = 0.683 (wt) - 0.223 (ht) + 16.15, BF = 0.525 (wc) - 24.36 and BF = 1.381 (BMI-for-age) - 16.22 for boys. Equations for girls were; BF = 0.704 (wt) - 0.230 (ht) +18.61, BF = 0.510 (wc) - 21.78 and BF = 1.510 (BMI-for-age) - 15.65. All the equations had strong concordance coefficient >0.9 in estimating body fat when compared with SIDT. This study concludes that dietary intake and physical activity are not absolute measures of body fat. Anthropometric measurements under-estimate body fat. Prediction equations can be used to accurately measure body fat. This study recommends the use of the modeled equations to estimate body fat among school children from low income population.
CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Globally, the prevalence of overweight and obesity has increased substantially (WHO, 2012). The rising prevalence of childhood overweight and obesity in several countries has been described as a global pandemic (Ng et al., 2014). As such, in developed countries, the prevalence of overweight and obesity among children and adolescents is 23.8% among boys and 22.6% among girls while in developing countries it stands at approximately 13% for both boys and girls (Ng et al., 2014). In 2014, the prevalence of overweight and obesity in Sub-Saharan Africa was reported as 11% (Muthuri et al., 2014). Specifically, the prevalence of overweight and obesity among school children in Nairobi City County stands at 19.0% (Kyallo, Makokha & Mwangi, 2013).

Childhood overweight and obesity are public health challenges of the 21st century which are responsible for 5% of global mortality (WHO, 2012) with detrimental long-term and short-term effects to health and self-esteem (Millán, Laín & Carlos, 2011). In the short term, overweight and obesity among children may prevent the child from playing normally with friends, wearing clothes they like and may expose them to ridicule by other children (Quattropani, 2013). In the long term, health consequences are strongly associated with cardiovascular diseases, diabetes and orthopedic problems (Albuquerque et al., 2012; Reilly et al., 2003; Singh et al., 2008).
Childhood overweight and obesity is an important predictor of adult overweight and obesity as obese children have 50-80% chances of growing up to be obese adults (Singh et al., 2008). Once a child grows up to be an obese adult, it is difficult to lose weight through diet and physical activity (Kamath et al., 2008; Onis et al., 2010). Overweight and obesity have led to a shift in the major causes of death from communicable diseases to a growing burden of modifiable non-communicable diseases (NCDs) (Onis et al., 2010; WHO, 2013).

The increasing burden of NCDs, particularly in the African-region, threatens to overwhelm the already over-stretched health services (WHO/AFRO, 2011). Projections indicate that by 2020, the largest increase in NCD deaths will occur in Africa which currently has a heavy burden of infectious diseases (Yo et al., 2015). Public health policies, therefore, should focus on preventive strategies starting at early ages (Mestrado, 2012; Nestle & Jacobson, 2000). To be effective, the preventive strategies require identification of contributing factors as well as an accurate assessment of overweight and obesity (Frieden, Dietz & Collins, 2010).

Assessment of overweight and obesity is commonly determined directly using anthropometric and body composition measurements (Duren et al., 2008; Mei et al., 2002). Dietary intake and physical activity patterns are associated with body weight and composition (Ma et al., 2003). Body weight consists of lean and fat mass and therefore understanding the factors that favor fat mass deposition could help in overweight and
obesity prevention and assessment (Bowen et al., 2015). Low physical activity in combination with excess energy consumption contributes to positive energy balance in the body which leads to changes in both body weight and body composition (Ramirez-zea et al., 2006). Body fat, not necessarily body weight, is the key component that leads to high risk of ill health. Assessment of body fat has been described as a better measure of the risk of weight-related diseases than body weight (Blanc et al., 2000; Freedman & Sherry, 2009). Unfortunately, anthropometric measurements which are used to assess the weight status of an individual do not distinguish between lean weight and weight due to fat (Atkin & Davies, 2000; Dietz et al., 2015; Freedman & Sherry, 2009; Lee & Gallagher, 2008).

The increasing epidemic of overweight and obesity among children highlights the importance of body fat assessment beyond body weight measurements for the purpose of both short and long term health interventions (Dehghan, Akhtar-Danesh & Merchant, 2005; Janssen et al., 2005; Salamone et al., 2014). This is more so due to the rapid changes in diet and physical activity patterns that are likely to contribute to the increasing prevalence of overweight and obesity among children (Kimani-Murage et al., 2015; Millán et al., 2011; Zaborskis et al., 2012). Furthermore, understanding factors that influence dietary practices and physical activity would be a major step towards reversing childhood overweight and obesity (Millan, Lain & Carlos, 2011). This involves interactions among multiple factors that may shape daily diet and physical activity behavior such as nutrition knowledge, attitude, socio-economic status, home and school environment (Ali et al., 2011).
Although assessment of nutritional status by means of body composition is gaining popularity, most of the commonly used methods are complex, costly and limited to laboratory settings (Kilpelainen et al., 2011; Mei et al., 2002). This has made body composition assessment not to be a routine procedure in nutrition status assessment, especially in developing countries. Therefore, anthropometry has continued to be used in assessing adiposity and its relative accuracy needs to be validated against a “gold-standard” measure of adiposity (Ramirez-zea et al., 2006).

Use of prediction equations to estimate body fat is an emerging practice as an alternative to the complex methods especially in resource-limited settings (Hoffman et al., 2000). However, prediction equations are population-specific and should be applied within the same population where they were developed (Gallagher et al., 2000). This study sought to validate anthropometry, dietary intake and physical activity as methods of assessing nutritional status using stable isotope dilution technique (SIDT) as the reference method for assessing body composition. The study also sought to develop prediction equations that can be used to estimate body fat among school children in Kenya.

The SIDT, also referred to as enrichment technique, is one of the safe, non-radioactive, non-invasive and non-restrictive body composition assessment methods that enable the assessment of body fat mass under free-living conditions (Blanc et al., 2000; Duren et al., 2008; Lee & Gallagher, 2008). The SIDT was recommended in the 1990s as a gold standard for measuring body composition, hence, it is considered as a reference method.
(IAEA, 2011). The SIDT uses a body compartment model to determine total body water, allowing the estimation of body fat mass (FM) and fat-free mass (FFM) and has a higher measurement sensitivity and specificity in relation to other methods (Silva et al., 2013). This study used hydrogen [Deuterium oxide (\(^{2}\text{H}\))] isotopes to assess body fat mass among school children.

Other documented methods for determining body fat include underwater weighing, dual-energy X-ray absorptiometry (DEXA), and total-body electrical conductivity. Some of these methods are limited to laboratory settings and are radioactive, while others, such as underwater weighing, are not suitable for children (Blanc et al., 2000). This study was part of an African regional project supported by the International Atomic Energy Agency (IAEA), RAF 6042 whose objective was to apply nuclear techniques to design and evaluate interventions to reduce obesity and related health risks.

1.2 Statement of the Problem

Developing countries, Kenya included, are currently experiencing the dual burden of malnutrition, with overweight and obesity being on the increase (Zaborskis et al., 2012). As a result, obesity and overweight among school going children has become a common nutritional problem, especially in urban schools (Kamath et al., 2008). Overweight and obesity has been strongly associated with increased risk of many health-related conditions (Johnson et al., 2012).
Measuring body parameters such as weight and height are used to indicate overweight and obesity status of children and are useful for practitioners when assessing individuals for excessive fat (Gallagher et al., 2000). The main assumption of anthropometric measurements is that body parameters are closely concomitant with body fatness, morbidity and mortality (Nuttall, 2015).

Though the association is strong, researchers also report a number of cases of overweight and obesity that are not accompanied by excess body fat (Blanc et al., 2000; Miller et al., 2005). On the other hand, research has shown cases of body weight within the normal range but with a high percentage of the body weight as fat (Kilpelainen et al., 2011; Romero-Corral et al., 2008). The true relation between anthropometric measurements and body fat is not well documented especially among children (Mei et al., 2002). This has left a dilemma on the accuracy of the commonly used anthropometric measurements to estimate body fat when used in research and clinical practice (Pasco et al., 2014). The gap, therefore, remains on how body fat can be measured accurately (Gallagher et al., 2000).

Health risks associated with weight come about if the composition is mainly fat above the recommended levels, and therefore methods for assessing overweight and obesity need to identify the amount of fat that constitutes body weight (Blanc et al., 2000). Few studies exist on the validity of anthropometry in the diagnosis of excess body fat among pediatric populations from other populations such as European children (Wickramasinghe et al.,
2008), Asian children (Dudeja et al., 2001) and Mexican children (Pablo, Valdes & Ortiz- hernandez, 2015). However, validation of dietary intake, physical activity and anthropometry to accurately classify overweight and obese children has not been examined among African children.

Classifying nutritional status according to adiposity is a health priority need that has not been achieved especially in developing countries (Kennedy, Shea, & Sun, 2009; Salamone et al., 2014). This is because body composition assessment methods are expensive, require sophisticated equipment, well-trained personnel and are therefore not applicable in most field research (Lee & Gallagher, 2008). Thus, most developing countries generally rely on cheaper techniques such as anthropometry despite the limitations. Due to the increasing global prevalence of overweight and obesity and the associated health risks that need to be addressed, there is a great need for simple approaches to estimate fat mass in less developed, resource-constrained countries that lack technology.

To achieve this, researchers have proposed the use of prediction equations in estimation of body fat (Goran, 2016). Although some equations have been modeled, they are mainly for Caucasian children populations (Javed et al., 2015; Romero-Corral et al., 2008). Moreover, most of these equations use the sum of skinfold thickness as a covariate which is not a common practice in Kenya (Ejlerskov et al., 2014; Hoffman et al., 2012). In addition, the equations, when tested among African children, were found to be poor
predictors of body fat (Duren et al., 2008; Marshall et al., 2004; Wong et al., 2000). Hence, no equation appropriate for African children population, has been modeled. As prediction equations are population-specific, it is therefore not recommendable to apply the existing equation to other populations. To this end, this study validated dietary intake, physical activity and anthropometric measurements as measures of body fat and developed prediction equation for estimating body fat among Kenyan school children.

1.3 Purpose of the Study
The purpose of this study was to validate anthropometry, dietary intake and physical activity as methods commonly used to assess overweight and obesity using SIDT as the gold standard method. The study also aimed to model anthropometric based prediction equations for estimating body fat among Kenyan children.

1.4 Objectives of the Study
The objectives of this study were to:

1. Establish dietary practices and related nutrition knowledge and attitudes among school children in Nairobi City County.
2. Measure physical activity level among school children in Nairobi City County.
3. Determine prevalence of overweight and obesity among school children in Nairobi City County.
4. Measure body composition using stable isotope (deuterium) dilution technique among school children in Nairobi City County.
5. Determine the relationship between energy intake, physical activity level and percent body fat among school children in Nairobi City County.


7. Model prediction equations for assessing body fat among Kenyan children.

1.5 Hypotheses of the Study

H₀₁: There is no significant association between energy intake and body fat among children in Nairobi City County.

H₀₂: There is no significant association between physical activity level and body fat among children in Nairobi City County.

H₀₃: There is no significant association between anthropometric measurements and body fat among school children in Nairobi City County.

H₀₄: Anthropometry, dietary intake and physical activity are not accurate measures of body fat.

H₀₅: Prediction equations cannot accurately estimate body fat among school children in Nairobi City County.

1.6 Significance of the Study

This study focused on assessing the validity of anthropometry, dietary energy intake and physical activity to estimate body fat. Information from this study can be used by policy
makers and nutrition programs implementers and interventions aimed at prevention and control of health risks associated with excess body fat. Users can apply the proposed prediction equations to accurately estimate body fat. In addition, findings and publications from this study will add knowledge to the existing body of research and provide a basis for future research.

1.7 Delimitation of the Study

The study only focused on school going children between 8-11 years since dietary practices and physical activity behavior are mostly formed at this age. The children at this age are pre-puberty, hence less interference of reproductive hormones on body composition. This was an age before the onset of growth spurt.

1.8 Limitation of the Study

This study was conducted among children in urban public day schools in Nairobi City County. The public urban population targeted in this study may not be similar in terms of socio-demographic characteristics, dietary practices and physical activity patterns to the children population in private schools in Nairobi and public schools in other rural parts of Kenya and thus, may limit the generalization of the findings.
1.9 Conceptual Framework

Figure 1.1 is a conceptual framework showing methods used in assessment of overweight and obesity.

![Conceptual Framework Diagram]

*Figure 1.1: Conceptual framework on assessment of percent body fat. Adapted and modified from Marshall et al., (2004).*

The state of adiposity can be determined directly by measuring body composition, anthropometry or using other proxy indicator methods such as dietary intake and physical activity level. Environmental and social factors which affect dietary practices and physical activity are contributing factors to overweight and obesity. Dietary practices among children are influenced by nutrition knowledge, attitudes and socio-demographic
characteristics. Poor dietary practices may be characterized by intake of high fat, high sugar and low fiber diets which contribute to high energy intake and consequently, high fat deposition.

Physical activity levels among children can be influenced by environmental factors and screen-based sedentary behavior. Sedentary lifestyles contribute to low physical activity associated with low energy expenditure and hence accumulation of body fat. On the other hand, increased physical activity level is associated with improved nutrition outcomes due to its influence on energy expenditure hence reduces chances of excessive fat deposition (Ma et al., 2003; Sallis & Glanz, 2006). Both dietary intake and physical activity influence body weight and composition. Excessive energy intake and low physical activity result in the food consumed not being utilized sufficiently. This leads to a positive energy balance thus excessive weight gain and fat deposition which is an indicator of an individual’s nutritional status (Corpeleijn, Saris & Blaak, 2009; Patel & Hu, 2008; Reilly, 2010; Shah et al., 2008).
CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of Nutrition Status among School Children

The nutrition status of an individual is a result of many inter-related factors. It is influenced mainly by quantity and quality of food consumed, physical activity level, genetics and health (Handa et al., 2008). The spectrum of nutrition status of children spreads from obesity to severe under-nutrition (Doak et al., 2000). Of particular concern is the upward trend in countries that have traditionally experienced under nutrition (Ehrenfeld, 2009).

In developing countries, under-nutrition among children has been the main concern (Müller & Krawinkel, 2005). However, with the change in lifestyle and dietary practices, most developing countries are facing the dual burden of under-nutrition and over-nutrition among children (Zaborskis et al., 2012). The strong association between early under-nutrition, especially stunting, with increased risk of obesity later in life has been reported (Eckhardt, 2006; Hoffman et al., 2000; Souganidis, 2011), therefore, for countries still facing under-nutrition, the risk of the obesity burden later in life is high. To effectively prevent and manage overweight and obesity, there is a great need for accurate diagnostic methods.

2.2 Determinants of Overweight and Obesity among School Children

Dietary transition and changes in physical activity level are some of the factors that have been associated with the emergence of overweight and obesity among school children
(Gupta et al., 2012). Therefore, environmental and social factors that impact on dietary practices and physical activity need to be assessed for prevention of overweight and obesity.

2.2.1 Dietary Practices

Dietary practices characterized by excess energy intake have been associated with increased prevalence of overweight and obesity (Hartline-Grafton et al., 2009; Peltzer & Pengpid, 2011). Factors associated with high energy intake include; increased portion sizes and caloric density of foods (Kant & Graubard, 2005), increased consumption of sweetened beverages (Bleich et al., 2009; Duffey & Popkin, 2007) and increased snacking (Brindal, 2012). In addition, consumption of meals away from home, more exposure to food advertisements that encourage and promote consumption of unhealthy foods and ease of access to fast food outlets are all likely to influence dietary practices (French et al., 2001; Grossman, Tekin & Wada, 2012; Harrison & Bost, 2011).

Growing evidence suggests that energy-dense foods have a stronger influence on energy intake than any single macronutrient (Darmon, Briend & Drewnowski, 2004; Moreno et al., 2000). This is mainly because people are likely to eat consistent food portions, and thus, selection of high energy dense food would make them consume more calories than required which would lead to positive energy balance (Ledikwe et al., 2006; Rolls, Drewnowski & Ledikwe, 2005). A balance between energy intake and energy expenditure is key to the maintenance of body fat and positive energy balance lead to overweight and obesity (St-Onge et al., 2005). Research has confirmed that one of the
hindrances to the control of obesity among children is great access and availability of energy-dense foods (Lean, Lara & Hill, 2006). Increased physical activity may not be sufficient to offset an energy-rich diet. Research demonstrates that it takes between 1-2 hours of extremely vigorous activity to counteract a single large-sized children’s meal of greater than 785 kilocalories (Dehghan et al., 2005). This indicates the importance of a healthy diet alongside efforts to promote an active lifestyle.

Consumption of fast foods and sweetened drinks contributes to high caloric intakes and has been shown to directly contribute to the obesity epidemic (Bray & Popkin, 2014; Parmar, 2014; Sambasivarao, 2013). Moreover, the availability of soft drinks and fast foods from local food outlets has aggravated their consumption (Doak et al., 2000; Kigaru et al., 2016; Smith, Lin & Lee, 2010). Caloric intake from beverages is less satiating compared with solid foods, leading to a high risk of consumption of large volumes of soft sweetened drinks (DiMeglio & Mattes, 2000). In addition, many caloric sweetened drinks lack sufficient nutrients, thereby adding caloric intake without nutritional benefit (Hu, 2013). A research review in Texas showed that as a measure to control obesity, accessibility to healthier foods is important (Patrick & Nicklas, 2005). This is because children are always likely to eat foods that are easily accessible.

Consumption of meals away from home, more exposure to advertisements of energy-dense foods, widespread food purchasing opportunities available to children and more access to restaurants and fast food outlets have encouraged and promoted consumption of
unhealthy foods (Juan, 2006). The fast food consumption in out of home set-ups even for young children has become common practice, especially in developing countries which are experiencing lifestyle changes related to diet due to rapid urbanization, the so-called nutrition transition (Ayala et al., 2008; Zaborskis et al., 2012).

School-age children spend more time away from their parents, hence peers and media influence the establishment and formation of their dietary practices (Triches & Giugliani, 2005). Foods consumed by school children have been reported to be low in fiber, vitamins and minerals yet high in calories and sugar (Krølner et al., 2011). Most chronic illnesses in adulthood begin from dietary practices essentially framed early in life (Abdollahi et al., 2008). Most studies in Kenya have mainly focused on undernutrition. Thus, there exists a gap to support the association between dietary practice and excess body fat deposition in Kenya.

2.2.1.1 Factors Associated with Dietary Practices

2.2.1.1.1 Demographic Characteristics

Food selections are directly associated with demographic characteristics of the family and or individuals (Gable & Lutz, 2000), increase in household size and decrease in household food availability (State, 2012). This is mainly related to the economic burden associated with large family sizes (Jones, 2005). This has been found not only to affect the quantity of diet at home, but also the quality of diet (Specter, 2004). In addition, studies have reported that in large families, availability of fruits and animal products was found to be rare and diets were predominantly characterized by cheap starchy and fatty
foods (DiSantis et al., 2013; Rasmussen et al., 2006). For instance, a study in India found an inverse relationship between household size and dietary quality among children (Das, 2014). A positive significant relation has also been observed between household size and dietary diversity among children (Gibson & Kim, 2007).

Age and sex of children have been associated with differences in dietary practices (Craig et al., 2010). Older children are more concerned about what they eat than young ones. A study among children in Saudi found that food choices are influenced by sex as girls are more likely to engage in snacking habits than boys (Al-Hazzaa et al., 2011). However, as children grow older and enter into puberty, girls become more conscious of their body image and they are likely to be more conscious of their eating habits in connection to their shape than boys. Similarly, the desire to be strong and energetic make boys eat more (Wardle et al., 2004). As children grow into adolescents, studies have reported a higher frequency of fruits and vegetable consumption among girls as compared to boys (Marie et al., 2016; Rasmussen et al., 2006).

In a study conducted among children in the United Kingdom, males consumed a greater number of portions of high fat/high sugar foods (Foster & Langley-evans, 2012). This may be accounted for by the fact that at all ages, the energy requirements of girls are lower than those of boys and this greater consumption of energy-dense foods in boys may serve as an adaptive purpose (Cooke & Wardle, 2005). Since these studies were
conducted in developed countries, it would be important to assess how this applies to a country like Kenya.

2.2.1.1.2 Socio-economic Characteristics

High income in households has also been associated with high occurrence of overweight and obesity among children (Warraich et al., 2009). However, cases of overweight and obesity are on the incline even among individuals from low and middle-income households (Maruapula et al., 2011). As such, several studies have observed higher overweight and obesity rates among lower income populations (Brown, 2004; Patrick & Nicklas, 2005; Taylor, Evers & McKenna, 2005). This could be due to factors such as food prices that influence food choice especially when income is restricted, leading to a selection of foods that are high in sugar and fat because they are among the least expensive (Taylor et al., 2005). Studies on dietary practices among low-income earners in urban African-American populations as well as among Kenyan children showed a high intake of sugary and high-fat diet among children (Kyallo et al., 2013; Wang & Lobstein, 2006).

Other factors that contribute to overweight and obesity are cultural beliefs associated with good health and successful parenting. A heavy child has been thought as a sign of good health and good parental care (Savage, Fisher & Birch, 2008). Parents who consider children who are big for their age as healthy are unlikely to be concerned about child overweight or to use restrictive feeding practices to prevent overweight. In addition, low-
income mothers have reported social stigmatization associated with low weight or “small” children (Savage, Fisher & Birch, 2008). Therefore, low-income parents have a strong desire for their children to be big and this contributes to the rising trends of obesity among low-income earners. There is paucity of knowledge on dietary practices of low income earners in relation to the occurrence of overweight and obesity in Kenya.

2.2.1.3 Nutrition Knowledge and Attitude

School age is a period where dietary practices are being formed and it is at this time that children start making their own choices about food which persist into adulthood (Abdollahi et al., 2008; Brown, 2004). Nutrition knowledge is among the factors that impact the choices people make about food (Plessis, 2011). Lack of, or low nutrition knowledge has been considered as a reason for poor dietary habits (Kostanjevec, Jerman & Koch, 2013). Nutrition knowledge is needed in the formation of good dietary habits among children (Ali et al., 2011; Choi et al., 2008).

According to the Kenya national food and nutrition security policy, nutrition knowledge has a significant effect in fostering healthy eating habit (Government of Kenya, 2011). Therefore, to advance more advantageous dietary patterns throughout the lifespan, knowledge about food and nutrition is believed to be important at an early age (Triches & Giugliani, 2005). However, some studies have reported that information alone may not be sufficient to cultivate legitimate dietary practices and that uplifting attitude and behavior change toward adhering to a good diet early in childhood contributes enormously to embracing good dietary practices (Brown, 2004; Triches & Giugliani, 2005). Brown
(2004) argues that nutrition education should aim at the application of nutrition knowledge to everyday life to maintain a more reasonable dietary lifestyle. School age children have been found to have insufficient knowledge on the importance of good dietary practices (Choi et al., 2008). Therefore, most of them select foods on the basis of preference, taste and peer pressure without proper judgment (Abdollahi et al., 2008). This results in increased calorie intake increasing the risk of overweight and obesity (Choi et al., 2008). Earlier studies done among Kenyan school age children have reported low nutrition knowledge and negative attitude to healthy foods among school children (David, Kimiywe & Waudo, 2012).

With the present modification in dietary habits to the western diet, increased fast food outlets, increased food advertisement/promotion, increase in televised food, lack of parental guidance and access to income by the children, there is a noteworthy need to empower children with the right information and create positive attitudes aimed at making appropriate food choices and decisions (Doak et al., 2000). In Kenya, studies have shown links between nutrition knowledge and dietary practices but there are minimal studies alluding to the association between attitude and dietary practices.

2.2.1.4 Environmental Factors

Children's dietary patterns evolve within the context of the family and social environment (Savage et al., 2008). Food habits formed in the early stage of life are carried up into adulthood (Patrick & Nicklas, 2005). Changes in environmental factors contribute to change in dietary practices among school children and have been linked to the rising
trends in overweight and obesity (Ayala et al., 2008). Therefore, changes in children’s diets should not be divorced from social environments such as family, school and food market.

A study among Irish children indicates that mothers are the biggest influencers of their children’s eating regimens (Walsh & Nelson, 2010). In this regard, changes in employment patterns and family structure have left women with less time for monitoring child feeding (Juan, 2006; Savage et al., 2008). Work life can influence food choices in several different ways, long hours, inflexible schedules, shift work, and multiple jobs have an impact on the time and energy available for food procurement and preparation.

This has led to most children having meals without parental supervision and guidance, leaving the decision on what to eat and how much to eat to the children (Patrick & Nicklas, 2005; Taylor et al., 2005). In addition, many school going children do not have lunch and mid-day snacks at home, and in such circumstances, they prefer portable snacks such as cakes, sweets, french fries and soft drinks which are high in sugar and fat. In the Islamic Republic of Iran, more than half of school age children have been found to choose their own snacks mainly due to the absence of parental supervision (Abdollahi et al., 2008). As such, children’s dietary practices have been shown to be influenced by friends and media (Taylor et al., 2005).
The school environment also plays a big role in influencing dietary practices among school children as it determines the type of foods available within the school environment while providing ideal settings to establish and promote healthy eating practices in children (Taylor et al., 2005). Nutrition policies in school, school nutrition programs and health curricula as well as teacher and peer modeling are crucial in influencing the type of dietary practices adopted (Pasco et al., 2014). Research conducted in Canada on food programs in schools identified a number of concerns regarding the nutritional quality of foods in schools, such as the availability of high fat, high sugar and low nutrient dense foods (Taylor et al., 2005). This indicates an information gap on the quality of foods available to school and their likely effect on children’s nutrition status.

2.2.2 Physical Activity

Physical activity is defined as body movement, produced by skeletal muscles resulting in energy expenditure (Millan et al., 2011) and is a key determinant of health across the human lifespan (Warburton, Nicol & Bredin, 2006). World Health Organization advocates for at least a minimum of 60 minutes of moderate to vigorous activity per day to accrue positive health outcomes (WHO, 2010). The Canadian sedentary behavior guidelines also recommend that children should limit their recreational sedentary screen time to not more than two hours per day (Tremblay et al., 2011).

Physical activity plays a great role in the prevention of overweight and obesity in childhood (Peltzer & Pengpid, 2011). Studies have confirmed that sedentary behavior
such as television watching is a risk factor for overweight and obesity (Patrick et al., 2004; Reilly, 2005; Rey-López et al., 2008). This is because inactive behavior contributes to limited energy expenditure which studies have linked to unhealthy body weight (Millán et al., 2011). An intervention study done among school children in 34 countries also reported positive effects on weight reduction with an increase in the level of physical activity among overweight and obese children (Janssen et al., 2005).

The World Health Organization classifies physical inactivity as a risk factor for overweight and obesity. Overweight and obesity are the fifth leading causes of global mortality and one of the greatest determinants of various chronic diseases such as heart disease, hypertension, diabetes and psychosocial problems (WHO, 2010). Although physical activity has been shown to provide numerous health and nutritional benefits for children (Strong et al., 2005), studies show that physical activity level is on the decrease and children do not undertake the recommended levels of physical activity (Hills, Andersen & Byrne, 2011; Millán et al., 2011).

An important contributor to the decrease in physical activity level is the changing physical activity environment, which provides fewer opportunities for spontaneous physical activity (Dehghan et al., 2005). The key factor to success in tackling the problem of obesity lies in understanding, measuring and altering “obesigenic” environments (Millán et al., 2011). Some environmental factors that are believed to contribute to low physical activity level among school children include increased use of motorized
transport to school, reduced opportunity for recreational physical activity such as lack of
playground or play items, increased sedentary recreation and the availability of multiple
television channels around the clock (Uauy, 2004).

Currently, children in most countries, Kenya included, spend a substantial amount of time
in school settings and therefore the school environment influences the physical activity
level of the children (Sallis & Glanz, 2006; Springer, Kelder & Hoelscher, 2006). The
education system in the modern world has reduced the time for physical activity in
schools (Atkin & Davies, 2000). Furthermore, non-availability of, or non-accessibility to
games facilities in schools has been reported as a barrier to participation in physical
activity among school children (Bocarro et al., 2012; Rezende et al., 2015; Ridgers et al.,
2007; Thomas & Kahan, 2008). Moreover, physical education in most schools is a
privilege for children, although it should be an essential part of every educational system
(Mendelson, 2007). School children also have assignments to carry home which limits
play time at home. These factors have been thought to largely contribute to the emerging
trend of overweight and obesity among school children (Atkin & Davies, 2000).

2.3 Nutrition Status Assessment Methods

The purpose of nutrition status assessment is to identify individuals or populations at risk
of malnutrition. This assessment is used when developing health care programs and for
measuring the effectiveness of the nutritional program and interventions. Assessment of
overweight and obesity aims to identify current and potential nutritional and health risk
problems related to excess body fat (Handa et al., 2008). Parameters for determination of overweight and obesity are anthropometric measurements, dietary intake, physical activity patterns, and body composition studies using various techniques (Coelho et al., 2013).

2.3.1 Anthropometric Measurements

Anthropometric measurements are the most basic direct and relatively non-invasive methods of assessing nutrition status (Duren et al., 2008). These measurements describe body mass, size, shape, but also a relative measure of the level of fatness (Mei et al., 2002). The most frequently anthropometric-based measurements and indices used among school children are weight, height, waist circumference, skinfold thickness and BMI-for-age (Dezenberg, et al., 1999; Ejlerskov et al., 2014; Hoffman et al., 2000). In Kenya, weight, height, waist circumference and BMI-for-age are commonly used measurements. These methods are simple, quick and require less expertise.

