THE ASSOCIATION BETWEEN DIETARY INTAKE AND RISK OF OVERWEIGHT AMONG 17-YEAR-OLD ADOLESCENTS IN SOWETO, JOHANNESBURG, SOUTH AFRICA, IN 2007/2008

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A Research Report submitted to the School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, in fulfillment of the requirements for the Degree of Masters in Epidemiology and Biostatistics.

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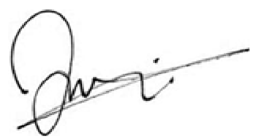
DECLARATION

I declare that this research report is my own work and the contribution of others has been appropriately acknowledged. The report submitted is for the award of the Degree of Master of Science in Epidemiology and Biostatistics of the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted for any degree purpose or examination to any College, University or Organization rather than the one thereof.



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Travel Awards

Travel award from the University of the Witwatersrand School of Public Health to attend and present a paper at the 9th PHASA conference in association with the African Federation of Public Health Associations (AFPHA) was held in Cape Town from 24-27 September 2013.

ABSTRACT

Background: Overweight continues to be a major indicator of adulthood non-communicable diseases (NCDs) risk and can be linked to early childhood and adolescent dietary lifestyles.

Research has shown that the burden of childhood and adolescent overweight in sub-Saharan Africa (SSA) and especially in South Africa is rising. There is therefore an urgent need to address this burden in the context of overweight risk related to nutrition transition. The current study used Birth to Twenty (BT20) cohort study data to examine the association between dietary intake and overweight status of 17-year old adolescents residing in Soweto, South Africa in 2007/2008.

Methods: A secondary data analysis was conducted including 227 seventeen-year old adolescents (43.6% boys) from the BT20 cohort study. A modified quantitative Food Frequency Questionnaire (FFQ) was used to estimate dietary intake. Height and weight were measured by trained research assistants and overweight was categorized using the International Obesity Task Force (IOBTF) cut-offs. A multinomial logistic regression model was used to examine the association between overweight category (BMI) and dietary intake, socio-demographic factors and other covariates. The base reference used for Body Mass Index (BMI) category was normal weight.

Results: The overall overweight prevalence was 14.5% (33/227), and prevalence of underweight was 23.3% (53/227) among the 17-year old Soweto adolescents. The prevalence of overweight was significantly higher in girls (19.3%) than boys (8.1%). The prevalence of underweight was 33.3% for boys and 15.6% for girls. The univariate analysis found the following macronutrient intake positively associated with boys' BMI category: fat 189.4g (IQR=119.9-239.8, $P<0.001$), proteins 154.6g (IQR = 98.7-198.2, $P<0.001$) and carbohydrate 673.1g (IQR = 461-794.2, $P<0.001$). The following macronutrients: fat 176.4g (IQR = 99.5-220.1, $P<0.001$), proteins

126.1g (IQR = 70.4-145, $P<0.001$.) and carbohydrates 523.1g (IQR = 326.6-640.9, $P<0.001$) were positively associated with girls' BMI category.

The socio-demographic factors found associated with girls' BMI were ethnicity (p=0.042) and maternal education (p=0.05). Also factors such as washing machine ownership (p=0.046), and parents having a car (p=0.048) were positively associated with boys BMI category.

The multinomial logistic regression showed no significant differences in dietary intake when overweight boys were compared to normal weight boys: fat intake (RRR=0.99, 95% CI=0.95-1.01), carbohydrate (RRR=0.99, 95% CI=.96-1.01) and energy intake (RRR=1.01, 95% CI=0.99-1.01). Similar non significant results were observed for girls: fat intake (RRR=1.0, 95% CI =0.96-1.01), carbohydrate (RRR=1.0, 95% CI =0.99-1.02) and energy intake (RRR=1.0, 95% CI=0.99-1.01).

Girls from the coloured community were more likely to be underweight than black African girls (RRR= 2.8, 95% CI=0.89-8.57). The results also showed that girls from mixed ancestral community (RRR= 0.25, 95% CI=0.05-1.20) were less likely to be overweight than black African girls.

Discussion and Conclusion: The survey indicated high prevalence of both underweight and overweight among 17 year old adolescents residing in Soweto. This underscores the urgent need for both underweight and overweight prevention interventions and also highlights the need for an integrated surveillance system for both underweight and overweight among South African adolescents.

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beyond. I know how the heat was on my family. My dear wife Mercy Bih and Kids, I am short of words to say thank you for the support.

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LIST OF ABBREVIATIONS

AMDR: Acceptable Macronutrient Distribution Ranges

ADSA: Association for Dietetics in South Africa

BMR: Basal Metabolic Rate

BMI: Body Mass Index

BT20: Birth to Twenty

CV: Coefficient of Variation

CVD: Cardiovascular Disease

DALYs: Disability Adjusted Life Years

DOBE: Department of Basic Education

DXA: Dual-Energy X-ray Absorptiometry Scans

FAO: Food and Agricultural Organization

IOTF: International Obesity Task Force

Kcal: Kilo Calories

Kg: Kilogram

KJ: Kilo Joules

M: Meter

NNSA: Nutrition Society of South Africa

NFCS: National Food Consumption Survey

NSNP: National School Nutrition Programme

OECD: Organization for Economic Cooperation and Development

EI: Energy Intake

EER: Estimated Energy Requirements

PAL: Physical Activities Level

RDA: Recommended Daily Allowance

RDI: Recommended Daily Intake

SAHSF: South African Heart and Stroke Foundation

SES: Socioeconomic

SSA: sub-Saharan Africa

TEE: Total Energy Expenditure

WHO: World Health Organization.

DEFINITION OF TERMS

Variable	Definition
Demographic information	Gives report about people in a locality such as sex, age, marital status, province of origin, residence etc.
Socioeconomic information	The combination of economic and sociological status of a person to measure status such as level of education, occupation, home type, own home, telephone, water use, water type, toilet use, toilet type, electricity, television, car, wash machine.
Anthropometric measurement	Measurement techniques used in measuring of height, body composition, weight, and BMI.
Dietary intake	Sufficient amount of food intake required to meet the nutrients requirements of an individual or nearly all the people.
Carbohydrates	Class of food used for energy generation: 1 gram of carbohydrate yields 17 KJ which is approximately 4Kcal (calories) of energy.
Proteins	Class of food essential for growth and repair of muscle and other body tissues: 1gram of protein yield 17 KJ which is approximately 4Kcal (calories) of energy.
Fats	Food source of energy, important in relation to fat soluble vitamins and body insulation: 1 gram of fat yields 39KJ (9 Kcal) of energy.
Underweight	$<10^{th}$ percentiles estimating adolescent less fat storage, an estimate of adult BMI <18.5.
Normal weight	The $\geq 10^{th}$ to 84^{th} percentiles which are adolescent estimate of normal weight from adult BMI range of 18.5 – 24.9: An indicator of healthy life of fitness due to less fat stored in the body.
Overweight	The $>85^{th}$ to 95^{th} percentiles which are the adolescents overweight corresponding to adult BMI range of 25.0–29.9. Emerged from excess body stored fat used as an indicator of one becoming obese

	[IOTF 2005]
Obesity	The >95th percentiles which are also the adolescents' obesity weight corresponding to adult condition of obesity: Excess stored fat due to excess energy.
Adolescent	Person between 10-19 years of age according to WHO
Dietary Intake	Intake of nutrients , minerals and others as derived from food intake.
Total energy expenditure (TEE)	Average energy spent by an individual or group in a day or 24h period.
Basal metabolic rate (BMR)	Minimal rate of energy expenditure necessary for cellular and tissue processes that can maintain life, measured under standard conditions of thermoneutrality, immobility, mental relaxation and fasting [FAO, 2001]. BMR = EI x PAL
Energy requirement (ER)	Balance energy expenditure needed for consistent healthy growth, body size and stature, physical activity, growth development, body physiological activities [FAO, 2001].
Physical activity level (PAL)	It is the ratio of EI to BMR (EI: BMR) at the end of 24h. PAL = EI/BMR.
Double labeled water (DLW)	Method used to measure TEE of humans characterized by the disappearance of doses of H_2O enriched with stable ^2H and ^{18}O isotopes [FAO, 2001].
Heart rate monitoring (HRM)	Average energy spent by an individual or groups obtained from the relationship between heart rate and O_2 consumption [FAO, 2001].
Under-nutrition	Inadequate intake or assimilation of nutrients [Relman 2013]. It encompasses both stunting, wasting and deficiency in nutrients.
Wasting stunting	Childhood wasting is an acute malnutrition [Kerac et al 2011] which is due to failure to thrive, stature, loss of body weight and cell mass [Copeland 1999; Caulfield et al 2006]. Stunting is

	chronic under-nutrition that account for retarded linear growth [Caulfield et al 2006]. Wasting occur because of inadequate nutrition over a shorter period. However, underweight encompasses both stunting and wasting [Caulfield et al 2006].
Obesogenic environment	Environment where obesity is easy to develop.
Sedentary lifestyle	Lifestyle with very little or low physical activities.

1.0 INTRODUCTION

Globally over 1.4 billion adults are overweight and among these over 200 million men and 300 million women are obese [WHO 2012; 2013]. In low-income countries more than 115 million people are suffering from overweight and obesity-related problems [WHO 2008]. There is, therefore, likelihood that overweight and obesity might soon overtake underweight and under-nutrition in many developing nations [Popkin & Gordon-Larson 2004; Misra and Khurana 2008] because of globalization and economic growth. With this shift, the Organization for Economic Cooperation and Development (OECD) suggests that by 2020 two thirds of the people in low-income countries will be overweight or obese if available preventive measures are not put in place [OECD 2012].

The World Health Organization (WHO) [WHO 2009] has classified overweight and obesity as a risk-factor transition or nutritional transition [Popkin et al 2004]. Reports show that as the development of a country progresses, disease burden shift from being infectious in nature to non-communicable risks of other lifelong threatening diseases, such as diabetes, cancers, and cardiovascular diseases (CVD) [Omran 1971; Reddy et al 2012] in part due to overweight and obesity [Reddy et al 2012]. On the basis of these risk findings the WHO has classified overweight and obesity as one of the world's 10 leading risk factors for disease burden and mortality, as measured by disability-adjusted life years [WHO 2009; Kruger et al 2005]. This disease burden and mortality has been accounted for by the high prevalence of adolescent overweight worldwide and the high proportion of adults developing obesity and its complications [Anounallah-Skhiri et al 2011; Guedes et al 2011].

Overweight, a phenomenon that was once a problem common to high-income countries is now slowly engulfing urban adolescents of low- and middle-income countries, especially

South African adolescents [Steyn et al 2005]. The increasing prevalence may be the result of changing lifestyles and dietary intake among adolescents [Steyn et al 2005].

Currently, Africa has the fastest growing childhood overweight rate in the world – where the rate of obesity among children in 2010 was more than double that of 1990 [de Onis et al 2010; Rossouw et al 2012], with South Africa having one of the highest rates in Africa [Steyn et al 2006; Reddy et al 2008; Rossouw et al 2012]. Reports by Mendez et al [2005] show that young women residing in both urban and rural areas of low-income countries have a compelling high prevalence of overweight when compared to high-come countries. This high prevalence is well pronounced in countries with advanced socioeconomic development including South Africa and Brazil [Kruger et al 2005; Guedes et al 2011]. Studies by Toriola et al [2012] confirm a high overweight prevalence among South African children in both urban and rural settings. However, such data, even within urban settings, is inadequate to assess the level of overweight and its consequences among adolescents, especially in countries with a fast developing economy such as South Africa. Furthermore, there is limited data that associates dietary intake and overweight in most settings in South Africa. There is therefore an urgent need to address overweight in adolescents in these settings, with a focus on the dietary intake. The current study uses Birth to Twenty (BT20) data to examine the association between dietary intake (energy, carbohydrate, protein and fat) and overweight status of 17-year old adolescents residing in Soweto, South Africa, in 2007/2008.

1.1. Background information

The body mass index (BMI), which is an index of overweight estimation, is calculated by weight (kg) / height (m^2) [Hu 2008]. Based on this calculation, WHO estimates the prevalence of obesity at 4.8% and 20.4% in low- and upper-income countries respectively [Guedes et al 2011].

In middle-income countries undergoing rapid economic transition such as South Africa, China and Brazil obesity is estimated at 17.1% in children [Kruger et al 2005; Guedes et al 2011] with South African estimates at 29 % for men and 56% for women [Puoane et al 2002**]**. Reports from the International Obesity Task Force (IOTF) and Global Burden of Diseases of 2002 show the mean BMI of South Africans for males and females as shown in Table 1 [Goedecke et al 2005]. However, the current data from the South African National Health and Nutrition Examination Survey (SANHANES-1) estimates the mean BMI for South African adolescent 15-17 years of age at 20.5% for males and 23 % for females. Those within the age range of 18-24 years were 21.1% for males and 26.2% for females [Shisana et al 2013].

Table 1: Body mass Index (BMI) category by age group among South Africans

Age (yrs)	**Males**	**Females**
	BMI (kg/m^2)	BMI(kg/m^2)
5-14	13.8	14
15-29	21.5	24.4
≥30	24.2	>28.8

Estimates from the National Household Food Consumption Survey show that 17.1% of urban South African children below nine years are overweight [Steyn et al 2005] and that this rate varies from province to province [Goedecke et al 2005]. Other reports from the South African Medical Research Council (SAMRC) indicate more overweight and obese girls (25%) than boys (7%) aged 13-19 years [Goedecke et al 2005]. This high prevalence, according to reports by du Toit [2010], indicates that "South African families do not know what their children eat during the day", which could be one of the likely contributing factors. Within the last decade, the prevalence of overweight and obesity among South African adolescents has increased rapidly [Reddy et al 2012]. Data from the South African National Youth Risk Behaviour Survey in 2002 and 2008 showed increased rates of overweight among adolescent boys and girls, from 6.3% in 2002 to 11.0% in 2008 and from 24.3% to 29.0%, respectively [Reddy et al 2012]. Other data from the International Association for the Study of Obesity in 2011 estimated obesity among boys aged 5-17 years in South Africa at 13.6% and girls at 17.7% [OECD, 2012]. Even though reasons for such high rates were not given, other reports have speculated that high rates can be partly attributed to poor eating habits, which increase with age [Feeley et al 2012], and less physical activity among South African adolescents [Vidulich et al 2006].