BMI-for-age results are expressed as BMI-for-age z-scores (BAZ) which is a reasonable indicator of body fatness for most children. Though high BAZ cut off points have been linked to morbidity and mortality, the true relation between BAZ and body fat is not well documented, especially among children (Mei et al., 2002). In addition, it has been suggested that BAZ may be a less sensitive indicator of overweight and obesity among children since it gives no indication of fat distribution (Uauy, 2004). Weight measurement can reveal if one weighs more than the recommended weight, but does not
reveal if that weight is fat or muscles (Onis et al., 2010). Since it is the increased amount of body fat that causes major health risks, questions have been raised about the adequacy of anthropometric measurements in measuring body fat (Deurenberg et al., 2001; Freedman & Sherry, 2009; Gallagher et al., 2000; Ringborg et al., 2003).

Waist circumference (WC) is defined as an excessive accumulation of fat around the organs inside the abdominal cavity and it is measured in between the lower rib and the upper border of the iliac crest (Albuquerque et al., 2012). It is a better indicator of fat stored in the abdominal area for assessment of cardiovascular risk factors (Hsieh, Yoshinaga & Muto, 2003). Health risks of obesity and metabolic syndrome are associated more with central obesity than with total obesity (Bergmann et al., 2010). Many of the current guidelines recognize that waist circumference is a good proxy indicator for central obesity alongside BMI-for-age (WHO, 2008).

Waist circumference is expressed in terms of waist to height ratio (WtHR) and it is a good indicator for risk of cardiovascular diseases. It is very simple to use and it is applied to both genders and ages with a cut-off of WtHR $\geq 0.50$ defining those with excess abdominal fatness (Albuquerque et al., 2012). Waist to height ratio is more sensitive than BAZ as an early warning of health risks (Ashwell & Hsieh, 2005). Use of WtHR can often identify people within the moderate range of BAZ who have a higher metabolic risk, almost certainly because it is more closely associated with central obesity (Ashwell & Hsieh, 2005). Waist to height ratio allows the same boundary values for children and
adults. Since the height and waist circumference of children increases continually as they grow, the same boundary value (WtHR ≥ 0.5) is used across all age groups (Hsieh et al., 2003). From this review, both BMI-for-age and waist circumference have been used as a surrogate measure of body fat mass while the true relationship between body measurements and body composition still remain uninvestigated.

2.3.2 Dietary Assessment Methods

Dietary practices are mainly assessed through 24-hour recall, food frequency and food diversity questionnaire (Wrieden et al., 2003). Dietary methods are usually triangulated with other methods in nutrition research such as biochemical, clinical and anthropometric methods for nutrition assessment purpose. Accurate reports on usual food consumption and nutrient intake are crucial to either investigate the nutrition status of the general population or estimate the association between diet and body parameters (Eisinger-Watzl et al., 2014).

A 24-hour dietary recall is mainly used to determine total energy intake when evaluating overweight and obesity (Ma et al., 2010). On the other hand, food frequency questionnaire is used to evaluate the frequency of consumption of certain food groups like vegetables and fruits which are high in fiber and consumption of fatty and sugary foods due to their immense contribution to daily caloric intake (Ma et al., 2003). Good indicators of diet assessment tools are associated with a number of improved nutrition
outcomes in areas such as anthropometric and biomarker measurements (Swindale & Bilinsky, 2006).

However, to determine whether there exists a relationship between ingested food and body composition, studies have relied on self-report by use of food records or dietary recalls (Thompson & Subar, 2013). Obese people tend to under-report food consumption while underweight people over-report (Goris et al., 2000). Therefore, assessment of nutritional biomarkers such as body fat composition is needed to validate self-reported dietary intake (Resnicow et al., 2000). There exists a gap on the true relationship between dietary intake and body composition as most existing studies report on dietary intake and anthropometric measurement.

2.3.3 Physical Activity Assessment

Physical activity level is a proxy determinant of nutrition status outcomes due to its influence on energy expenditure (Bowen et al., 2015; Sallis & Glanz, 2006). Low energy expenditure leads to lipogenesis resulting to excess fat deposition (Corpeleijn et al, 2009). Changes in body composition influence physical activity level, whereby when one became obese, the level of physical activity goes down (McManus & Mellecker, 2012), making the assessment of physical activity level key in risk of non-communicable diseases. Physical activity level can be determined using a variety of physiological indicators, laboratory methods, direct observation, motion sensors, and self-report measures using physical activity questionnaires (Sallis & Glanz, 2006; Tremblay et al.,
Non-intrusive, valid and precise methods are needed to understand how the intensity, frequency, and duration of physical activity influence nutrition status (Kohl, Fulton, & Caspersen, 2000) as well as for assessing physical activity at various ages (Kowalski, Crocker, & Donen, 2004). Physical activity questionnaire for children (PAQ-C) is a frequently utilized physical activity assessment tool among children because it is typically cheap and easily administered to large populations.

Accelerometers, which can measure continuously the intensity, frequency, and duration of body movement for extended periods of time have also been used. Accelerometers measure accelerations caused by body movements in one to three orthogonal planes (vertical, Medio lateral and anteroposterior) and generate the activity counts and minutes spent above pre-defined thresholds (Plasqui & Westerterp, 2007; Rowlands & Eston, 2007). This method provides a more accurate and precise measurement of all intensity levels of physical activity with the entire range from sedentary to very vigorous (Plasqui & Westerterp, 2007). The accelerometer can be used in combination with PAQ-C to enhance the accuracy of data collected.
2.3.4 Body Composition Assessment

Body composition refers to the compartments that make up the body, mainly the fat and fat-free compartment (Wells & Fewtrell, 2006). The fat-free mass consists of water, bone, non-osseous mineral and protein which makes different compartment models (IAEA, 2011) (Figure 2.1).

![Diagram of body composition models](image)

*Figure 1.2: Body composition models. Source (IAEA, 2011)

Body weight consists of both fat mass (FM) and fat-free mass (FFM) which are of more significance when assessing nutrition status than just the total body weight (Lee & Gallagher, 2008; McCarthy et al., 2006; Salamone et al., 2014). Water forms the largest component of the body make up. At birth, the body contains 70-75% water, but as the body matures, this proportion can decrease up to 60% in lean individuals and up to 40%
in obese people (Kirchengast, 2010). Water is found exclusively within the FFM, which is approximately 73.2% in adults. With an estimate of total body water (TBW), the amount of fat-free mass can be estimated thus enabling calculation of body fat by subtracting the FFM from the total body weight (IAEA, 2011). In conditions where there is adequate nutrition, the body water compartment remains a steady condition of flux, with water atoms entering and leaving the body. Excess or deficiencies of any of the components that make up the body can lead to adverse health consequences (Ploeg et al., 2014). This study adopted the two compartment model of body composition assessment that allowed assessment of fat mass and fat free mass.

The measurement of body composition can provide a more objective means of assessing nutrition status as it measures the actual body fat (Lee & Gallagher, 2008). With more children being exposed to obesigenic environments, human body composition has become increasingly important as evidence identifying relative body fat as a significant predictor of mortality accumulates (Wells et al., 2006). There are several methods for measuring body fat composition. However, all the available methods are complex and have cost-related limitations (Lee & Gallagher, 2008).

Commonly used techniques for the accurate measurement of body fatness include densitometry (underwater weighing), DEXA, total body electrical conductivity, magnetic resonance imaging (MRI), nuclear magnetic resonance (NMR) and Stable Isotope Dilution Techniques (Wells & Fewtrell, 2006). Although all these measures provide a
better indication of an individual’s body fatness than anthropometry, they can be expensive, intrusive, radioactive and not widely available (Sun et al., 2005). In addition, most of them are limited to research settings and not in nutrition practice, for instance, DEXA, MRI and NMR, while others such as underwater weighing are not suitable for use among children (Mei et al., 2002).

The SIDT uses a non-radioactive isotope to determine total body water, allowing the estimation of FM and FFM. This technique has been shown to be accurate in determining the percentage body fat mass under free-living conditions. In addition, SIDT requires less cooperation from the subjects (IAEA, 2011). This makes SIDT valuable specifically among children due to low cooperation required (Wells & Fewtrell, 2006). Use of SIDT adds value by increasing the sensitivity and specificity in body composition assessment. It’s one of the most accurate methods of body composition assessment compared to conventional techniques (Silva et al., 2013).

Deuterium (²H) is one of the stable (non-radioactive) isotopes of hydrogen used in body composition assessment. However, use of deuterium in assessment of body composition has limitations due to high cost, especially in resource constrained countries (Blanc et al., 2000). Moreover, its use has been restricted by the relative complexity of measuring deuterium at low concentrations. In addition, although use of stable isotope dilution techniques have been accepted as the gold standard for body composition analysis, none of the techniques can be considered to meet the highest standards of accuracy. This is
because the techniques do not quantify body composition directly but predict from measurements of total body water (Bila et al., 2013; Duren et al., 2008). The technique of using deuterium to determine total body water is referred to as isotope dilution or enrichment method. A pre-determined amount of deuterium oxide is diluted with a known amount of water in a cup \( C_1 V_1 \), and then it is added to a body pool of unknown volume \( V_2 \) which is the body water, which contains a small amount of deuterium (natural abundance), thus the enrichment. This gives a total volume \( V_1 + V_2 \) (Figure 2.2).

![Deuterium enrichment/dilution](image)

**Figure 2.2: Deuterium enrichment/dilution, Source (IAEA, 2011)**

The deuterium oxide is allowed to mix freely with the water and a sample of body fluid in the form of urine or saliva is taken after 2-3 hours. Deuterium is considered to have completely mixed with body water after 2-3 hours, also known as equilibrium. After this,
the concentration of deuterium in saliva, urine or breast milk sample is measured \( (C_2) \). Then the size of the volume of water (body water) \( (V_2) \) can be calculated as \( V_2 = C_1V_1/C_2 \). This, therefore, allows determination of total body water. For accurate results, the volume of water consumed \( (V_1) \) should be subtracted from the calculated TBW. The isotope dilution method measures total body water given that lipids are hydrophobic and thus the body’s fat mass is anhydrous. However, there has been no focus on use of direct body composition assessment methods in Kenya.

2.4 Safety and Use of Stable Isotopes in Human Studies

The use of stable isotope techniques for human studies has been in practice for over 50 years. It uses deuterium, a non-radioactive and a stable isotope of hydrogen (Krumbiegel, 2010). It is declared safe to be used orally in form of deuterium oxide (IAEA, 2011). The method is safe and has been validated widely among different populations (Lof & Forsum, 2004). According to Knapp and Gaffney (1972), there is no radiation hazard associated with stable isotopes. The absence of radiation hazard also makes the synthesis and handling of stable isotope-labeled compounds much simpler.

Once taken, it is easily eliminated from the body in form of urine, saliva, sweat and human milk as it mixes easily with body water within 3-4 hours (IAEA, 2011). Therefore, if physical activity, food and fluid intake are not controlled, they can lead to loss of tracer isotope from the body. The dose for children is usually very small 0.5 g of \( \text{D}_2\text{O} \) per kg body weight (Bila et al., 2013). The doses of stable isotope tracer substances
that are recommended for use in clinical diagnostic and research purposes appear safe and without any adverse effects (Koletzko, Sauerwald & Demmelmaier, 1997). Therefore, the occurrence of side-effects lies above the usual tracer dosages in clinical use. Use of stable isotope technology has been applied in human nutrition research (Koletzko, Sauerwald & Demmelmaier, 1997; Mirinda-da-Cruz & Mokhtar, 2003; Veillon, 2001). The main advantage of stable isotopes is the absence of exposure to radiation which makes it safe for use even among pregnant women and infants (Veillon, 2001).

2.5 Relationship between Energy Intake and Body Fat

It is generally believed that the current obesity epidemic is mainly due to environmental changes that affect energy intake (Gupta et al., 2012). However, the relative and absolute contributions of energy intake on obesity are unknown (Ekelund & Sardinha, 2004). The diet composition as well as total energy intake, may be influential (Bowen et al., 2015). Observational and intervention studies assessing the association between energy intake and body fat have demonstrated excessive energy intake and increase the risk of weight gain (Choi et al., 2008; D’Addesa et al., 2010; Freedman & Sherry, 2009; Triches & Giugliani, 2005; Warraich et al., 2009).

However, weight can be stored in form of lean mass or fat mass which is mainly influenced by the balance between energy intake and expenditure (Bowen et al., 2015). Increased energy intake from fat and low energy expenditure has been implicated as a causal or facilitating factor in the deposition of body fat (Atkins & Davies 2000). In
contrast, some studies show no association between energy intake, weight and body fat (Burns, 1993; Kelishadi et al., 2003; Rodríguez & Moreno, 2006; Willett, 1998). The true relationship between energy intake, body weight and fat has not been established. The major limitation is that use of accurate methods to assess body fat has not been employed when assessing these relationships, especially among African children. Most studies have used skinfold thickness as a measure of body fat reporting significant correlations (Bowen et al., 2015; Ledikwe et al., 2006; Moreno et al., 2000; Timpson et al., 2008).

2.6 Relationship between Physical Activity and Body Fat.

Sedentary behaviors are associated with the increased prevalence of obesity (Gregory et al., 2003; Kowalski et al., 2004; Rey-López et al., 2008). This is because a sedentary lifestyle contributes to low daily energy expenditure which eventually results to fat deposition and increased body weight (Corpeleijn et al., 2009). Studies have demonstrated that physical activity influences energy expenditure and modifies body composition favorably by reducing the fat mass (Bouchard, Blair & Haskell, 2007; Ekelund & Sardinha, 2004; Rennie et al., 2005; Warburton et al., 2006). However, the effect on body fatness was only significant for the amount of time spent at moderate and vigorous physical activity, an indication that is attaining the recommended time of >60 minutes of moderate to vigorous physical activity to accrue health benefits is of great importance (WHO, 2010).
In the same study, there was no association between physical activity and body fatness when body fatness was defined as BMI-for-age, indicating that BMI-for-age and the body fat may be different entities and that BMI-for-age may be a limited measure of body fatness in children. This is mainly because physical activity is likely to improve body fat profile even if there is no reduction in body weight which may be accounted by fat-free mass (Bouchard, Blair & Haskell, 2007; Bowen et al., 2015; Ness et al., 2007; Rennie et al., 2005). However, some other studies have shown a significant relationship between physical activity and body fat (Ness et al., 2007; Wareham et al., 2005). This indicates a need for further investigation on the actual relationship between physical activity and body fat. Yet, no known studies have been conducted among African populations.

2.7 Validation of Anthropometry in Estimating Body Fat

Anthropometric parameters are easy to obtain in assessing overweight and obesity (Charbonneau-Roberts et al., 2005). Studies show a number of cases of overweight and obesity that are not accompanied by excess body fat (Blanc et al., 2000; Miller et al., 2005). In addition, research has shown cases of body weight within the normal range but with a high percentage of body weight as fat (Kilpelainen et al., 2011; Romero-Corral et al., 2008). This leaves a gap on the relation between anthropometric measurements and body fat. Application of anthropometry indices assumes that differences in body measurements among individuals reflect differences in adiposity and that individuals with identical anthropometric measurements have identical body composition (Going et al., 2011).
Factors that influence body composition in ways not detected by anthropometric measurements include gender, puberty, age, children who have not reached full growth (stunted), race/ethnicity and physical activity (Angelica & Fong, 2008; Charboneau-Roberts et al., 2005; Dudeja et al., 2001; Kennedy et al., 2009). Among tall individuals, anthropometric measurements such as BMI underestimate obesity but overestimate among the shortest individuals (Charboneau-Roberts et al., 2005). The difference in height especially of the legs is likely to either increase the BMI-for-age cut off values or reduce it.

Stunting also alters appropriateness of the relationship between anthropometric measurements and body composition (Paula et al., 2011). This is because nutritionally stunted children are likely to have impaired fat oxidation compared to non-stunted children (Hoffman et al., 2000; Souganidis, 2011). Impaired fat oxidation is a risk factor for excess fat deposition. Moreover, different people may have the same weight and height but have very different body compositions. One person may be very muscular and lean with a substantial percentage of the weight coming from metabolically active muscle tissue, whereas another may be very sedentary and pudgy with a large percentage of the weight accounted for by inert fat tissue (Zanovec et al., 2009).

A study conducted among school children demonstrated that when comparing body composition variables across physical activity quartiles, no significant differences were observed for BMI-for-age; however, subjects in the highest quartile of physical activity
had a lower body fat and a higher lean tissue mass compared to subjects in the other three groups. This indicates that masculine individual may have high BMI but low body fat mass (Zanovec et al., 2009). During the aging process, there are many changes that occur in body composition even without changes in body weight (Genton et al., 2011). This is mainly indicated as an increase in body fat and a decrease in lean tissue (Marie-Pierre, 2010). Populations over 60 years of age have high body fat due to alterations in hydration factors and fat-free mass that makes the elderly to have a high fat composition (Hughes et al., 2002).

Different ethnic groups may also have different body fat mass at the same anthropometric cut-off values. For example, Asian populations have been shown to have higher percentages of body fat and lower levels of lean body mass for every level of BMI compared to Caucasians (Charbonneau-Roberts et al., 2005; Devi, 2003). Therefore, observations have led to the lowering of BMI cut-off points for Asian populations for identifying at-risk individuals (WHO, 2004a). It has also been indicated that Black people have an increased proportion of bone and muscle tissue compared to whites (Dudeja et al., 2001). Differences in body composition between White and African-American populations have been noted whereas BMI African-Americans tend to have more lean mass and skeletal mass than Whites (Angelica & Fong, 2008).

Children increase in size and change in proportions and body composition with an increase in age. Consequently, as girls grow into pubertal age, they tend to deposit more
fat mass than boys (Katzmarzyk et al., 2012; Kennedy et al., 2009). Therefore, children with the same weight and stature and have distinctive age are likely to have contrasts in muscle to fat ratio. The precision of anthropometric measurements likewise depends on the level of obesity. Among obese children, anthropometry is a good indicator of excess adiposity, but among relatively normal or thin children, difference in fat mass is likely to be observed in the same anthropometric cut-off points (Freedman & Sherry, 2009; Pasco et al., 2014). It should be noted, however, that the cut points chosen for anthropometric measurements and body fatness can strongly influence estimates of screening performance (Freedman & Sherry, 2009).

The potential influence of the cut-off points used for levels of anthropometric indices and body fatness on the screening performance of anthropometric measurements can be large and must be considered when interpreting the results of various studies. Studies conducted among Italian (Pelegrini et al., 2015) and African adolescents (Fernández et al., 2004) found that the best diagnostic value of WtHR for high body fat was 0.41, lower than the internationally proposed value of 0.50. Another study used cut-off values of +1.5SD for obesity and found a high sensitivity of BMI-for-age in diagnosing excess body fat (Javed et al., 2015).

A few studies have examined the performance of anthropometry to distinguish between fat mass and fat-free mass in comparison with techniques known to accurately measure body composition giving mixed results (Freedman & Sherry, 2009; Javed et al., 2015).
Indices of diagnostic performance utilized as part of such studies include sensitivity, which indicates the likelihood that a person who truly has excess body fat will have a positive test result in relation to anthropometry cut-off values defining obesity. The second index is specificity, defined as the possibility that a person who does not have excess body fat by the reference technique will have a negative test result.

Studies have suggested that the failure of many epidemiological studies to demonstrate a high diagnostic performance of anthropometric measurements can be explained by the inadequate ability of anthropometric measurements to distinguish body fat from a lean mass in diverse populations (Javed et al., 2015; Romero-Corral et al., 2008). Thus, it is imperative to know the precision of anthropometric measurements to identify body adiposity to validate its utilization in clinical practice to either diagnose or rule out excessive body fat at the individual level. No known study has been conducted to assess the performance of anthropometric measurements among African populations.

2.8 Prediction Equations in Estimating Body Fat

Body composition assessment often relies on anthropometric measurements or complex and expensive methods such as SIDT (Huang, Watkins & Goran, 2003). Since the precision and dependability of anthropometric measurements alone have been questioned, therefore, in many circumstances, it is recommended to utilize prediction equation for evaluating total body fat using a combination of simple demographic and anthropometric variables (Hoffman et al., 2000). This would allow quick determination of body
composition without the need for specialized laboratories, radiation exposure, or expensive equipment (Huang, Watkins & Goran, 2003). Prediction equations have been shown to accurately estimate body fat as an alternative to the expensive and complex direct measures (Bunc, 2000).

Validity and accuracy of prediction equations in the estimation of body fat depends on its application and the precision of the modeled equation. This is mainly because prediction equations are population-specific and application of equations on a different population from the one for which it was developed would certainly not predict body fat accurately (Deurenberg et al., 2001; Katzmarzyk et al., 2012). Furthermore, prediction equations with precision above 0.8 are considered accurate for use in populations where they were developed or among populations with similar characteristics (Moura et al., 2013).

Various prediction equations have been developed to estimate body composition among different children populations other than children in developing countries (Deurenberg et al., 2001; Pongchaiyakul et al., 2005; Ramirez-zea et al., 2006). The majority of these equations have typically utilized the sum of skin fold measurements as a covariant. In Kenya, measurement of skin fold thickness is not a typical practice as opposed to the use of weight, height and waist circumference. Therefore, using prediction equations for measuring body fat creates a need to develop equations that are specific to Kenyan children population.
2.9 Summary of Literature Review

Literature has shown that most methods used to determine body composition are limited to research settings. Anthropometric measurements, dietary practices and physical activity level remain the most commonly used direct and indirect methods of determining nutrition status. These methods are cheap, easy to use in clinical and research settings. However, they have some limitations as they do not directly assess body composition. Given the increased obesity levels and health risks associated with excess body fat, ideally, direct measures of body composition should be used to determine body fat levels as a factor associated with health risk.

However, direct techniques of body composition assessment are not commonly used because they are costly and may not be applicable to the nutrition assessment practice in the developing world. Therefore, the use of anthropometric measurements, physical activity level and dietary intake as measures of nutrition status has continually been used as a relative measure of fatness. However, there are limitations on what these measures can provide. In this regard, there is a need for validation of anthropometry, dietary intake and physical activity methods. Use of equations in estimating body fat is gaining global interest as alternative methods of measure of body composition. However, there are few non-African children based equations hence the need for the development of equations that can be used to provide better information related to body fat in individuals and populations. This study sought to address these gaps.
CHAPTER THREE: METHODOLOGY

3.1 Research Design
This study adopted a cross-sectional analytical design and both quantitative and qualitative data were collected.

3.2 Research Variables
3.2.1 Independent Variables
The independent variables of this study were dietary practices, physical activity characteristics and anthropometric measurements (BMI-for-age and waist circumference) of school children.

3.2.2 Dependent Variables
The dependent variable for this study was percent body fat.

3.3 Study Area
The study was carried out in Nairobi City County which is the commercial and political capital of Kenya (Appendix A). Nairobi City County covers an area of 696.1 kilometers square. It borders Kiambu County to the North, Machakos County to the East and Kajiado County to the south. Nairobi City County is divided into nine sub-counties namely Starehe, Kamukunji, Kasarani, Makandara, Embakasi, Njiru, Dagoretti, Langata and Westlands (GOK, 2014). The inhabitants of Nairobi city face the consequences of
nutrition transition due to lifestyle change which are associated with the rising prevalence of overweight and obesity among school children (Kyallo et al., 2013).

3.4 Target Population

The target population comprised school going children aged 8-11 years from four urban day public schools which was the target for RAF 6042 project. This age group forms a window of opportunity to assess nutritional disorders missed during the early years and well before the onset of adolescence. Children aged 8-11 years were purposively selected since the study’s focus was on those children who would respond to the data collection tools and had not entered pubertal period due to effect of pubertal hormones on growth and body composition. Day schools were selected because dietary intake and physical activity in day schools are more varied than in boarding schools.

3.4.1 Inclusion Criteria

Pupils aged 8-11 years who assented and whose parents consented to this study by signing consent forms (Appendix B), were included in the study.

3.4.2 Exclusion Criteria

Children with known chronic medical conditions such as diabetes were excluded from the study since the study involved fasting for about 4 hours.
3.5 Sample Size Determination

The sample size was calculated by Cochran formula: \( n_o = \frac{Z^2pq}{e^2} \) for cross-sectional studies (Israel, 1992).

Where:

\( n_o \) = the desired sample size

\( Z \) = the standard normal deviation at 95% confidence level (1.96)

\( P = (0.19) \) which is the proportion in the target population estimated to have overweight and obesity (Kyallo et al., 2013)

\( q = (1-p) = 0.81 \)

\( d = \) the desired level of precision (0.05)

\( n_o = (1.96)^2(0.19) (0.81)/ (0.05)^2 = 237 \)

The finite population correction for population less than 10,000 was done to produce a sample size proportional to the population by the formula;

\[ n = \frac{n_o}{1 + \left(\frac{n_o}{N}\right)} \]

\( n \) = the sample size

\( n_o \) = the desired sample size

\( N \) = the estimate of children aged 8-11 years from four study schools was 720 which were the target sites for the RAF 6042 project in which this study was part of.

\( n = 237/ [1 + (237/ 720)] = 178 \)

To cater for non-response, the calculated sample size was increased by 15% to give a final sample size of 205. Data was collected on sample of 202 children who signed and expressed willingness to participate in the study.
3.6 Sampling Procedure

Nairobi City County was purposively selected as it has been reported to have shifted towards western culture in terms of dietary practices and lifestyle (Schmidhuber & Shetty, 2005) (Figure 3.1)

**Figure 3.1: Sampling procedure**

N=Children aged 8-11 year in each school, S=Calculated sample size per school, A=actual sample size per school realized.
Kasarani sub-county was randomly selected from the 9 sub-counties in Nairobi City County and four schools from a total of 25 were randomly selected. The desired sample size was drawn from the four schools. Proportionate to size sampling was used to determine the number of children to be selected from each school. At the school level, stratified random sampling was used to select children from each age category; 8, 9, 10 and 11 years.

3.7 Data Collection Tools

A structured questionnaire (Appendix C) was used to collect information on demographic and socio-economic characteristics, nutrition knowledge and attitude, dietary energy intake and physical activity of the participating children. Focus group discussions (FGDs) (Appendix D) were conducted among the children to generate more information on dietary practices and physical activity. Key informants questionnaire (Appendix E) was administered to the head teachers of the participating schools. This helped generate information on the school environment for pupils’ physical activity, playground, play items and time for physical activities. It also aimed to establish the availability of school meals and presence or absence of school tuck shops.

3.8 Pre-testing of Data Collection Tools

Pre-testing of both quantitative and qualitative data collection tools was done in a fifth primary school located in the same Sub-County but not participating in the main study. A total of 45 children were involved in the pre-test of the data collection instruments with
the aim of assessing whether the designed tools would collect the intended information. To pre-test the process of saliva collection and analysis of body composition, 10 children were involved. From the results obtained from the pre-test exercise, it was noted that some demographic characteristics and some components of the 24-hour recall could only be answered by the parents. Therefore, the procedures were modified to follow up children at home after identifying them at the school level for complementary information from parents. The PAQ-C was modified to capture games and activities found in a Kenyan set up.

### 3.9 Reliability and Validity of Data Collection Tools

The reliability of the data collection tools was tested aiming at Cronbach alpha coefficient of 0.70 or higher (Fraenkel, 2000). Data collection tools were administered twice and saliva samples were collected twice after dosing to the pre-test sample and the two results were correlated in order to evaluate the test for reliability of the data collection tools. A Cronbach coefficient of 0.82 was obtained in this study when pre-test data on nutrition knowledge, attitude, dietary intake, anthropometric measurements and body fat were analyzed for reliability. After pre-testing, the information collected with the tools was checked against the objectives. The tools were modified to ensure that only intended information was collected. Any question providing unnecessary information was eliminated, while some more questions were added as needed.
3.10 Selection and Training of Research Teams

The research team consisted of the principal researcher who trained the research team and oversaw the data collection process. Four research assistants with a degree in the field of Nutrition assisted in taking the anthropometric measurements, administration of the questionnaires fixing and monitoring of the accelerometers. Two laboratory technologists assisted in deuterium dosing, saliva collection and analysis.

The training was facilitated by the principal researcher. The training focused on ethical issues, purpose and objectives of the study and data collection procedures. The laboratory technologists were trained on saliva samples collection, deuterium dosing procedure and saliva samples analysis. The other research assistants were trained on how to take anthropometric measurements and administration of questionnaires. During the training, emphasis was laid on the calibration of instruments, preparation and positioning of the participants and accurate reading and recording of the measurements. The research team was also trained on how to program, initialize and fix an accelerometer for the collection of physical activity data. To reduce on measurement errors, the training also involved demonstrations and role plays until the research assistants were clear on the anthropometric procedures.

The whole data collection team was taken through the questionnaires including key informant questionnaire, focus group discussion guide and dietary questionnaire to understand the kind of information the study aimed to collect. The team was also trained on how to check for the completeness and consistency in the questionnaire before leaving
the field. The training was done for four days, in day one, the team was trained on the anthropometric measurements and demonstrations were done; day two, they were trained on physical activity questionnaire and fixing of accelerometers; day three, they were trained on food frequency questionnaire, dietary diversity questionnaire, 24 hour recall questionnaire and knowledge questionnaire and finally, in day four, they were trained on administration of hydrogen isotopes and saliva sample collection and analyses.