Previous research has shown that dietary intake, levels of activity, meal patterns, genetics, ethnicity, hormonal, psychological and sociological factors can influence the risk of overweight/obesity [Kruger et al 2005; Reddy et al 2008; Feeley et al 2011; Guedes et al 2011]. These risk factors can have both physical and psychological effects. The physical effects are similar to those seen in adulthood and have been highly associated with chronic diseases and other metabolic risk factors [Steyn et al 2006; Joubert et al 2007; Mayosi et al 2009**]**.

Dietary habits and eating practices go with lifestyle and determine dietary intake, which is the consumption of nutrients (carbohydrates, fat, proteins etc) to generate energy (kJ) [FAO/WHO/UNU 2001; Institute of Medicine 2005]. Dietary intake that generates body energy higher than body energy expenditure increases body weight [Reddy et al 2008]. Increase in body weight is due to the fact that the excess non-expended energy derived from the diet will be stored as excess fat in the body [Flatt 1995; Goedecke et al 2005]. This set of conditions increases the body weight and causes overweight and obesity, that predisposed individuals to diabetes and other non-communicable diseases (NCDs). These diseases are highly associated with high rates of morbidity and mortality during childhood and adulthood [Reddy et al 2008; Rossouw et al 2012].

It has been shown that the complications of being overweight emerge as a result of a changing behavioural lifestyle that starts at early ages and can be tracked from adolescents into adulthood [Jolliffe & Janssen 2006; Wilkinson & McCargar 2008; Rossouw et al 2012]. The early detection of overweight should therefore be emphasised because of its potential to decrease risk and complications. Factors such as lack of access to safe and nutritious food, inconsistent access to healthy food such as fruits and vegetables and reduced physical exercise also account for early adolescent overweight [Bellows & Moore 2013]. Although reports by Wilkinson & McCargar [2008] show no association between physical activity and overweight, some early findings establish a strong association between television watching, sedentary behavioural activities and energy expenditure [Buchowski and Sun 1996].

The report of the Department of Health (DOH) in 2008 shows that malnutrition in South African children is marked by both under-nutrition and over-nutrition, leading to either stunted growth (retarded or reduced linear growth rate) and/or overweight respectively [Goedecke et al 2005]. There is strong evidence that nutritionally stunted children have an increased risk (80%) of overweight [Steyn et al 2005] later in life, but the underlying mechanisms are still unknown [Haffman et al 2000]. However, according to Haffman et al [2000] stunting in children could be due to impairment of fat oxidation arising from a low metabolic rate with normal resting energy expenditure.

Although stunting coexists with overweight, which is a common phenomenon among children in low-income countries, other studies have shown that stunting is a pressing issue of hunger and under-nutrition [Armstrong et al 2011]. Twenty per cent to 25% of preschoolers in sub-Saharan countries are underweight [United Nations, 2012]. The prevalence of stunting in South Africa ranges from 23% to 30% [Steyn et al 2001; Kruger et al 2005] while that of obesity is greater than 17% [Goedecke et al 2005]. In South Africa stunting and overweight have been observed to occur both in the same household and have been indicated as a significant public health burden [Jinabhai et al 2003; Mamabolo et al 2005].

Studies have shown that as the prevalence of overweight continues to increase over time, other risks such as high blood pressure, sleeping and breathing problems such as snoring (sleep apnea) and hormone imbalances also emerge [Han et al 2010; Steyn et al 2006; Joubert et al 2007; Mayosi et al 2009**]**. Other studies have shown that 70% of obese children with high cholesterol and hypertension are at risk of developing cardiovascular disease [Freedman et al 2007]. Also increased risk of impaired glucose tolerance – a common phenomenon exhibited by those with type 2 diabetes due to insulin resistance – is a characteristic frequently seen in childhood obesity [Whitlock et al 2005]. Overweight and obese adolescents are more likely to develop severe complications (especially coronary heart diseases and diabetes mellitus) during adulthood compared to non-obese children in childhood [Freedman et al 2001].

Furthermore, apart from health consequences, obese individuals often suffer from social and psychological consequences such as low self-esteem, depression and structurally from stigma and discrimination [WHO, 2000; Kruger et al 2005], which have a very significant impact both on health and the economy.

1.2 Statement of problem

Research have shown that adolescents suffer from a wide range of overweight and obese related diseases and overweight/obesity related disease have far reaching implications for communicable and NCDs in adolescence [Steyn et al 2006; Joubert et al 2007]. Since 2000, the prevalence of overweight and obesity in South Africa and other low-income countries has remarkably increased among adolescents [Hedley et al 2004; Steyn et al 2005]. However, with the rapid nutritional transition and urbanization of Soweto and lifestyle changes since 1994, has severely affected the adolescents population, with high overweight/obesity. Because of the importance of overweight and obesity in public health, the trends in adolescence should be closely monitored among Soweto adolescents in order to prevent the likelihood complications at adulthood.

1.3 **Justification for the study**

Overweight continues to be a major indicator of adulthood non-communicable diseases (NCDs) risk and can be linked to early childhood and adolescent dietary lifestyles [Puoane et al 2002]. Most NCD risk in adulthood can be traced to early childhood risky behaviours and adolescent risky behaviours. Research shows that the burden of childhood OW and adolescent OW in sub-Saharan Africa (SSA), and especially in South Africa, is rising. Studies by Reddy et al [2012] show an increasing trend of overweight among youth in all races in South African.
An earlier report by Steyn et al [2005] indicates that by virtue of the South Africa economy and its rapid demographic and nutritional transition, South African adolescent dietary lifestyle has changed drastically resulting in high risk overweight/obesity related diseases.

South Africa chronic diseases especially overweight/obesity related account for more than one-third of chronic diseases according to disability adjusted life years (DALYs) in 2000 [Norman et al 2006]. Despite the overweight/obesity related disease challenges faced by the South African health systems, new policies and programmes have been initiated with support from health organizations such as the Association for Dietetics in South Africa (ADSA), the Nutrition Society of South Africa (NNSA) and the Consumer Goods Council of South [SAHSF 2014]. For example the cooperation between the Department of Health (DOH) and other departments have map out some food policy such as the reduction of high salt intake in bread, margarine and other food sources which has enlightened the public on the consequences of high salt intake in food[SAHSF 2014]. Report from the South African Heart and Stroke Foundation (SAHSF) shows that 80% of NCDs relating to overweight/obesity and high salt in food can be prevented through modified behavioural life styles [SAHSF 2014]. Therefore, this has prompted the DOH in exploiting legal methods with stake holders on the possibilities of legislative lowering of salt in South African commercial foods [Bertram et al 2012; SAHSF 2014].

Since overweight and its related consequences are difficult to treat, the need for early prevention intervention in childhood and adolescence is important. Early detection and control are necessary to prevent further consequences. Therefore, the current data obtained from BT20 cohort for this study was used to investigate the relationship between dietary intake and overweight among 17-year-old adolescents. A guide for future hypotheses and health planning of adolescent overweight prevention intervention. The study will highlight the need for a nutritional programme focusing on good eating practices and a healthy lifestyle among adolescents [Rudolf 2009]. This include

- behavioral-base weight-management interventions among adolescents in Soweto
- a guide to influence policy for parents toward their children's dietary intake and lifestyle.

2.0 LITERATURE REVIEW

In African countries policies concerning the awareness of overweight and obesity are limited. The policies are weak or do not exist at all. However, in some high-income countries, overweight and obesity rates have been slowed down during the past three decades because of polices formulated to tackle the root causes of overweight and obesity [OECD 2012]. Some of these policies include high taxes on food rich in fat, sugar, soft drinks with artificial sweeteners, biscuits, pastries and salt, as well as restrictions on their consumption. Countries such as Denmark, France, Finland and Hungary have instituted such laws [OECD 2012].

The problem in Africa is that most African governments have not realised the health consequences and burdens arising from overweight and obesity. For example, reports compiled by Bamidele et al [2011] from Nigeria see under nutrition as a major problem among adolescence with overweight and obesity yet a considered problem. In South Africa the problems of overweight and obesity are currently under study with very limited information addressing the burden [Steyn et al 2001; Goedecke et al 2005]. Based on the current SANHANES-1 study the prevalence of overweight generally among South African is steadily increasing (Shisana et al 2013). According to report by OECD (2012) dietary intakes which generate energy above the body requirement if not utilized will accumulate as fat, increasing the likelihood of developing overweight. Being overweight in adolescence is causing a likelihood of persistence adulthood overweight unless measures are taken to control weight loss [NIH 2005].

2.1 Dietary intake (Diet)

Generally**,** dietary intake is the average daily intake of foods comprising of micronutrients (vitamins and minerals) and macronutrients (carbohydrates, fat, protein) and other classes of foods to provide energy, growth and proper functioning of the body [Taylor et al 2002; Steyn et al 2006].

Globally unhealthy dietary intake is a common phenomenon among adolescents. In low-income countries, adolescents display unhealthy diets and lifestyles that can lead to under nutrition or overweight and obesity [Aounallah-Skhiri et al 2011]. These unhealthy diets can result from insufficient or unbalanced nutrients that do not meet the recommended daily intake. In South Africa most diets are frequently deficient in minerals and vitamins such as calcium, iron, potassium, vitamin B6, niacin, folate and other essential vitamins [Steyn et al 2006], because South Africans tend to consume high energy-dense foods with a high level of saturated fat, carbohydrates, cholesterol and fibre, which have limited necessary minerals for growth [Goedecke et al 2005; Steyn et al 2005; Steyn & Nel 2006]. Among these food types, the most averagely consumed are maize porridge, bread, sugar, tea, coffee, margarine and milk [Steyn & Nel 2006].

According to the WHO, a daily allowance of less than 10% of energy for saturated fat, polysaturated fat 6-10%, carbohydrate 55-75%, protein 10-15% and fibre 25g and sodium not more than 2g per day is recommended [Steyn & Nel 2006]. Approximately about 400-500g of fruits and vegetables are recommended to prevent CVD, stroke and hypertension (WHO 2007). Micronutrient deficiencies such as iron, vitamin A, iodine, and zinc among adolescent account for devastating effects including the impairment of growth, impairment of the immune function and thus risk related mortality from NCDs and infectious diseases [Bundy et al 2006].

2.1.1 The energy needs of the adolescent

Energy by definition is the capacity to do work (Scott, 2005) or a change due to growing tissues synthesis of which excess is generated and dissipated as body heat (FAO/WHO/UNU 2001; Scott 2005). In humans energy synthesised from food substances (especially fat and protein, and carbohydrate, other macronutrients and micronutrients) can be used for growth, deposited and stored as fat in tissues, or generated and dissipated as heat [Story and Stang 2005].

This energy known as the total energy expenditure (TEE) is the sum of "*basal energy expenditure, thermic effect of food, physical activity, thermoregulation, and the energy expended in depositing new tissues and in producing milk*" [ADA 2013]. TEE which describes the energy spent by an individual or groups in an average 24-hour period [Black, 2000; FAO/WHO/UNU 2001; Samuel-Hodge et al 2004; Torun 2005; Tooze et al 2011].

In adolescents, because of their puberty characteristics the TEE is influenced by rapid growth rate, body composition and their reproductive system [Butte et al 2012]. It is actually during this period that females acquire 12% of adult stature and 36% of adult weight while the males tend to acquire 20% of adult stature and 50% of adult weight (Butte et al 2012). This shows that adolescent dietary energy requirements to support a healthy system, growth, maturation and other activities such as physical activities must be high enough to support this transformation to the adult age. According to Story and Stang [2005], it is actually during adolescence that total nutrients requirements are higher than at any other time in the life cycle, and failure in acquiring the right nutrients during this period can lead to delayed sexual maturation, slow linear growth and other complications [Story and Stang 2005].

Studies have shown that in a day (24 hours) the TEE, which is expressed as a multiple of basal metabolic rate (BMR), accounts for the energy used to maintain life. This is because TEE are very costly to measure and BMR are therefore used as proximate measure of TEE. On the basis of this the Schofield equations have been developed by the WHO for estimating BMR after accounting for sex, age and body weight[Schofield 1985, Butte et al 2012] as shown in any of the equations in Table 2. Body weight and age are the main necessary determinants of energy expenditure of healthy subjects since sex and age seem to report normal body compositions, which have been shown to correlate highly at childhood and adolescence [Torun 2005].

Table 2: WHO estimate of BMR as derived from Schofield equations

Male: 10 to 18 years of age	**Female: 10 to 18 years of age**
BMR (MJ/day) = (0.074 x body weight [kg]) + 2.754………….. eqn (1) BMR (kcal/day) = (17.69 x body weight [kg]) + 658… …… ….. eqn (2)	BMR (MJ/day) = (0.056 x body weight [kg]) + 2.898.. …… …… eqn (3) BMR (kcal/day) = (13.38 x body weight [kg]) + 693. . …… ….. …eqn (4).

In this case the ratio EI to BMR (EI: BMR) can be used to define cut-off values of under reported energy intake derived from the Goldberg equation [Black 2000]. Since TEE comprises multiples of BMR, the ratio of EI to BMR is known as "physical activities level" (PAL), where EI is the product of PAL and BMR (PAL x BMR) [Samuel-Hodge et al 2004]. Therefore, under reported energy intake can be redefined as EI < (BMR x PAL) or a ratio of EI: (BMR x PAL) less than one [Samuel-Hodge et al 2004].