3.11 Data Collection Procedures

3.11.1 Socio-demographic Characteristics

Socio-demographic characteristics of the children and their households were collected using a questionnaire. This included information on parents’ occupation, the size of the house, type of toilet, source of water and household head.

3.11.2 Dietary Practices

A 24-hour dietary recall was administered to the children on two randomly picked weekdays and one weekend day at home (Appendix C). Children were identified at school and followed home for the administration of 24 -hour recall. A detailed description of the foods eaten and amount consumed was estimated by using common household utensils and food photos album. Volumes and weights of commonly used household measures for commonly consumed foods were determined before the study to help in establishing volumes and weight of the foods consumed. The respondents were asked to state the type and amount of ingredients used to cook the meal for the entire
household. Then the volume of food cooked, amount served to the respondent, the leftover amount from the serving and the volume of food consumed was determined. The amount of ingredients consumed in grams were then calculated and used to analyze the amount of energy and nutrients consumed using Nutri-survey software.

To assess the frequency of food intake, a 7 day food frequency questionnaire (FFQ) was administered to the children at home. The FFQ had a list of 7 food groups namely; cereals, roots and tuber, fruits, vegetables, legumes, pulses and nuts (plant proteins), meat, poultry and fish (animal proteins), milk and milk products. The FFQ was modified to capture other food groups such as fast foods and sweetened beverages. A dietary diversity score was established by assessing the number of food groups consumed by the children. All the food items consumed by the pupils were categorized into 14 food groups as recommended by FAO (2008). These are cereal; vitamin A rich vegetables and tubers; white roots and tubers; dark green leafy vegetables; other vegetables; vitamin A rich fruits; other fruits; organ meat; flesh meat; eggs; fish; legumes, nuts and seeds; milk and milk products and oils and fats.

3.11.3 Nutrition Knowledge and Attitudes

The level of nutrition knowledge was determined using 10 nutrition knowledge questions regarding food, nutrition and healthy eating. The tool was designed by the principal researcher and reviewed by a team of experts from IAEA. To assess the attitude towards
practicing good dietary habits, the study children were asked questions on their feeling about healthy eating (Appendix C).

### 3.11.4 Physical Activity Level

A physical activity questionnaire for children (PAQ-C) was administered to the study children. This questionnaire is internationally validated and accepted for use in elementary school (Kowalski et al., 2004). In addition, the study also used ActiGraph GT3X model 6 accelerometer on a sub-sample of 20% of the study children. The accelerometer mounted on an elastic belt was placed at child’s waist at the right side of the body to capture the activity level (Figure 3.2).

![Figure 3.2: A child wearing an accelerometer](image)

The child wore the accelerometer daily for seven days (Trost et al., 2000). A physical activity diary was given to the child to record the non-wear period plus the sleep period
To ensure adherence, the parents were requested to ensure the child wore the accelerometer immediately after waking up. At school, the teachers and researcher were involved in spot checking on proper positioning of the accelerometer.

### 3.11.5 Anthropometric Measurements

Anthropometric measurements namely weight, height and waist circumference were taken to assess the child’s nutrition status using the procedure outlined in the IAEA SOPs for taking anthropometric measurements (Appendix G). Height was taken with a Holtain stadiometer (Holtain Limited Dyfed, UK). The participant was asked to stand on the stadiometer facing the person taking the measurements. The participant’s head was positioned such that the eyes were looking straight forward, without tilting the head. The participant was asked to put the feet together, heels against the stadiometer and knees straight. The researcher ensured that the eyes were at the same level as the ears, and then the measuring headboard was moved gently down to the head of the participant. The participant was asked to breathe in and stand tall. The height was read to the nearest 0.1cm with the eyes of the measurer being at the same level with the headboard.

Weight was taken using an electronic scale (Seca model 770; Seca Hamburg, Germany). The scale was placed on a firm and flat surface. The scale was switched on and the measurer waited until the display showed 0.0. The participants were asked to remove their footwear, any coats, heavy sweaters, keys or heavy pocket contents. They were then asked to step onto the scale with one foot on each side of the scale. They were asked to...
stand still, face forward, place arms on the side and wait until they were told to step off. The readings were taken to the nearest 0.1 kg. The scale was tarred to zero after every measurement. The scales accuracy was periodically calibrated using a reference weight.

Waist circumference was measured using a Lufkin (W606 pm) constant tension tape. The measurements were taken at the end of normal expiration with the arms of the participants relaxed at the sides. Measurements were taken at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. The measurements were taken to the nearest 0.1cm. All anthropometric measurements were taken three times and the average calculated. Blood pressure was determined using Omron blood pressure type series 7. The participants were asked to be seated five minutes before measuring the blood pressure, and to be relaxed, not to talk, and with their back supported. The participants were requested to keep their feet on the floor without crossing the legs.

The left arm was supported at the same level with the heart and with the palm facing upwards. Clothes were removed or rolled up on the arm ensuring that there was no tight clothing constricting the arm. The cuff was then placed on neatly around the upper arm above the elbow with the sensor of the bladder over the brachial artery. The Velcro fastener was used to attach the cuff snugly around the arm, but not tightly. The monitor was then switched on and the reading of both systolic and diastolic pressure recorded. The monitor was then switched off while leaving the cuff into place. Then the monitor
was switched on again after four minutes for the second reading. The readings were taken three times and measurements recorded using the conventional method: systolic pressure in mm Hg “over” diastolic pressure in mm Hg.

3.11.6 Focus Group Discussions and Key Informants

Focus group discussions and key informant interviews were used to generate in-depth information on dietary practices and physical activity. Key informant interviews were held with the head teachers of the participating schools to get in-depth information on the school environment in terms of physical activity and dietary practices. Two FGDs per school each comprising of 8 children were researcher facilitated using an FGD guide. All the deliberations of the discussion were recorded. The researcher ensured that the selected venues were relaxed and free from disruption. Deliberate efforts were made to ensure discussion questions followed each other as they appeared in the guide.

3.11.7 Body Fat Determination

This study used Deuterium (²H) which is one of the stable (non-radioactive) isotopes of hydrogen used in body composition assessment.

3.11.7.1 Preparation of the Deuterium

Deuterium dose was prepared at Kenyatta University laboratory. The weighing of deuterium was done using an electronic weighing scale which was able to measure up to 0.01g accuracy. A 60 ml bottle with a wide mouth was weighed together with the lid
(Wa). The weight was recorded and the amount of dose that corresponded to the weight of the child was added to the bottle using a measuring cylinder and the weight (Wb) taken and recorded. The actual weight (Wc) of the dose consumed by the child was calculated as Wc=Wb-Wa. The dose was weighed to four significant places (00.00g). A record of the batch number of the stock solution of deuterium oxide used to make the doses, the date the doses were prepared, the dose number, the weight of the bottle, the weight of the bottle plus dose and the weight of the dose were all recorded in a spreadsheet.

3.11.7.2 Preparation and Dosing of the Participants

The procedures outlined in the IAEA, SOPs for saliva sample collection, dosing and analysis were followed (Appendix H). Each participant was given a deuterium dose which corresponded to their weight to drink using a straw (Table 3.1).

Table 3.1: Standardized dose of deuterium oxide given to children

<table>
<thead>
<tr>
<th>Body weight (kg)</th>
<th>Weight of $^2$H$_2$O required (g)</th>
<th>Approximate dilution of 1g in 5 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>11-20</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>21-30</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>31-50</td>
<td>20</td>
<td>No dilution</td>
</tr>
<tr>
<td>&gt;50</td>
<td>30</td>
<td>No dilution</td>
</tr>
</tbody>
</table>


Participants were asked to empty the bladder then they were weighed in light clothing (0.1 kg) as per anthropometry procedures. A baseline saliva sample (4 mls) was then collected from the participants (Figure 3.3).
Dose bottle was inverted to ensure that contents were fully mixed

The participants were asked to empty bladder

Participants were weighed in light clothing (to 0.1 kg) as per anthropometry procedures

Baseline saliva sample was collected

The participant drank by straw the dose of \( ^2 \text{H}_2 \text{O} \). mL of drinking water was added to the bottle and participant drank it to rinse the mouth.

Collect first post-dose saliva sample after 2 hours

Collect second post-dose saliva sample after 3 hours

Wait for 2 hrs for the dose to equilibrate with body water

Wait for a further 1 hour

Figure 3.3: Procedure for dosing the participants

The participants were then given 40 ml of drinking water to rinse the mouth. The time of taking deuterium dose was immediately recorded on the participant dosing form.
(Appendix I). The participants waited for two hours after which the first post-dose saliva sample was collected. The participants were asked and monitored not to consume food or liquids and to avoid physical activity during the equilibration period. This was mainly to minimize the loss of deuterium in urine and sweat. During this time the participants were engaged in responding to the physical activity and nutrition knowledge questionnaire. This was vital as it helped the researcher to control the participants from engaging in physical activities or consuming foods and drinks. After two hours, first post-dose saliva sample was collected and finally a second post-dose saliva sample was collected after another one hour.

3.11.7.3 Procedure for Collection and Storage of Saliva Samples

To collect the saliva sample, the participants were given a dry cotton swab and asked to rotate it around their mouth for 2 minutes until it was fully soaked in the saliva. The participants were asked to move the cotton swab to the front of their mouth. This was then transferred into the syringe barrel. This was done by removing a plunger from a 20 ml plastic syringe, which was replaced into the syringe barrel and used to squeeze the saliva out of the syringe into the appropriately labeled 4 ml cryovials. The process was repeated until 4ml of saliva was attained. All the samples were labeled appropriately and sample bottles were tightly capped.

The saliva sample bottles were stored in two small lockable bags for each participant; one for the baseline sample and one for the post-dose samples permanently marked. Then the
two small zip-lock bags were then put in another zip-lock bag labeled permanently with the participant's identification number. The bags were then immediately stored in a cool box during the transportation from the field, after which they were frozen at -20\(^\circ\)C in a freezer at Kenyatta University laboratory, awaiting transportation to Nairobi University where analysis was done.

3.12 Data and Statistical Analyses

3.12.1 Dietary Practices, Nutrition Knowledge and Attitude Analyses

Data from 24-hour recall was analyzed using Nutri-survey computer software to establish the amount of calories consumed in a day. This was then compared with the recommended daily energy requirements’ for children by FAO and WHO to determine the adequacy of energy intake (FAO/WHO, 2001). The DDS was calculated from the 14 food groups (FAO, 2008). A score of \(\leq 3\) was considered as low dietary diversity, \(4-5\) was considered as moderate while a score of \(\geq 6\) was considered as high dietary diversity (FAO, 2008). Food frequency was considered regular if taken more than 4 times a week (Swindale & Bilinsky, 2006). To determine the nutrition knowledge, each correct response was coded as 1 and an incorrect response as 0. The total score for every child was calculated from all correct responses with a maximum of 10. Overall knowledge level was the total of correct responses converted to percentage.
3.12.2 Physical Activity Analyses

Physical activity was analyzed following the procedure described by Kowalski et al., (2004) where scoring was done from a set of 9 questions (items) in the PAQ-C. The mean of all activities on the activity checklist was calculated to form a composite score for question 1. For questions 2 to 8, the reported value that was ticked off for each item was used (the lowest activity response being a 1 and the highest activity response being a 5). For question 9, the mean of all days of the week was calculated (“none” being a 1, “very often” being a 5) to form a composite score for question 9.

Once a value from 1 to 5 for each of the 9 questions was obtained, the mean of these 9 questions, was then calculated to get the final PAQ-C activity summary score. Score values of 1 to 2 indicated low physical activity, >2 to 3 moderate activity, >4 as high where a score of 5 indicated very high physical activity (Chen et al., 2008; Kowalski et al., 2004; Voss, Ogunleye & Sandercock, 2013). The accelerometers were initialized using 15 minutes epoch. Data from the accelerometer was downloaded and analyzed using Acti-life software version 6.3 using the cut off points recommended by Puyau et al., (2002) and valid wear time of four days. Results were further compared with the WHO recommendation of 60 minutes in moderate to vigorous activity in order to accrue health benefits (WHO, 2010).
3.12.3 Anthropometric Data Analyses

Anthropometric data was analyzed using WHO Anthroplus software to determine the BMI-for-age z-scores among the study children. The distribution of BMI-for-age z-score was then described according to WHO guidelines as follows; <-2SD as thin, >-1SD as normal, >+1SD as overweight and >+2SD as obese (WHO, 2009). Abdominal obesity was defined using waist-to-height ratio cut-off value of ≥ 0.50 (Albuquerque et al., 2012). Blood pressure was categorized as systolic blood pressure ≥140mmHg and/or diastolic blood pressure of ≥90 mmHg classified according to ages and sexes using the cut-off of National High Blood Pressure Education Program as quoted by Robinson et al., (2004).

3.12.4 Body Fat Analyses

Analyses of deuterium enrichment in the saliva samples was performed using Fourier Transform Infrared Spectrometry (FTIR) Shimadzu FTIR IR prestige-21 Model at the department of Pediatrics and Child Health at the University of Nairobi. In preparation and calibration of the FTIR equipment; an instrument calibration standard of 1017 ppm against which the saliva samples were read was first measured at 2300-2900cm-1 using the IR solution software on the FTIR after which the spectrum was exported to the MRC software, the ‘isotope.exe program’ for reading in ppm to get the calibration curve (Appendix J).

Saliva samples were completely thawed before analyses. The vials containing the saliva samples were centrifuged for 10 minutes with the lids on, to move any condensation on
the lid back to the bulk of the sample and to remove bubbles. The window of the cell was then cleaned with lint free tissue. A disposable plastic syringe was filled with 1 ml saliva sample then pushed through into the cell. This was done while firmly pressing a folded absorbent paper over the exit port of the cell to absorb excess sample and prevent ingress of air. Any splash on the outside of the cell window was cleaned using an absorbent paper and presence of bubbles was checked by holding the cell up to a light.

The cell was then inserted into the sample compartment chamber of the FTIR machine for reading of the absorbance. Absorbance was then measured from 2300-2900 cm\(^{-1}\) using the IR solution software on the FTIR. The spectrum was then exported to the MRC software, the ‘isotope.exe program’ for reading in ppm against the calibration standard with deuterium enrichment of 1017 ppm. The procedure was done thrice for the baseline sample to form the background and for the two post-dose samples (samples collected at two hours and at three hours), and the mean for the two was calculated. This gave the TBW for the respondents which allowed the calculation of FM and FFM. To avoid cross-contamination a new syringe was used for each new sample. When all the samples were analyzed, the cell was rinsed using good quality drinking water before storing. The unused portions of each saliva sample were placed in storage at -20°C for a period of 6 months after which they would be disposed of.
3.12.4.1 Calculation of Body Fat from Total Body Water

Calculation of TBW was done from the dose of deuterium oxide consumed and the concentration of deuterium in saliva, including correction for non-aqueous exchange. The results were given in mg $^2$H$_2$O per kg H$_2$O (ppm).

$$TBW (kg) = \frac{\text{Dose } ^2\text{H}_2\text{O (mg)}}{\text{enrichment } ^2\text{H in saliva (mg/kg)}}$$

The $^2$H space is usually 1.041 times TBW due to the fact that deuterium in body water enters other pools within the body, which is known as non-aqueous exchange, thus TBW was calculated as:

$$TBW (kg) = \frac{\text{Dose } ^2\text{H}_2\text{O (mg)}}{\text{concentration } ^2\text{H in saliva (mg/kg)}} / 1.041$$

Then,

$$\text{FFM (kg)} = \frac{\text{TBW (kg)}}{\text{hydration factor (Lohman hydration factors for children was used) (Appendix K)}}$$

$$\text{FM (kg)} = \text{body weight (kg)} - \text{FFM (kg)}$$

Results were expressed as % body weight

$$\text{FM (\%)} = \frac{\text{FM (kg)}}{\text{body weight (kg)}} \times 100$$

3.12.4.2 Categorization of Body Fat

The percent body fat was categorized as follows; <12.5% = low fat, 12.5-20% = normal fat, >20-25% as over fat and >25% as obese for boys while for girls, <15% as low fat, 15-25% as normal fat, >25-30% as over fat and >30% as obese (McCarthy et al., 2006).
3.12.5 Qualitative Data Analyses

Qualitative data from FGDs and key informant interviews were coded by assigning labels to variable categories. Then frequencies were determined. Common themes were then established and clustered in a patterned order to clarify variables. Inferences were made from the specific information under every theme and conclusions drawn from the findings. The findings were triangulated with the reported quantitative data.

3.12.6 Statistical Analyses

Data were entered into EpiData software which allows for double entry. This enabled cross validation of the data and consistency and normalcy checks. Data were then transferred to SPSS (version 20.0) software for further statistical analyses. Data were described using descriptive statistics; mean and percentages and summarized using tables and figures. Data were further analyzed by use of inferential statistics where Pearson product moment correlation (r) was used to determine the relationship between energy intake, physical activity score, BMI-for-age and percent body fat. Chi-square test was used to establish the relationship between nutrition knowledge, attitude and dietary practices. Wilcoxon test was used to compare the proportion of children in various level of energy intake, proportion of children at various level of physical activity and the proportion of children in various body fat categorizations. Mean differences in body fat, weight, height, waist circumference and age between boys and girls was done using t-test. The odds ratio was used to test for association between body fat, dietary intake and physical activity.
Cohen’s Kappa (k) was used to test for concordance between BAZ, energy intake, physical activity level and percent body fat categorization. Strength of agreement was described as follows; $k \leq 0.20$ as poor, 0.21- 0.40 fair, 0.41- 0.60 moderate, 0.61- 0.80 good, 0.81-1.0 very good (Kwiecien, Kopp-Schneider & Blettner, 2011). The bland-Altman analysis was used to assess the level of agreement between the actual fat mass scores derived from the reference method (SIDT) and the fat mass scores estimated using the prediction equations at the 95% confidence intervals. This was done using MEDCAL software based on the method described by Bland and Altman (Myles & Cui, 2007). For comparable measurements, differences should be centered on zero and should show no systematic variation in the mean of measurement pairs.

### 3.13 Development of Prediction Model

To model prediction equations that can best predict total body fat among school children, variables to be included in the model were tested for outliers using Turkey’s analysis. To model an equation, the data should have no outliers, and the variables should be within the acceptable range, with the upper and lower distribution limits of the median being $\pm 2$ times the inter-quartile range (Ramirez-zea et al., 2006). All the independent variables were checked to ensure that they had a relationship or association with the dependent variable. A correlation with a P-value of at least 0.02, with the independent variable was required for the dependent variable to be considered in the equation development (Wong, 2013).
The study sample was then randomly split into two groups using random number generator, the first group was for the development of the equation and the second group was for cross-validation as recommended by Wong (2013). A sample of at least 40 per group is considered adequate for validation of prediction equation (Wong, 2013). The two groups were stratified for sex and tested for homogeneity in key variables to include in the equations using independent sample t-test. The equations were modeled using step-wise multiple regression procedure and each variable tested for the extent to which it improved the equation. A variable should be included in the model if it raises $R^2$ by at least 0.02. The best prediction equations were selected based on $R^2 > 0.8$ and with a minimum standard error of <3.5 (Moura et al., 2013).

3.14 Ethical Considerations

Research approval was obtained from Kenyatta University Graduate School (Appendix L) while ethical clearance was obtained from Kenyatta University Ethical Review Committee (Appendix M). Research permit was obtained from National Commission for Science, Technology and Innovation (NACOSTI) (Appendix N). The head teachers and parents were given an informed consent form to sign prior to the study. All participating children were given a written assent form to sign after being informed of procedures and purpose of the study (Appendix A). The respondents were assured of data confidentiality during and after the study. The school head teacher, parents and pupils were informed of the benefits and the anticipated risks of the study.
CHAPTER FOUR: RESULTS

4.1 Socio-demographic Characteristics of the Children

The age distribution of the study children was between 8-11 years with majority (40.6%) being 11 years and the mean age was 10.1±0.9. Slightly more than half of the children (54.0%) were girls while 46% were boys. There was no significant difference between the number of boys and girls ($\chi^2=1.267$, $p=0.260$). The average household size was 4.9±1.4. Most households (79.7%) had fathers as household heads. Majority of the households (73.3%) had access to flush toilets either inside or outside the house and 97.6% had access to tap water (Table 4.1).

Table 4.1: Household and children characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Characteristics</th>
<th>N=202</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Boys</td>
<td>93</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Girls</td>
<td>109</td>
<td>54</td>
</tr>
<tr>
<td>Age (years)</td>
<td>8</td>
<td>15</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>38</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>67</td>
<td>33.2</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>82</td>
<td>40.6</td>
</tr>
<tr>
<td>Type of toilet</td>
<td>Flush toilet outside</td>
<td>80</td>
<td>39.6</td>
</tr>
<tr>
<td></td>
<td>Flush toilet inside house</td>
<td>68</td>
<td>33.7</td>
</tr>
<tr>
<td></td>
<td>Pit latrine</td>
<td>54</td>
<td>26.7</td>
</tr>
<tr>
<td>Source of water</td>
<td>Outside tap water</td>
<td>128</td>
<td>63.4</td>
</tr>
<tr>
<td></td>
<td>Indoor tap water</td>
<td>69</td>
<td>34.2</td>
</tr>
<tr>
<td></td>
<td>Other water sources</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>Household size</td>
<td>≤ 3</td>
<td>30</td>
<td>14.9</td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>147</td>
<td>72.8</td>
</tr>
<tr>
<td></td>
<td>&gt;6</td>
<td>25</td>
<td>12.3</td>
</tr>
<tr>
<td>Household head</td>
<td>Father</td>
<td>183</td>
<td>79.7</td>
</tr>
<tr>
<td></td>
<td>Mother</td>
<td>19</td>
<td>20.3</td>
</tr>
</tbody>
</table>
4.2 Dietary Practices among the Children

4.2.1 Dietary Diversity among the Children

The mean DDS for the children was 3.8±1.4. The majority (70.3%) had consumed three food groups in the previous 24 hours which is considered as low dietary diversity. Slightly more than a fifth (22.8%) had moderate DDS while 6.9% had high DDS.

4.2.2 Food Frequency Consumption among the Children

The main food groups consumed in the previous 7 days were; cereals (83.7%), vegetables (82.2%) and roots and tubers (77.7%) (Table 4.2). Only 6.4% and 9.9% consumed flesh food and fruits, respectively for more than 4 times in the previous 7 days prior to data collection.

<table>
<thead>
<tr>
<th>Food group consumed</th>
<th>N=202</th>
<th>4-7</th>
<th>2-3</th>
<th>Once</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Cereals</td>
<td>169</td>
<td>83.7</td>
<td>33</td>
<td>16.3</td>
<td>0</td>
</tr>
<tr>
<td>Roots and tubers</td>
<td>157</td>
<td>77.7</td>
<td>45</td>
<td>22.3</td>
<td>0</td>
</tr>
<tr>
<td>Flesh foods</td>
<td>13</td>
<td>6.4</td>
<td>43</td>
<td>21.3</td>
<td>103</td>
</tr>
<tr>
<td>Legumes</td>
<td>35</td>
<td>17.3</td>
<td>124</td>
<td>61.4</td>
<td>43</td>
</tr>
<tr>
<td>Fruits</td>
<td>19</td>
<td>9.9</td>
<td>67</td>
<td>33.2</td>
<td>99</td>
</tr>
<tr>
<td>Leafy vegetables</td>
<td>166</td>
<td>82.2</td>
<td>27</td>
<td>13.4</td>
<td>5</td>
</tr>
</tbody>
</table>

More than half (59.9%) had not consumed nuts even once in the previous seven days prior to the study. Milk (not mixed in tea) had been consumed only once by 61.4% of the children. About a quarter of the children (28.2%), consumed sweetened drinks more than 4 times or for at least 2-3 times in a week (35.6%). Commonly consumed sweetened
drinks were fizzy drinks (sodas) and artificial juices. The proportion of children who had eaten fast foods above 4 times in a week was 40.6%. The fast foods commonly consumed were french fries, cakes, doughnuts, crisps, smokies, biscuits and chocolates (Table 4.3).

Table 4.3: Frequency of consumption of various snacks by the children

<table>
<thead>
<tr>
<th>Snacks consumed</th>
<th>N=202</th>
<th>4-7/7days</th>
<th>2-3/7days</th>
<th>Once/7days</th>
<th>Never/7days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Fruits</td>
<td>19</td>
<td>67</td>
<td>99</td>
<td>17</td>
<td>8.4</td>
</tr>
<tr>
<td>Nuts</td>
<td>3</td>
<td>24</td>
<td>54</td>
<td>121</td>
<td>59.9</td>
</tr>
<tr>
<td>Milk</td>
<td>24</td>
<td>43</td>
<td>124</td>
<td>11</td>
<td>5.4</td>
</tr>
<tr>
<td>Sweetened drinks</td>
<td>57</td>
<td>72</td>
<td>27</td>
<td>46</td>
<td>22.8</td>
</tr>
<tr>
<td>Fast foods</td>
<td>82</td>
<td>66</td>
<td>0</td>
<td>54</td>
<td>26.7</td>
</tr>
</tbody>
</table>

At home, most of the children (82.1%) mainly ate food as they watched television (TV) (Table 4.4).

Table 4.4: Eating environment among the study children at home

<table>
<thead>
<tr>
<th>Eating environment at home</th>
<th>N=202</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Ate in front of TV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-7 times a week</td>
<td>131</td>
<td>64.9</td>
</tr>
<tr>
<td>2-3 times a week</td>
<td>33</td>
<td>16.3</td>
</tr>
<tr>
<td>Never</td>
<td>38</td>
<td>18.8</td>
</tr>
<tr>
<td>Total</td>
<td>202</td>
<td>100</td>
</tr>
<tr>
<td>Eating meals with the family</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-7 times a week</td>
<td>137</td>
<td>67.8</td>
</tr>
<tr>
<td>2-3 times a week</td>
<td>43</td>
<td>21.3</td>
</tr>
<tr>
<td>Never</td>
<td>22</td>
<td>10.9</td>
</tr>
<tr>
<td>Total</td>
<td>202</td>
<td>100</td>
</tr>
</tbody>
</table>
Close to a third of the children (32.2%) took their meals alone most days without the presence of parents. Almost all the study children (95.5%) carried some money to the school to buy mid-morning snacks and/or lunch.

### 4.2.3 Energy Intake among the Children

The estimated mean energy intake for both girls and boys was slightly lower than the daily energy requirements (ERs) for this age group. However, the mean difference was not significant except for boys aged 11 years (Table 4.5).

**Table 4.5: Energy intake among the children**

<table>
<thead>
<tr>
<th>Energy intake</th>
<th>Age (Years)</th>
<th>Energy Requirement</th>
<th>Estimated mean energy intake</th>
<th>t-test P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>8</td>
<td>1830</td>
<td>1707.4 ±125.2</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>1978</td>
<td>1814.6 ±209.2</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2150</td>
<td>1927.4 ±145.7</td>
<td>0.059</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>2341</td>
<td>2054.6 ±339.1</td>
<td>0.041*</td>
</tr>
<tr>
<td>Girls</td>
<td>8</td>
<td>1698</td>
<td>1643.6 ±234.4</td>
<td>0.075</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>1854</td>
<td>1805.3 ±445.7</td>
<td>0.112</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>2006</td>
<td>1899.9 ±103.2</td>
<td>0.056</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>2149</td>
<td>2037.1 ±146.3</td>
<td>0.063</td>
</tr>
<tr>
<td>All</td>
<td>8-11</td>
<td>2086</td>
<td>1901.2±281.3</td>
<td>0.054</td>
</tr>
</tbody>
</table>


Though the energy intake was slightly below the recommended energy intake, it was observed that, 29.7% of the children had an energy intake above 120% of the ERs (Table 4.6).
Table 4.6: Proportion of children with various energy intakes

<table>
<thead>
<tr>
<th>Energy intake categorization</th>
<th>N=202</th>
<th>N=93</th>
<th>N=109</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Inadequate &lt;80%</td>
<td>11</td>
<td>5.4</td>
<td>7</td>
</tr>
<tr>
<td>Adequate (80-120%)</td>
<td>131</td>
<td>64.9</td>
<td>60</td>
</tr>
<tr>
<td>Excess (&gt;120%)</td>
<td>60</td>
<td>29.7</td>
<td>26</td>
</tr>
</tbody>
</table>

80% -120% is the WHO recommendation of daily energy adequacy

Only 5.4% of the children failed to meet 80% of ERs for energy intake. Carbohydrates, protein and fats provided 56.5%, 8.4% and 35.1% of the total energy intake, respectively.