On the basis of this information, equation 5 can also be used to determine the lower- and upper cut-off limits of reported energy intake [Goldberg & Black 1998; Black 2000].

$$\mathrm{EI:BMR} = \mathrm{PAL} \times \exp\left[\frac{\mathrm{SD} \times \left(\frac{S}{100}\right)}{\sqrt{n}}\right] \text{…. ……….. …………… eqn 5}$$

Where PAL = Physical activity level

SD = -2 for lower and +2 for upper limit 95% CI or -3 for lower and +3 for upper limits 99% CI

n= number of subjects

S = Overall CV (Confident variation) for PAL, taking into account the variability in energy intake and BMR [Black 2000].

Which is given by the equation

$$S = \sqrt{[CV^2_{rw}/K + CV^2_B + CV^2_P]}$$

CV^2_{rw} = within individual variation in energy intake

CV^2_B = the variation in repeated BMR measurement or precision of estimated and measured BMR [Black 2000].

CV^2_P = The between subject variation in PAL

The energy requirement (ER) of adolescents, therefore, can be calculated from energy expenditure and the energy for growth (tissue synthesis and energy deposited in term of fat in theses tissues) [Torun 2005]. With this idea, the energy deposited in tissues that are used as an index of determining overweight and likely obesity is shown in equations 6 and 7.

Energy requirement (ER) = energy expenditure + energy used synthesizing tissues + energy deposited as fat in tissues … ……. ….eqn (6)

Therefore,

Energy deposited as fat in tissues = ER- [energy expenditure + energy used synthesizing tissues] … ……. ….eqn (7)

The energy intake in this case exceeds energy expenditure [Krebs et al 2007]. The energy is therefore deposited as fat in tissues and this is excess energy obtained from protein, fat and carbohydrates [Krebs et al 2007]. This stored energy varies among individuals, depending also on the PAL, growth rates and health of the subject. With normal growth weight gain in an adolescent does not change much with the amount of energy stored in terms of fat (negligible and approximately 1%) compared to the total energy requirement. Therefore it is assumed that the body weight gain during this period is relatively constant [Black 2000; Torun 2005]. This concept of energy is known as energy balance because no weight loss or gain occurs. The energy requirement in this case can be adjusted as:

Energy intake (EI) = Total energy expenditure (TEE). ……. eqn (8)

Indicating that the ratio of EI to TEE (EI:TEE=1) will be equal to one.

In this case the TEE for an adolescent will be based on the dietary estimated energy requirements (EER) predicted from age, height, weight, growth factor and physical activity (IOM 2002; Butte et al 2012) as shown in equations 9 and 10 below, which refer to childhood.

For boys 9-18 years:

EER (kcal/d) = 88.5 - 61.9 x Age [y] + PA x (26.7 x Weight [kg] + 903 x Height [m]) + 25 (Growth Factor)… …. … .. .. eqn (9)

This EER occurs when:

PA = 1.00 if sedentary (PAL ≥1.0 and <1.4);   PA = 1.13 if low active (PAL ≥1.4 and <1.6); PA = 1.26 if active (PAL ≥ 1.6 and <1.9); and PA = 1.42 if very active (PAL ≥1.9 and <2.5)

For girls 9 through 18 years:

EER (kcal/d) = 135.3 - 30.8 x Age [y] + PA x (10.0 x Weight [kg] + 934 x Height [m]) + 25 (Growth Factor)… … … . .. … eqn (10)

This EER occurs when:

PA = 1.00 if sedentary (PAL ≥1.0 and <1.4); PA = 1.16 if low active (PAL ≥1.4 and <1.6); PA = 1.31 if active (PAL ≥1.6 and <1.9) and PA = 1.56 if very active (PAL ≥1.9 and <2.5)

Therefore, if the EI is less than TEE (EI<TEE), the implication is that the ratio of EI to TEE will be less than one and there will be some form of energy underreporting [Samuel-Hodge et al 2004] where the TEE is measured from doubly labelled water (DLW) [Samuel-Hodge et al 2004; Tooze et al 2012]. The ratio of EI to TEE can be used to validate cut-off values for under-reporting of energy intake. According to Samuel-Hodge et al [2004], the ratio of defining EI to TEE for under reporting is approximately less than 0.79 (<0.79) at 95% confidence interval with TEE measured using DLW.

Apart from using EER to estimate TEE, the quadratic polynomial regression equations can be used to predict TEE for adolescent boys and girls per day at constant age as shown in equations 10 and 11[FAO 2001; Torun 2005]. From these equations, the average daily recommended dietary reference of energy intake was found to range from 97% - 98% in all healthy specific age groups [Story and Stang 2005]. On the basis of the quadratic regression analyses the WHO estimated the standard daily recommended average energy requirement (KJ/day) on weight for "**adolescent males aged 17-18 years at 14322 KJ/day and females at 10513 KJ/day"** [FAO/WHO/UNU 2001] while the "**TEE for males aged 17-18 years at 14263 KJ/day and females 10513 KJ/day"**, as shown in Table 3.

Table 3: The daily energy requirement as derived from quadratic regressions according to FAO/WHO/UNU (2001)

Age	**Male**		**Female**	
	Daily energy requirement (KJ/day)	TEE(KJ/day)	Daily energy requirement(KJ/day)	TEE(KJ/day)
14-15	12558	12419	10286	10206
15-16	13348	13221	10462	10408
16-17	**13952**	**13856**	**10513**	**10496**
17-18	**14322**	**14263**	**10513**	**10513**

Note: 1Kcal = 4.184KJ (4.2KJ) **[**FAO/WHO Handbook on human nutritional requirements 1974]**.**

Other reports by Story and Stang [2005] also indicate the KJ/day on weight as calculated from the quadratic regression analyses for females aged 14-18 years at 13238 KJ/day and 19-30 year-old females at 10093 KJ/day while that for males 14-18 years is estimated at 13238KJ/day and 19-30 year-old males at 12881 KJ/day. According to FAO/WHO/UNU [2001] and Torun [2005] weight is regarded is regarded a major factor of TEE when compared to age because the exclusion of age from the model equation does not increase the error estimates [Torun, 2001].

For boys

$TEE(MJ/day) = 1.298 + 0.265kg - .00011kg^2$ ………. .. eqn (11) :

$n_{weighted} = 801$; $r = 0.982$, $r^2 = 0.964$ and see = 0,518

For girls

$TEE(MJ/day) = 1.102 + 0.273kg - .00019kg^2$ ………. .. eqn (12)

$n_{weighted} = 808$; $r = 0.955$, $r^2 = 0.913$ and see = 0,650

Where : MJ = mega joule, r= correlation coefficient, r^2 = coefficient of determination. $n_{weighted}$ = sample size, see = standard error of the estimate of the quadratic equations [Torun, 2001].

2.1.2 Protein need of adolescents

Protein and amino acids of adolescents vary between 10%-30% of energy need, but it is highly influenced by the amount required by the body for growth and maintenance [FAO/WHO/UNU 2001; Story and Stang 2005]. Protein apart from being the essential building component of the body system, they equally act as fuel or energy supplier when carbohydrates and lipid are low in the body[FAO/WHO/UNU 2001; Story and Stang 2005]. Females require high protein intake for unit increase in height as from 11 years while males from 15 years [Story and Stang 2005]. The recommended daily intake (RDI; nutrient sufficient to meet the requirements 97–98% of healthy individuals) of protein by adolescent at 14-18 years of age for body growth is approximately 52g/d for boys and 46g/d for girls [FAO/WHO/UNU 2001; Story and Stang 2005]. Protein intake lower than the RDI may result in retardation in linear growth and sexual maturity [Story and Stang 2005]

2.1.3 Carbohydrate need of adolescents

Carbohydrates account for more than 50% - 60% of the daily body energy **[**Tarnopolsky 2003; Story and Stang 2005] and according to the WHO the RDI for adolescent aged 14-18 years for both boys and girls is 130g/d [FAO/WHO/UNU 2001; Story and Stang 2005]. An excess amount above the RDI may be stored as fat.

2.1.4 Fat need of adolescents

Fat is the main source of diet for insulation, growth and development and accounts for more than 30% of calorie intake [Story and Stang 2005]. The acceptable macronutrient distribution ranges (AMDR) among adolescents aged 14-18 years vary according to the type of fat from 25% - 35%. Table 4 shows the WHO recommended daily requirement for carbohydrate, protein and fat g/day for adolescents [FAO/WHO/UNU 2001].

Table 4: Daily recommended requirement for carbohydrate, protein and fat g/day for adolescents

Age group	**Male-recommended requirement**			**Female-recommended requirement**		
	Carbohydrate	**Protein**	**Fat**	**Carbohydrate**	**Protein**	**Fat**
9-12	130	34	12	130	46	11
14-18*	**130**	**52**	**16**	**130**	**46**	**12**
19-30	130	56	17	130	46	12

Key: 14-18* =17 years adolescent recommended daily macronutrients requirement is within this range according to FAO/WHO/UNU 2001

2.2 Dietary assessment methods

Food intake depends on individual access to food and how safe and nutritious the food is to meet the dietary preferences [FAO 1998]. The dietary assessment can be classified into two major categories: retrospective reporting of intake (dietary history, 24-hour recall, and food frequency) and current or prospective recording of consumption (dietary records, weighed intake) [Ferro-Luzzi 2001; Wireden et al 2003; Thompson & Subar 2008]. Generally the method to be employed depends on the population to be sampled, study participants, researcher skills, resources, respondent burden and study objectives [Willet 1990].

2.2.1 Diet history (retrospective method)

Diet history, a retrospective method assesses individual diet intake by asking the respondent to self report through interview led about the past diet [Thompson & Subar 2008]. Diet history collects information from individuals about the type and the preparation of the food, frequency of intake of the various foods and the composition of the foods [van Beresteyn et al 1987; Bloemberg et al 1989]. The detailed assessment of the meal preparation (fried, baked, boiled etc.) gives better understanding of the food [Thompson & Subar 2008]. The diet history is usually referred to as the Burke "diet history" because it was originally developed by Burke. At times diet history overlaps with 24-hour recall diet assessment.

The setbacks involve the effort and expert difficulties in capturing and coding of information if diet history is led by an interviewer. However, self-administered automated diet history instruments are currently available [Bloemberg et al 1989; Kohlmeier] but limited accessibility and the problems of validation and calibrations exist. The validity of a diet history approach, according to Thompson and Subar [2008], is difficult because of the lack of accurate independent knowledge, especially on long-term intake. Therefore, intake is often misreported. In most cases nutrient intake from diet history is usually higher than the standard estimates [van Liere et al 1997].

2.2.2 Twenty four (24)-hour recall (retrospective method)

Here the respondent is asked to provide detailed information on foods and drinks consumed over a 24-hour period [Thompson & Subar 2008]. Twenty-four hour recall usually requires low respondent burden, which is very convenient in large-scale surveys [Thompson & Subar 2008; Wrienden et al 2003]. However, the problems encountered are the estimation of the portion sizes consumed, bias in recording, poor memory dependence, the inability to provide accurate measurement of individual intake [Wrienden et al 2003; Thompson & Subar 2008].

Some of the 24-hour recall limitations have been improved by the multiple pass 24-hour recall, which is mainly used to asses diet and nutrition in large studies (e.g National Health and Nutrition Examination Survey). The multiple pass 24-hour recall diet focuses on the food consumed over a period of 3-5 days during which the participant is asked to recall and describe everything consumed in the 24 hours prior to the interview [Wrienden et al 2003; Thompson & Subar 2008]. Being a staged approach, the multiple pass 24-hour recall diet has been used to improve precision with 24-hour recall and minimises under-reporting and increases reliability [Wrienden et al 2003]. The 24-hour recall has been applied in a South African setting by Wolmarans et al [1988], Steyn et al [1993] and MacIntyre et al [2002] to assess dietary intake among adolescents.

2.2.3 Weighed food records (Prospective)

This method involves the individual or investigator in weighing the food or drink prior to consumption and proper recordings being made, even of the leftovers. The process can be recorded up to 7 days [Wrienden et al 2003]. The method gives precisely sized portions, does not require recall of the food eaten or quantified intake and also gives self-monitoring of one's weight and control. The method is rarely used in the South African setting. It involves high investigator cost, high respondent burden and misreporting [Wrienden et al 2003; Thompson & Subar 2008].

Similar to weighed food records is the estimated food record, which uses household measures such as spoons, cups and food photographs to quantify the food. This weighed food records technique may give poor estimation of the portion sizes [Wrienden et al 2003].

2.2.4 Food frequency questionnaires (FFQ) (Retrospective method)

The FFQ is a method used by respondents to ask and report the frequency of each food consumed from a list of foods at a specific period of time [Thompson & Subar 2008]. The method is very suitable for large-scale surveys and can be self-completed and posted; in this way there is a low investigator cost. The underlining principle of FFQs is usually to obtain information about the whole diet consumed, of which a broad range of nutrients can then be estimated [Crozier et al 2010] or an aspect of the diet of interest [Severo et al 2009]. The overall nutrient intake is usually derived by summing all the products of each reported food according to the specific nutrient in the food type to estimate the daily nutrient intake [Thompson & Subar 2008].

However, the FFQ can be faulted by over reporting (intake misreported) and the estimated food portion sizes not being precisely quantifiable and therefore require validation [Wrienden et al 2003; Thompson & Subar 2008]. At times the cognitive task for the participants may not be possible [Thompson & Subar 2008]. The FFQs have been used to determine dietary intake in South African populations by Steyn et al [2006] and MacIntyre et al [2002]. Earlier reports by MacIntyre et al [2000] showed FFQ as a reproducible and valid tool in an African population. The method when compared to others is widely used to assess dietary intake in adolescents in South Africa and elsewhere [Rockett et al 1995; Frost et al 1995; Tur et al 2004; Zingoni et al 2009].

2.3 Overweight and Obesity

Overweight/obesity according to the OECD [2011] is an abnormal or excessive fat accumulation that may impair health and present health risks. The difficulty faced in assessing the impact of overweight and obesity is how to estimate the impact. BMI and percentiles are some epidemiological surrogate measures used to estimate body total fat [Cornier et al 2002]. The BMI [weight (kg)/height^2 (m) = kg/m^2] is the most commonly used and widely accepted measure of overweight in adults (>25kg/m^2) and obesity (>30kg/m^2) [Cole et al 2000]. This method is simple and gives a very quick snapshot for both children and adults by assessing and classifying the body weight (underweight, normal, overweight or obese). However, BMI is a surrogate measure of body fatness because it does not differentiate fat mass from other body-internal components, such as the distribution of body fat, water, muscle, and skeletal weight [Ayvaz & Çimen 2011]. Apparently BMI can be influenced by age, sex, ethnicity [Piccoli et al 2002].

Childhood overweight and obesity is surprisingly difficult to define. Cole et al [2000] propose another method for estimating overweight and obesity in childhood, based on pooled international data for BMI that can be linked to a wide adult obesity cut-off point of 30 kg/m^2. Furthermore, Cole et al [2000] suggest the 95th centile (percentile) of the United States BMI reference as the proposed cut-off point for childhood obesity. The definition is less internationally recognised than others. However, the definition can be used as a direct comparison of trends in childhood obesity worldwide [Cole et al 2000]. Table 5 shows the cut offs of adolescent BMI according to Brettschneider et al [2011].

The International Obesity Task Force (IOTF) cut offs are used to determine overweight (> 84th percentiles) and obesity (>95th percentiles) among adolescents, which corresponds to adult definitions of overweight and obesity. Adolescent BMI is interpreted relative to age and sex, because body fat changes within children and adolescents according to age and varies by sex. Therefore, the percentiles specific to age and sex classified as underweight (< 10th percentiles), normal weight (> 10 percentiles-84th percentiles), overweight (>84th percentiles-95th percentiles) and obesity (>95th percentiles) are used. This age-determined BMI is relative to the position of the adolescent BMI value among adolescents of the same sex and age [Dietz & Robinson 1998; Cole et al 2000; IOTF 2005; Brettschneider et al 2011] as shown in Table 5. Table 5 shows the general adolescents and adult cut-off BMI as a measure of underweight, normal, overweigh and obesity according to WHO [2000].

Table 5: Percentile cut-off point for adolescents and adult BMI cut off.

Adolescent and children BMI cut off		**Adult BMI cut off**	
Centile (percentile)	Cut-off BMI	Adult BMI	Adult Status
Lower (thin)	$<10^{th}$	Below 18.5	Underweight
Normal	$\geq 10^{th}$ to 84^{th}	18.5 – 24.9	Normal
Over weight	$>84^{th}$ to 95^{th}	25.0 – 29.9	Overweight
Obese	$>95^{th}$	30.0 and Above	Obese

Another body composition method for estimating body fat for BMI determination is the dual-energy X-ray absorptiometry scans (DXA), which both accurately measures the bone mineral density as well as estimates fat-free mass and fat mass [Sjostrom, 1993; Kelly et al 2009; Flegal et al 2011; Micklesfield et al 2012]. This comparison method has been used in detail to estimate the subcutaneous visceral adipose tissue fat in the abdominal cavity, which is highly associated with BMI, obesity and obesity-related diseases [Sjostrom, 1993; Micklesfield et al 2012]. Therefore, DXA can accurately and precisely measure the whole body and regional distribution of fat and lean tissue. The limitation in clinical medicine research is the cost and the time required for MRI acquisition and image analysis [Schoeller et al 2005; Micklesfield et al 2012]. The DXA scanning measures and can correctly estimate the body fatness in children who are overweight and obese. Furthermore, according to Flegal et al (2011), the BMI obtained from DXA correlates closely with total body fat. However, it is not a precise measure of fatness. The greatest problem with both methods is that neither BMI nor measures of adiposity have been associated with clinical outcomes.

2.4 Factors related to overweight

2.4.1 Genetic factors relating to overweight

Vertical genetic traits have been shown to be associated with an increase in an individual's susceptibility to excess body weight [Chagnon et al 2002; Bellows & Moore 2013]. According to Crowther [2009], these genetic traits can influence the BMI by affecting energy balance mechanisms. It has been shown that more than 300 genes, markers, and chromosomal regions coding for various proteins are associated with varied human obesity phenotypes [Chagnon et al 2002] and up to 30%-70% of the variance genes for BMI in humans can be determined by genetic factors [Loos & Bouchard, 2003]. Naturally the derivable calculation of BMI, height and weight are a heritable trait located in loci.

According to reports by Lee (2009), obesity is a multi-factorial disorder with several heritable traits developed as a result of long-time interaction between the "*obesogenic*" environment and the individual gene susceptible to excess overweight. Therefore, the predominant severe monogenic human obesity has been shown to be a long-time disruption of the leptin (a hormone that regulates energy intake and energy expenditure homeostasis) melanocortin pathway [Farooqi, 2005; Coll et al 2007]. The leptin-melanocortin pathway plays a major role in the understanding of the weight gain mechanism and obesity disease. Leptin therapies can reduce energy intake that introduces energy imbalance [Farooqi, 2005 Coll et al 2007]. Also the gene that regulates fat has been established and indicates that individual ability to store excess fat and become susceptible to overweight is genetically regulated. Reports by Farooqi [2005], show that these genes have been dormant in low-income populations for a long time and incidence has recently increased as a result of changing environmental and lifestyle behaviour. Therefore, genes and behaviour seem to correlate before a person becomes susceptible to overweight, obesity and their complications. For genes to become a risk factor for obesity, other factors such as intake of high-energy dense foods low in vitamins and micronutrients in combination with other factors such as environmental and SES must play a significant role. Therefore, overweight and obesity are complex phenotypic characteristics due to biological and environmental factors acquisitions.

Furthermore, it has been shown that obesity risk is more likely in individuals from families with a long obesity history than with families without this obesity history [Pinhas-Hamiel et al 1996; Comuzzie, 2002; Farooqi, 2005]. Therefore, the possibility of identifying overweight adolescents equally according to high-risk family history is necessary in diagnosis [Pinhas-Hamiel et al 1996]. However, the mechanisms through which overweight develops have not been fully understood because of its complex multi-factorial disease outcomes, although those with a risk of developing obesity can provide insight to mechanism therapies [Davison & Birch 2001].

2.4.2 Socioeconomic factors relating to overweight

Socioeconomic status (SES) factors have been found to be associated with dietary intake, overweight and obesity [Gordon-Larsen et al 2003]. These factors include level of education, home type, own home, having a telephone, water use, water type, toilet use, toilet type, electricity, owing a television or a car or a washing machine, etc. In South Africa, the black and 'coloured' (descendants from mixed white and black origin) adolescents have higher rates of underweight and overweight than their white counterparts, which has been linked to SES factors [Gordon-Larsen et al 2003; Reddy et al 2008]. Acculturation of the white girls have pressured them to be thin, while a positive social value have made black South African girls to be large for culture-related reasons [Pouane et al 2002; Monyeki et al 2008; Crowther, 2009].

Overweight and obesity among South Africans adolescents has been found to be associated with social and economic factors. Overweight adolescents, especially females, are less likely to be married [Gortmaker et al 1993; Goedecke et al 2005], likely to have a lower household income and higher poverty rate when compared to their normal-weight peers [Goedecke et al 2005]. However, Guedes et al [2011] found some interesting associations between overweight and obesity among Brazilian adolescents. The prevalence of overweight and obesity among Brazilian adolescents is gradually increasing in accordance with higher SES compared to South African adolescents [Goedecke et al 2005]. Brazilian families with a higher SES demonstrate tenfold higher odds of being overweight and obese compared to adolescents from a lower socioeconomic class [Guedes et al 2011]. This finding is different from those from other developing countries where it is assumed that adolescents having a lower SES because of their low income are more likely to engage in eating higher-density energy foods that are cheaper and easier to access (such as carbohydrates) than nutritive foods rich in vitamins and micronutrients consumed by families with a higher SES [Guedes et al 2011]. For South Africa this is not true because of the mixed culture population, better economic shift and changing lifestyles among adolescents, which leads to under nutrition and over nutrition at the same time [Rossouw et al 2012; Reddy et al 2012].

The level of physical inactivity among adolescents is increasing contributing to the increasing prevalence of overweight and obesity[Micklesfield et al 2014]. The prevalence of physical inactivity, has been estimated at 43%–49% among South Africans adolescents age 15 years and older [Joubert et al 2007] when compared to other African countries adolescents between 13 and 15 years of age who are 50% physically active [Peltzer 2009]. The increasing overweight/obesity epidemic among South African adolescent is not only envisage in Urban areas. Rural South African adolescents equally undergo physical inactivity [Cook et al 2010].

A recent study among adolescents from rural South African setting reported an overwhelming prevalence of overweight and obesity 10 and 20 years at 15-25%[Kimani-Murage et al 2010], when compared to national report of 17 years of age at 20.5% for males and 23 % for females % [Shisana et al 2013] a finding that is higher than anticipated, but still lower than in urban South African adolescents [Reddy et al 2012]. Another report by Micklesfield et al [2014] reported an increasing pubertal development associated with an increasing sedentary time among rural south African adolescent.

2.4.3 Demographic factors related to overweight

Numerous factors of demography and conditions affect the dietary intake of the adolescent population of South Africa. Early reports by Puoane et al [2002] and currently by Feeley et al [2012] have shown that high-energy food intake is common among South Africans. This phenomenon differs with area of residence, ethnicity, age and level of education. Studies have shown that urban adolescents exhibit poor dietary intake compared to rural dwellers due to differences in lifestyle, which may influence their diet [Hoffmann et al 2012]. Current reports by Feeley et al [2012] have shown that poor dietary eating practices from birth to the age of 20 increase with age, especially breakfast skipping, eating while watching television and fast food consumption.

Among the ethnic groups in South Africa, black women have been shown to be more obese and more insulin resistant as compared to white women. Black women also have low visceral adipose tissue and insulinopaenia [van der Merwe et al 2001; Goedecke et al 2005]. These results are similar to those currently reported by Reddy et al [2012] where blacks still have the highest rate of obesity as compared to the other 3 ethnic groups (Indians, coloured and the whites). This high insulin resistance therefore exposes black women to a greater likelihood of developing type 2 diabetes as compared to white women [van der Merwe et al 2001].

Overweight and obesity differ greatly among South African age groups, genders, ethnic groups and geographical areas. According to Armstrong et al [2011], the prevalence of overweight and obesity among South African children and adolescents is increasing. Between 1994 and 2004, the prevalence of overweight and obesity in adolescence rose from 1.2%-13% and 0.2%-3.3% respectively [Armstrong et al 2011]. The rates were compared between the Primary Schools' Anthropometric Survey and The Health of the Nation Study [Armstrong et al 2011]. Findings by Labadarios [1999] reported the following geographic differences of overweight and obesity among 1- 9-year-old South African children[Feeley 2012c], as shown in Table 6.

Table 6: Geographic differences of overweight and obesity among 1- 9-year-old South Africans

Location	**% Prevalence**	**95% CI**
National	17.1	15.0-19.23
Formal Urban	21.1	16.0-21.19

Tribal areas	15.8	13.52-16.80
Informal urban	13.4	10.02-16.80
Farm dwellers	10.8	6.03-15.05

However, socio-demographic association to overweight/obesity among South Africa as described by Bauman et al 2012], are influenced by multiple factors interacting at different levels. The exploration of socio-demographic (Fig 1) associated with overweight/obesity involves an inter-ralated net work of factors from individual, social, community, State and National level factors.

2.5 Consequences of overweight and obesity

According to the WHO report of 2012, overweight and obesity are the fifth risk factors associated with deaths, of which 2.8 million deaths a year are attributed to overweight or obesity in adults in 2010 [WHO 2012]. The expected number of overweight children in developing countries is approximately 35 million, with 8 million in developed countries. More deaths are linked to overweight and obesity than underweight [WHO, 2012], which might be the result of increased dense-energy diet (fatty foods, high salt and sugars, low vitamins, and nutrients) and increased BMI. However, according to reports by the WHO [2008] and the OECD/WHO [2012], more than 50% of all deaths of children aged under five are due to underweight. A high BMI is the main attributable risk factor for chronic diseases. The major consequences associated with obesity are premature death, disability, physical and psychological effects and breathing difficulties of childhood [WHO 2012]. Others include metabolic syndrome which has been shown to be a precursor to CVD and type 2 diabetes [Bray, 1985; Grundy, 2000; Misra and Khurana, 2008; Lee, 2009]. According to Bray [1985], these outcomes, therefore, can be used as a means of providing guidelines for the prevention overweigh by encouraging physical exercise, good nutritional habits, education of tobacco use by adolescent in schools.

2.5.1 Economic consequences

However, apart from the deleterious effect of HIV and tuberculosis, the health consequences of overweight and obesity among South African adolescent is increasing and exerting a huge burden on the government [Shisana et al 2013]. South Africa is ranked one of the highest with hypertension rates globally, a risk factor of overweight/obesity related diseases such as stroke and heart diseases [Shisana et al 2013]. According WHO these diseases are preventable [WHO 2012].

As already described overweight/obesity is a significant driver of NCDs and there are approximately one billion overweight/obesity individuals as compared to 850 million underweight worldwide [Yach et al 2006; FAO, WFP and IFAD 2012]. This number stretches and exerts a huge impact on health systems and health costs (Allison et al 1999; OECD 2010). The consequences are a high economic burden on individuals, families, insurance companies, the workplace and government.