4.3 Nutrition Knowledge and Attitude among the Children

Nutrition knowledge and attitude was established mainly on the snacking habit of the children. Close to half of the children (49.5%) had moderate nutrition knowledge (Table 4.7). The mean knowledge score was 51.6 ± 1.6. Almost all the children (90.6%) knew fruits are healthy snacks. Only a minority identified the role of various food groups in the body (Table 4.7). Majority of the children (64.9%) reported not to care about what they ate since they were still young and only 35.1% of children reported being concerned about the foods they eat.
Table 4.7: Nutrition knowledge level and attitude among school children on consumption of snacks

<table>
<thead>
<tr>
<th>Nutrition knowledge level (Percentage)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (&lt;40)</td>
<td>66</td>
<td>32.7</td>
</tr>
<tr>
<td>Moderate (41-69)</td>
<td>100</td>
<td>49.5</td>
</tr>
<tr>
<td>High (&gt;70)</td>
<td>36</td>
<td>17.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attitude towards healthy eating</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concerned about what you eat</td>
<td>131</td>
<td>64.9</td>
</tr>
<tr>
<td>Not concerned</td>
<td>71</td>
<td>35.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aspects of nutrition knowledge tested</th>
<th>n (202)</th>
<th>% with correct answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits are healthy snacks</td>
<td>183</td>
<td>90.6</td>
</tr>
<tr>
<td>When you eat too much fat you can become fat</td>
<td>126</td>
<td>62.4</td>
</tr>
<tr>
<td>Fruit and vegetables are good to fight against illnesses</td>
<td>150</td>
<td>74.3</td>
</tr>
<tr>
<td>Eating a lot of sugar, sweets and sweet food, is good for health</td>
<td>178</td>
<td>88.1</td>
</tr>
<tr>
<td>Eating a lot of sugar, sweets and sweet food can make you fat</td>
<td>46</td>
<td>22.8</td>
</tr>
<tr>
<td>Food group that you should eat the most every day</td>
<td>62</td>
<td>30.7</td>
</tr>
<tr>
<td>Food group that you should eat the least every day</td>
<td>93</td>
<td>46.0</td>
</tr>
<tr>
<td>Food group that gives your body the best energy</td>
<td>43</td>
<td>21.3</td>
</tr>
<tr>
<td>Food group that your body uses to build muscles</td>
<td>93</td>
<td>46.0</td>
</tr>
<tr>
<td>Food group that best protects the body against illnesses</td>
<td>124</td>
<td>61.4</td>
</tr>
</tbody>
</table>

4.4 Relationship between Nutrition Knowledge, Attitude and Practices among Children

Nutrition knowledge had no significant relationship with frequency and type of snacks consumed by the children (Table 4.8). Even those who knew that a high consumption of sugar and sweetened beverages are not good for health consumed sugary foods and drinks. In addition, knowledge on consumption of fat did not have a significant impact on lowering the consumption of fast foods. Likewise, knowledge on the importance of fruits to the body did not translate into higher consumption of fruits.
Table 4.8: Association between dietary intake and nutrition knowledge

<table>
<thead>
<tr>
<th>Relationship between knowledge score and food frequency consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonated drink                                          r = -0.101; p= 0.061</td>
</tr>
<tr>
<td>Artificial juice                                          r = -0.112; p= 0.059</td>
</tr>
<tr>
<td>Chips                                                      r = -0.115; p= 0.062</td>
</tr>
<tr>
<td>Chocolate                                                  r = -0.157; p= 0.078</td>
</tr>
<tr>
<td>Sausages                                                   r = -0.101; p= 0.061</td>
</tr>
<tr>
<td>Doughnuts                                                  r = -0.114; p= 0.060</td>
</tr>
<tr>
<td>Smokies                                                    r = -0.129; p= 0.063</td>
</tr>
<tr>
<td>Sweets                                                     r = -0.165; p= 0.058</td>
</tr>
<tr>
<td>Sandwich                                                   r = -0.154; p= 0.69</td>
</tr>
<tr>
<td>Popcorns                                                   r = -0.185; p= 0.06</td>
</tr>
<tr>
<td>Cakes                                                      r = -0.165; p= 0.06</td>
</tr>
<tr>
<td>Assorted Fruits                                            r =(-0.101 -0.170); p&gt;0.05</td>
</tr>
</tbody>
</table>

Attitude was found to have a significant relationship with consumption of sweetened beverages ($\chi^2 = 64.738$ df= 6, P = <0.001), fast foods ($\chi^2 = 101.7$ df= 6, P =<0.001) and fruits ($\chi^2 = 111.7$ df= 6, P= <0.001). Children who did not care about what they ate had a higher frequency of fast food and sweetened beverages consumption than those who felt that they should be concerned. From odds ratio test, children who frequently consumed fast food, sweetened beverages and fat were 3.11, P<0.001 (CI, 1.03 to 3.32), 2.43, P=0.001 (CI, 1.354 to 10.55) and 3.01 P<0.001 (CI, 1.27 to 7.033) times more likely to have high energy intake, respectively compared to their counterparts.

4.5 Physical Activity Level among the Children

Physical activity level of the children was assessed by use of physical activity questionnaire for children (PAQ-C) and by use of accelerometers. The mean physical activity score for all the children by PAQ-C was $2.9\pm0.6$. Girls had a significantly lower
physical activity mean score (2.8±0.6) compared to boys (3.1±0.5) \((t= 2.978, P=0.003)\). Close to half of the children (45.0%) had moderate physical activity level (PAL) with almost similar proportion (43.6%) having low activity level as recorded from PAQ-C score. Only a small proportion (11.4%) had high physical activity score (Figure 4.1). From the accelerometer data, the mean period (minutes) spent by the children in moderate to vigorous physical activity (MVPA) was 37.6±17.5. Only 15.2% of the children met the recommended minimum of 60 minutes spent in moderate to vigorous physical activity daily (WHO, 2010). The study results shows no significant difference (Wilcoxon-test, \(p=0.058\)) between children who were active by PAQ-C (11.4%) and by accelerometer (15.2%).

![Figure 4.1: Proportion of children in various Physical activity levels by PAQ-C](image)

Further analysis of children’s involvement in physical activity indicates that a third of the children (32.3%) always participated in physical education (PE) lessons, while 31.2% and 20.8% were sedentary during mid-morning and lunch breaks, respectively (Table 4.9).
Table 4.9: Physical activity involvement among the children

<table>
<thead>
<tr>
<th>Physical activity</th>
<th>Type of activity done</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of participating in PE</td>
<td>Do not participate</td>
<td>41</td>
<td>20.3</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
<td>96</td>
<td>47.5</td>
</tr>
<tr>
<td></td>
<td>Participate always</td>
<td>65</td>
<td>32.2</td>
</tr>
<tr>
<td>Physical activity level (break time)</td>
<td>Sedentary</td>
<td>63</td>
<td>31.2</td>
</tr>
<tr>
<td></td>
<td>Moderate activity</td>
<td>72</td>
<td>35.6</td>
</tr>
<tr>
<td></td>
<td>Highly active</td>
<td>67</td>
<td>33.2</td>
</tr>
<tr>
<td>Physical activity level (lunch time)</td>
<td>Sedentary</td>
<td>42</td>
<td>20.8</td>
</tr>
<tr>
<td></td>
<td>Moderately active</td>
<td>105</td>
<td>52.0</td>
</tr>
<tr>
<td></td>
<td>Highly active</td>
<td>55</td>
<td>27.2</td>
</tr>
<tr>
<td>Means of transport to school</td>
<td>Walking/cycling to school</td>
<td>132</td>
<td>65.3</td>
</tr>
<tr>
<td></td>
<td>Motorized transport</td>
<td>70</td>
<td>34.7</td>
</tr>
<tr>
<td>Frequency of playing electronic games</td>
<td>Every day</td>
<td>76</td>
<td>37.6</td>
</tr>
<tr>
<td></td>
<td>Most days (3-6 days/week)</td>
<td>53</td>
<td>26.2</td>
</tr>
<tr>
<td></td>
<td>1-2 days</td>
<td>73</td>
<td>36.2</td>
</tr>
</tbody>
</table>

More than a third (34.7%) used motorized transport to school while 37.6% of the children engaged in electronic sedentary activities such as TV watching, play station and phone games every day. Significant correlations were found between means of transport to school and PAL (χ² test P<0.001), PAL and engagement in sedentary activities during break time and lunch break (χ² test, p<0.001), (χ² test, p=0.002), respectively. Children found to engage most of the time in electronic games had low PAL than those who engaged for fewer days (χ² test, P<0.001).

Additional information from the key informants shows that schools had structured physical education (PE) lessons timetabled for an average of three times per week and taking an average of 35 minutes for each lesson though most children did not participate
in PE lessons. Most of the schools had an average of one designated playground area which was used for various games. Some of the play items found in the schools include baseball, foot balls, hula hoops and skipping ropes but they were inadequate with respect to the school population as reported by the head teachers (KI). All the schools had no provision for indoor games for use during bad weather. The head teachers reported that there were no free or low-cost facilities like recreation centers, parks and play grounds within reach of the children.

4.6 Anthropometric Measurements and Nutrition Status among the Children

The mean body weight for the study population was 30.5±6.8, mean height was 137.5±7.6, mean waist circumference was 58.9±6.9, and BMI-for-age was 16.0±2.4 (Table 4.10). There was no significant difference (P>0.05) in anthropometric measurements between girls and boys.

Table 4.10: Anthropometric measurements among children

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean total (n=202)</th>
<th>Boys (n=93)</th>
<th>Girls (n=109)</th>
<th>t-test p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>30.5±6.8</td>
<td>29.6±5.7</td>
<td>31.2±7.5</td>
<td>0.095</td>
</tr>
<tr>
<td>Height</td>
<td>137.5±7.6</td>
<td>136.5±6.0</td>
<td>138.2±8.7</td>
<td>0.120</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>58.9±6.9</td>
<td>57.8±5.9</td>
<td>59.7±7.6</td>
<td>0.050</td>
</tr>
<tr>
<td>Systolic pressure</td>
<td>91.3±8.8</td>
<td>90.4±7.2</td>
<td>92.0±9.9</td>
<td>0.182</td>
</tr>
<tr>
<td>Diastolic pressure</td>
<td>60.2±8.0</td>
<td>59.1±7.4</td>
<td>61.1±8.3</td>
<td>0.073</td>
</tr>
<tr>
<td>BMI-for-Age</td>
<td>16.0±2.4</td>
<td>15.8±2.1</td>
<td>16.2±2.6</td>
<td>0.257</td>
</tr>
</tbody>
</table>

Prevalence of overweight and obesity among children in this study was 8.0% of which 3.0% were obese while 5.0% were overweight (Table 4.11). A small proportion of children (7.4%) were thin. Using WtHR to assess central obesity, 6.9% of children were
found to have central obesity which was higher compared to overall obesity using BMI-for-age z scores.

Table 4.11: Nutrition status of children using BMI-for-age and WtHR

<table>
<thead>
<tr>
<th>Nutrition Status</th>
<th>N=202</th>
<th>N=93</th>
<th>N=109</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All %</td>
<td>Boys %</td>
<td>Girls %</td>
</tr>
<tr>
<td>Thin* (&lt;-2SD)</td>
<td>15 7.4</td>
<td>8  8.6</td>
<td>7  6.4</td>
</tr>
<tr>
<td>Normal* (&gt;1SD)</td>
<td>171 84.7</td>
<td>80 86.0</td>
<td>91 83.5</td>
</tr>
<tr>
<td>Overweight* (&gt;+1SD to &lt;+2SD?)</td>
<td>10 5.0</td>
<td>2  2.2</td>
<td>8  7.3</td>
</tr>
<tr>
<td>Obese* (&gt;+2SD)</td>
<td>6  3.0</td>
<td>3  3.2</td>
<td>3  2.8</td>
</tr>
<tr>
<td>Overweight + Obese*</td>
<td>16  8.0</td>
<td>5  5.4</td>
<td>11 10.1</td>
</tr>
<tr>
<td>Central obesity (WtHR)**</td>
<td>14  6.9</td>
<td>3  3.2</td>
<td>11 10.1</td>
</tr>
<tr>
<td>Normal</td>
<td>188 93.1</td>
<td>90 96.8</td>
<td>98 89.9</td>
</tr>
</tbody>
</table>

*WHO (2009) BMI-for-Age Z scores
**WtHR cut-off (Albuquerque et al., 2012)

4.7 Body Composition Characteristics among the Children

Complete data for body composition was for 179 participants. The percent body fat for the study children was 24.0±7.3 with girls having significantly higher percent body fat compared to boys (p<0.05) (Table 4.12).

Table 4.12: Mean body composition characteristics

<table>
<thead>
<tr>
<th>Body composition</th>
<th>N=179</th>
<th>N=80</th>
<th>N=99</th>
<th>t-test p values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean body fat (kg)</td>
<td>7.74±4.1</td>
<td>6.08±3.2</td>
<td>9.08±4.2</td>
<td>p&lt;0.001*</td>
</tr>
<tr>
<td>Mean percent body fat</td>
<td>24.00±7.3</td>
<td>19.65±5.9</td>
<td>27.52±6.4</td>
<td>p&lt;0.001*</td>
</tr>
<tr>
<td>Mean fat free mass</td>
<td>75.99±7.3</td>
<td>80.34±5.9</td>
<td>72.47±6.2</td>
<td>p&lt;0001*</td>
</tr>
<tr>
<td>TBW</td>
<td>58.07±5.4</td>
<td>60.97±4.5</td>
<td>55.72±4.9</td>
<td>p&lt;0001*</td>
</tr>
</tbody>
</table>

* Significant differences between boys and girls
The proportion of children with excess body fat was 24.0%, 33.0% had over fat while 3.3% had low fat (Table 4.13).

**Table 4.13: Proportion of children in various body fat categories**

<table>
<thead>
<tr>
<th>Body fat categories*</th>
<th>N=179</th>
<th>N=80</th>
<th>N=99</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Boys</td>
<td>Girls</td>
</tr>
<tr>
<td>Low fat</td>
<td>6</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Healthy fat</td>
<td>71</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>Over fat</td>
<td>59</td>
<td>21</td>
<td>38</td>
</tr>
<tr>
<td>Excess fat</td>
<td>43</td>
<td>16</td>
<td>27</td>
</tr>
</tbody>
</table>

*McCarthy et al., (2006) cut off point for percent body fat

4.8 Relationships between the Study Variables

Table 4.14 shows relationship between body fat and anthropometric measurements and the study independent variables. There was a significant correlation between the percent body fat with; energy intake, physical activity, sex, waist circumference, BMI-for-age and blood pressure. Similarly, BMI-for-age was found to have significant correlations with total energy intake, physical activity, waist circumference and blood pressure. Sex had no significant relationship with BMI-for-age and waist circumference though it was found to have significant association with percent body fat where girls had more fat compared to boys. Age was found to have no significant relationship with percent body fat, waist circumference and BMI-for-age. Energy intake, physical activity and blood pressure were found to correlate significantly with waist circumference.
### Table 4.14: Association between energy intake, physical activity, BMI-for-age, waist circumference and percent body fat

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Independent variable</th>
<th>Pearson correlation test</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent body fat</td>
<td>Energy intake</td>
<td>r = 0.621</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Physical activity score</td>
<td>r = -0.396</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>BMI-for-age</td>
<td>r = 0.757</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Minutes in MVPA</td>
<td>r = -0.149</td>
<td>0.046*</td>
</tr>
<tr>
<td></td>
<td>Waist circumference</td>
<td>r = 0.627</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Diastolic blood pressure</td>
<td>r = 0.245</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Systolic blood pressure</td>
<td>r = 0.202</td>
<td>0.006*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>r = 0.072</td>
<td>0.337</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
<td>χ² = 11.95</td>
<td>0.008*</td>
</tr>
<tr>
<td>BMI-for-age</td>
<td>Energy intake</td>
<td>r = 0.451</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Physical activity score</td>
<td>r = -0.335</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Minutes in MVPA</td>
<td>r = -0.196</td>
<td>0.021*</td>
</tr>
<tr>
<td></td>
<td>Systolic blood pressure</td>
<td>r = 0.219</td>
<td>0.003*</td>
</tr>
<tr>
<td></td>
<td>Diastolic blood pressure</td>
<td>r = 0.291</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
<td>χ² = 1.530</td>
<td>0.326</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>Energy intake</td>
<td>r = 0.659</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Physical activity score</td>
<td>r = -0.529</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Minutes in MVPA</td>
<td>r = -0.293</td>
<td>0.046*</td>
</tr>
<tr>
<td></td>
<td>Diastolic blood pressure</td>
<td>r = 0.277</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Systolic blood pressure</td>
<td>r = 0.199</td>
<td>0.005*</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>r = 0.325</td>
<td>0.337</td>
</tr>
<tr>
<td></td>
<td>Sex</td>
<td>χ² = 3.66</td>
<td>0.056</td>
</tr>
</tbody>
</table>

*Significant associations*

### 4.9 Association between Energy Intake, Physical Activity and Percent Body Fat

The odds ratio was used to measure the level of risk associated with low physical activity and increased energy consumption in relation to body fat mass (Table 4.15). Children who had high energy intake were 1.977 times likely to have high body fat than those with low energy intake (OR= 1.977; p=0.021 CI, 0.98 to 3.98). Similarly, children with low physical activity had 1.003 likelihood of having high body fat (OR= 1.003; p=0.004 CI, 1.30-4.71).
Table 4.15: Risk of having excess fat in relation to energy intake and physical activity level

<table>
<thead>
<tr>
<th>Variables</th>
<th>Healthy fat</th>
<th>Excess fat</th>
<th>Total</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low energy intake</td>
<td>62 (80.5%)</td>
<td>69 (67.6%)</td>
<td>131</td>
<td>1.977</td>
</tr>
<tr>
<td>High energy intake</td>
<td>15 (19.5%)</td>
<td>33 (32.4%)</td>
<td>48</td>
<td>(CI, 0.98 to 3.98)</td>
</tr>
<tr>
<td>Total</td>
<td><strong>77 (43.0%)</strong></td>
<td><strong>102 (57.0%)</strong></td>
<td><strong>179 (100%)</strong></td>
<td></td>
</tr>
<tr>
<td>Low PA</td>
<td>23 (29.9%)</td>
<td>56 (54.9%)</td>
<td>79</td>
<td>1.003</td>
</tr>
<tr>
<td>Moderate/ High PA</td>
<td>54 (70.1%)</td>
<td>49 (45.1%)</td>
<td>113</td>
<td>(CI, 1.30 to 4.71)</td>
</tr>
<tr>
<td>Total</td>
<td><strong>77 (43.0%)</strong></td>
<td><strong>102 (57.0%)</strong></td>
<td><strong>179 (100%)</strong></td>
<td></td>
</tr>
</tbody>
</table>

4.10 Validation of Nutrition Status Assessment Methods using Stable Isotope Dilution Technique

This comparison was done using a sample of 179 since the study had complete data on body composition for 179 participants.

4.10.1 Comparison of the Nutrition Status by use of SIDT and Anthropometry

The proportion of children who were overweight and obese by stable isotope dilution technique (SIDT) was 57.0% compared to 8.4% by BMI-for-age z-scores (BAZ). The proportion of children who had excess body fat by SIDT was 24.0% compared to 2.8% by BAZ and 7.3 % by waist to height ratio (WtHR) (Figure 4.2). Results show significant differences in the proportion of children classified as underweight, normal, overweight and obese by anthropometric methods and by use of SIDT method (Wilcoxon Test, P<0.05).
In terms of the agreement between anthropometry and SIDT in measuring excess body fat, the study found low agreement between the definition of overweight and obesity using BAZ and definition of overweight and obesity using SIDT ($\kappa = 0.129$, $P < 0.001$). Only 14.7% of the children with excess body fat were correctly identified as obese by use of BAZ. The level of concordance between WtHR as a measure of excess body fat and SIDT was moderate ($\kappa = 0.357$, $P < 0.001$). Only 27.9% the children with excess body fat were correctly identified as obese by use WtHR. This indicates that anthropometric measurements severely underestimates overweight and obesity.

4.10.2 Comparison of Energy Intake in Relation to Body Fat Levels

The proportion of children who had excess body fat as per stable isotope dilution technique was 57.0%, while those with excess energy intake were 26.8% (Figure 4.3). Results show significant differences between the proportion of children with excess body
fat through actual measurement by use SIDT and those with excess energy intake as a proxy indicator of fat deposition (Wilcoxon Test, P<0.05).

Figure 4.3: Proportion of children with various energy intake and body fat levels

A further test for concordance between children with energy intake and those with excess body fat showed a low concordance level (κ = 0.119). About 67.6% of children with high body fat were reported to have energy within the recommended levels showing discordance.

4.10.3 Comparison of Physical Activity levels in Relation to Body Fat

The proportion of children with excess body fat was 57.0%, and those in low physical activity were 44.1%. Those with normal fat were 43.1% compared to 55.9% who were in moderate to high physical activity level (Figure 4.4). The two proportions were significantly different (Wilcoxon Test, P<0.05).
Test for agreement on the proportion of children with low physical activity and those with excess body fat showed moderate agreements (κ = 0.241). Close to a third (29.9%) of children with low physical activity had a healthy fat level as per SIDT despite being in the lower quartile of physical activity while 45.1% were obese and had high physical activity.

### 4.11 Development and Validation of Prediction Equations

A random number generator was used to produce a split sample for the development of prediction equations and a sample for cross-validation (Table 4.16). The two groups were then stratified by sex and tested for homogeneity in key characteristics to be included in the equations using a two-sample t-test. There was no significant difference in all the characteristics between the test sample and the cross-validation sample for both girls and boys (P<0.05) (Table 4.16).
Table 4.1: Comparison of anthropometric measurements, physical activity level, energy intake and body composition between children in the test and cross validation sample for boys and girls

<table>
<thead>
<tr>
<th>Variables</th>
<th>Means for test sample</th>
<th>Means for Validation sample</th>
<th>t-test P values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boys</strong> (n=80)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>10.0±0.97</td>
<td>10.3±0.89</td>
<td>0.124</td>
</tr>
<tr>
<td>Weight</td>
<td>28.9±3.7</td>
<td>30.5±7.4</td>
<td>0.233</td>
</tr>
<tr>
<td>Height</td>
<td>135.2±6.9</td>
<td>137.4±66</td>
<td>0.184</td>
</tr>
<tr>
<td>WC</td>
<td>57.7±3.1</td>
<td>58.1±7.6</td>
<td>0.771</td>
</tr>
<tr>
<td>BMI-for-A</td>
<td>15.8±1.5</td>
<td>16.2±2.6</td>
<td>0.424</td>
</tr>
<tr>
<td>PAS</td>
<td>3.0±0.6</td>
<td>2.96±0.9</td>
<td>0.788</td>
</tr>
<tr>
<td>Body fat</td>
<td>5.6±2.1</td>
<td>6.5±4.0</td>
<td>0.193</td>
</tr>
<tr>
<td>PBF</td>
<td>19.1±5.1</td>
<td>20.2±6.5</td>
<td>0.434</td>
</tr>
<tr>
<td>Kcal</td>
<td>2284.6±146.9</td>
<td>2259.9±256.5</td>
<td>0.832</td>
</tr>
<tr>
<td><strong>Girls</strong> (n=99)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>10.0±0.8</td>
<td>10.2±0.9</td>
<td>0.282</td>
</tr>
<tr>
<td>Weight</td>
<td>31.55±7.7</td>
<td>31.7±6.7</td>
<td>0.829</td>
</tr>
<tr>
<td>Height</td>
<td>138.3±9.4</td>
<td>139.8±8.6</td>
<td>0.406</td>
</tr>
<tr>
<td>WC</td>
<td>60.0±7.8</td>
<td>60.5±7.1</td>
<td>0.784</td>
</tr>
<tr>
<td>BMI-for-A</td>
<td>16.3±2.7</td>
<td>16.2±2.3</td>
<td>0.879</td>
</tr>
<tr>
<td>PAS</td>
<td>3.0±1.0</td>
<td>2.9±0.9</td>
<td>0.405</td>
</tr>
<tr>
<td>Body fat</td>
<td>9.1±4.3</td>
<td>9.1±4.1</td>
<td>0.958</td>
</tr>
<tr>
<td>PBF</td>
<td>27.62±6.6</td>
<td>27.4±6.2</td>
<td>0.882</td>
</tr>
<tr>
<td>Kcal</td>
<td>2141.6±153</td>
<td>2115.08±141</td>
<td>0.364</td>
</tr>
</tbody>
</table>

WC=Waist circumference, PAS= Physical activity Score

All the independent variables namely; weight, height, age, BMI-for-age, waist circumference, physical activity and energy intake were then tested for their performance in predicting body fat for both girls and boys independently using step wise addition. Table 4.17 shows a stepwise addition of variables in the development of prediction equations and the performance of each variable in the equations for estimating total body fat among boys.
**Table 4.17: Regression equations showing how various variables predict body fat mass among boys**

<table>
<thead>
<tr>
<th>Equations</th>
<th>Variables</th>
<th>Equations</th>
<th>(R^2)</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt /ht</td>
<td>Weight</td>
<td>0.533 (wt) -9.84</td>
<td>0.76</td>
<td>1.7</td>
</tr>
<tr>
<td>Wt/ht</td>
<td></td>
<td>0.752 (wt) -0.254 (h) + 17.82</td>
<td>0.91</td>
<td>0.8</td>
</tr>
<tr>
<td>Wt/ht/age</td>
<td></td>
<td>0.756 (wt) -0.246 (ht) - 0.164(a) +18.92</td>
<td>0.92</td>
<td>0.8*</td>
</tr>
<tr>
<td>Wt/ht/kcal</td>
<td></td>
<td>0.747 (wt) -0.258 (ht) - 0.001 (kcal) +18.39</td>
<td>0.92</td>
<td>0.9*</td>
</tr>
<tr>
<td>Wt/ht/kcal/pa</td>
<td></td>
<td>0.74 (wt) -0.256 (ht)- 0.001 (kcal) -0.13 (pa)+19.04</td>
<td>0.92</td>
<td>0.8*</td>
</tr>
<tr>
<td>WC</td>
<td>Wc</td>
<td>0.536 (wc) -25.316</td>
<td>0.88</td>
<td>0.9</td>
</tr>
<tr>
<td>WC/age</td>
<td></td>
<td>0.550 (wc) -0.256 (a)-23.410</td>
<td>0.88</td>
<td>0.8*</td>
</tr>
<tr>
<td>WC/kcal</td>
<td></td>
<td>0.522(wc) -0.001 (kcal)-26.31</td>
<td>0.88</td>
<td>0.8*</td>
</tr>
<tr>
<td>WC/pa</td>
<td></td>
<td>0.545 (wc)+0.107 (pa)-25.954</td>
<td>0.88</td>
<td>0.8*</td>
</tr>
<tr>
<td>WC/kcal/pa</td>
<td></td>
<td>0.532 (wc) -0.001 (kcal)-0.164 (pa)-27.547</td>
<td>0.88</td>
<td>0.8*</td>
</tr>
<tr>
<td>BMI-for-age</td>
<td>BMI-for-age</td>
<td>1.614 (BMI-for-age) -19.92</td>
<td>0.89</td>
<td>1.1</td>
</tr>
<tr>
<td>BMI-for-age/kal</td>
<td></td>
<td>1.578 (BMI-for-age) - 0.001 (kcal) -21.69</td>
<td>0.90</td>
<td>0.9*</td>
</tr>
<tr>
<td>BMI-for-age/kal/pa</td>
<td></td>
<td>1.599 (BMI-for-age) -0.0187 (pa) -19.14</td>
<td>0.90</td>
<td>0.9*</td>
</tr>
<tr>
<td>BMI-for-age/kal/pa</td>
<td></td>
<td>1.568 (BMI-for-age- 0.001 (kcal) -0.130 (pa) -20.74</td>
<td>0.90</td>
<td>0.9*</td>
</tr>
</tbody>
</table>

*Shows no further improvement of the predictive power of the equation with the addition of more variables. A variable should raise \(R^2\) by at least 0.02 for it to be considered in the final model (Wong, 2013).

\(R^2 = \text{variance of the model};\ \text{SEE is standard error of the estimate.}\)

\(Wt=\text{weight (kg)},\ a=\text{age (yrs.)},\ WC=\text{waist circumference (cm)},\ ht=\text{height (cm)},\ PA=\text{physical activity (PAQ-C score)}.