The economic costs of overweight and obesity are classified into direct and indirect costs. The direct costs are those faced by the individual, government and insurance in terms of hospital cost such as laboratory diagnosis, hospital bills, admission fees etc [IOTF 2005], while the indirect costs deal with mortality and morbidity derived from lost productivity, absenteeism and bed rest [Runge 2007]. Estimated expenditures for health care for overweight and obese individuals are roughly 25% higher than those for normal-weight individuals and increase immensely as other complications set in [OECD 2010]. These estimates are responsible for 1% - 3% of total health expenditure in most countries [OECD 2010]. In the USA, for example, the cost is approximately 5% - 10% [OECD 2010]. One of the main components of overweight risk burden globally is diabetes [Sturn 2002]. The average cost of hospital care of diabetes per person in Latin America is estimated at $550, exceeding the per capita GDP health expenditures [Barcelo et al 2003]. In South Africa the rate of mortality due to type 2 diabetes is comparably higher than other SSA `of which 75% men and 86% women overweight/obese suffer from type 2 diabetes. The cost of treating and controlling diabetes and its related consequences in South Africa are quit very high [Bradshaw et al 2007; Joubert et al 2007]. This high cost has a huge potential impact on the South African economy. Reports by van der Merwe et al [2006] show that obese individuals contribute roughly 7% lost to productivity costs and disability pension cost to employers are 1.5-2.8 times higher in obese individuals than in normal-weight South Africans. In addition, obesity has a pronounced effect on mortality (7%) in South Africa and in conjunction with HIV and AIDS (30%) is damaging the economy and shrinking the work force [Joubert et al 2007; Puoane & Hughes 2007].

2.6 Prevention of overweight/obesity

As stated earlier increasing prevalence of overweight/obesity is a major risk factor for most NCDs in both developed and developing countries. Therefore, the most preventable method of overweigh/obesity is by knowing one's BMI, eating style and early childhood development dietary habits [Gubbels et al 2011**]**. Knowing the influence of childhood overweight/obesity on adulthood complications is of utmost importance to initiate interventions to curb the problem worldwide. This prevention is done by taking the positive actions needed to turn the epidemic. However, action cannot be taken without knowing the etiological factors that are tailored to trigger weight gain and eventually the cause of obesity and its consequences. From previous studies the alteration in diet from low- to excess high-energy dense dietary intake low in vitamins and micronutrients and less exercise have been shown to promote weight gain [Report of the joint WHO/FAO Expert Consultation, 2003; Swinburn et al 2004; de Lauzon-Guillain et al 2006]. These changes in diet toward high-fat- and high-energy dense foods, low nutrients and sedentary lifestyles are some of the probable cause of childhood and adult obesity around the world [Swinburn et al 2004].

On the basis of genome-wide association studies, polygene alleles responsible for body weight and height regulation explain childhood and adult body weight [Hinney & Hebebrand 2009]. There is a likelihood that polygene will be explored further in assessing the implication and prevention of childhood obesity [Hinney & Hebebrand 2009]. Other factors include lack of weight control behaviours, as earlier reported by Stice et al [2005]. Knowing the risk factors, it is easier to set up prevention and control mechanisms. The most proxy control measures are the lifestyle reduction of high-energy dense food intake. According to a report from the Joint WHO/FAO Expert Consultation [2003] nutrient and physical activity influence gene expression over the years and predispose individuals to obesity. Other reports have shown that soft drink consumption is another significant risk factor for overweight because of increased energy intake and weight [Vartanian et al 2007]. Moreover, overweight is a growing phenomenon in developing countries because of the growing market and high consumption of soft drinks in the developing countries [Advertising Age 2007].

To reduce high energy intake and overweight developing, the Centers for Disease Control and Prevention (CDC) proposed the serving of high-nutrient foods (low energy dense) such as vegetables and fruits with appropriate energy-dense foods. These low energy dense foods may help in weight management by providing high portions of nutrients and fibre [Swinburn et al 2004; de Lauzon-Guillain et al 2006].

The Joint WHO/FAO Expert Consultation [2003] has shown that genetic variability to dietary responses can trigger high cholesterol levels. The cholesterol level can be used to target and prevent chronic diseases. In general, according to the WHO [2004] and the OECD [2012] the following slogan can limit weight gain and obesity. The slogan “fit not fat” has been used by the OECD in fighting overweight and obesity [OECD, 2012] by promoting an increased uptake of low-energy dense foods (vegetables, fruits etc) and limiting the amount of high energy dense food required for appropriate calories.

Product reformulation or limitation of high-energy dense foods, high total fats and sugars, increased consumption of fruits and whole grains, increased intake of vegetables and nuts have a high significant effect with overweight [CDC 2011]. Regular physical exercise, keeping a healthy energy balance and keeping a healthy weight are vital. The reduction of fat, sugar and salt in commercially processed food products and the consumption of healthy and nutritious products are important. Other childhood targets that improve a healthy life including changes in school meals, better facilities for physical exercise and health education are highly encourage [CDC 2011]. Other intervention policies include the National School Nutrition Programme (NSNP) of the Department of Basic Education (DOBE) especially for poor families, to enhance learning capacity through school feeding programmes, promoting and supporting food production and improve food security in school communities and strengthening nutrition education in schools and communities [DOBE, 2013]. According to the food act all food labels in South Africa must comply with the latest food labeling and advertising law in order to inform and protect the South African consumer [de Villiers 2011]. In addition intervention from parents are vital in ensuring that, their children have better healthy food choices for their growth and development including physically active, which has become an increasingly sedentary lifestyle.

2.7 Aims and objectives of the study

2.7.1 Aims

To investigate the association between reported dietary intake and overweight among 17-year-old adolescents in the BT20 study of 2007/08.

2.7.2 Research question

Is dietary and energy intake associated with overweight among 17-year-old adolescents from Soweto, Johannesburg?

2.7.3 Study objectives

I. To describe the socio-demographic factors, weight and BMI of 17-year-old adolescents in the BT20 cohort in 2007/2008.

II. To describe the dietary intake among 17-year-old adolescents in the BT20 cohort, in terms of fat (g), carbohydrate (g), protein (g) and total energy intake (kJ) in 2007/2008.

III. To determine the association between dietary intake (energy, fat, carbohydrate, protein) and overweight among 17-year old adolescents in the BT20 cohort in 2007/2008.

IV. To determine the risk factors, including dietary intake, associated with overweight among 17-year-old adolescents in the BT20 cohort in 2007/2008

The proposed conceptual framework of the covariates, dietary and energy intake has a complex association with BMI category. This framework summaries the complex maps of factors associated with the overweight and obesity. Fig. 1 shows the conceptual frame work of biological, socioeconomic, demographic and other factors associated with BMI.

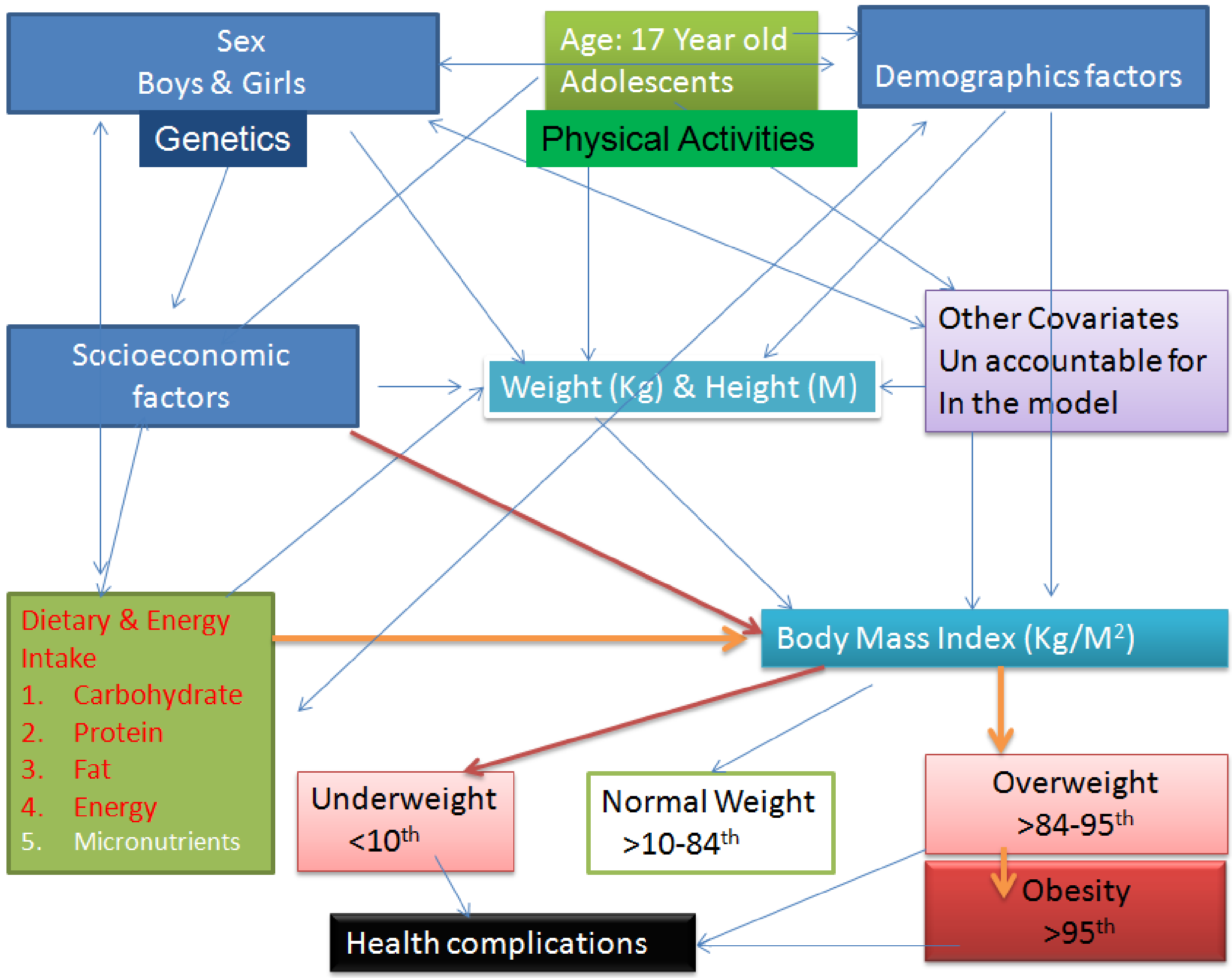

Fig: 1.Conceptual frame work of factors associated with body mass index.

3.0 METHODOLOGY

3.1 Study design

This study was based on secondary data collected from a cross-sectional survey among 17-year-old adolescents from the BT20 cohort study in 2007/2008.

3.2 Study population

A total of 227 adolescents were randomly selected from 1,600 17-year old adolescents in the BT20 cohort study. The BT20 cohort study is a longitudinal ongoing study on a cohort of children (n=3273) that were born in the metropolitan area of Soweto, Johannesburg, South Africa in 1990 [Richter et al 2007]. The BT20 study group measured the physical and psychological development, including growth, bone mineral density, body weight and BMI [Richter et al 2007]. The study is one of the largest and longest running studies of infant-, child- and adolescent health and development in Africa, and one of only a few large-scale longitudinal birth cohort studies in the world [Richter et al 2007]. The information on adolescents used was based on their dietary intake collected in 2007/2008 and their SES factors collected at birth.

3.2.1 Sample size calculation

The choice of 227 participants was based on time constraints in coding of the data on the FFQ, capturing of the data into FFQ software, checking and verification of the data generated from the FFQ software and updating the information into FFQ software. However, the sample size provided a reasonable estimate of the key parameters at 95% CI. The assumed population estimate (p) was 17 ± 3% prevalence and the expected overweight in Soweto was set at (1-p):

The sample size was calculated according to Gorstein et al [2007], as shown below.

$$\mathrm{n} = \frac{z^2 p(1-p)}{d^2}$$

where:

- z = 1.96
- p = Estimate of the expected proportion
- d = Margin of error estimation (approximately = 5% = 0.05)

This gave us a sample size of 227 adolescents, to determine the association between explanatory variables overweight.

3.2.2 Inclusion and exclusion criteria

Candidates who were 17 years of age, non-diabetic and originated from the BT20 cohort were eligible to be randomly selected for the study. Those who were pregnant and/or on a special prescribed diet were also excluded.

3.3 Measurement instrument and variables

3.3.1 The evaluation of the Food Frequency Questionnaire (FFQ)

The BT20 study uses a modified interviewer-led quantitative FFQ to estimate an individual 's energy intake [Zingoni et al 2009]. The dietary intake questionnaire had approximately 214 food items [Steyn & Senekal 2005] commonly eaten by at least 3% of the South African population, modified from the dietary survey of 1983 [Nel & Steyn 2002]. The FFQ has not been validated due to financial resources however, it has been assessed against Dennis et al. 2003 criteria and it scores s (13/15; 87%) as shown in Appendix II. The FFQ make use of food flash cards of various excellent high-quality food photographs and designs [Steyn &Senekal 2005].

The interview was done by well-trained interviewers. The food intake information obtained from the participants was estimated in terms of household measures (e.g. 1 cup or 2 serving spoons) as well as two-dimensional current-size drawing of foods (slices etc), and utensils [Steyn et al 2006]. The procedures:

1.The participants were given the food flash cards items to peruse and select into a pile of "rarely eat/never or drink"

2. There after they were asked to re-classify the remaining food flash cards into a pile of

- "eat/drink less frequently (‘occasional’)"
- "eat regularly and in the past seven days".

3. Data was obtained by asking the participants the frequency and quantity of the listed foods "**eat regularly" and in the past seven days**. The details of the food items eaten in the past 7-days were recorded in the FFQ Table (Appendix 1) and the whole process took approximately 1 hour to complete.

4. The amount or quantity of food in grams consumed daily by each participant was calculated by multiplying the portion, weight, or amount by the frequency of consumption per day and per week. The total was then divided by 7 and the quantity recorded in grams. The time period was known as “data coding”.

5. The data was checked for quality by the senior nutritionist and anomalies were queried and corrected together with the interviewer.

6. The total gram of the different food items were calculated and the participant identifiers was entered or captured into the Foodfinder Dietary Analysis Programme III computer base programme developed by the MRC [Langenhoven et al 1991].

7. The Foodfinder Dietary Analysis Programme III automatically calculate the individual energy in kilojoules (KJ), macronutrient intake in grams (g), and micronutrients in micrograms (mcg) [MRC, 2002].

8. The captured data was later exported into an Excel spreadsheet and verified according to the type of food, code and the grams captured per food item per participant identifier. The incorrectly captured data was corrected and updated in the FFQ Foodfinder software program.

3.3.2 Outcome variables

In the current study a weighing scale balance (for weight) and a stadiometers (for height) were used to estimate the adolescent BMI as reported in other studies in South Africa and other settings [Rockett et al 1995; Frost et al 1995; Tur et al 2004; Zingoni et al 2009]. The weightand height were measured by well-trained staff who used standard anthropometric techniques. The electronic scale (SECA Ltd Germany) that was calibrated daily was used for weight measurement to the nearest 0.1 kg while a portable stadiometer (Holtain Ltd UK) was used to measure height to the nearest 0.1cm.

The weighing balance was preferred in the current study because of the portability, compact nature and interviewers found it easy and friendly to use. However, the weighing balance can be over-stretched and approximation to the nearest 0.1 cm reduces the accuracy.

Throughout the study overweight/obese will be referring to overweight as the outcome (Mo-suwan et al 2000; Mathews et al 2011) and identifies the fattest adolescents who are at risk of becoming diabetic. Overweight/obesity (BMI >85th percentile) was estimated from the BMI where the BMI is the weight (kg) divided by the height (m) squared (BMI = kg/m^2), according to IOTF cut offs. This approach uses percentiles based on age and gender and therefore creates the age- and gender-specific cut-off points for adolescents. In general, adolescents with BMI category values less than the 10th percentile value are considered as underweight, between 10th ≤ 85th percentiles as normal weight, more than 85th to 95th percentiles as overweight and above the 95th percentile as obese [Kromeyer-Hauschild et al 2001; Reddy et al 2012]. Because of the small sample size and the nature of the outcome of the study, **overweight cut off was considered at ≥85th percentile (including those that were obese).** In medical expressions overweight and obesity are considered risk factor of NCD due to excess stored body fat [Krebs et al 2007]. On this basis BMI category was re-categorised as thin [<10th (underweight)], normal weight [>10^{th} to 85^{th} (normal weight)] and overweight [>85^{th} (overweight/obese)]. This cut off confirms the reports by Bellows & Moore [2013] that overweight and obesity are consequences of excess body weight that poses a medical risk to adolescent.

3.3.3 Exposures variables

3.3.3.1 Evaluation of energy intake

The key exposure variable of this study was total dietary intake (fat, carbohydrates, protein and energy (kJ). The modified FFQ developed by the Medical Research Council (MRC) was used to assess the dietary intake. The Goldberg cut-off energy was used to determine energy intake (EI) [FAO/WHO/UNU 1985; Black 2000]. Since the energy from the various food samples was calculated by the Foodfinder software program version III, the EI for the study was then estimated using the ratio of energy generated from the FoodFinder (KJ/day) to basal metabolic rate (BMR) (KJ/day) (EI:BMR). BMR is the amount of energy expended daily at rest. The BMR was calculated using the equations

BMR (kcal/day) = {17.69 x body weight (kg)} + 658 for boys

While

BMR (kcal/day) = {13.38 x body weight (kg)} + 693 for girls.

The upper and lower cut-off points were then determined from sedentary lifestyle of 1.55 X BMR or EI:BMR as defined from physical activity level (PAL), according to the WHO standard [FAO/WHO/UNU 1985; Black 2000]. The energy was then categorised using ≤1.55 x BMR or EI:BMR ≤ 1.55 as under-reported and >1.55 x BMR or EI:BMR > 1.55 as over-reported.

3.3.3.2 Socioeconomic variables

In the BT20 study interviews were conducted by trained staff at the research site at Chris Hani Baragwanath Hospital. An interviewer-led questionnaire was used to collect data from participants' mothers regarding the type of home, own home, telephone, water use, water type, toilet use, toilet type, electricity, television, car and washing machine to assess the SES status of the participant at the birth of the BT20 child.

3.3.3.3 Demographic variables

Each participant's demographic information such as mother's age, gender, date of birth, place of birth, and ethnicity were collected through the same standard interviewer-led questionnaire at the time of birth.

3.4 Data management and analysis

3.4.1 Data Quality assurance

The information needed for the data analysis included: coding of the data on the Food Frequency Questionnaire (FFQ), capturing of the data into food composition software, checking and verification of the data generated from the software and updating the information into software. The final data was then exported to STATA 12.1 software for statistical analysis.

3.4.2 Descriptive statistics

The analysis was done using STATA 12.1 (Stata Corp LP, College Station, Texas 77845 USA). The variables were extracted from the BT20 data, cleaned and coded. BMI was generated from height and weight (BMI = weight/height^2 = (kg/m^2). The data was described using mean and standard deviation for continuous variables such as weight, height and BMI because they were normally distributed. Skewed continuous data (fat, carbohydrate, protein and energy) were analysed using the median and interquartile range (IQR) because these are not affected by extreme outliers resulting from the under- and over-reporting of dietary intake or energy estimates. Such a summary was presented for variables of diet (fat, protein and carbohydrate), energy, BMR and PAL. Cross-tabulations of socio-demographic variables with the categorised BMI were also presented to investigate any associations.

3.4.3 Inferential statistics

The Chi square test was used to determine association between categorical variables and categorised BMI category. Fisher exact was used to determine association between categorical variables and categorised BMI when one of the expected cell counts was less than 5. The Wilcoxon signed-rank test was undertaken to assess for association between diet intake (energy, fat, protein, carbohydrate) and un-categorised BMI because the data were highly skewed.

The variables that were found to be significantly associated with BMI category at 20% significance level were considered in the multinomial logistic regression to determine further significance in the multivariable situation. The multinomial logistic regression was used because the BMI category outcome was nominal and had more than 2 categories. . Normal weight was used as the base category in relation to underweight and overweight/obesity categories. In multinomial logistic regression the relative risk ratios (RRR) were interpreted in a similar way as the odds ratios (OR). Pair wise correlation was used to check for correlation among the independent variables and significant variables ($p < 0.05$) with a correlation greater than 70% were excluded from the modelling process. (Only one of the variables was excluded and not both.)

3.5 Ethical consideration

The authority and approval to use the BT20 data for the study was provided by Professor Shane Norris (Appendix IIa), Director of the Developmental Pathways for Health Research Unit (DPHRU) at the University of the Witwatersrand. Ethical approval for the study was provided by the Human Research Ethics Committee at the University of the Witwatersrand (reference no: M120862 appendix 1Ib).

4.0 RESULTS

Table 7 describes the overall socio-demographic characteristics by gender among 17-year-old adolescent in Soweto, 2007/2008. Of the 227 subjects sampled, 99 (43.6%) were boys and 128 (56.4%) were girls. The majority were of black origin, with 56.1% of these being girls and 43.9% boys. More than 50% of the participants were delivered at public hospitals. Nearly all the 17-year-old participants' mothers had formal education. Of the 171 individuals whose mothers had secondary education 75 (43.9%) were boys and 96 (56.1%) were girls. Of those whose mothers had a post-secondary education, 9(56.2%) were boys and 7(43.8%) were girls. It was also observed that the majority of both boys and girls (>50%) lived in rented houses with indoor hot and cold water, toilet flush inside, own refuse bin and equally having a television and a fridge. Less than 50% had cars and washing machines for laundry (Table 7).

Table 7: The distribution of socio-demographic characteristics by gender in 227 17-year-old adolescents, Soweto, 2007/2008

Variable	**Number**	**Male (%) n=99**	**Female (%) n=128**
Mother's age group (years)			
<30	49	22(44.9)	27(55.1)
20-30	131	55(42.0)	76(58.0)
>30	47	22(46.8)	25(53.2)
Ethnicity			
Black	171	75(43.9)	96(56.1)
Coloured	53	24(45.3)	29(54.7)
Asian	3	-	3(100)
Place of birth			
Soweto	134	60(44.8)	74(55.2)
Diepmeadow	32	14(43.7)	18(56.3)
Mixed ancestral settlement	51	21(41.2)	30(58.8)
Suburban JHB	10	4(40)	6(60)

Birth weight(kg)			
Low weight	21	79(33.3)	14(66.7)
Normal weight	206	92(44.7)	114(55.3)
Type of hospital			
Public	202	91(45.1)	111(54.9)
Private	25	8(32)	17(64)
***Maternal education**			
No formal education	2	1(50)	1(50)
Primary	24	13(54.2)	11(45.8)
Matric	171	75(43.9)	96(56.1)
Post education	16	9(56.2)	7(43.8)
Type of home			
Shack	9	4(44.4)	5(55.6)
Flat	12	6(50)	6(50)
House	153	68(44.4)	85(55.6)
Shared house	20	11(55)	9(45)
Room	14	4(28.6)	10(71.4)
Own home			
Own	50	24(38)	26(52)
Rental Person	37	15(39.5)	23(60.5)
Rental local	120	54(45)	66(55)
***Water facilities**			
Indoor hot & cold	159	71(44.6)	88(55.4)
Indoor cold	30	13(43.3)	17(56.7)
***Toilet facilities**			
Flush inside	158	71(44.9)	87(55.1)
Flush outside	31	13(41.9)	18(58.1)
Refuse use			
Own bin	177	78(44.1)	99(55.9)
Own heap	9	4(44.4)	5(55.6)
Leave in street	41	17(41.5)	24(58.5)

***Television**			
Yes	138	60(43.5)	78(56.5)
No	52	23(44.2)	29(55.8)
***Car**			
Yes	42	12(28.6)	30(71.4)
No	148	71(48)	77(52)
***Fridge**			
Yes	140	59(42.1)	81(57.9)
No	51	25(49)	26(51)
***Washing machine**			
Yes	38	14(36.8)	24(63.2)
No	153	70(45.7)	83(54.3)
***Telephone**			
Yes	99	44(44.4)	55(55.6)
No	92	40(43.5)	52(56.5)

Note: * = Variable with missing data.

Table 8 summarises the WHO cut-off BMI category among 227 17-year-old Soweto adolescents.

Table 8: Body mass index using WHO cut-off percentiles for 17-year-old adolescents in Soweto 2007/2008(n=227)

BMI Categories	**Boys (%)**	**Girls (%)**	**Overall: (%)**	**P value**
	n=99	**n=128**	**n=227**	
Underweight	33(62.3)	20(37.7)	53(23.4)	0.002
Normal weight	58(41.1)	83(58.9)	141(62.0)	
Overweight	2(8.3)	22(91.7)	24(10.6)	
Obese	6(66.7)	3(33.3)	9(4.0)	

As shown in Table 8, those with percentiles lower than the 10^{th} were 53(23.4%), between 10^{th} and 85^{th} were 141(62.0%), greater than 85^{th} to 95^{th} were 24(10.6%) and greater than the 95^{th} percentile were 9(4.0%). The results showed a greater proportion of girls being overweight/obese

22(91.7%) when compared to their male counterparts 2(8.3%). The overall prevalence of underweight among the BT20 adolescents was 23.4%, overweight 10.5% and obese 4.0%.

However, for further analysis the overweight/obese participants were re-classified as overweight/obese (>85th percentiles), according to Mo-suwan et al [2000]. Therefore, from now onwards the prevalence of overweight/obese among 17-year-old adolescents in Soweto will be referred as 14.5% (33/227) and underweight as 23.4% (53/227).

Table 9 summarises the mean and standard deviation of BMI category in the 17-year-old adolescents from the study.

Table 9: Anthropometric body mass index characteristics of 17-year-old adolescents in Soweto, 2007/2008(n=227)

Gender	**Variable**	**No**	**Mean ± SD**	**Min & max value**	**Confidence interval**
Boys					
	BMI(kg/m^2)	99	20.4±4.2	15.6-37.3	19.5-21.2
	Height(m)	99	1.7±0.1	1.3- 1.9	1.7 - 1.73
	Weight (kg)	99	60.2±12.8	43.8-117.5	57.7 - 62.8
Girls					
	BMI(kg/m^2)	128	21.7±0.3	10.5- 30.5	21.1-22.3
	Height(m)	128	1.6±0.1	1.4- 2.0	1.62- 1.61
	Weight (kg)	128	55.9±10.3	26 - 86.3	54.05- 57.66

The boys' mean BMI was 20.4±4.2 kg/m^2 (95% CI 19.5-21.2) and the mean BMI for girls was 21.7±0.3 kg/m^2 (95% CI 21.1-22.3). The average height of the boys was estimated at 1.7±0.1 meters (95% CI 1.7 - 1.73) and girls at 1.6±0.1 meters (95% CI 1.4- 2.0). The average weight of the boys was 60.2±12.8 kg (95% CI 57.7 - 62.8) and that of girls was 55.9±10.3 kg (95% CI 54.05- 57.66).

Table 10 represents the dietary and energy anthropometric characteristics by gender in 17-year-old adolescents in Soweto, 2007/2008.

Table10: Daily energy and macronutrient intake assess by gender in 17-year-old adolescents, Soweto, 2007/2008

Variable	**Boys: Median(IQR)**	**P value**	**Girls : Median(IQR)**	**P value**	**Recommended Daily Allowance (RDA)**	
					Boys	**Girls**
Energy Intake (kJ)*	22474(14822-26744)	<0.001	18204(11226-21516)	<0.001	14322	10513
Fat(g)	189.4(119.9-239.8)	<0.001	176.4(99.5-220.1)	<0.001	-	-
Protein(g)	154.6(98.7-198.2)	<0.001	126.1(70.4-145.5)	<0.001	52	46
Carbohydrate(g)	596.98 (461-794.2)	<0.001	523.1(326.6-640.9)	<0.001	130	130
BMR(kJ)	7238(6018-11494)		6914(4695-9175)		-	-
EI : BMR(kJ	3.1(0.72-7.5)		2.7(0.21-11.2)		1.83	1.72

The median and IQR interquartile range (IQR) of diet content (fat, protein, and carbohydrate), energy, BMR and PAL by gender showed a significantly higher amount when compared to the daily allowance [Torun 2001]. The median macronutrient intake for boys was positively associated with BMI: fat 189.4g (IQR119.9-239.8, *P<0.001*), proteins 154.6g (IQR 98.7-198.2, *P<0.001*) and carbohydrate 596.98g (IQR 461-794.2, *P<0.001*) while the association for girls was fat 176.4g (IQR 99.5-220.1, *P<0.001*), proteins 126.1g (IQR 70.4-145, *P<0.001*.) and carbohydrates 523.1g (IQR 326.6-640.9, *P<0.001*). The median energy intake for boys 2,247(IQR 14822-26744, *P<0.001*) was positively associated with BMI and that for girls was 18204(IQR 11226-21516, P<0.001) as shown in Table 11.