The first model using height and weight had the highest prediction power, followed by the model for BMI-for-age and then waist circumference model. Addition of age, energy intake and physical activity score did not significantly raise the prediction power of all the equations for predicting body fat among boys. The same variables were tested for their performance in predicting body fat among girls (Table 4.18).
Table 4.1: Regression equations showing how various variables predict body fat mass among girls

<table>
<thead>
<tr>
<th>Equations</th>
<th>Variables</th>
<th>Equations</th>
<th>$R^2$</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt /ht</td>
<td>Weight</td>
<td>0.50 (wt) -6.83</td>
<td>0.79</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Wt/ht</td>
<td>0.69 (wt) -0.23 (h)+15.1</td>
<td>0.93</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Wt/ht/age</td>
<td>0.69 (wt) -0.215 (ht)-0.136(a) +15.56</td>
<td>0.93</td>
<td>0.8*</td>
</tr>
<tr>
<td></td>
<td>Wt/ht/kcal</td>
<td>0.73 (wt) -0.217 (ht)-2.19(s)-0.001 (kcal) +18.71</td>
<td>0.93</td>
<td>0.9*</td>
</tr>
<tr>
<td></td>
<td>Wt/ht/kcal/pa</td>
<td>0.69 (wt) -0.22 (ht)- 0.001 (kcal) -0.16 (pa)+19.42</td>
<td>0.93</td>
<td>0.8*</td>
</tr>
<tr>
<td>WC</td>
<td>Wc</td>
<td>0.53 (wc) -21.97</td>
<td>0.89</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Wc/age</td>
<td>0.52 (wc) -1.185 (a)-20.59</td>
<td>0.90</td>
<td>1.0*</td>
</tr>
<tr>
<td></td>
<td>Wc/a/kcal</td>
<td>0.49 (wc) -0.001 (kcal)-23.81</td>
<td>0.90</td>
<td>1.0*</td>
</tr>
<tr>
<td></td>
<td>Wc/kcal/pa</td>
<td>0.516 (wc)-0.08 (pa)-22.06</td>
<td>0.90</td>
<td>1.0*</td>
</tr>
<tr>
<td></td>
<td>Wc/a/kcal/pa</td>
<td>0.52 (wc)-0.001 (kcal) 0.42 (pa)-24.21</td>
<td>0.90</td>
<td>1.0*</td>
</tr>
<tr>
<td>BMI-for-age</td>
<td>BMI-for-age</td>
<td>1.49 (BMI-for-age) -15.43</td>
<td>0.90</td>
<td>1.0</td>
</tr>
<tr>
<td>BMI-for-age/age</td>
<td></td>
<td>1.48 (BMI-for-age) -0.333 (a) -18.28</td>
<td>0.91</td>
<td>1.0*</td>
</tr>
<tr>
<td>BMI-for-age/kcal</td>
<td></td>
<td>1.62 (BMI-for-age) - 0.003 (kcal)-11.46</td>
<td>0.91</td>
<td>0.9*</td>
</tr>
<tr>
<td>BMI-for-Age/kcal/pa</td>
<td></td>
<td>1.50 (BMI-for-age) -0.026 (pa)-15.59</td>
<td>0.91</td>
<td>0.9*</td>
</tr>
<tr>
<td>BMI-for-Age/kcal/pa</td>
<td></td>
<td>1.61 (BMI-for-age- 0.003 (kcal)-0.007 (pa)-11.39)</td>
<td>0.91</td>
<td>0.9*</td>
</tr>
</tbody>
</table>

* Shows no further improvement of the predictive power of the equations with the addition of more variables. A variable should raise $R^2$ by at least 0.02 for it to be considered in the final model (Wong, 2013), $R^2$ = variance of the model; SEE is standard error of the estimate. Wt=weight (kg), a=age (yrs), wc=waist circumference (cm), ht=height (cm), PA-physical activity (score).

As observed in the models among boys, similarly, age, energy intake and physical activity score did not significantly raise the prediction power of all the equations for predicting body fat among girls. The first model using height and weight had the highest prediction power, followed by the model for BMI-for-age and then waist circumference model. The equations with the highest prediction power based on recommendations by
Moura et al., 2013 of a prediction power $>0.8$ and SEE $<3.5$ were selected for cross-validation (Table 4.19).

**Table 4.19: Equations with the highest prediction power**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Equations</th>
<th>$R^2$</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>1. BF= 0.752 (wt) -0.254 (h) + 17.82</td>
<td>0.91</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>2. BF= 0.536 (wc) -25.316</td>
<td>0.88</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>3. BF= 1.614 (BMI-for-age) -19.92</td>
<td>0.89</td>
<td>0.8</td>
</tr>
<tr>
<td>Girls</td>
<td>1. BF= 0.69 (wt) -0.23 (h) + 15.91</td>
<td>0.93</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>2. BF= 0.53 (wc) - 21.97</td>
<td>0.89</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>3. BF= 1.49 (BMI-for-age) -15.43</td>
<td>0.90</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The equations were used to create estimated body fat scores in the cross-validation sample and were then compared with the actual percent body fat score derived from the SIDT as the reference method and tested for any significant difference (Table 4.20).

**Table 4.20: Comparison of actual mean body fat and the predicted mean body fat for cross-validation sample**

<table>
<thead>
<tr>
<th>Equations</th>
<th>Actual mean body fat (n=89)</th>
<th>Predicted mean body fat (n=90)</th>
<th>t-test P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. BF= 0.752 (wt) -0.254(h)+18.62</td>
<td>6.50±4.0</td>
<td>6.41±3.8</td>
<td>0.170</td>
</tr>
<tr>
<td>2. BF= 0.836 (wc) -25.19</td>
<td>6.50±4.0</td>
<td>5.73±3.6</td>
<td>0.264</td>
</tr>
<tr>
<td>3. BF=1.614 (BMI-for-age) -19.92</td>
<td>6.50±4.0</td>
<td>6.55±4.2</td>
<td>0.722</td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. BF= 0.69 (wt) -0.23 (h)+15.91</td>
<td>9.10±4.1</td>
<td>8.99±3.2</td>
<td>0.834</td>
</tr>
<tr>
<td>2. BF= 0.53 (wc) -21.97</td>
<td>9.10±4.1</td>
<td>9.23±4.3</td>
<td>0.214</td>
</tr>
<tr>
<td>3. BF=1.49 (BMI-for-age) -14.43</td>
<td>9.10±4.1</td>
<td>8.89±2.4</td>
<td>0.654</td>
</tr>
</tbody>
</table>

No significant differences were observed between derived fat mass score using the equations and the actual measured fat mass score using SIDT. The sample that was used to develop the equations and the cross-validation sample were then combined and used to develop the final equations (Table 4.21).
Table 4.21: Final equations for the whole sample

<table>
<thead>
<tr>
<th>Sex</th>
<th>Equations (N=179)</th>
<th>R²</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>1. BF = 0.683 (wt) - 0.223 (h) + 16.15</td>
<td>0.91</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>2. BF = 0.525 (wc) - 24.36</td>
<td>0.88</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>3. BF = 1.381 (BMI-for-age) - 16.22</td>
<td>0.89</td>
<td>1.0</td>
</tr>
<tr>
<td>Girls</td>
<td>1. BF = 0.704 (wt) - 0.231 (ht) + 18.61</td>
<td>0.93</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2. BF = 0.510 (WC) - 21.78</td>
<td>0.89</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>3. BF = 1.510 (BMI-for-age) - 15.65</td>
<td>0.90</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Further analysis was done using t-test for comparison of means for the predicted body fat and the actual measured body fat. All the equations showed no significant difference between the two means (P>0.05) (Table 4.22).

Table 4.22: Comparison of actual body fat and predicted values for the whole sample

<table>
<thead>
<tr>
<th>Equations</th>
<th>Actual mean body fat</th>
<th>Predicted mean body fat</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. BF = 0.683 (wt) - 0.223 (h) + 16.15</td>
<td>6.08±3.2</td>
<td>6.21±3.4</td>
<td>0.875</td>
</tr>
<tr>
<td>2. BF = 0.525 (wc) - 24.36</td>
<td>6.08±3.2</td>
<td>6.25±3.3</td>
<td>0.807</td>
</tr>
<tr>
<td>3. BF = 1.381 (BMI-for-age) - 16.22</td>
<td>6.08±3.2</td>
<td>6.23±3.3</td>
<td>0.989</td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. BF = 0.704 (wt) - 0.231 (ht) + 18.61</td>
<td>9.08±4.2</td>
<td>8.94±3.7</td>
<td>0.947</td>
</tr>
<tr>
<td>2. BF = 0.510 (WC) - 21.78</td>
<td>9.08±4.2</td>
<td>8.96±3.7</td>
<td>0.934</td>
</tr>
<tr>
<td>3. BF = 1.510 (BMI-for-age) - 15.65</td>
<td>9.08±4.2</td>
<td>8.95±3.7</td>
<td>0.968</td>
</tr>
</tbody>
</table>

Fat mass scores predicted by equations were tested for agreement with the actual measured body fat scores using Bland-Altman plots. The Bland-Altman plots for the equation based on weight and height for girls shows that agreement of the body fat score obtained using prediction equations and the actual measured scores using SIDT was good with the average bias of 0.9 and a concordance coefficient of 0.95 (Figure 4.5). The differences between the predicted fat scores and the actual fat scores were condensed
towards zero and the majority of the scores were within the mean ± 1.96 SD. The precision of the equation based on weight and height for girls was high ($R^2 = 0.94$).

![Bland-Altman plot](image)

Figure 4.5: Bland-Altman plot of body fat estimates by SIDT and prediction equation based on height and weight for girls. Concordance correlation coefficient =0.95, CI, 0.93-0.97, Person precision = 0.94, Bias =0.9

The second equations for girls using waist circumference shows that the precision of this equation was equally high (0.95) and concordance between the two methods was strong (0.95). The differences between the fat scores measured using the two methods were clustered towards zero and were within ± 1.96 SD (Figure 4.6).
Figure 4.6: Bland-Altman plot of body fat estimates by SIDT and prediction equation based on waist circumference for girls. Concordance correlation coefficient =0.95, CI, 0.92-0.96, Pearson precision = 0.95, Bias = 0.9

The precision for the BMI-for-age equation for girls was 0.94 and concordance coefficient of 0.94 (Figure 4.7). The bias was small (0.9) and the differences of the fat scores measured using the two methods was condensed towards zero.
Figure 4.7: Bland-Altman plot of body fat estimates by SIDT and prediction equation based on BMI-for-age model for girls, Concordance correlation coefficient = 0.94, CI, 0.92-0.96, Pearson precision = 0.94, Bias = 0.9

The weight and height equation for boys predicted body fat with a high precision of 0.9. The agreement of the fat scores measured by the equation and those measured by the reference method was strong (0.9). The differences between the fat scores measured using weight and height equation and SIDT were centered towards zero and majority of the scores were within the mean ± 1.96 SD (Figure 4.8).
**Figure 4.8**: Bland-Altman plot of body fat estimates by SIDT and prediction equation based on weight and height among boys, Concordance correlation coefficient = 0.94, CI, 0.93-0.97, Pearson precision = 0.94, Bias = 0.9

Concordance coefficient between the BMI-for-age equation and the reference method was strong (0.91), the bias was small (0.91) and the difference between the scores was centered towards zero and the limits of agreement were narrow (Figure 4.9).
The agreement of the fat scores predicted using the waist circumference equation and those measured by the reference method was strong (0.93) and the bias was small. The differences between the fat scores measured by SIDT and fat scores predicted by waist circumference equation were centered towards zero and were within the limits of agreement which was narrow (Figure 4.10).
Figure 4.10: Bland-Altman plot of body fat estimates by SIDT and prediction equation based on waist circumference among boys. Concordance correlation coefficient=0.93, CL, 0.89-0.95, Pearson precision=0.93, Bias -0.9

The fat scores predicted by the three equations were converted to percent body fat and were used for categorization of nutrition status of the children. Agreement of nutrition status categorization based on predicted percent body fat and actual measured percent body fat was further tested for concordance using Kappa. All the equations showed a high concordance >0.9, high sensitivity and specificity (>90%) and only a small proportion of children of about 5.0% were incorrectly classified (Table 4.23).
Table 4.23: Measure of agreement between the reference method (SIDT) and the developed equations in classifying nutrition status of the children.

<table>
<thead>
<tr>
<th>Assessment methods</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>FN*</th>
<th>FP*</th>
<th>Cohen’s kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIDT</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Equation 1</td>
<td>97.2</td>
<td>97.8</td>
<td>2.2</td>
<td>2.8</td>
<td>0.950</td>
</tr>
<tr>
<td>Equation 2</td>
<td>94.4</td>
<td>95.6</td>
<td>4.4</td>
<td>5.6</td>
<td>0.900</td>
</tr>
<tr>
<td>Equation 3</td>
<td>94.4</td>
<td>95.6</td>
<td>4.4</td>
<td>5.6</td>
<td>0.900</td>
</tr>
<tr>
<td><strong>Girls</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIDT</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Equation 1</td>
<td>96.9</td>
<td>97.1</td>
<td>2.9</td>
<td>3.1</td>
<td>0.933</td>
</tr>
<tr>
<td>Equation 2</td>
<td>95.4</td>
<td>97.1</td>
<td>2.9</td>
<td>4.6</td>
<td>0.912</td>
</tr>
<tr>
<td>Equation 3</td>
<td>95.4</td>
<td>94.1</td>
<td>5.9</td>
<td>4.6</td>
<td>0.889</td>
</tr>
</tbody>
</table>

*FN-False negatives, FP=false positive
CHAPTER FIVE: DISCUSSION

This study validated nutrition status assessment methods for assessing overweight and obesity among school children using SIDT method which directly measures body fat. This study also developed prediction equations for estimating percent body fat among Kenyan children.

5.1. Nutrition Knowledge and Attitude among School Children

Nutrition knowledge is necessary for the development of good dietary habits in children (Ali et al., 2011; Choi et al., 2008). Past studies have reported low nutrition knowledge among school children (David et al., 2012; Flynn et al., 2006; Webb & Beckford, 2014). More studies have associated lack of nutrition knowledge with poor dietary habits (Choi et al., 2008; Phometsi et al., 2006; Welch et al., 2005). Lack of knowledge about adverse effects of unhealthy diet in urban school children in India explained the high intake of dietary fat resulting in a high prevalence of obesity (Gupta et al., 2012). However, other studies have shown contrary results where gains in nutrition knowledge did not translate into positive changes in dietary practices (Abdollahi et al., 2008; Sherman & Muehlhoff, 2007; Worsley, 2002).

Children in this study had moderate nutrition knowledge in contrast to the low knowledge in the above-referenced studies. These findings could be attributed to the fact that health and nutrition lessons were being offered in school. However, nutrition knowledge which was determined by asking the children a set of questions related to nutrition in this study
did not significantly predict appropriate nutrition practices. Children in this study continued to engage in unhealthy dietary practices such as over consumption of sweetened beverages and fast foods despite having some level of nutrition knowledge. This current study confirms that knowledge alone, though important in influencing dietary practices is not sufficient in informing dietary choices made by the children. Findings from the FGDs indicated that children selected foods based on taste. “I like eating sweets, cakes and chocolate because they taste sweet” reported by one of the children.

Positive attitude and behavior change toward healthy eating early in childhood contribute tremendously to embracing sound food habits (Brown, 2004; Triches & Giugliani, 2005). A study in Zambia, demonstrated that linking nutrition knowledge and practice need behavior and attitude change (Sherman & Muehlhoff, 2007). A study among Kenyan children revealed a poor attitude towards healthy eating which led to poor dietary practices (David et al., 2012). Findings from this study showed that school children had a poor attitude towards healthy eating. Children felt that there was no need to be worried about what they ate as they were still young. The attitude was a significant determinant of the dietary practices adopted by the children which is in agreement with the above studies. Findings of this study confirm the importance of not only nutrition knowledge but also molding a positive attitude towards healthy eating to influence dietary practices.
5.2 Dietary Practices among School Children

Diet is a major contributor to the development of obesity which is a risk factor for chronic non-communicable diseases. Monitoring dietary practices is important for early identification of nutrition problems among school children (Zaborskis et al., 2012). The WHO Global Strategy for diet recommendations calls for achieving an energy balance, limiting the energy intake from fats, reducing the intake of free sugars, attaining minimum dietary diversity and increasing fruit and vegetable consumption (WHO, 2004b). However, most children do not meet the recommended standards of dietary guidelines and are devoid of healthy dietary practices (Naeeni et al, 2014). A study in Malawi reported low diet diversity and high consumption of fast foods (Katungwe, 2015). Another study based on American data reported high consumption of fast foods and inadequate fruit and vegetables consumption among children (Shields, 2006). Similar practices have been reported among children in developing countries (Kaushik, Narang & Parakh, 2011).

A review in developing countries reported increased utilization of sweetened carbonated beverages, diets high in fat and low fiber (Gupta et al., 2012). The same study observed low intake of vegetables, fresh fruits and milk. Furthermore, the study observed a higher frequency of consumption of energy-dense fast foods (Gupta et al., 2012). Another study in Asia reported that 28% and 13.8% of children had consumed fruits and vegetables only once per week, respectively (Peltzer & Pengpid, 2012).
Findings from this study demonstrate that dietary practices of children were poor with diets of the majority of the children having minimum diversity where only cereals, root and tubers and vegetables were commonly consumed. Consumption of fast food and sweetened drinks was high while for fruits was low. Though the majority of the children had energy intake within the daily energy requirements, close to a third (29.7%) had excess energy intake above the energy requirements. This was mainly due to excessive fat and sugar intake from fast foods and sweetened beverages which are energy dense. Fast foods and sweetened drinks significantly correlated with total energy intake.

The contribution of protein to the total energy was low and fat contributed more than 30% of the total energy. High consumption of fast foods in this study could be attributed to the fact that, most children (95%) were given money to buy snacks while at school and they made choices on what to buy. Commonly bought snack were sweets, carbonated sweetened drinks, doughnuts and french-fries, which are high in fat and sugar yet depleted of other nutrients, despite the fact that other healthy snacks like groundnuts, fruits and flesh milk and yoghurt were easily available as reported by the key informants. Findings from this study are in agreement with the above-referenced studies that demonstrated poor dietary practices among school children. This is indicative of the dietary transition from previous observed inadequate energy and nutrient intake especially in developing countries to energy-dense, nutrient poor foods.
The environment in which the children live determines the food behavior and quality of their nutrition (Nepper & Chai, 2015). This study assessed the suitability of family and environment surrounding the school in promoting good dietary practices among the children. Family environment has the potential to impact and improve good dietary practices (Taylor et al., 2005). The recurrence of shared family meals positively affects children’s food knowledge and practice (Walsh & Nelson, 2010). Earlier studies found that the percentage of school children spending more time away from their parents during meals is increasing (Choi et al., 2008; Triches & Giugliani, 2005). Thus, parents miss out the chance to teach and mold positive behavior towards healthy eating and to impart good nutritional practices (Savage et al., 2008). Another study has reported a positive link between children’s eating alone with poor dietary practices due to lack of parental guidance (Choi et al., 2008).

From the current study, 32.2% of the children were found to have their meals at home mainly on their own without parents’ supervision. Children who ate alone without their parents had significantly higher frequency of fast food and sweetened beverages consumption. This can be attributed to the fact that presence of parents is likely to guide children on the right portions of food and food combinations. In the absence of a parent, for example, children are likely to add more sugar to their tea than when parents are observing them. Children are also likely to omit vegetables in their diet while parents are away. Further, about a third of children who ate fruits, reported the reason for eating fruits was because they watched other family members, especially parents eat fruits. This
agrees with finding from other studies that have demonstrated the importance of family meals in molding good dietary practices (Birch et al., 2009; Triches & Giugliani, 2005).

Television is an opening of food adverts and promotion which molds dietary practices of children (Grossman et al., 2012; Harrison & Bost, 2011). The majority of the televised foods are junk foods which are exceedingly prepared with high sugar and fat content. These televised adverts greatly influence the food choices of children (Dixon et al., 2007). This has been confirmed in a study among primary school children in Tehran which reported that the foods consumed by children had previously been advertised on TV and were mainly junk foods and highly processed (Abdollahi et al., 2008). Aggressive advertising practices, compounded by the availability of relatively low cost of energy-dense foods and improved purchasing power significantly affected food choices made by children (Gupta et al., 2012).

The majority of the children in this study ate while watching television daily. Those that had access to television daily had a higher consumption of fast foods and sweetened beverages. This is because exposure to the television exposes children to most of the junk foods advertised and promoted in the media. Moreover, this is an age where children want to try new food items that they see being advertised. Accessibility of fast food outlets is emerging as a factor influencing children food choices. Studies in Nairobi demonstrated the presence of numerous low-cost fast food outlets accessible to school children. More studies have linked easy access to fast foods as a contributing factor to
increased consumption (Gupta et al., 2012; Smith et al., 2010). Research has also demonstrated that children are more likely to eat the accessible foods that are in a ready to eat form (Patrick & Nicklas, 2005).

In agreement with the above studies, accessibility of low-cost snacks in the environment neighboring the school intensified the consumption of fast foods and sweetened drinks as reported in the FGDs and by the key informants in this study. There were many food vendors accessible to children who sold low-cost energy-dense foods. From the key informants, it was clear that schools had no policy to regulate what is sold in the surrounding environment. Findings of this study demonstrate the significance of not only the accessibility of food as well as the availability of healthier foods as a measure to advance good dietary practices among children. This is because children at this age are likely to eat what is easily accessible to them as reported by Patrick and Nicklas (2005).

Systematic errors can occur in dietary studies on the part of the interviewer during estimation of portion sizes (Conway, Ingwersen & Moshfegh, 2004; Wrieden et al., 2003). The respondent can also under report or over report intakes of certain foods. Under or over reporting errors are more influential while associating dietary intake and nutritional outcomes based on anthropometric and biochemical assessment. Food photographs and food models which depicted food portion sizes were used to minimize on misreporting on portion sizes. A 24 HR multiple pass recall method was used to probe for complete description of foods and to overcome the recall bias (Wrieden et al., 2003).
5.3 Physical Activity Level among Children

The rising trends in overweight and obesity among children has been associated with the current shift in the activity patterns from outdoor spontaneous activities to indoor computerized activities (Gupta et al., 2012). Physical activity is associated with nutrition status due to its influence on energy expenditure (Ma et al., 2003; Sallis & Glanz, 2006). Choices of physical activity are influenced by the suitability and the level of safety of the environment. WHO global strategy on physical activity has recognized that inappropriate environments contribute to low levels of physical activity (WHO, 2004b). In this study, physical activity was measured by PAQ-C and by accelerometer. This allowed accurate quantification of physical activity level among school children.

A study conducted in Eldoret, Kenya found out that only 16.5% of school children met the physical activity WHO recommendations of >60 minutes spent in moderate to vigorous activity (Ojiambo et al., 2012). A multi-national study reported 11.4% of study children met the WHO recommendations (LeBlanc et al., 2015). A study from France showed the percentage of study participants who attained 60 or more minutes were 19.3% (Janssen et al., 2005). In another study conducted among school children in Nairobi, only 12.6% of the participating children met the WHO recommendation (Muthuri et al., 2014a).

Studies have reported that low physical activity among children is attributed to the physical environment that offers fewer opportunities for spontaneous physical activity
(Bocarro et al., 2012; Rezende et al., 2015; Ridgers et al., 2007; Thomas & Kahan, 2008). A review in developing countries demonstrated that lack of open spaces and play grounds in schools and communities and reduced emphasis on physical activity in schools has led to a further decline in physical activity among children (Gupta et al., 2012). Similar to the above studies, only a small proportion of children (15.2%) met the WHO guidelines for physical activity which compare well with the Nairobi study though the figures were lower than the study in Eldoret, Kenya.

Low levels of physical activity in this study were associated with the means of transport to school. Children who engaged in active transport had relatively high physical activity score compared to those using inactive transport. Participation in games during school breaks significantly contributed to the level of physical activity. Children reported in the FGDs that participation in games was not compulsory for children and games were not supervised. In addition, this study found out that physical education lessons were not given much attention and children were left alone to make individual choices on what to do during the PE lessons. Therefore, some children chose to engage in sedentary activities like sitting down in groups especially girls.

A study by Cardon et al. (2009) alluded to the fact that provision of play material and play ground is not sufficient enough to increase the engagement in physical activity and that of importance is more structured and supervised activities. Past work has found that children can acquire up to 40% of their daily moderate-to-vigorous physical activity
(MVPA) during school break times (Ridgers et al., 2013). The schools had only one designated playground which was not marked for different games hence it was used for all types of games. This hindered the level of engagement in physical activity since different children wished to engage in different types of games and since the field was only one, this was not possible as reported in the FGDs. In addition, the same field was shared among girls and boys. This led to withdrawal by the girls (Reported by girls in the FGDs). Studies have reported the importance of playground markings and allocating play space for different games in increasing activity level among school children (Broekhuizen, Scholten & Vries, 2014; Stratton & Mullan, 2005).

Lack of adequate play items was found to affect the level of engagement in physical activity. Findings of this study indicate that most children do not meet the recommended level of physical activity which is in agreement with the previous cited studies. The results also demonstrate the importance of appropriate school environment to promote physical activity for school children. Understanding the barriers to increasing physical activity is likely to help inform and direct campaigns to promote physical activity among children.

There could also have been a number of limitations related to scoring and interpretation of physical activity (Welk et al., 2000). In the present study, a standardized validated instrument (PAQ-C) with a probe-type protocol was used to maximize the potential for acquiring accurate responses. Therefore, the results may be more reflective of the study
Moreover, the physical activity level in this study was validated using accelerometers, a gold standard test of physical activity level.

5.4 Anthropometric Characteristics among Children

Over time, child under-nutrition has remained one of Sub-Saharan Africa’s most fundamental challenges (de Onis & Blossner, 2003; Jamison et al., 2006). However, with the change in lifestyle and dietary practices, most developing countries are facing the burden of both under-nutrition and over-nutrition among children. Of concern are the rising trends in overweight and obesity (Zaborskis et al., 2012).

A study among children in both public and private schools in Nairobi, Kenya, reported a prevalence of 19.0% of overweight and obesity (Kyallo et al., 2012). Another study among school children in both private and public schools in Nairobi reported a higher prevalence of 20.8% of overweight and obesity (Muthuri et al., 2014a). A more recent study in public schools alone in Nairobi, Kenya reported 7.3% of overweight and obesity (Okoh & Alikor, 2015). In a Tanzania study, 12.2% of children aged 6-9 years, and 10.3% of children aged 10-12 years were reported to be overweight/obese, respectively (Mosha & Fungo, 2010). In Sub-Saharan Africa, a systematic review showed that overweight and obesity stands at 10.6% (Muthuri et al., 2014b). A study in Eastern Mediterranean region reported the prevalence of overweight among children aged 6-11 years to be 16% (Musaiger, 2004). In developed countries such as Canada and the United States of America, studies have reported childhood overweight and obesity prevalence of
29% and 33%, respectively (Ogden et al., 2012; Shields, 2006). Most of these studies have reported a higher prevalence of overweight and obesity among girls than boys (Dehghan et al., 2005; Kyallo et al., 2013; Muthuri et al., 2014b; Onis et al., 2010).

Results from this study indicate that both under-nutrition and over-nutrition coexisted in this study population with 7.4% of the children being underweight and 8.0% being overweight and obese. Girls had higher proportions of overweight and obesity (10.1%) compared to boys (5.4%). There are few studies that have been conducted in Kenya targeting the school age children. Comparing this current finding with the previous two studies by Kyallo et al. (2013) and Muthuri et al. (2014b), there are variations in the prevalence of overweight and obesity among the school-aged children in Nairobi.

The possible explanation could be due to the fact that this current study focused on public schools in lower socio-economic status while the studies by Kyallo et al. (2013) and Muthuri et al. (2014b), targeted children from mixed economic status. In developing countries, though overweight and obesity are being observed among populations of low economic status, the prevalence is likely to increase with a rise in economic status. However, the figures of this study are slightly higher than figures from a study by Okoh (2014), which also targeted only public schools. This indicates an increase in the prevalence of overweight and obesity among Kenyan school children.
Though the figures of this current study are lower than the prevalence reported in developed countries, they are indicative of an existing threat to childhood overweight and obesity among Kenya’s urban school-aged children. Results from this study are of public health importance as 80% of childhood obesity will be carried up to adulthood and it is very difficult to treat adult obesity (Lifshitz, 2008). This has a major implication on the economic burden of the health sector as obesity is a major factor contributing to the burden of non-communicable diseases which has already overstretched the health sector.

5.5 Body Composition Characteristics among Children

Body weight consists of both fat mass and fat-free mass which are of more significance when assessing nutrition status than just the total body weight (Lee & Gallagher, 2008). The accumulation of adipose tissue early in childhood is clinically significant because there is a significant relationship with adverse health, including dyslipidemia, cardiovascular diseases, diabetes and arthritis (Gallagher et al., 2000). This study assessed the nutrition status of school children by determining body composition using SIDT.

Previous studies have reported various levels of percent body fat among children. A study in Manipur using Tanita body composition analyzer showed mean percent body fat of 15.9±5.3 and 23.2±6.1 among boys and girls, respectively (Rajkumari et al., 2012). By use of dual energy X-ray absorptiometry, the mean percentage body fat in boys was 23.5 and in girls was 33.6 in North-Indian school children (Khadgawat et al., 2013). In another
study in America, the mean percentage body fat in boys was 25.6 and in girls was 32.3 (Angelica & Fong, 2008). A study in the USA reported 17.6% of body weight in boys and 23.9% in girls as fat (Going et al., 2011). Based on deuterium dilution techniques, a study among Mexican children observed mean percent body fat of 15.9±6.9 among boys and 23.1±7.2 among girls (Valencia et al., 2012). A study in Dodoma, Tanzania, using bioelectrical impedance, reported percent body fat of 24.1 in girls and 24.0 in boys (Mosha & Fungo, 2010).

From our findings, girls had a mean percent fat mass of 27.52±6.4 while boys had 19.65±5.9. Boys tend to deposit more fat-free mass than fat mass while girls tend to deposit more fat mass than fat-free mass. The proportion of children with excess body fat was 24.0%, an indication of obesity. Percent body fat was significantly associated with blood pressure indicating those with high body fat had high blood pressure compared to those with low percent body fat. Though the above-referenced studies used a different method in assessment of body fat, the mean percent body fat for this current study was higher than the Manipur, USA, Tanzania and Mexican children and lower than North Indian children and Mexican children. To the best of my knowledge, there lacks national data on a direct measure of body fat in Kenya among school age children. Similarly, no study has reported on the proportion of children with excess body fat. This study forms a preliminary study for direct assessment of body composition for school age children and calls for more studies in this age group.
5.6. Relationship between Energy Intake and Body Fat

Dietary intake is a predictor of nutrition status (Ma et al., 2003). The occurrence of overweight and obesity has been associated with excess energy intake (Hartline-Grafton et al., 2009; Peltzer & Pengpid, 2011). Consumption of excess energy more than what the body expends, results in the storage of energy as fat (Sambasivarao, 2013). Several studies from different countries have shown significant correlations between energy intake and body fat mass (Bowen et al., 2015; Ledikwe et al., 2006; Moreno et al., 2000; Timpson et al., 2008). A study among Dutch school children showed similar association (Atkin & Davies, 2000; Labree et al., 2015).