Table 11 presents the overview association between socio-demographic characteristics and dietary intake and BMI of 17-year-old boys in Soweto 2007/2008.

Table 11: Distribution of socio-demographic factors by BMI among 17-year old boys in Soweto, 2007/2008 (n=227)

Variable	**Total**	**Underweight**	**Normal**	**Overweight**	**P value**
Energy intake cut off					0.08
Underreported (≤1.35)	4	1(25.0)	2(50)	1(25.0)	
Normal(cut off 1.36-1.54)	6	2(33.3)	2(33.3)	2(33.3)	
Over reported (>1.55)	89	30(33.7)	54(60.7)	5(5.6)	
Mother's age group(years)					0.385
<20	22	7(31.8)	14(63.4)	1(4.6)	
20-30	55	20(36.4)	32(58.2)	3(5.5)	
>30	22	6(27.3)	12(54.6)	4(18.2)	
Ethnicity					0.628
Black	75	25(33.3	45(60.0)	5(6.7)	
Coloured	24	8(33.3)	13(54.2)	3(12.5)	
Birth weight (kg)					0.148
Low	7	5(71.4)	2(28.6)	00	
Normal	92	28(30.4	56(60.9)	8(8.7)	
Type of hospital					0.024
Public	91	31(34.1)	55(60.4)	5(5.5)	
Private	8	2(25)	3(37.5)	3(37.5)	
Own home					0.523
Own	24	8(33.3)	13(54.2)	3(12.5)	
Rental person	15	5(33.3)	8(53.3)	2(13.3)	
Rental local	54	20(37)	32(59.3)	2(3.7)	
Toilet use					0.051
Sole usage	28	7(25)	17(60.7)	4(14.3)	

Shared	56	22(39.3)	33(58.9)	1(1.8)	
Car					0.048
Yes	12	4(33.3)	5(41.7)	3(2.5)	
No	71	24(33.8)	44(62)	3(4.2)	
Washing machine					0.046
Yes	14	6(42.9)	5(35.7)	3(21.4)	
No	70	23(32.9)	44(62.9)	3(4.3)	
Telephone					0.259
Yes	44	16(36.4)	23(52.3)	5(11.4)	
No	40	13(32.5)	26(65)	1(2.5)	

Note: ξ= No male Asian

Of the 89 boys that showed over reported energy intake, 54 had normal weight (60.7%) while 5 experienced overweight (5.6%) as shown in Table 11. Over 90% of the boys were delivered in public hospitals and 60.4% of this group had normal weight and 5.5% were overweight. Equally among the boys who made use of a sole toilet, 14.3% were overweight while of those who shared a toilet, only 1.8% were overweight. Among the boys from homes with washing machine, 21.4% were overweight versus 4.3% who did not own one, as shown in Table 11.

Table 12 describes the overview relationship between the socio-demographics of 17-year-old girls and their BMI category.

Table 12: Distribution of socio-demographic characteristics by BMI category in 17-year-old girls in Soweto, 2007/2008

Variable	Total	underweight	Normal	Overweight	P value
Energy intake (kJ)					0.277
Underreported (cut off <1.35)	17	2(11.8)	9(52.9)	6(35.3)	
Normal(cut off 1.36-1.54)	10	2(20.0)	5(50.0)	3(30.0)	
Over reported (cut off <1.55)	101	16(15.8)	69(68.3)	26(15.8)	

Mother's age group (years)					0.333
<20	27	3(11.1)	19(70.4)	5(18.5)	
20-30	76	12(15.8)	52(68.4)	12(15.8)	
>30	25	5(20.0)	12(48.0)	8(32.0)	
Ethnicity					0.042
Black	96	11(11.5)	63(65.6)	22(22.9)	
Coloured	29	8(27.6)	19(65.5)	2(6.9)	
Asian	3	1(33.3)	1(33.3)	1(33.3)	
Place of birth					0.510
Soweto	74	10(13.5)	46(62.2)	18(24.3)	
Diepmeadow	18	3(16.7)	13(72.2)	2(11.1)	
Suburban JHB	6	1(16.7)	3(50)	2(33.3)	
Birth weight					0.373
Low	14	4(28.6)	8(57.1)	2(14.3)	
Normal	114	16(14)	75(65.8)	23(20.2)	
Type of hospital					0.236
Public	111	15(13.5)	73(65.8)	23(20.7)	
Private	17	5(29.4)	10(58.8)	2(11.8)	
Own home					0.550
Own	26	6(23.1)	14(53.9)	6(23.1)	
Rental person	23	3(13	17(73.9)	3(13)	
Rental local	66	8(12.1)	44(66.7)	14(21.2)	
Water use					0.233
Sole usage	37	7(18.9)	21(56.8)	9(24.3)	
Shared	30	4(33.3)	24(80)	2(6.7)	
No access	38	5(13.2)	24(63.2)	9(23.7)	
Water facilities					0.855
Indoor hot & cold	88	14(15.9)	58(65.9)	16(18.2)	
Indoor cold	17	2(11.8)	11(64.7)	4(23.5)	
Toilet use					0.594

Sole usage	46	9(19.6)	29(663)	8(17.4)	
Shared	59	7(11.9)	40(67.8)	12(20.3)	
Television					0.389
Yes	78	14(18)	48(61.5)	16(20.5)	
No	29	2(2.9)	21(72.4)	6(20.7)	
Car					0.465
Yes	30	6(20)	17(56.7)	7(23.3)	
No	77	10(13)	52(67.5)	15(19.5)	
Fridge					0.306
Yes	81	13(16.1)	49(60.5)	19(23.5)	
No	26	3(11.5)	20(76.9)	3(11.5)	
Washing machine					0.464
Yes	24	3(12.5)	14(58.3)	7(29.2)	
No	83	13(15.7)	55(66.3)	15(18.1)	

As shown in Table 12, out of the 101 girls that over reported their energy, 15.8% were overweight while 68.3% had normal weight. Girls from the black community were overweight (22.9%) when compared to those of coloured race (6.9%). Those that were delivered in Soweto Township were 24.3% overweight as compared to those from Diepmeadow (11.1%) and Indian/coloured townships (10%) respectively (Table 12).

Tables 13 and 14 show the results of the multivariate multinomial logistic regression of factors associated with overweight, relative to the base category normal weight. The relative risk ratios **(**RRR), which are interpreted in a similar way as odds ratios(OR) were used to express the unit change per explanatory variable as shown in Tables 13 (boys) and 14 (girls) respectively.

Table 13: Relative risk ratios associated with BMI category among 17-year-old boys in Soweto, 2007/2008

BMI	Variable	Number	RRR (95% CI)	P value	ΦRRR (95% CI)	P value
Underweight						
	Washing machine					
	Yes	14	1.00		1.00	
	No	70	0.47(0.11 - 1.97)	0.302	0.48(0.12 - 1.9)	0.300
	Car					
	Yes	12	1.00		1.00	
	No	71	0.44(0.09 - 2.16	0.309	0.52(0.11 - 2.4)	0.406
	Protein	99	0.98(0.96 - 10)	0.182	-	-
	Fat	99	0.98(0.95 - 1.0)	0.331	1.0(0.98 - 1.0)	0.988
	Carbohydrate	99	0.99(0.97 - 1.0)	0.302	0.99(0.99 - 1.0)	0.925
	Energy intake	99	1.0(0.999 - 1.0)	0.325	1.0(0.99 - 1.0)	0.829
Over weight/obese						
	Washing machine					
	Yes	14	1.00			
	No	70	0.1 (0.01 - 0.81)	0.03	0.1(0.01 - 0.82)	0.032
	Car					
	Yes	12	1.00			
	No	71	0.15(0.01 - 1.41)	0.095	0.17(0.19 - 1.51)	0.114
	Protein	99	0.99(0.96 - 1.01)	0.673	-	-
	Fat	99	0.98(0 .93 - 1.01)	0.408	0.99(0.95 -1.01)	0.507
	Carbohydrate	99	0.98(0.95 - 1.01)	0.161	0.99(0.96 -1.02)	0.161
	Energy intake	99	1.0(0.996 - 1.01)	0.283	1.01(0.99 - 1.01)	0.272

Key: RRR= Relative risk ratio; ΦRRR= adjusted

The relative risk ratios (RRR) of boys becoming overweight according to their SES characteristics, the macronutrients and the energy intake are summarised in Table 13. Comparing overweight boys to normal weight boys, there was no significant associated risk of becoming overweight by consuming fat (RRR 0.99, 95% CI 0.95-1.01) and carbohydrate (RRR 0.99, 95%

CI 96 - 1.01). The study found no significant association between boys energy intake and overweight (RRR 1.0, 95% CI 0.99 to 1.01).

The results showed that boys from homes with washing machine were less (RRR 0.01, 95% CI - 0.01-0.81) likely to become overweight than those from homes without washing. Boys from homes without washing machine were less (RRR 0.47, 95% CI 0.11-1.97) likely to become underweight than those from homes with washing machines.

Table 14 shows the RRRs of girls becoming overweight as a result of a unit change in the covariates in relation to their BMI.

Table 14: Relative risk ratios associated with BMI category among 17-year-old girls in Soweto, 2007/2008

BMI	**Variable**	**Number**	**RRR (95% CI)**	**P value**	**ΦRRR (95% CI)**	**P value**
Underweight						
	Ethnicity					
	Black	96	1		1	
	Coloured	29	2.9(0.12 - 3.21)	0.069	2.8(0.89 - 8.57)	0.078
	Asian	3	9.0(0.32 - 254.55)	0.226	6.1(0.34 - 110.6)	0.221
	Fat	128	0.99(0.95 - 1.02)	0.668	1.0 (0.95 -1.01)	0.341
	Protein	128	1.0(0.98 - 1.01)	0.627	-	-
	Carbohydrate	128	1.0(0. 98 - 1.01)	0.853	1.0(0.99 - 1.01)	0.705
	Energy intake	128	1.0(0.99 - 1.02)	0.971	1.0(0.99 - 1.01)	0.455
Over weight/obese						
	Ethnicity					
	Black	96	1		1	
	Coloured	29	0.26(0.05 - 1.26)	0.095	0.25(0.05 - 1.20)	0.083
	Asian	3	2.1(0.13 - 37.27)	0.591	2.2(0.13 - 37.70)	0.585
	Fat	128	1.0(0.94 - 1.02)	0.833	1.0(0.96 - 1.011)	0.588
	Protein	128	1.0(0.98 - 1.01)	0.546	-	-
	Carbohydrate	128	1.0(0.98 - 1.01)	0.631	1.0(0.99 - 1.01)	0.894
	Energy intake	128	0.99(0.99 - 1.01)	0.664	1.0(0.99 - 1.01)	0.792

The results showed that girls from a mixed ancestral community (coloureds) were more likely to be underweight than black African girls (RRR 2.8, 95% CI 0.89-8.57), although this was not significant. However, the results should be interpreted with caution because of the large 95% CI. Girls from the Asian community were 2.2 (95% CI 0.13-37.70) times more likely to become overweight than black African girls although the results were not significant. The results also showed that girls from a mixed ancestral community (RRR 0.25, 95% CI 0.05-1.20) were less likely to be overweight than black African girls (Table 14)

There was no significant difference in dietary intakes among overweight girls when compared to normal weight girls: fat (RRR 1.0, 95% CI 0.96 - 1.01, p= 0.585), carbohydrate (RRR1.0, 95% CI 0.99 - 1.01, p= 0.894) nor energy (RRR1.0, 95% CI 0.99 - 1.01, p= 0.792). The trend was similar in underweight girls compared to normal weight girls (Table 14).

5.0 DISCUSSION

The main aim of the study was to examine the association between the dietary intake and BMI category among 17-year-old adolescents in the BT20 living in Soweto. The study was aimed at 17-year old adolescent because of the availability of data in BT20 study. Furthermore, South Africa does not have any documented dietary intake for 17-year adolescent and the data collected have provided a baseline information which will be followed up as the participants turn 22 years of age. The baseline data will provide future useful information on the changes in dietary intake from late adolescent to early adulthood among BT20 study in Soweto,. Although the results do not show statistically significant associations, probably due to the small sample size, the descriptive results provided useful insights on the prevalence of overweight and underweight among BT20 adolescent. Due to limited data on dietary intake among 17-year-old adolescents globally, the study at this stage compared the 17-year-old BT20 adolescents to the general adolescent range of 10-19 years old according to WHO definition of adolescent.

The mean weight for 17-year-old boys (60.2±12.8 Kg) was lower when compared to SANHANES-1 mean weight for boys 15-24 years [Shisana et al 2013] but the mean weight was similar to other South African adolescent earlier studies [Toriola et al 2012; Moselakgomo et al 2012] and elsewhere by Freedman et al [2007] and Aounallah-Skhiri et al [2011]. Similarly, the mean weight for girls (55.9±10.3 Kg) conformed to similar studies in South Africa [Toriola et al 2012; Moselakgomo et al 2012], Tunisia [Aounallah-Skhiri et al 2011], Spain [Vicente-Rodriguez et al 2008] and the USA [Freedman et al (2007].

Using the IOTF reference BMI cut offs, the overall overweight prevalence was 14.5% among the 17-year-old adolescents in the current study. This result was comparable to results from adolescent studies carried out in Spain, Russia, and USA that ranged from 9%-31% while those of China ranged from 0.2%-11% [Moreno et al 2001; Jinabhai et al 2003]. The overweight prevalence in the current study (14.3%) was lower than those previously described by Reddy et al [2008] in the 2002 (16.9%) South African National Youth Risk Behaviour Survey (SANYRBS). Participants in the Reddy et al [2008] study were 18 years of age. The prevalence of underweight among the adolescents in this study was observed at 23.4%. This was a very significant result indicating the coexistence of both overweight and underweight among 17-year-old Soweto boys. The prevalence was lower than those earlier reported by Reddy et al [2008] from the 2002 SANYRBS, which showed a prevalence of 9% underweight and overweight 16.9%. Equally, the National Food Consumption Survey (NFCS) of 1999 showed a prevalence of 10.3% underweight among South African children [Labadarios et al 2005].