According to a study in Great Britain, increased energy intake was found as a causal or facilitating factor to the deposition of body fat. Children with higher energy intakes were reported to have higher percent body fat (Atkin & Davies, 2000; Labree et al., 2015). However, some studies have failed to identify an association between energy intake and body fat (Bowen et al., 2015; Burns, 1993; Kelishadi et al., 2003; Rodriguez & Moreno, 2006; Willett, 1998). Results from this study indicate a positive significant association between total energy intake and body fat. Children with high energy intake were 1.3 times more likely to have high body fat compared to those with low energy intake. These research findings suggest that total energy intake is significantly associated with nutrition status and therefore interventions can be made around modifying dietary practices.
5.7 Relationship between Physical Activity and Body Fat

A sedentary lifestyle contributes to low daily energy expenditure which eventually leads to increased body fat (Corpeleijn et al., 2009). A study among Dutch school children demonstrated that physical activity influences energy expenditure thus preventing body fat deposition (Atkin & Davies, 2003). A study in England reported a substantial reduction in body fat with an increase in physical activity (Ness et al., 2007). More studies have reported that increased physical activity level modifies body composition favorably by reducing fat mass even when physical activity produces no loss in body weight (Bouchard et al., 2007; Ness et al., 2007; Rennie et al., 2005). More studies have reported that physical activity was independently inversely associated with percentage fat mass (Ekelund et al., 2005; Ness et al., 2007; Wareham et al., 2005; Zanovec et al., 2009). This study found an inverse relationship between physical activity and percent body fat. Children with high physical activity level had significantly lower body fat compared to those in low physical activity level tercile. Findings from this study are in agreement with previous studies and demonstrate that physical activity is likely to influence body composition among the children.

5.8 Comparison of Anthropometry and SIDT in Assessing Body Fat

Methods of assessing direct body composition are expensive and complicated (Kilpelainen et al., 2011; Mei et al., 2002). Anthropometry has continued to be used to estimate body fat and its relative accuracy needs to be validated against a “gold-standard” measure of adiposity (Ramirez-zea et al., 2006). The major concerns about the
performance of anthropometric measurements are to correctly identify excess body fatness (Dietz et al., 2015; Going et al., 2011; Javed et al., 2015).

Studies have reported a low sensitivity of BMI-for-age in estimating adiposity (36–66%) (Dietz et al., 2015; Freedman & Sherry, 2009; Romero-Corral et al., 2008). A review conducted from 32 studies reported a low sensitivity (50%) of anthropometric measurements in assessing body fat, suggesting that about half of individuals not labeled as obese indeed had excess body fat (Javed et al., 2015). A study among children in Guatemala found that BMI-for-age does not correspond to the same proportion of body fat (Ramirez-zea et al., 2006). Studies have shown that BMI-for-age underestimates overweight and obesity in tall individuals and overestimated overweight in short individuals and those with high lean body mass (AHK, 2015; Bagust & Walley, 2000; Charbonneau-Roberts et al., 2005). Only a study among children in Brazil have found anthropometric measurements as good predictors of body fat but by established new cut-off points (Pelegrini et al., 2015).

Findings from this study shows a low sensitivity (14.6%) of BMI-for-age in estimating adiposity where the use of BMI-for-age categorized 85.4% of children with excess fat by body composition as normal. The findings of this current study are an indication that the WHO recommended BMI-for-age cut-off points to classify overweight and obesity underestimates the prevalence of overweight and obesity based on measures of body
fatness leading to wrong interventions. This has health consequences, as the opportunity to intervene and reduce health risk in these individuals is lost.

A study in Nagpur found that use of WtHR underestimated the proportion of children classified as obese (Pande, Sharma & Vali, 2016). Some studies conducted among Italian (Pelegrini et al., 2015) and African adolescents (Fernández et al., 2004) using a WtHR cut-off value of 0.41 found that WtHR as a good diagnostic measure for excess body fat. However, the cut-off value used in the above studies was lower than what is internationally recommended (0.50). In this study using Waist to height ratio cut-off value of 0.50 had a sensitivity of 27.9%. Out of those children with excess body fat by use of SIDT 72.1% were classified as normal by use of WtHR. The study findings indicated a low concordance between anthropometry and SIDT as methods of assessing body fat. The results indicate that body measurements may not always correspond to body fat.

5.9 Comparison of Energy Intake and Body Fat Levels

The energy content of the diet affects the composition of the human body (Atkin & Davies, 2000). However, some studies have reported that the macronutrient composition of diet and not necessarily the energy content of the diet can also be a possible explanation to body composition. According to a study in India, the protein content of the diet was found as the main determinant of body fat deposition and not necessarily the total energy intake (Bowen et al., 2015). In another study, fat composition of the diet was
found to be the main determinant of body fat (Atkin & Davies, 2000). However, the
findings of this study showed that a significant proportion of children (26.6%) classified
within the excess energy category had healthy body fat. Similarly, more than half of
children within excess body fat category had energy intake within the acceptable levels.
This can be explained by the fact that adiposity occurs in the case of positive energy
balance if energy expenditure is not increased proportionately. Therefore, in case of
energy balance between expenditure and intake, body fat deposition is likely not to occur.
The inverse association between energy intake and body fat has also been attributed to
the fact that more active individuals are likely to have higher energy intakes (Bowen et
al., 2015).

5.10 Comparison of Physical Activity level and Body Fat Levels

Lower levels of physical activity lead to obesity or excess body fat, though there is also
evidence of underweight among sedentary children especially where dietary intake is
inadequate. In this study, though there were significant correlations between physical
activity and percent body fat, close to a third of children with low physical activity had
healthy body fat level. These were mainly children in the lower quartile of energy intake
and therefore, they were unlikely to have excess body fat. This indicates that though
physical activity affects body composition profile, it may not be an absolute measure of
body composition especially where diet is not controlled. However, there are possible
limitations with inferring causality when using cross-sectional design as it was the case in
this study.
5.11 Equations for Predicting Body Fat among Children

Use of prediction equations to estimate body fat is an emerging practice as an alternative to the complex methods especially in resource-limited settings (Hoffman et al., 2000). A number of anthropometric prediction equations for estimation of body composition have previously been developed and validated using various reference methods (Cameron et al., 2004; Ejlerskov et al., 2014; Huang et al., 2003). Prediction equations are population based and should be applied within the same population where they were developed (Gallagher et al., 2000). This study successfully developed possible equations for the prediction of percent body fat that used variables that are feasible to measure in the field.

In the past, various anthropometric variables have been used to model prediction equations for estimation of body fat. In a study among Latino children aged 9-11 years, weight, sex, height and age based equations, showed that weight alone accounted for 86% of the measured total body fat (Huang et al., 2003). With an addition of height, gender and abdominal skin fold it accounted for 96.7% of the body fat. In an equation developed in the USA to estimate body fat, weight alone accounted for 90% of the variance while only 4% was explained by sex and skin folds measurements (Dezenberg et al., 1999).

The equation developed among 6-14 year-old Mexican children reported that weight, sex and triceps skin fold accounted for 91% of body fat with weight alone accounting for 75% (Valencia et al., 2012). Equations developed using BMI-for-age indicated that BMI-for-age alone has a moderate predictive power of 78% (Angelica & Fong, 2008). Another
equation that used BMI-for-age among American children indicated a low predictive power of 62% (Naidoo et al., 2015). Waist circumference alone has been shown to have a low predictive power of 58% (Angelica & Fong, 2008). In this study, the equations developed were gender specific and weight alone was moderately predictive for both girls (79%) and boys (76%). Unlike in the Latino children equation, weight alone in this study was not strong enough to accurately predict body fat among Kenyan children. The addition of height to the equation raised the prediction power to 94% and 93% for girls and boys, respectively. This study also found that BMI-for-age and waist circumference had equally strong prediction power though slightly lower compared to the height and weight equations. The overall prediction power of the developed equations in this study could not be compared with other previously developed equations. This is because previously developed equations for school children have mainly utilized the sum of skin fold thickness as a covariant which this study did not measure.

According to Moura et al. (2013), prediction equations with a power of above 0.8 are considered accurate for use and therefore all the three equations for each gender met the threshold for predicting body fat in the study population. The variables used in different equations depend on what a country commonly use (Wang & Kumanyika, 2007). In Kenya, measurement of skin fold thickness is not a common practice. It is recommended that other variables that can improve the equation like sex and age be added (Huang et al., 2003). Studies have reported sex as a significant predictor of body fat (Kirchengast, 2010; Nightingale et al., 2013). However, concerning age, studies have been bivocal with
some indicating no improvement of predictive power with addition of age (Huang et al., 2003; Navder et al., 2014; Valencia et al., 2012), while others have included age in their model (Lohman et al., 2000; Naidoo et al., 2015). In this study, the equations were sex specific and age did not improve the precision of the equations. Further addition of energy intake and physical activity did not significantly improve the equations prediction power. Therefore, in circumstances where practitioners may not be able to obtain physical activity and energy intake data, anthropometric based equations are adequate in estimating body fat with high predictive power.

The equations modeled among urban children in Nairobi in this study may need to be validated among other non-urban populations before generalization. Findings may be limited to those children who have not entered pubertal stage as fat deposition increases with sexual maturity. Since age did not improve the equations significantly, it is not clear whether differences in body fat exist across school children up to 17 years within the Kenyan population since our study was limited to children up to 11 years. However, a major strength of this study lies in the measurement of body fat which was based on the use of SIDT, a method considered to be a gold standard. Given the paucity of data on anthropometric equations for Kenyan children, results from this study provide a preliminary way to predict total body fat from anthropometric measurements using a reasonably strong criterion measure. In a Kenyan setting, weight, height and waist circumference are easy to obtain. Therefore, the currently modeled equations may be particularly cost-effective.
CHAPTER SIX: SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary of the findings, conclusions and the recommendation.

6.1 Summary of the Findings

Children in this study had moderate nutrition knowledge. Knowledge had no association with dietary practices adopted by the children. However, attitude significantly influenced dietary practices. The diet of the children was characterized by relatively high consumption of soft drinks and fast foods. The availability of fast foods around the school environment and the fact that children had pocket money made it easier for the children to access them. There was no policy to regulate food items sold in shops in the school vicinity. Consumption of fast foods and soft sweetened drinks contributed significantly to total energy intake which in turn was associated with elevated body weight and percent body fat. Close to a third of the children (29.7%) had excess energy intake.

Children in this study had a moderate level of physical activity and only 15% of the children met the recommended level of physical activity. Physical activity level was found to have a significant inverse association with percent body fat. Schools had only one field which was used for various games and therefore inadequate for the number of children. Play items such as hula hoops, balls and skipping ropes were inadequate. During physical education lessons and school breaks, participation in games was on a voluntary basis and not compulsory for the children. Thus, the majority of the children
chose to engage in sedentary activities instead of participating in games. This contributes to the observed low level of physical activity among the study children.

Both under-nutrition and over-nutrition coexisted in this study population with about 8.0% of the pupils being overweight and obese, while on the other hand, about 7.4% were underweight. Children with central obesity were 6.9% which is a predisposing factor to most cardiovascular related diseases. There were more girls who were overweight and obese compared to boys. The proportion of children with excess body fat was 24.0% which is an indication of obesity while 33.0% had over fat. Mean percent body fat for girls was significantly higher compared to boys.

Energy intake and physical activity score had a significant relationship with BMI-for-age and percent body fat. Waist circumference and BMI-for-age had a significant relationship with percent body fat. However, further statistical analysis on the concordance between energy intake, physical activity level and body fat indicate a low level of agreement as 45.1% of those with low physical activity and 26.8% of those with excess energy did not have excess body fat. Similarly, there was low concordance in the definition of nutrition status based on BAZ (κ =0.129) and WtHR (κ=0.357) in comparison to SIDT. In the present study, three sex-specific equations were developed and cross-validated. The equations based on weight and height, waist circumferences and BMI-for-age, predicted body fat with high precision (>88%).
6.2 Conclusion

Children in this study had poor dietary practices, characterized by high consumption of sweetened beverages and fast foods. This led to excess energy intake observed among the children in this study. There were many food outlets around the school environment which made fast foods accessible to children. Though children had some level of nutrition knowledge, it did not translate into practice. The majority of the children had moderate physical activity and failure to participate in school games and physical education lessons contributed to the observed level of physical activity. Physical activity and energy intake significantly correlated with body fat. Therefore this study rejects the hypotheses that; ‘there is no significant association between energy intake, physical activity level and body fat’.

Concordance between anthropometry and SIDT in assessing nutrition status was poor whereby BMI-for-age z-score severely underestimated prevalence of overweight and obesity based on measures of body fatness by SIDT. Only 14.7% and 27.9% of children with excess body fat were identified as being obese by use of BAZ and WtHR, respectively. Similarly the sensitivity of physical activity and energy intake as proxy indicators of body fat was low. This study, therefore, fails to rejects the hypothesis that; ‘dietary intake, physical activity and anthropometry are not accurate measures of body fat’.
Body fat estimated using the modeled equations in this study had no significant difference with the fat scores measured using SIDT and therefore, this study rejects the hypothesis that; ‘prediction equation cannot accurately estimates body fat among school children in Nairobi City County’.

6.3 Recommendations

6.3.1 Recommendations for Policy

- Ministry of Health-Division of Nutrition to develop a policy to guide on the method of assessing body fat as anthropometric cut off points are not always concomitant with cut off points for body fat.
- Ministry of Education, Science and Technology to strengthen policy that governs participation of children in physical education lessons and games to enhance children physical activity level.

6.3.2 Recommendations for Practice

- Health practitioners should use anthropometry measurements as tools to tract changes in body parameters but not as a measure of body fat.
- Health practitioners to educate the general population on the concept of body fat since a normal person according to body measurements can have excess body fat irrespective of their weight.
- Heath practitioners can use the developed equations in estimation of body fat.
6.3.3 Recommendations for Research

- Further research is necessary for other groups such as adolescent and adults on the association between anthropometry measurements, dietary intake, physical activity and body composition.

- Further research is needed on development and use of prediction equations in assessing overweight and obesity.
REFERENCES


APPENDIX A: MAP OF NAIROBI CITY COUNTY

STUDY AREA – Nairobi City County

Constituency
- Dagoretti North
- Dagoretti South
- Embakasi Central
- Embakasi East
- Embakasi North
- Embakasi South
- Embakasi West
- Kamukunji
- Kilimani
- Roysambu
- Ruaraka
- Mathare
- Embakasi North
- Embakasi South
- Embakasi Central
- Embakasi East
- Kasarani
- Langata
- Makadara
- Starehe
- Westlands

Author: Ruth Kamunya - 5/5/2013
APPENDIX B: INFORMED CONSENT

Principal/Head teacher/Parent/guardian/Pupil

My name is Zipporah Ndungu, a student of Kenyatta University, Department of Food, Nutrition and Dietetics, PO BOX 43844-00100 GPO Nairobi, Telephone Number +254-723623236.

I am undertaking a study on Validation of nutritional status assessment methods in assessment of overweight and obesity using isotope dilution technique. This study is part of a Project RAF6042: APPLYING NUCLEAR TECHNIQUES TO DESIGN AND EVALUATE INTERVENTIONS TO REDUCE OBESITY AND RELATED HEALTH RISKS, among school children aged 8-11 years from public day primary schools.

The procedures of the project are non-invasive, safe, and non-radioactive and have been widely used in all human populations. In Kenya, the procedures have even been carried out among breastfeeding mother-infant pairs.

This study will involve:

1. Collecting data on demographic and socio-economic characteristics of the sampled children in the sampled schools.
2. Collecting child’s data on dietary practices.
3. Measuring the child’s physical activity which will involve wearing accelerometer for only seven days during day time at school and at home.
4. Taking the child’s anthropometric measurements (weight, height and waist circumference).
5. Collection of saliva samples once from the child before and after taking a dose of heavy water within a difference of 4 hours.
The findings of this study will help Government ministries and other stakeholders in accurate assessment of obesity as a health risk. The process will take 7 days to be completed. The information given will be treated with the utmost confidentiality and will only be used for the purpose of this study. Participation for the school and the pupils is voluntary and there will be no payment for participation.

**Procedure to be followed**

The respondent and the guardian/parent in this study will be asked questions related to the respondent’s dietary practices, physical activity and anthropometric data. The parent/guardian will also be asked for information on the household socio-demographic characteristics.

For dietary practices the respondent will be provided with a food diary where he/she will be expected to document all foods consumed at home and at school. 24 hour recall will be conducted at home where the respondent will be asked to recall the type and amount foods taken in the last 24 hours. The parent/caregiver will be asked to state the type and amount of ingredients used to cook the meal for the entire household. The parent will also be expected to give information on the amount of food cooked for the entire family, the amount served to the index child and the left over amount from the serving, if any. This process will involve use of commonly used household measures like jugs, serving spoons, table spoons, standard cups and bowls which the researcher will come with to help accurately determine the amount of foods consumed by the respondent. This will be done on three different days including a weekend day.

For physical activity, the respondents will be asked questions on the type of activities done in the last seven days and the duration of the activities. The respondent will also be given an accelerometer to wear for seven days to capture his/her daily activity. Accelerometer is a small device mounted on a belt. The respondent will be expected to tie the accelerometer around the waist areas over the clothes. It is light and comfortable to wear. The respondent will remove the device while sleeping or while taking a shower.
The respondent will keep a diary on the time when the device was removed and the time when it was tied back. The respondent will be followed up with a phone call through the parent/guardian to be reminded to wear the accelerometer and to fill in the diaries.

For anthropometric measurements, it will involve taking the weight, height and waist circumference. The weight will be taken using a bathroom scale while the respondent is standing straight and with light clothes. The height will be taken using a Stadiometer while the respondent is standing straight and without shoes. Waist circumference will be taken around the waist using a tape measure. For girls a female enumerator will take the waist circumference while for boys, a male enumerator will take the waist circumference.

For body fat composition, saliva sample will be collected 2 hours after breakfast. The weight of the respondents will be taken before collection of the saliva sample. This will be done after they have voided their bladder and bowels. The participants will then drink a dose of heavy water containing deuterium. This water is safe and non-radioactive. Another saliva sample will be collected 3 to 4 hours after. The participants will be expected not to consume food or liquids and to avoid physical activity during the four hour period. To collect the saliva sample the participants will be given a dry cotton swab and asked to move it around their mouth for 2 minutes or until it is sodden. The participants will then be asked to move the cotton swab to the front of their mouth. This will then be transferred into the syringe barrel.

The principal/head teacher will be expected to help the study team to access the children while in school. The parent/guardian will help in providing information about the household regarding diet during the 24 hour recall interview and also provide information on household socio-demographic characteristics.

You can ask any question related to this study any time and you may stop the procedure at any time without any consequences.
Benefits
By participating in this study, the school will help us to accurately assess nutritional status, activity level and specifically body fat composition for early prevention and management of childhood obesity which has become a health burden in our health care system. The school, parent/guardian and the pupil will also benefit by understanding the current dietary practices, body fat composition and physical activity level of the children in this school. If found to have a problem, advice on appropriate action will be provided to the school, parent and the child.

Discomfort and risks
Principal/Head teacher
Only the sampled children will wear the accelerometer. This may create curiosity among those who have not been sampled. If any tension arises among the two groups you may end the study without any consequences.

Parent/Guardian
Some of the questions you will be asked may require you to give detailed information on how you cook your food and socio demographic information concerning your household. If this makes you uncomfortable, you may refuse to answer the questions and end the interview without any consequences.

Pupil
Some of the questions you will be asked may require you to give information on how much food you eat, and this may make you uncomfortable. It will also involve wearing an accelerometer for seven days and you may feel uncomfortable. If this happens, you may refuse to answer the questions and to wear the accelerometer and you may end the study without any consequences.
Confidentiality
In the questionnaire the name of the school and the child will not appear. The name of the school and the child will only be recorded on a confidential code book for the purpose of tracking and for identity purpose. The questionnaires will be kept safely in a locked cabinet.
If you have any question you may contact the following:

Zipporah Ndungu
Department of Food, Nutrition and Dietetics- Kenyatta University
PO Box 43844-00100
Email address: zippymaina@gmail.com
Telephone no. 0723 623236

Dr. Dorcus Mbithe Kigaru
Department of Food, Nutrition and Dietetics- Kenyatta University
PO BOX 43844-00100 GPO Nairobi
Email address: dorcusmbithe@yahoo.com
Telephone no: Office- 020-8710901ext 57139, Mobile 0728379785

Kenyatta University -Ethics Review Committee
PO BOX 30568 -00100 GPO Nairobi
Email-director-crd@ku.ac.ke
Respondent’s statement (Principal/head teacher)

My name is ………………………………………………………… Principal/head teacher of …………………………………………………………

Zipporah Ndungu, a student of Kenyatta University, Department of Food, Nutrition and Dietetics, PO BOX 43844-00100 GPO Nairobi, Telephone Number +254-723623236, has informed me about the research on validating of anthropometric measurements using isotope dilution technique which is part of the project RAF 6042: APPLYING NUCLEAR TECHNIQUES TO DESIGN AND EVALUATE INTERVENTIONS TO REDUCE OBESITY AND RELATED HEALTH RISKS. She has explained to me the benefits and the risks involved. I understand that the study will involve pupils in my school aged 8-11 years.

I understand that the research procedures are non-radioactive and/or not harmful to human health. It has also been explained to me that the information obtained from this study will assist in the improvement of the weight management, obesity and related risk factors of Kenyan children and future generations. I have been assured of confidentiality on any information that will be obtained from pupils in this school. The participation of my school in this study is voluntary and without any element of force or coercion. I have willingly accepted that my school should participate in the study. I understand that for any information or question about the project, Zipporah Ndungu can be conducted. I have read and understand this consent form.
Parent/guardian statement

My name is ...................................................... parent/guardian of (pupil’s name) ...................................... of class......................... In (name of school)........................................

Zipporah Ndungu, a student of Kenyatta University, Department of Food, Nutrition and Dietetics, PO BOX 43844-00100 GPO Nairobi, Telephone Number +254-723623236, has informed me about the research on validating of anthropometric measurements using isotope dilution technique which is part of the project RAF 6042: APPLYING NUCLEAR TECHNIQUES TO DESIGN AND EVALUATE INTERVENTIONS TO REDUCE OBESITY AND RELATED HEALTH RISKS. She has explained to me the benefits and the risks involved. I understand that the study will involve my child aged 8-11 years.

I understand that the research procedures are non-radioactive and/or not harmful to human health. It has also been explained to me that the information obtained from this study will assist in the improvement of the weight management, obesity and related risk factors of Kenyan children and future generations. I have been assured of confidentiality on any information that will be obtained from me and/or my child. The participation of my child in this project is voluntary and without any element of force or coercion. I have willingly accepted that my child participates in the project. I understand that for any information or question about the project, Zipporah Ndungu can be conducted. I have read and understand this consent form.

Parent/guardian Name........................................... Sign ................Date.............................
LETTER OF ASSENT BY PUPIL’S

My name is ______________________________ of class________________. In (name of school)__________________________

Zipporah Ndungu, a student of Kenyatta University, Department of Food, Nutrition and Dietetics, PO BOX 43844-00100 GPO Nairobi, Telephone Number +254-723623236, has informed me about the research on validating of anthropometric measurements using isotope dilution technique which is part of the project RAF 6042: APPLYING NUCLEAR TECHNIQUES TO DESIGN AND EVALUATE INTERVENTIONS TO REDUCE OBESITY AND RELATED HEALTH RISKS. She has explained to me the benefits and the risks involved.

I understand that the research procedures are non-radioactive and/or not harmful to human health. It has also been explained to me that the information obtained from this study will assist in the improvement of the weight management, obesity and related risk factors of Kenyan children and future generations. I have been assured of confidentiality on any information that will be obtained from me. My participation in this project is voluntary and without any element of force or coercion. I have willingly accepted to participate in the project. I understand that for any information or question about the project, Zipporah Ndungu can be conducted. I have read and understand this consent form.

Child’s Name____________________________ Class________________________ Date____________________________
APPENDIX C: LEARNER (PUPIL) QUESTIONNAIRE
VALIDATION OF NUTRITIONAL STATUS ASSESSMENT METHODS IN ASSESSMENT OF OVERWEIGHT AND OBESITY USING ISOTOPE DILUTION TECHNIQUE

Country __________________________  Country code __________
Name of school ______________________  School Number _________
Name of interviewer ___________________  Date__________ (dd/mm/yyyy)
Questionnaire 4-digit ID ________________  Class/Grade __________

Section A: Tell us about you and your family
We would like to learn more about you and your family. Please answer all questions. Remember that there is no right or wrong answer, and that every person is different. We will not share any of your personal information with anyone else, and all of your answers will remain private.

1. Name _____________________________________________________  (Write your name in full, do not use abbreviations)
2. Are you a boy or a girl? (tick one)  □  Boy  □  Girl
3. How old are you? ________ Years
4. Including yourself, how many people currently live in your home? ________
5. Who is the household head □  Father  □  Mother
6. How many rooms are there in your house? ________ rooms
   (Include rooms like the kitchen, lounge/sitting room, bedrooms and any outside structures; do not include bathrooms)
7. In your home, what is the main source of water? (Tick one)
   □  Indoor tap water
   □  Outside tap water
   □  Other water source
8. What kind of toilet do you usually use at home?
   □  Flush toilet inside the house
   □  Flush toilet outside the house
   □  Pit latrine/bucket
   □  Other type, Specify ________________
CHILD'S PUBERTAL STATUS:
(Girls only) Have you started menstruating (bleeding every month/period)?  YES/NO

Section B. Attitude on Healthy eating habits
1. I do not have to worry about the kind of foods I eat because I am still young
   1. Agree
   2. Neutral
   3. Disagree

Section C. Nutrition Knowledge
1. Do you have school lessons where you talk about healthy eating?
   1. Yes
   2. No
2. Is eating fruit and vegetables every day good for our bodies to fight against illnesses like colds and flu?
   1. Yes
   2. No
   3. I don’t know
3. Eating a lot of sugar, sweets and sweet food.
   Is good for health
   1. Yes
   2. No
   3. I don’t know
   Can make you fat
   1. Yes
   2. No
   3. I don’t know
   Is bad for your teeth
   1. Yes
   2. No
   3. I don’t know
4. Look at the following pictures and fill in the LETTER (A, B, C, D, E, F or G) of the food group you think best fits the answer to the questions below (You can choose a group more than once)
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat, Chicken, Fish, Eggs</td>
<td>Brown Bread, Rice, Samp, Mealie meal</td>
<td>Vegetables</td>
<td>Fruit</td>
<td>Sugar, Sweets</td>
<td>Fats, oils</td>
<td>Milk, Maas, Yoghurt, Cheese</td>
</tr>
</tbody>
</table>

4.1 Choose the food group that you should eat the MOST of every day

4.2 Choose the food group that you should eat the LEAST of every day

4.3 Choose the food group that gives your body the best ENERGY

4.4 Choose the food group that your BODY uses to BUILD MUSCLES

4.5 Choose the food group that best PROTECTS THE BODY AGAINST ILLNESSES
Section D: Dietary practices
4.1 Food Frequency table

4.1.1 How many meals do you normally consume per day _____________?

4.1.2 Have you consumed the following foods in the last 7 days? _____ 1 = Yes 2 = No

4.1.3 If yes, state the number of times? ______________________

<table>
<thead>
<tr>
<th>Food</th>
<th>Y/N</th>
<th>Frequency</th>
<th>Food</th>
<th>Frequency</th>
<th>Y/N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fruits and vegetables</strong></td>
<td></td>
<td></td>
<td><strong>Proteins- Legumes and meats</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sukuma wiki (Kales)</td>
<td></td>
<td></td>
<td>Beans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbages</td>
<td></td>
<td></td>
<td>Black beans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td></td>
<td></td>
<td>Green grams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amaranth</td>
<td></td>
<td></td>
<td>Lentils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cowpeas leaves</td>
<td></td>
<td></td>
<td>Pigeon peas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ripe banana</td>
<td></td>
<td></td>
<td>Beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pawpaw</td>
<td></td>
<td></td>
<td>Chicken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mangoes</td>
<td></td>
<td></td>
<td>Eggs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oranges</td>
<td></td>
<td></td>
<td>Milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stinging nettle</td>
<td></td>
<td></td>
<td>Milk products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td>Peas</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cereals/grains</strong></td>
<td></td>
<td></td>
<td>Punch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize meal</td>
<td></td>
<td></td>
<td>Rabbit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Githeri</td>
<td></td>
<td></td>
<td>Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maize porridge</strong></td>
<td></td>
<td></td>
<td>Fats/ Oils / Sugar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td>Cooking fat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
<td>Cooking oil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irish Potatoes</td>
<td></td>
<td></td>
<td>Sugar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bread</td>
<td></td>
<td></td>
<td>Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chapati</td>
<td></td>
<td></td>
<td>Roots and tubers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandazi</td>
<td></td>
<td></td>
<td>Yams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finger millet</td>
<td></td>
<td></td>
<td>Arrow roots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw banana</td>
<td></td>
<td></td>
<td>Sweet potatoes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amaranth grain</td>
<td></td>
<td></td>
<td>Others</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2 Food diversity score questionnaire of the index child

Now I would like to ask you about the types of foods that you ate yesterday during the day and at night.

| QN | FOOD GROUP                               | EXAMPLE                                                                 | YES=1
|----|------------------------------------------|-------------------------------------------------------------------------|-------
|    |                                          |                                                                         | NO=0  |
| 1A | Cereals                                  | Any *ugali*, bread, rice, chapati, biscuits, or any other Foods made from millet, sorghum, maize, rice, wheat | A................. |
|    |                                          |                                                                         |       |
|    |                                          |                                                                         | B................. |
|    | B Vitamin A rich vegetables              | pumpkin, carrots, squash, or sweet potatoes that are orange inside + other locally available vitamin-A rich vegetables (e.g. red sweet pepper) |       |
|    |                                          |                                                                         |       |
|    | White tubers and roots                   | white potatoes, white yams, white cassava, or other foods made from roots | C................. |
|    |                                          |                                                                         |       |
|    | D DARK GREEN LEAFY VEGETABLES            | dark green/leafy vegetables, including wild ones + locally available vitamin-A rich leaves such as amaranth, cassava leaves, kale, spinach etc. | D................. |
|    |                                          |                                                                         |       |
|    | E OTHER VEGETABLES                       | other vegetables (e.g. tomato, onion, eggplant), including wild vegetables | E................. |
|    |                                          |                                                                         |       |
|    | F VITAMIN A RICH FRUITS                  | ripe mangoes, cantaloupe, apricots (fresh or dried), ripe papaya, dried peaches + other locally available vitamin A-rich fruits | F................. |
|    |                                          |                                                                         |       |
|    | G OTHER FRUITS                           | other fruits, including wild fruits                                     | G................. |
|    |                                          |                                                                         |       |
|    | H ORGAN MEAT (IRON- RICH)                | liver, kidney, heart or other organ meats or blood-based foods         | H................. |
|    |                                          |                                                                         |       |
|    | I FLESH MEATS                            | beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds | I................. |
|    |                                          |                                                                         |       |
|    | J EGGS                                   | chicken, duck, guinea hen or any other egg                             | J................. |
|    |                                          |                                                                         |       |
|    | K FISH                                   | fresh or dried fish or shellfish                                       | K................. |
|    |                                          |                                                                         |       |
|    | L LEGUMES, NUTS AND SEED                 | beans, peas, lentils, nuts, seeds or foods made from these             | L................. |
|    |                                          |                                                                         |       |
|    | M MILK AND MILK PRODUCTS                 | milk, cheese, yogurt or other milk products                           | M................. |
|    |                                          |                                                                         |       |
|    | N OILS AND                               | oil, fats or butter added to food or used for                          | N................. |

*Note: QN stands for Question Number.*
<table>
<thead>
<tr>
<th></th>
<th>FATS</th>
<th>cooking</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>RED PALM PRODUCTS</td>
<td>Red palm oil, palm nut or palm nut pulp sauce</td>
<td>O..........................</td>
</tr>
<tr>
<td>P</td>
<td>SWEETS</td>
<td>sugar, honey, sweetened soda or sugary foods such as chocolates, candies, cookies and cakes</td>
<td>P..........................</td>
</tr>
<tr>
<td>Q</td>
<td>SPICES, CONDIMENTS, BEVERAGES</td>
<td>spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages OR local examples</td>
<td>P..........................</td>
</tr>
</tbody>
</table>

Did you eat anything (meal or snack) OUTSIDE of the home yesterday? Household

### 4.3 24- Hour recall

42.3.1 What drink/foods did you consume yesterday starting from the time you woke up to the time you went to sleep? Fill in the 24 hour recall table.

<table>
<thead>
<tr>
<th>Time/meal</th>
<th>Type of dish</th>
<th>Ingredient</th>
<th>HH measure</th>
<th>Amt (g)</th>
<th>Vol cooked</th>
<th>Vol served</th>
<th>Vol not eaten</th>
<th>Vol consumed</th>
<th>Amt taken (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Snack</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Snack</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Supper</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Snack</td>
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<td></td>
</tr>
</tbody>
</table>
Section E: Lifestyle and Health

1. In the last 7 days, did you eat in front of the television/computer?
   1. Yes (Always)
   2. No (none)
   3. Sometimes (2-3 times per week)

2. In the last 7 days did you eat your main meal with your family?
   1. Yes (Always)
   2. No (None)
   3. Sometimes (2-3 times per week)

3. In the past 7 days did you bring a lunchbox to school? Is yes, how many days?
   1. Yes (always)
   2. No (none)
   3. Sometimes (2-3 times per week)

   If no, state the reason ______________________________________________________

4. How many days in the last 7 days do you bring money to school?
   1. Every day (5 days)
   2. 2-3 times per week
   3. never

5. In the past 7 days did you buy anything from the tuck shop/school canteen/vendor?
   a. Yes (every day)
   b. No (none)
   c. Sometimes (2-3 times per week)

6. Do you participate in the school feeding scheme? / Do you receive lunch (a meal) from your school every day?
   a. Yes (every day)
   b. No (none)
   c. Sometimes (2-3 times per week)

7. In the past 7 days did you eat fruit?
   a. Yes (every day)
   b. No (none)
   c. Sometimes (2-3 times per week)

   If you do eat fruit, why do you eat them?
   a. Because you like the taste?
   b. Because people at home eat fruit
   c. Because you are told to eat them

   Any other reason ______________________________________________________

8. In the past 7 days did you eat vegetables?
   a. Yes (every day)
   b. No (none)
   c. Sometimes (2-3 times per week)

   If you do eat vegetables, why do you eat them?
   1. Because you like the taste
   2. Because people at home eat vegetables
   3. Because you are told to eat them

   Any other reason ______________________________________________________

9. When you feel like a snack, what do you eat?
Chips
a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)

Sweets
a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)

Fruit
a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)
d. 

Sandwich or cereal
a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)

Chocolate
a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)

Others (specify)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Sometimes (2-3 times per week)</th>
</tr>
</thead>
</table>

10. In the past 7 days, did you consume sweetened beverages (cold drinks such as Afia, Minute Maid, Quencher, fizzy drinks, squash, soda, sweet drink)?
a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)

Others ____________________________ Specify

a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)

11. In the past 7 days have you eaten fast foods (e.g. (hot) chips, burger, sausage/smokies, biscuits, chocolate, doughnuts, nuts, popcorns, hotdog, pizza)? Others

__________________________

a. Yes (every day)
b. No (none)
c. Sometimes (2-3 times per week)
Section F: 5.0 Physical Activity

1. Have you done any of the following activities in the past 7 days (last week) in your spare time when you are not at school?

(This includes activities that you do when you are not at school and may include games that you play with your friends, at home, or in the street)

*If yes, how many times? Only mark one circle per row*

<table>
<thead>
<tr>
<th>Activity</th>
<th>No</th>
<th>1-2</th>
<th>3-4</th>
<th>5-6</th>
<th>≥7 times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skipping/clapping &amp; jumping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skating/skate boarding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dodge ball/catchers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking for exercise/hiking</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Bicycling (riding on your bike)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Jogging or running/cross country</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swimming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseball/rounders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dancing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rugby</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badminton/tennis/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soccer/football</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Volleyball</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hockey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basketball/netball</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hide and seek</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cricket</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Running with wheels/tyres</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judo/karate/boxing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trampoline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

_________________________..............................
_________________________..............................


2. In the last 7 days, during your physical education (PE) classes at school, how often were you very active (playing hard, running, jumping, throwing)?

(Check only one)

I don’t do PE ..................................................................................

Hardly ever................................................................................................................

Sometimes.......................................................................................

Quite often..................................................................................................................

Always....................................................................................................................

3. In the last 7 days, what did you do most of the time at school break?

(Check one only)

Sat down (talking, reading, doing schoolwork)..................................................

Stood around or walked around................................................................................

Ran or played a little bit............................................................................................

Ran around and played quite a bit........................................................................

Ran and played hard most of the time....................................................................

4. In the last 7 days, what did you normally do at lunch time (besides eating lunch)?

(Check one only)

Sat down (talking, reading, doing schoolwork)...

Stood around or walked around................................................................................

Ran or played a little bit............................................................................................

Ran around and played quite a bit........................................................................

Ran and played hard most of the time....................................................................

5. In the last 7 days, on how many days right after school, did you do sport, dance, or play games in which you were very active?

(Check one only)

None .......................................................................................................................

1 time last week.................................................................................................

2 or 3 times last week...........................................................................................

4 times last week.................................................................................................

5 or more times last week....................................................................................
6. In the last 7 days, on how many evenings did you do sports, dance, or play games in which you were very active?
(Check one only)

None.................................................................................................................................
1 time last week.............................................................................................................
2 or 3 times last week....................................................................................................
4 or 5 times last week....................................................................................................
6 or 7 times last week....................................................................................................

7. On the last weekend, how many times did you do sports, dance, or play games in which you were very active?
(Check one only)

None.................................................................................................................................
1 time.................................................................................................................................
2 — 3 times.......................................................................................................................
4 — 5 times.....................................................................................................................
6 or more times................................................................................................................

8. Which one of the following describes you best for the last 7 days?
(Listen to the teacher reading all of the options first before you answer)

A. All or most of my free time was spent doing things that did not require much physical effort
..........................................................................................................................

B. I sometimes (1 — 2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics) ..............................................

C. I often (3 — 4 times last week) did physical things in my free time ..........................

D. I quite often (5 — 6 times last week) did physical things in my free time ..............

E. I very often (7 or more times last week) did physical things in my free time ..........

9. Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity or any of the activities included in Table 1) for each day last week.

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>little bit</th>
<th>Medium</th>
<th>Often</th>
<th>Very often</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.0 LEARNER MEASUREMENTS

1. CHILD’S AGE: __________ years

2. CHILD’S DATE OF BIRTH (d/m/y) ________________ (verify by school records)

3. CHILD’S ANTHROPOMETRY:
   a) WEIGHT (kg.): 1st: ________ 2nd: ________ mean: ________
   b) HEIGHT (cm.): 1st: ________ 2nd: ________ mean: ________
   c) WAIST CIRCUMFERENCE (cm): 1st: ________ 2nd: ________ mean: ________
   d) BLOOD PRESSURE (mm/Hg):
      First reading: systolic: ________ diastolic: ________
      Second reading: systolic: ________ diastolic: ________
      Third reading: systolic: ________ diastolic: ________
      Mean (2nd and 3rd): systolic: ________ diastolic: ________
APPENDIX D: FOCUS GROUP DISCUSSION GUIDE

PROJECT RAF 6042: DESIGNING AND EVALUATING INTERVENTIONS TO REDUCE OBESITY AND RELATED HEALTH RISKS

Focus group discussion guide

1. From the following list of food items taken as snacks which ones do you classify as either as healthy snacks or as junk (foods of low nutritive value)?

<table>
<thead>
<tr>
<th>Chocolate</th>
<th>Pizza</th>
<th>Quencher juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisps</td>
<td>Ice-cream</td>
<td>Packet milk</td>
</tr>
<tr>
<td>Pineapple</td>
<td>Sweet</td>
<td>Doughnut</td>
</tr>
<tr>
<td>Oranges</td>
<td>Porridge</td>
<td>Smokies</td>
</tr>
<tr>
<td>Ground nuts</td>
<td>Arrowroots</td>
<td>Sausage</td>
</tr>
<tr>
<td>Milk</td>
<td>Popcorns</td>
<td>Sandwich</td>
</tr>
<tr>
<td>Cake</td>
<td>Fresh Orange juice</td>
<td></td>
</tr>
</tbody>
</table>

2. Which of these snacks do you like eating?
3. What are the reasons for your choices?
4. Do you eat the snacks at home or at school? (allow the children to give more details on this)
5. When given money by your parents which snack would you buy?
6. What are the reasons for your choices?
7. Do your parents’ guide you on what snack/foods to buy while at school?
8. Are your parents aware of the snacks you eat while away from home (allow more discussion)?
9. What is your opinion on being fat?
10. What are the reasons for your opinion?
11. Which are the foods that can make someone to become fat?
12. From the following, where do you get most information on either food, nutrition and about healthy eating?
   a. Television
   b. Radio
   c. School
d. Church  
e. Parents at home  

13. Give examples of food items under the following categories and cost for a portion  
   a. Fast foods  
   b. Sweetened drinks  
   c. Fruits  
   d. Nuts  
   e. Milk  

14. What are some things you have learnt about dietary habits from your parents?  

15. List other avenues where you have received information concerning food and eating habits
APPENDIX E: KEY INFORMANT (SCHOOL HEAD TEACHER) INTERVIEW

GUIDE

Country ______________________ Country code ____________
Name of school ___________________________ School Number ____________
Name of interviewer ______________________ Date ____________ (dd/mm/yyyy)
Name of observer ________________________ Date ____________ (dd/mm/yyyy)

Position at school of person being interviewed: ______________________

Date of Consent signed: ____________ (dd/mm/yyyy)

Section A: School Demographics and Neighborhood Environment

We would like to learn more about your school and the learners and community that your school serves. All answers will remain confidential, and your school will never be mentioned by name or area in any communication or publications emanating from this project.

1. Grade levels in your school: From Grade ____ to Grade ____
2. Number of classes: ______
3. Number of learners in your school: ______
4. Number of teachers: ______
5. The socioeconomic status of the learners within the school and the community that it serves may best be described as:
   ___ a) lowest socioeconomic status in relation to the region
   ___ b) low to moderate socioeconomic status in relation to the region
   ___ c) mixed low, moderate or high socioeconomic status in relation to the region
   ___ d) upper middle income groups in relation to the region
   ___ e) do not know
6. How do most learners travel to your school?
   ___ a) car or private vehicle
   ___ b) walk
   ___ c) ride bicycles
   ___ d) public transport (bus or train)
   ___ e) other _____________________________
7. Please answer the following questions as they best describe the physical environment of the neighborhood surrounding the school (Optional):

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. There are many shops, markets or other places to buy things within easy walking distance of the school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. There are transit stops (bus, taxi or train) within a 10-15 minute walk from the school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. In the neighborhood, there are several free/low cost facilities, like recreation centres, parks,&amp; playgrounds.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. The crime rate in the neighborhood near the school makes it unsafe to go walking at night.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. There is so much traffic on the street that it makes it difficult or unpleasant to walk or cycle in this neighborhood.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. The neighborhood near the school is relatively free from litter, rubbish and graffiti.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8. Please answer the following questions as they best describe the food environment of the neighborhood surrounding the school (Optional):

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. There is large selection of fresh fruits and vegetables available in shops &amp; stores in this neighborhood.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. The fresh fruits and vegetables in shops &amp; stores in this neighborhood are of high quality.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. There is a large selection of low-fat products available in shops &amp; stores in this neighborhood.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. There are many fast food restaurants or vendors that sell high fat, or high sugar, low quality foods in this neighborhood.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section B. School health, physical activity and nutrition environment observation
9. Which of the following describes the condition of the school/buildings/surrounds?

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>No, not at all</th>
<th>A little or somewhat</th>
<th>Yes, very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Clean, with very little litter present</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Neat, well-looking after, and regular maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Disrepair and evidence of vandalism, broken windows, graffiti, and similar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Painted murals, planted beds, shade trees, benches for sitting or similar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. The name board of the school sponsored by a food / beverage company?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
10. Please indicate whether the following amenities/facilities are available at the school:

<table>
<thead>
<tr>
<th></th>
<th>No, not available</th>
<th>Yes, available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An indoor hall for activity and physical education in bad weather?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers/supervisors seen supervising learners during break times</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posters or messages visible concerning healthy eating, physical activity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. Please indicate the number of playgrounds/designated play areas for learners.

Number of playgrounds/designated play areas: ________

12. Describe the condition of these playgrounds:

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Mostly grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Mostly sand with stones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Cement or tarred surfaces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Generally free of glass and other dangerous objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Some/ a lot of glass and other dangerous objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Generally, Grounds clear of litter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. Please indicate whether the equipment listed is available for use by learners (and the number if available) as well as, the state of the equipment.

<table>
<thead>
<tr>
<th></th>
<th>No/ Non-functional</th>
<th>Yes- number/ Mostly or fully functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Jungle gyms and/or climbing frames</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Slides and/or see-saws</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Swings / hanging tyres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Playground drawings (hopscotch, four-square, snakes and ladders, fantasy-type markings, or similar)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
14. Please indicate the number of sports fields available for learners.
Number of sports fields: ________

15. Describe the condition of these sports fields:

<table>
<thead>
<tr>
<th>Condition Description</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Mostly grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Mostly sand with stones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Generally free of glass and other dangerous objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Some/a lot of glass and other dangerous objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Generally, Grounds clear of litter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16. Please indicate whether the equipment listed is available for use by learners (and the number if available) as well as, the state of the equipment.

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>No/Non-functional</th>
<th>Yes-number/ Mostly or fully functional</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Nets or goal posts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Painted lines or courts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Swimming pool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Netball/basketball/volleyball/tennis courts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. if yes, what is the condition?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Please indicate the availability of the equipment listed below in this school:

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>None</th>
<th>A few</th>
<th>Many</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Skipping ropes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Hoola hoops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Soccer balls/soccer goal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Netballs/Nets/Posts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Basketballs/Nets/Posts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Cricket bats/pads/wickets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Hockey sticks/balls/pads/goals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. Rugby balls/goal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. Tennis racquets/nets/balls</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
18. Is structured physical activity currently in the weekly timetable for the learners?
   _____Yes  _____No
If yes:
   a. How many sessions per week? _______ Sessions/week
   b. How long is each physical activity session? _______ Minutes/session

Section C. School feeding programme/nutrition policies/vendors:
20. Is there a tuck shop/snack shop/canteen at the school? If so, please indicate the items that are sold in the shop from the list provided:

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Is there a tuck shop/snack shop at the school? If yes, which of the following items are available?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>Sweets</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>Chocolates</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>Chips (crisps)</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>Fizzy cool drinks or other cool drinks</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>Sports drinks, such as Energade™</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>100% Fruit juice</td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>Fresh fruits or salads</td>
<td></td>
</tr>
<tr>
<td>i</td>
<td>Cooked meals (w/ protein, vegetables, starch)</td>
<td></td>
</tr>
<tr>
<td>j</td>
<td>White bread sandwiches</td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>Brown bread sandwiches</td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>Hamburgers / hotdogs</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>Koeksisters / doughnuts</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>Slap chips / chip roll</td>
<td></td>
</tr>
</tbody>
</table>
20. Are there formal or informal vendors at or adjacent to the school? If so, please indicate the items that are sold by these vendors from the list provided:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>o</td>
<td>Sausage rolls / pies</td>
</tr>
<tr>
<td>p</td>
<td>Ice suckers – bunny licks / ice cream</td>
</tr>
<tr>
<td>q</td>
<td>Other: __________________________</td>
</tr>
</tbody>
</table>

21. What are the top three barriers to health-promotion programmes in schools? Place a 1, 2 or 3 next to the applicable barrier.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Too little time within the timetable</td>
</tr>
<tr>
<td>b.</td>
<td>Too many competing priorities</td>
</tr>
<tr>
<td>c.</td>
<td>Lack of capacity / training and availability of human resources</td>
</tr>
<tr>
<td>d.</td>
<td>Lack of financial resources</td>
</tr>
<tr>
<td>e.</td>
<td>Inadequate facilities</td>
</tr>
<tr>
<td></td>
<td>Lack of interest / willingness from outside organisations</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>g.</td>
<td>Lack of interest from learners</td>
</tr>
<tr>
<td>h.</td>
<td>Lack of interest / support from teachers</td>
</tr>
<tr>
<td>i.</td>
<td>Lack of interest / support from parents</td>
</tr>
<tr>
<td>j.</td>
<td>Unsafe for learners to stay after school to participate</td>
</tr>
</tbody>
</table>
APPENDIX F: PHYSICAL ACTIVITY DIARY

ACTIVITY DIARY INSTRUCTIONS

What is your ...?

First Name                            Last Name

1. Clip the actigraph activity monitor to the belt provided and place it around your waist. Position the monitor so that it rests over your hipbone directly underneath your RIGHT armpit. If worn correctly, you should be able to see the sticker that says “top”. Refer to picture for proper placement.

2. Keep the monitor on all day, including when you may take a nap.

3. **You may remove the monitor when you go to bed at night, but remember to place it back on in the morning.**

4. The waist monitor MUST be removed when bathing (either bath or shower) or when going swimming. **DO NOT GET THE WAIST MONITOR WET!**

5. Every day when you get out of bed in the morning, please fill in the time you put the waist monitor on in the diary. If you remove the waist monitor, for example when you take a bath or go for swim, please also fill in the time you take the monitor off. Just before going to bed, please fill in the time. See an example of a diary on the next page.

PLEASE FILL IN THIS DIARY EVERY DAY!

If you have any questions please call:

_____________________________
Serial Number of the Acti-Graph

Code

DAY 1 ACTIVITY DIARY

1. Today’s date:       
                        
                        Month       Day            Year

2. Day: ○ Monday ○ Tuesday ○ Wednesday ○ Thursday ○ Friday ○ Saturday ○ Sunday

3. Starting time (Right after getting up): 

   : ○ AM ○ PM

4. If you take off the waist monitor during the day, please fill in the time and describe the activity while you are NOT wearing the monitor bellow:

   a. Time taken off: ○ AM ○ PM
   b. Activity while NOT wearing MONITOR: _____________________________
   c. Time put back on: ○ AM ○ PM

5. End time (right before going to sleep): ○ AM ○ PM
ACTIGRAPH RETURN AND READING

1. What is your ...?


First Name . Last Name

2. Date participant returned Acti-Graph to the clinic:


Month / Day / Year ○ did not return Acti-Graph.

3. How many days was the ActiGraph worn?
   (Examiner Note: After retrieving the data from the ActiGraph review the ActiGraph Event Editor information on the computer screen and record «Days Recorded»)


4. How many of the days that the ActiGraph was worn were valid?
   (Examiner Note: After retrieving the data from the ActiGraph review the ActiGraph Event Editor information on the computer screen and record «Valid Days»)


5. Was any activity collected and recorded on the ActiGraph?

○ Yes ○ No

Why wasn’t any activity collected and recorded on the ActiGraph?
   (Please mark all that apply.)

○ Cognitive problems
○ Dexterity problems
○ Vision Problems
○ Travels Plans interfered
○ Participant took off; did not replace or restart correctly
○ Equipment failure; periods not recorded
○ Actigraph lost
○ Participant refused
○ Other (Please specify:

6. Was diary completed?

○ Yes ○ No (No diary entries were made)
   ○ No (Some diary entries were made)
APPENDIX G: STANDARD OPERATIONAL PROCEDURE FOR
ANTHROPOMETRIC MEASUREMENTS

Introduction

Blood pressure is taken from the participants to determine the Proportion of the population with raised blood pressure. Height and weight measurements are taken to calculate body mass index (BMI). That is used to determine the prevalence of overweight and obesity in the population.

Units of Measurement

The table below shows the standard units of measurement for physical measurements used in STEPS and their upper and lower limits for data entry purposes.

<table>
<thead>
<tr>
<th>Physical Measure</th>
<th>Unit</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (SBP)</td>
<td>mmHg</td>
<td>40</td>
<td>300</td>
</tr>
<tr>
<td>Diastolic blood pressure (DBP)</td>
<td>mmHg</td>
<td>30</td>
<td>200</td>
</tr>
<tr>
<td>Height</td>
<td>cm</td>
<td>100</td>
<td>270</td>
</tr>
<tr>
<td>Weight</td>
<td>Kg</td>
<td>20</td>
<td>350</td>
</tr>
<tr>
<td>BMI (body mass index)</td>
<td>Kg/m2</td>
<td>11</td>
<td>75</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>cm</td>
<td>30</td>
<td>200</td>
</tr>
<tr>
<td>Hip circumference</td>
<td>cm</td>
<td>45</td>
<td>300</td>
</tr>
<tr>
<td>Heart rate</td>
<td>beats/minute</td>
<td>30</td>
<td>200</td>
</tr>
</tbody>
</table>

Sequence of Tests

In most sites, the physical measurements (Step 2) are done immediately after the behavioral measurements (Step 1). Since the participant must have rested for 15 minutes before the blood pressure measurement. It is most convenient to start the Step 2 measurements with blood pressure as the participant will have already been sitting for The duration of the interview. The Step 2 measurements should hence be taken from the participant

In the following order:

1. Blood pressure (and heart rate, if measured)
2. Height
3. Weight
4. Waist circumference

**Equipment required for tests**

The equipment you will need for taking physical measurements include:

1. blood pressure monitor and appropriate cuff sizes;
2. height measuring board;
3. weighing scales;
4. wooden board (in case of uneven surfaces for scales);
5. tape measure;
6. pen;
7. chair or coat rack for participant's clothes;
8. curtain or screen to provide privacy if no private area is available for taking Measurements.
9. clipboard

**Physical Measurements,**

**Privacy**

Where possible, all physical measurements should be conducted in a private area. In some settings (e.g. school), a separate room for boys and girls is necessary to take each measurement. Where this is not possible, a separate area should be screened off to provide privacy for waist and hip circumference measurements at minimum.

Allow the participant to select the degree of privacy – some may be concerned about going behind a screen or out of sight of others with people they do not know. It is recommended that a minimum of two (2) persons be allowed in the room while others stand in a queue outside the room.

---

**When to take physical measurements and record**

It is recommended that physical measurements are taken immediately after the step 1 Results of Step 2 measures are to be recorded on the same participant instruments.
Results

If physical measurements are taken some time after Step 1 interviews (not Recommended), care should be taken to ensure data collection forms are correctly matched with their original instruments.

Introductions

Prior to taking physical measurements, explain that you will be taking the following measurements:

1. blood pressure
2. height
3. weight
4. waist circumference

For Expanded

- heart rate
- Hip circumference.

Taking Blood Pressure and Recording Heart Rate

Introduction

Blood pressure is taken to determine the prevalence of raised blood pressure in the population.

Equipment

To take blood pressure you will need the following:

1. digital automatic blood pressure monitor, e.g. OMRON
2. Appropriate size cuffs.

Preparing the Participant

Ask the participant to sit quietly and rest for 15 minutes with his/her legs Uncrossed. If physical measurements (Step 2) are done immediately after the Behavioral measurements (Step 1), as recommended, the participant should have already been seated for at least 15 minutes, and the blood pressure Measurements can be done immediately after finishing the Step 1 questions.
Three Measurements

Three blood pressure measurements should be taken. During data analysis the mean of the second and third readings will be calculated. The participant will rest for three minutes between each of the readings.

Recording the Blood pressure Measurements

For recording the results of the blood pressure measurements, do the following:

- Record your Interviewer ID (if not already filled in) in the participant’s Instrument;
- After each of the three measurements, record the results in the participant’s Instrument;
- Check that all readings are correctly filled in the instrument
- Inform the participant on the blood pressure readings only after the whole Process is completed.

Recording Heart rate Measurements

If a country/site decides to include the expanded measurement of heart rate, the recording should be done along with the recording of the blood pressure measurements after each of the three measurements. Heart rate and blood.

OMRON Procedure

The instructions below apply to the use of an OMRON blood pressure monitor. However, more detailed operating instructions are included with the Device and should be reviewed before taking any blood pressure measurements. Note that in case you use a different digital automatic blood pressure monitor, you should also read the instructions for the according machine carefully.
**Applying the OMRON cuff**

Follow the steps below to select an appropriate size and apply the cuff:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Place the left arm* of the participant on the table with the palm facing upward.</td>
</tr>
<tr>
<td>2</td>
<td>Remove or roll up clothing on the arm.</td>
</tr>
<tr>
<td>3</td>
<td>Select the appropriate cuff size for the participant using the following table:</td>
</tr>
<tr>
<td></td>
<td><strong>Arm Circumference (cm)</strong></td>
</tr>
<tr>
<td>17 - 22</td>
<td>Small (S)</td>
</tr>
<tr>
<td>22 - 32</td>
<td>Medium (M)</td>
</tr>
<tr>
<td>&gt; 32</td>
<td>Large (L)</td>
</tr>
<tr>
<td>4</td>
<td>Position the cuff above the elbow aligning the mark ART on the Cuff with the brachial artery.</td>
</tr>
<tr>
<td>5</td>
<td>Wrap the cuff snugly onto the arm and securely fasten with the Velcro. <strong>Note:</strong> The lower edge of the cuff should be placed 1.2 to 2.5 cm above the inner side of the elbow joint.</td>
</tr>
<tr>
<td>6</td>
<td>Keep the level of the cuff at the same level as the heart during Measurement.</td>
</tr>
</tbody>
</table>

*Note: If the right arm is used, note this in the right hand side margin on the Participant’s Instrument.
Taking the Measurement with an OMRON

Follow the instructions below to take the blood pressure measurement:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Switch the monitor on (dark purple button) and press START (Light purple button).</td>
</tr>
<tr>
<td>2</td>
<td>The monitor will start measuring when it detects the pulse and the &quot;Heart&quot; symbol will begin to flash. The systolic and diastolic blood pressure readings should be displayed within a few moments (Systolic above and diastolic below).</td>
</tr>
<tr>
<td>3</td>
<td>Record the reading in the participant’s instrument.</td>
</tr>
<tr>
<td>4</td>
<td>Switch the monitor off, but leave the cuff in place.</td>
</tr>
<tr>
<td>5</td>
<td>Wait three minutes, and then repeat steps 1-4 two more times.</td>
</tr>
</tbody>
</table>

Measuring Height; Introduction

The height of eligible participants is taken to help calculate their body Mass index (BMI), which is their weight relative to their height, and therefore to determine the prevalence of overweight and obese people in the population.

Equipment

To measure height, you need a portable height/length (Stadiometer) Measuring board.

Assembling the Measuring Board

Follow the steps below to assemble the measuring board:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Separate the pieces of board (usually 3 pieces) by unscrewing the Knot at the back.</td>
</tr>
<tr>
<td>2</td>
<td>Assemble the pieces by attaching each one on top of the other in The correct order.</td>
</tr>
<tr>
<td>3</td>
<td>Lock the latches in the back.</td>
</tr>
<tr>
<td>4</td>
<td>Position the board on a firm surface against a wall.</td>
</tr>
</tbody>
</table>
Procedures  Follow the steps below to measure the height of a participant:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ask the participant to remove their:</td>
</tr>
<tr>
<td></td>
<td>- footwear (shoes, slippers, sandals, etc.)</td>
</tr>
<tr>
<td></td>
<td>- head gear (hat, cap, hair bows, comb, ribbons, etc.).</td>
</tr>
<tr>
<td></td>
<td><strong>Note:</strong> If it would be insensitive to seek removal of a scarf or veil, the measurement may be taken over light fabric.</td>
</tr>
<tr>
<td>2</td>
<td>Ask the participant to stand on the board facing you.</td>
</tr>
<tr>
<td>3</td>
<td>Ask the participant to stand with:</td>
</tr>
<tr>
<td></td>
<td>- feet together</td>
</tr>
<tr>
<td></td>
<td>- heels against the back board</td>
</tr>
<tr>
<td></td>
<td>- knees straight.</td>
</tr>
<tr>
<td>4</td>
<td>Ask the participant to look straight ahead and not tilt their head up.</td>
</tr>
<tr>
<td>5</td>
<td>Make sure eyes are the same level as the ears.</td>
</tr>
<tr>
<td>6</td>
<td>Move the measure arm gently down onto the head of the participant and ask the participant to breathe in and stand tall.</td>
</tr>
<tr>
<td>7</td>
<td>Read the height in centimeters at the exact point.</td>
</tr>
<tr>
<td>8</td>
<td>Ask the participant to step away from the measuring board.</td>
</tr>
<tr>
<td>9</td>
<td>Record the height measurement in centimeters in the participant’s Instrument.</td>
</tr>
<tr>
<td>10</td>
<td>Record your Technician ID code in the space provided in the Participant’s instrument.</td>
</tr>
</tbody>
</table>

Measuring Weight: Introduction

The weight of eligible participants is taken to help determine their body mass Index (BMI), which is their weight relative to their height, and therefore to determine the prevalence of overweight and obese people in the population.

Equipment  To measure weight, you will need the following equipment:

- portable electronic weighing scale (or Tanita weighing scale);
- a stiff wooden board to place under the scales, if you are likely to have problems with uneven surfaces (such as dirt or mud floors or carpet);
- a generator, if electronic scales are being used and electricity is not guaranteed in all survey areas (check if scale can work with batteries).
Set up requirements: Make sure the scales are placed on a firm, flat surface

Do not place the scales on:

- carpet
- a sloping surface
- A rough, uneven surface.

Electronic Scales

Follow the steps below to put electronic scales into operation:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Put the scale on a firm, flat surface.</td>
</tr>
<tr>
<td>2</td>
<td>Connect the adaptor to the main power line or generator.</td>
</tr>
<tr>
<td>3</td>
<td>Turn on the scale.</td>
</tr>
<tr>
<td>4</td>
<td>Switch the scale on and wait until the display shows 0.0.</td>
</tr>
</tbody>
</table>

Procedures Follow the steps below to measure the weight of a participant:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ask the participant to remove their footwear (shoes, slippers, Sandals, etc.) And socks.</td>
</tr>
<tr>
<td>2</td>
<td>Ask the participant to step onto scale with one foot on each side of The scale.</td>
</tr>
<tr>
<td>3</td>
<td>Ask the participant to: □ stand still □ face forward □ place arms on the side and □ wait until asked to step off.</td>
</tr>
<tr>
<td>4</td>
<td>Record the weight in kilograms on the participant’s instrument. If the participant wants to know his/her weight in pounds, convert by multiplying the measured weight by 2.2.</td>
</tr>
</tbody>
</table>

Measuring Waist Circumference

Introduction  Waist circumference measurements are also taken to provide additional information on overweight and obesity.
Equipment  To take waist circumference measurements you will need a:

1. The Lufkin (W606PM) tape / constant tension tape (for example, Figure Finder Tape Measure)
2. pen
3. Chair or coat stand for participants to place their clothes.
4. clipboard

Privacy
A private area is necessary for this measurement. This could be a Separate room for boys and girls, or an area that has been screened off from other people within the household.

Preparing the Participant
This measurement should be taken without clothing, that is, directly over the skin.

If this is not possible, the measurement may be taken over light clothing. It must not be taken over thick or bulky clothing. This type of clothing must be removed.

How to take this measurement should be taken:

Measurement

1. at the end of a normal expiration;
2. with the arms relaxed at the sides;
3. At the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone).
**Procedure:** Follow the steps below to measure the waist circumference of a participant:

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standing to the side of the participant, locate the last palpable rib and the top of the hip bone. You may ask the participant to assist you in locating these points on their body.</td>
</tr>
<tr>
<td>2</td>
<td>Ask the participant to wrap the tension tape around themselves and then position the tape at the midpoint of the last palpable rib and the top of the hip bone, making sure to wrap the tape over the same spot on the opposite side. <strong>Note:</strong> Check that the tape is horizontal across the back and front of the participant and as parallel with the floor as possible.</td>
</tr>
<tr>
<td>3</td>
<td>Ask the participant to: Stand with their feet together with weight evenly distributed across both feet; hold the arms in a relaxed position at the sides; breathe normally for a few breaths, then make a normal expiration.</td>
</tr>
<tr>
<td>4</td>
<td>Measure waist circumference and read the measurement at the level of the tape to the nearest 0.1 cm, making sure to keep the measuring tape snug but not tight enough to cause compression of the skin.</td>
</tr>
<tr>
<td>5</td>
<td>Record the measurement on the participant’s Instrument. <strong>Note:</strong> Measure only once and record.</td>
</tr>
</tbody>
</table>
APPENDIX H: STANDARD OPERATIONAL PROCEDURE FOR ANALYSIS OF DEUTERIUM ENRICHMENT BY FTIR

Purpose
This SOP describes the procedure for analysis of deuterium enrichment by Fourier transform infrared spectrometry (FTIR) in saliva samples collected from studies of body composition and human milk intake assessed using deuterium dilution techniques.

Scope
This procedure should be followed by all participants in projects funded by the International Atomic Energy Agency (IAEA).

Any queries comments or suggestions relating to this SOP should be addressed to a technical officer at the Nutritional and Health Related Environmental Studies section of the Division of Human Health, IAEA, Vienna, Austria or C.Slater@iaea.org.

Last updated by Christine Slater 21 June 2012.

Safety requirements
a. Laboratory coats and gloves must be worn at all times in the work area.
b. Wear closed flat shoes.
c. Long hair should be tied back.
d. The work area should be clean and tidy.
e. No eating, drinking or applying of cosmetics in the laboratory.

Associated documents
a. Local laboratory safety rules.
b. Local rules for receipt and traceability of samples.
c. FTIR manufacturer’s operating manual.
d. Study report forms and SOP’s.
f. Standard Operating Procedure for saliva sampling

Notes
The FTIR Laboratory:
The FTIR should be sited in a well-ventilated room to avoid build-up of CO₂ in the atmosphere. Ideally the room should be air conditioned with controlled temperature and humidity. The bench on which the FTIR is placed should not be subject to vibration from nearby equipment or external sources.

Do not leave the cover of the sample chamber open for longer than the time it takes to put the cell in the holder.

Do not move the FTIR once it has been installed.
Cleaning the FTIR

Use a water-dampened cloth to wipe the exterior of the instrument to keep the FTIR dust free. It is not advisable to wipe the inside of the sample compartment. If spillage from the cell occurs inside the compartment, clean up immediately with an absorbent lint-free cloth.

Care of the FTIR cell

Do not dismantle the cell unless there is a problem. The spacers are very fragile. If they are damaged the path length will change and the seal will be broken. Fill the cell with clean water before storing. Replace water every week if it has not been used. Alternatively, air dries the cell using a syringe.

Dose of D₂O when samples are analyzed by FTIR

The standardized dose for assessment of body composition in adults is 30 g 99.8 atom % deuterium oxide (D₂O), which gives a target enrichment in body water of 900 (range 500-1500) mg D₂O/kg body water after the dose has equilibrated with body water (Day 1 in human milk intake methodology).

Limit of detection

The limit of detection is approximately 100 mg/kg mg D₂O/kg body water.

Periodic Inspection and Maintenance Checks

The following checks should be made periodically according to the Manufacturer’s instructions:

a. Evaluation of the power spectrum
b. Evaluation of the accuracy and reproducibility of the wavenumber using the polystyrene film
c. Evaluation of the resolution
d. Evaluation of the reproducibility of absorbance/transmittance
e. Monitoring the interferometer

Quality Control

a. All measurements are made with reference to gravimetrically prepared standards.
b. Label bottles carefully with date and calculated D₂O enrichment.
c. The balance used for preparing standards must be on a stable table away from open windows and draughts. Switch off air conditioning units when using the analytical balance.
d. Balances must be level and calibrated before use.
e. All glassware must be clean and dry before use.
f. Keep a laboratory note book to record details of weights when making standards, and keep a record of all samples analyzed, including QC checks.
g. Analyze standards as samples at the beginning, middle and end of each day.

**Equipment**

a. Fourier Transform Infrared Spectrometer  
b. Liquid cell with 100 μm path length and calcium fluoride window  
c. Centrifuge with buckets to take sample vials, ideally refrigerated (1000 g)  
d. Electronic balance weighing to 0.0001 g  
e. Electronic balance weighing to 0.1 g  
f. Voltage stabilizer/UPS for all electronic equipment (electronic balances/FTIR)  
g. Racks for sample vials

**Consumables**

a. Deuterium oxide (99.8 atom % $^2$H)  
b. Supply of local drinking water  
c. 250 mL borosilicate glass bottles with PTFE-lined screw caps for the aliquots of the calibration standard and local drinking water used as “working standards” on a daily basis  
d. 100 mL borosilicate glass bottles with PTFE-lined screw caps for storing standards (calibration curve)  
e. Labels for bottles  
f. Permanent ink pens for writing on labels  
g. 1 mL disposable plastic syringes with Luer tip for filling FTIR cell  
h. Paper tissues/absorbent paper  
i. Lens paper to clean window of FTIR cell  

Volumetric flasks (1 L, 100 mL or 50 mL) for making calibration standards  
Automatic pipettes plus tips (1mL, 200 μL, 20 μL) for making calibration standards  
Wash bottle for filling volumetric flasks
Procedures: Preparation of the calibration standard

a. A large volume of a calibrating or standard solution of approximately 1000 mg/kg (ppm), or 1 g/L should be prepared (gravimetrically) by weighing 99.8 atom % deuterium oxide (D₂O) and diluting in normal drinking water from the region. Do not use distilled water to make the calibration standard. Distilled water is subject to fractionation.

b. Using an analytical balance (accurate to 0.0001 g), weigh a clean, dry 50 mL volumetric flask with its stopper in place, or another similar container e.g. a clean, dry glass bottle with a cap.

c. Add a small volume (~20 mL) of drinking water to the flask, replace the cap and weigh again.

d. Add 1 g of D₂O to the bottle. If you are using an adjustable pipette to transfer 1 g D₂O, then the volume selected should be 0.9 mL, as the density of D₂O is higher than water (1.105 g/mL and 1.000 g/mL respectively at 25°C). Replace the stopper or cap to avoid losses by evaporation, and note the weight. Calculate the weight of D₂O in the bottle.

e. Weigh a clean dry 1 L volumetric flask with its stopper. At this stage a balance weighing to 0.1g can be used.

f. Quantitatively transfer the water from the 50 mL container into the 1 L volumetric flask using a funnel. Add local drinking water to the smaller container and pour it into the larger container. Repeat this at least three times to ensure that all the deuterium oxide is transferred. Be careful not to spill any.

g. Add local drinking water to the 1 L volumetric flask up to the mark. Replace the stopper and weigh again.

h. After noting the weight, transfer the calibration standard to a clean, dry glass bottle with a PTFE lined screw cap.

i. Keep a similar volume of the local drinking water to use as a zero-standard or blank to measure the background spectrum.

j. Calculate the enrichment of the calibration standard as follows:

k. If (A) is the weight of D₂O, (B) is the weight of drinking water plus D₂O in the 1L flask, then the weight of added drinking water is (B-A).

l. Enrichment of D₂O in the calibration standard = A/(B-A) x 10⁶ mg/kg

m. See Appendix 1 for example calculation.

n. Transfer the contents of the volumetric flask into four 250 mL borosilicate glass bottles with PTFE-lined screw caps. Save a similar quantity of the water used to make the dilution. Use one of each of these as “working standards”. The remainder will remain unopened until required. This has the advantage of only exposing a small portion of the calibration standard to the atmosphere at any time.

o. Write the date, D₂O enrichment and the initials of the person who prepared the standard on the label.
p. The shelf-life of the calibration standards will depend on the quality of the local drinking water. The bottles should be stored in a cool dark place out of direct sunlight, but not in the same refrigerator as the D₂O. Wrapping bottles in aluminum foil helps to protect the contents from light.

**Accuracy and precision: preparation of a standard curve**

a. The accuracy and precision of deuterium analysis over the range of enrichments likely to be encountered should be checked periodically (as a training exercise and whenever the FTIR has not been used for 6 months or more) using gravimetrically prepared standards. The enrichment should range from 0 (natural abundance drinking water) to 2000 mg/kg, i.e. an enrichment above that likely to be encountered in saliva samples.

b. Standards should be made (in 100 mL local drinking water) according to the following table. The D₂O can be pipetted into the volumetric flask (column 2), but it must be accurately weighed (column 3). Also note the weight of the drinking water added to make up the volume (column 4). The actual enrichment (mg/kg) can be calculated from the weights as described previously.

### PREPARATION OF FTIR STANDARDS

<table>
<thead>
<tr>
<th>Target enrichment (mg/kg D₂O)</th>
<th>μL D₂O</th>
<th>Weight D₂O (g) to 4 decimal places</th>
<th>Weight drinking water added (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td></td>
<td></td>
</tr>
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<td>200</td>
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<td></td>
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<td>400</td>
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<td>90</td>
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<td></td>
</tr>
<tr>
<td>1500</td>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>180</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Standards should be analysed in triplicate according to the procedure described in sections 11 and 12.

b. Plot the calculated enrichment on the x-axis and the measured enrichment on the y-axis of the calibration curve (see Appendix 2).

c. Accuracy is determined from the gradient and intercept of the linear regression line through the data. The gradient should be close to 1 (>0.95) and the intercept should be close to 0 (-0.5 to + 20). If not, there is a problem with the weighing, with the calculations or with the analysis. Check the data input and, if necessary, start again and make new standards.

d. Precision is the standard deviation (SD) of repeated measures of the same sample. Precision is usually expressed as the coefficient of variation (CV), which is the standard deviation expressed as percent of the mean, SD/Mean x 100. The CV should be less than 1%.

e. Within-day and between-days precision of analysis can be determined by repeated measures of the same standard.
Filling the FTIR cell

a. Bottles containing standards should be inverted before opening to mix any condensation on the side of the bottle or in the cap into the main contents of the bottle. This is because the condensate is fractionated relative to the water.

b. Saliva samples must be completely thawed before analysis (ice is fractionated relative to liquid water). The vials containing specimens of saliva should be centrifuged for 10 minutes at 1000 g (with the caps on) to move any condensation in the lid down into the bulk of the specimen, and to remove bubbles.

c. Clean the window of the cell with lens (lint-free) tissue before starting.

d. The capacity of the cell is approximately 150 mL. By pushing through 1 mL saliva or reference water, traces of the previous sample are removed.

e. Fill 1 mL disposable plastic syringe with sample (standard or saliva).

f. Firmly press folded absorbent paper over the exit port to absorb excess sample and prevent ingress of air or use a second syringe to remove excess.

g. Fill the cell by firmly pushing the syringe plunger.

h. Remove excess/splashes from the outside of the cell window using absorbent paper.

i. Check for bubbles by holding the cell up to a light.

j. If there are visible bubbles in the cell, add more sample as described above until all of the bubbles have been pushed out.

k. Measure the absorbance from 2300-2900 cm⁻¹ as described in section 12.

l. Remove the sample using the same syringe that was used for filling. Discard the syringe.

m. Use a new syringe for each sample to avoid cross-contamination.

n. Next Sample: Repeat from step 1.

o. Analyze the 0 and 1000 mg/kg standards as samples in the middle and at the end of the batch to check the calibration of the FTIR.

p. When all the samples have been analyzed, rinse the cell with drinking quality water and fill with water or dry by pushing air through with a syringe before storing.

Procedure for filling the cell. Fill the cell using a 1 mL syringe; check for bubbles by holding the cell up to a light, place the cell in the sample chamber of the FTIR.
Good Laboratory Practice

Care must be taken to avoid fractionation during sample analysis. Evaporation causes fractionation. The vapor contains less deuterium than the liquid water. Evaporative losses result in an increase in the deuterium content of the water left behind.

Do not pour standards into beakers. Evaporation causes fractionation. Keep in a screw cap bottle and sample from the bottle.

Do not leave bottles and vials open to the atmosphere (fractionation). Remove the cap for only the time required to fill the pipette or syringe.

Do not put excess back in the bottle. Discard in the waste.

Precautions must be taken to avoid cross-contamination between samples. Do not use syringes for more than one sample when filling cells.

Do not touch the computer keyboard while wearing gloves. If possible work in pairs. One person can fill the cell and put it into the chamber of the FTIR. The second person can work at the computer and record details in the laboratory notebook.

Dispose of excess saliva in disinfectant and incinerate syringes with clinical waste.

Preparing the FTIR for measurement

The FTIR should be switched on 30 minutes before using to allow the electronics to stabilize.

Firstly ensure that both the interface and the mirror are working properly.

The spectrometer settings should be checked. Ensure that the following are set:

- Measurement mode: Absorbance
- Apodization: SqrTriangle
- No of scans: 32
- Resolution: 2.0
- Range (cm⁻¹):
  - Minimum: 2300
  - Maximum: 2900

The ‘Background’ unenriched (natural abundance) water spectrum can now be taken.

Next prepare to calibrate the instrument. Use the calibration standard with deuterium enrichment about 1000 mg/kg (ppm) deuterium oxide. Obtain the spectrum. Remember to set a suitable filename. The peak due to deuterium should have a maximum at about 2510 cm⁻¹.

There will be interference from CO₂ on the low energy (right hand) side of the peak. This might be either positive or negative (in the example shown it is positive).

This spectrum should now be saved to disc in a form that can be read by the special MRC software. Choose ‘File’ from the main menu bar at the top, and then ‘Export’. Choose a filename. Ensure that the exported file type is ‘ASCII Simple Text (*.txt)’. Then click on ‘Save’.
Now launch the “isotope.exe” program.

In the section for the standard select the file that has just been exported, and Load it.

Now set the calibration level. Click on the “Cal level set” button.

Enter the calculated enrichment of the calibration standard in the dialogue box and then click on “OK”.

The system is now ready to make measurements of deuterium isotope composition of water or saliva samples.

To check that the reference and calibrant levels have been correctly set the following two steps should be performed.
Refill the sample cell with the background unenriched water sample, and measure it as though it were a sample. The spectrum should be almost featureless, apart from the possibility of CO₂ interference.

Now export this file and read it into the “isotope.exe” software.

a. The reported concentration of D₂O should be small, in the range –10 to +10 mg/kg (ppm).

b. This is the most difficult measurement to make since it is heavily influenced by any slight imperfection in sample cell filling.
c. Now re-measure the calibration standard water in the same way. The answer obtained should be within 1% of the set value (i.e. for 1000 mg/kg (ppm) should lie between 990 and 1010 mg/kg.

Supporting information:

a. IAEA Human Health Series No.3. Assessment of Body Composition and Total Energy Expenditure in Humans Using Stable Isotope Techniques.

b. IAEA Human Health Series No.7: Stable Isotope Technique to Assess Human Milk Intake in Breastfed Babies.

c. IAEA Human Health Series No.12: Introduction to Body Composition Assessment using the Deuterium Dilution Technique with Analysis of Saliva Samples by FTIR.

d. IAEA distance learning module on analysis of deuterium enrichment by FTIR.

History review:

a. This draft was prepared at the IAEA Regional (AFRA) Training Course on Standard Operating Procedures (SOP) for Isotope Techniques in Infant and Young Child Nutritional Status, Dare es Salaam, United Republic of Tanzania, 17-21 August 2009.

b. It was adapted for general use by Christine Slater, Nutritional and Health Related Environmental Studies Section, Division of Human Health, IAEA, 11 January 2010.

c. Last update 21 June 2012.
APPENDIX I: PARTICIPANT DOSING FORM

BODY COMPOSITION COLLECTION FORM

A. Child’s demographics:
Date: __________________________
Participant’s Study ID__________ Age________ (years) Gender________ (male, female)
Actual Body weight _________ (kg)  Height_________ (cm)
(To the nearest 0.1kg)  (To the nearest 0.1cm)

B. Total Body Water Measurement:

(i) Before dosing (IMPORTANT)

Participant fasted? Tick appropriate box  Yes  No
If not, when did you last eat something? _____________________
Comment: (Any issues that need to be noted during saliva collection or fasted status)
………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………

(ii) DOSING

DOSING NUMBER ______
Was the Container opened just before dosage?  Yes  No
Was the entire dose consumed?    Yes  No
If not, what was the weight of the dose that was consumed? _______________
Was the Container rinsed with 50ml water?        Yes          No  No
Was the same Straw used?   Yes             No
Comment: …………………………………………………………………………………………
(iii) **SPECIMEN TIMES**

TIME OF BASELINE SALIVA SAMPLE: ____________ TIME DOSE TAKEN: __________

**POST DOSE SALIVA SAMPLES**

TIME OF 2 HOUR SAMPLE: __________
TIME OF 3 HOUR SAMPLE: __________

Amount of Fluid taken during Post Dose sample collection period:
________________________

Emptied bladder during Post Dose sample collection?  Yes [ ]  No [ ]

Comment:
..............................................................................................................
# APPENDIX J: CALIBRATION CURVE FOR SALIVA SAMPLES ANALYSIS

**FTIR Model:** Shimadzu FTIR
**IRPrestige-21**

<table>
<thead>
<tr>
<th>Target ppm</th>
<th>wt flask (g)</th>
<th>wt water 20ml (g)</th>
<th>wt H2O + D2O (g)</th>
<th>Calculated D2O ppm</th>
<th>Measured D2O ppm</th>
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</thead>
<tbody>
<tr>
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<td>0</td>
<td>0.04</td>
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<tr>
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<td>19.6964</td>
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<td>84.0392</td>
<td>19.5689</td>
<td>163.7662</td>
<td>99.2959</td>
</tr>
</tbody>
</table>

Note: The Standard Curve gives an indication of the accuracy. The gradient should be close to 1 and greater than 0.95. The intercept should lie between -0.5 and +20 i.e. +20 > b > -0.5

Fill in blue/grey cells

**Calculated (X)**
- 0.00
- 19.13
- 257.35
- 403.35
- 607.51
- 811.15
- 952.27
- 1472.52
- 1804.62

**Measured (Y)**
- 0.04
- 42.76
- 205.27
- 394.30
- 597.13
- 822.19
- 924.88
- 1440.11
- 1804.62

**SLOPE** 0.9744

**INTERCEPT** 1.1570

**Deuterium Standard Calibration Curve - Kenya FTIR, 11/02/2015**

![Graph of Deuterium Standard Calibration Curve](image-url)
APPENDIX K: BODY HYDRATION FACTOR FOR CHILDREN

TABLE 1. HYDRATION OF FFM (%) IN CHILDREN AND ADOLESCENTS

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Boys</th>
<th>Girls</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>79.0</td>
<td>78.8</td>
</tr>
<tr>
<td>1–2</td>
<td>78.6</td>
<td>78.5</td>
</tr>
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<td>3–4</td>
<td>77.8</td>
<td>78.3</td>
</tr>
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<td>5–6</td>
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<td>13–14</td>
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<td>15–16</td>
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<td>75.0</td>
</tr>
<tr>
<td>17–20</td>
<td>73.8</td>
<td>74.5</td>
</tr>
</tbody>
</table>

APPENDIX I: RESEARCH APPROVAL BY GRADUATE SCHOOL

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School
TO: Zipporah Wanjira Ndungu
C/o Foods, Nutrition and Dietetics Dept.

DATE: 25th June, 2014
REF: 1187/23463/2012

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that Graduate School Board, at its meeting of 11th June, 2014, approved your Research Proposal for the Ph.D Degree Entitled, “Validation of Nutritional Status Assessment Methods using Stable Isotope Dilution Technique among Primary School Children in Nairobi County, Kenya.”

You may now proceed with your Data Collection, subject to clearance with the permanent Secretary, Ministry of Higher Education, Science and Technology.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University’s Website under Graduate School webpage downloads.

By copy of this letter, the registrar (Academic) is hereby requested to grant you substantive registration for your Ph.D studies.

Thank you,

DAVID NJOROE
FOR: DEAN, GRADUATE SCHOOL

C.C. Chairman, Department of Foods, Nutrition and Dietetics

Supervisors:

1. Dr. Dorcus Mbithe
   C/o Department of Foods, Nutrition and Dietetics
   Kenyatta University

2. Dr. Catherine Macharia - Mutie
   Directorate of Research Management & Development
   Ministry of Education, Science and Technology
   C/o Department of Foods, Nutrition and Dietetics
   Kenyatta University
APPENDIX M: ETHICAL CLEARANCE LETTER

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

F. O. Box 43844 - 00100 Nairobi
Tel: 8710901/12
Fax: 8711212/8711575

Date: 7th October, 2014

Our Ref: KU/E/COMM/51/363

Ndungu Zipperah Wanjiru
Kenyatta University,
P.O Box 43844, Nairobi

Dear Zipperah,

APPLICATION NUMBER KIU/242/218 - "VALIDATION OF NUTRITIONAL STATUS ASSESSMENT METHODS USING STABLE ISOTOPE DILUTION TECHNOLOGY AMONG PRIMARY SCHOOL CHILDREN IN NAIROBI COUNTY, KENYA"

1. IDENTIFICATION OF PROTOCOL
The application before the committee is with a research topic, "Validation of nutritional status assessment methods using stable isotope dilution technology among primary school children in Nairobi County, Kenya," received on 22nd July, 2014 and discussed on 11th and 23rd September, 2014.

2. APPLICANT
Ndungu Zipperah Wanjiru

3. SITE
Nairobi - Day Primary (Public) Schools, Kenya.

4. DECISION
The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines AND APPROVED that the research may proceed for a period of ONE year from 7th October, 2014.

5. ADVICE/CONDITIONS
   i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
   ii. Serious and unexpected adverse events related to the conduct of the study are reported to this board immediately they occur.
   iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
   iv. Submit an electronic copy of the protocol to KUERC.

When replying, kindly quote the application number above.

If you accept the decision reached and advice and conditions given please sign in the space provided below and return to KU-ERC a copy of the letter.

PROF. NICHOLAS K. GIKONYO
CHAIRMAN ETHICS REVIEW COMMITTEE

I hereby accept the advice given and will fulfill the conditions therein.

Signature: ........................................... Dated this day of ........................................... 2014.

cc. Vice-Chancellor
    Director: Institute for Research Science and Technology
APPENDIX N: RESEARCH PERMIT BY NACOSTI

THIS IS TO CERTIFY THAT:
MISS. ZIPPOHAN WANJIRU NDUNGU
of KENYATTA UNIVERSITY, 0-100
NAIROBI has been permitted to conduct
research in Nairobi County

on the topic: VALIDATION OF
NUTRITION STATUS ASSESSMENT
METHODS USING ISOTOPE TECHNOLOGY
AMONG SCHOOL GOING CHILDREN IN
PUBLIC PRIMARY SCHOOLS IN NAIROBI,
KENYA

for the period ending:
4th October, 2016

[Signature]
Applicant’s

[Signature]
Secretary
National Commission for Science,
Technology & Innovation

Permit No : NACOSTI/P/14/5834/3852
Date Of Issue : 11th December, 2014
Fee Received : Ksh 2,000