On the basis of gender differences, both boys (33.3%) and girls (15.6%) showed a higher underweight when compared to other reports by Toriola et al [2012] where underweight among black Africans adolescents boys was 4.6% versus 5.3% girls. The prevalence of overweight boys (9.1%) in Toriola et al 2012 study was similar to the prevalence estimated in the current study (8.1%). However, the prevalence of overweight girls was lower (11.0%) in Toriola et al [2012] when compared to the result of 19.5% girls in the current study. In another similar report by Jacobs & De Ridder [2012], boys' underweight prevalence was 19.0% when compared with 11.0% of girls, while overweight was estimated at 1.0% for boys and 4.0% for girls among black South Africans, in rural areas of the North West Province of South Africa.

The current study found that girls were overweight/obese than boys, which confirms earlier similar reports from the 2002 SANYRBS findings where a higher proportion of adolescent girls than boys in South Africa were found to be overweight [Reddy et al 2008]. A detailed report from the Reddy et al [2012] SANYRBS survey equally showed that 0.7% of the boys were overweight in 2002 and 1.0% in 2008 versus 1.9% girls in 2002 and 1.3% in 2008 respectively. Similarly, other reports by the International Association for the Study of Obesity in 2011 estimated obesity among boys aged 5-17 years in South Africa at 13.6% and girls at 17.7% [OECD, 2012]. However, the opposite was observed by Monyeki et al (2008), where South African boys were more overweight than girls and were similar to those observed in Spain [Vicente-Rodriguez et al 2008] and China [Jinabhai et al 2003] where boys were more overweight than girls.

The present study showed a high prevalence of overweight among 17-year-old adolescents. Studies from other South African settings estimate the increase to be due to regular watching of television [McVeigh et al 2004] as well as fewer physical activities, consumption of snack foods and high-energy dense foods/micronutrient-poor foods [Temple et al 2006]. Also Lambert et al [2000] observed that fitness levels in 12-18-year-old adolescents in Western Cape schools was associated with obesity as a result of inactivity – measured by greater television viewing over time. According to findings by Wiecha et al [2006], increased television viewing by youths is closely associated with increased dietary intake. However, other reports by Ballard-Barbash et al [1996] showed an inverse association between energy intake and BMI and, therefore, differed from earlier reports by Fricker et al [1989] that showed a positive association between energy intake and BMI (overweight) category.

The study equally provided information on the gender and ethnic differences in overweight, probably resulting from the SES and socio-demographic factors that have been demonstrated to underline similar epidemics in other settings. The current study showed that black African boys residing in Soweto (6.7%) were less overweight than their coloured (12.5%) counterparts. The trend was similar to those of the SANYRBS reported by Reddy et al [2012], where in 2008 survey, 0.9% black Africans boys were overweight when compared to 2.3% coloured boys. Black Africans girls were 22.9% overweight versus 6.9% coloured girls. A similar trend in overweight was observed for the girls where black Africans girls were 1.4% overweight when compared to 2.6% of coloured girls.

Boys from homes with a sole toilet usage were more overweight (14.8%) compared to those from shared toilet 1.8%). The same similar pattern was observed for the girls from homes with washing machine where 29.2% were overweight versus 18.1% from non washing machine homes. This is because human physical laundry is a form of physical activity when compared to machine laundry. Excessive human calories are lost during human physical laundry when compared to sedentary life assisted washing machine. Other findings have indicated that adolescents from homes with poorer maternal education backgrounds are less likely to have accurate perceptions about high (sugary, fatty foods) and low- (fruits and non-starchy vegetables) energy dense foods. Most high energy dense foods have low nutrient content when compared to low energy dense foods with high nutrient content [WCRF/AICR, 1997].

The median daily dietary intake and energy intake for both boys and girls in this study was higher than the recommended daily allowance of the UK references [Torun 2001; FAO/WHO/UNU 2001; Torun 2005]. They were also significantly higher than those reported by Aounallah-Skhiri et al [2011]. Studies indicate that macronutrient and energy intake cannot fit exactly with the recommended allowance. This was further confirmed by the recent findings by Grobbelaar et al [2013] who estimated the daily carbohydrate intake at 334.7g exceeding the recommended daily allowance of 130g while in the current study it was estimated at 523g for girls.

The ratio of energy intake to basal metabolic rate (EI:BMR) cut offs < 1.55 in the present study showed misreported energy intake. This ratio was very high (79%)when compared to those earlier reported by dos Santos et al [2010], who showed that 65.6% of energy intake in adolescents is usually misreported. This misreporting (under or over) of dietary intake remains one of the difficulties in validating estimates of food intake [Macdiarmid & Blundell 1997]. As earlier reported EI:BMR has been used as a guide to assess the accuracy of food records where EI:BMR < 1.2 is regarded as low energy intake for body weight maintenance [Goldberg et al 1991]. On the basis of the EI:BMR<1.2, Gregory et al [1990] and Kleges et al [1995] found under-reporting of energy intake of approximately 39% and 54% respectively in the national surveys of the DNSBA and NHANES II respectively. However, in the current study the EI:BMR < 1.55 was used and more than 4% of boys and 13.2% of girls showed under reporting of energy intake versus 90% boys and 80% girls over reporting energy intake. The EI:BMR (PAL) cut offs of <1.55 were used in the study as against <1.22 cut-offs to assume the physical activity of the 17-year-old adolescents because cut offs of <1.55 is the value defined by the WHO as a sedentary level of energy expenditure [FAO/WHO/UNU 19985]. This cut offs of <1.55 was equally used in support of earlier reports by Black [2000] that the cut offs of <1.55 are preferable when the energy expenditure or physical activity of a population is unknown. Furthermore, the cut offs of <1.55 have also been reported by Ballard-Barbash et al [1996], Körtzinger et al [1997], Briefel et al [1997], Price et al [1997], Gnardellis et al [1998], Goldberg & Black [1998], Joffe et al [2010] and Joffe et al [2012] as the most appropriate method in assessing reported energy intake.

The analysis of the Australian Children's Survey by Rangan et al [2011] shows that under reporting is associated with higher BMI, higher PAL, living in an urban location and a lower level of parental education while over reporting is associated with a lower BMI and lower PAL. Studies have shown that dietary intake and energy intake play a significant role in determining the BMI. Excessive energy is usually converted and stored as fat mass, a purposive risk factor for overweight/obesity and other likely health consequences. The current study showed no risk associated with dietary and energy intakes in overweight or obese adolescents in either gender. However, there was a high prevalence of overweight/obese among 17 year old adolescents, indicating a likelihood of stored fat mass but no significant risk with dietary intake and energy intake. Such null association agrees with most cited cross-sectional studies and cohort studies [Anounallah-Skhiri et al 2011; Grobbelaar et al 2013] because of bias methodologies encountered in reported energy intake – for example, reporting bias, measurement errors etc. [dos Santos et al 2010]. In FFQ small details such as the food source and description, preparation or cooking methods are usually ignored, even though these details play a significant role in the type of food consumed. One major flaw is dependency on the participant's memory in identifying the food consumed and the evaluation of portion sizes [Willett 1998; Gibson 2005]. Therefore, misreporting bias of food consumed by participant is common, which might not be intentional [Willett 1998]. Information obtained should be rough estimate of total food intake over the designated period of time.

Also, the association between dietary intake and energy intake with overweight is a complex inter-related complex system because of other influential risk factors mentioned earlier [Goedecke et al 2005; Kruger et al 2005]. The non inclusion of risk factors such as physical exercise that have been shown to be significantly associated with overweight, may limit the significant outcome of this study [Aounallah-Skhiri et al 2011; Thivel et al 2013]. Studies show that high intensity physical exercise is significantly associated with high adolescent weight loss [Thivel et al 2012], which might be masking the real significant association with overweight in this study. The non inclusion of physical exercise might have contributed to the increased prevalence of overweight among the adolescents in Soweto, indicating overweight as an emerging health risk [Jinabhai et al 2003].

Earlier reports by Mela & Aaron [1997] indicated this variation in BMI and PAL to be linked to inaccurate information about dietary intake, especially when individuals perceive they are overweight even if they are not. This phenomenon of under reporting energy intake is not only common in overweight and obese individuals [Goldberg & Black 1998]. However, underweight subjects equally tend to over-report. For example, studies by Sigman et al [1989] found that most Kenyan children tend to report higher energy intake yet were underweight for their age. In addition, adolescents from under privileged socio-demographic locations may tend to over-report their energy intake when they are among their peers from high socio-demographic locations.

Under reporting may also be due to under-recording or failure of the respondents to record all the consumed or underestimate the foods consumed [Rangan et al 2011]. Previous reports by Macdiarmid & Blundell [1997] show that individuals tend to under report because they feel embarrassed about what they eat or guilty about providing information about specific foods or the amounts they consume. Although the daily intakes for both girls and boys exceeded the recommended daily allowance, the girls’ energy intake was still lower than that of boys [Torun 2001; FAO/WHO/UNU 2001; Lambert et al 2004; Torun 2005].

The information from interviewer-led FFQ are usually vast and in certain populations the cognitive ability to provide accurate summary of food intake over a longer period is limited [Siebelink et al 201; Wrieden et al 2003; Crozier et al 2010; Siebelink et al 2011]. According to Macdiarmid & Blundell [1997] the use of biomarkers in validating the record of foods eaten is important and at the same time takes account of individual psychological attention. Behaviour, memory and perception involved in self-reporting must be cross checked. However, Behaviour, memory and perception was not assess in this study because of cost restrictions.

The problem why adolescent are less likely to have healthy weigh are due to inter-relation of the factors associated with overweight/obesity risk. The individual level risks factors associated with overweight/obesity are inseparable from social, environment, community, and national risk factors. For example functional genes and environment associated with overweight/obesity were there and continue to be there as the vertical family lineage tree grows. Therefore, understanding the environment should also be a key factor. For example an adolescent with poor diet can increase the effects of functional genes, while a healthy lifestyle and early intervention will reduce the negative impact [Wellcome Trust Sanger Institute 2008]

6.0 CONCLUSION

The daily dietary and energy intake among 17-year-old adolescents residing in Soweto were higher than the daily recommended reference allowance for 17 year olds [FAO/WHO/UNU 2001]. There was no associated risk between the energy intake and overweight. However, the survey indicated a high prevalence of both underweight and overweight 17-year-old Soweto adolescents. The study, therefore, highlights the need for a comprehensive nutrition programme focusing on good eating practices and a general healthy lifestyle among adolescents. South Africa, being already in the upper middle-income status, according to the GDP, needs an integrated surveillance system for both underweight and overweight adolescents to track adolescents' lifestyles. A surveillance monitoring systems such as the launching of a BMI measurement program in Soweto communities and schools with minimal harm but huge maximum benefits should be instituted. Other implementation include strategies of discouraging sedentary lifestyles and promoting physical activity and healthy eating habits among adolescents in Soweto. Programmes such as overweight/obesity media education talks, schools competition on activities on good dietary habits should be encourage. Furthermore, similar investigations in other settings outside of Soweto are needed to augment the scarce data and information on adolescents' dietary behaviour and overweight to support the epidemiologic utility of the study in sub-Saharan Africa.

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8.0. APPENDICES

Appendix I: Abstract of the quantitative FFQ Table dietary intake used in the study (For more information contact DPHRU, Wits).

Generic Sketch (look up)	**A. Food items (with FPM numbers)**	**B. Description of food item**	**Tick for yes**	**C. Item code**	**D. Amount usually eaten(g) Generic/amount = g**	**E. Eaten every day**	**F. Eaten every week**	**G. Eaten Occasionally**	**H. Never eaten**	**Grams (g) /day**
						Times/ day	Times/ week			
	DAIRY-BLUE									
	1.Tea	Ordinary		4038						
		Herbal		4053						
		Rooibos		4054						
	1. Sugar in tea			3989						
	2. Milk in tea	Full cream		2718						
		Low fat 2%		2772						
		Skim fat free		2775						
		Other								
	1. Coffee			4037						

	2. Milk in coffee	Full cream		2718						
		Low fat 2%		2772						
		Skim fat free		2775						
		Other								
	2. Sugar in coffee			3989						
	2. Milk as a drink	Full cream		2718						
		Low fat 2%		2772						
		Skim fat free		2775						
	3. Buttermilk/maas	Buttermilk		2713						
		Maas		2787						
	4. Milk drinks, flavoured									
X	**5. Yoghurt**	Fruit, LF, sweetened		2732						
		Plain LF		2734						

Appendix II: Quantitative derived scoring of dietary intake (Further information contact DPHRU, Wits).

In a review undertaken by Dennis et al (2003, the authors devised a scoring system to denote the quality of the FFQ used as a dietary intake tool. Nine categories were assessed and include:

1. Did the instrument have a quantitative element?
    a. 0 pts = frequency only
    b. 1 pt = frequency (and amount)
    c. 2 pts = quantitative
    d. Possible score: 2 pts
2. How many food items were measured by the FFQ?
    a. 0 pts = not stated
    b. 1 pt = <=70 items
    c. 2 pts = 71 – 110 items
    d. 3 pts = 111 – 150 items
    e. 4 pts = >150 items
    f. Possible score 4 pts
3. Was the FFQ completed by in interviewer?
    a. 0 pts = not stated
    b. 1 pt = self
    c. 2 pts = interviewer
    d. Possible score 2 pts
4. Was the FFQ pretested in the study population?
    a. 0 pts = not stated
    b. 1 pts = yes
    c. Possible score 1 pt
5. Was the FFQ used a validated instrument?
    a. 0 pts = not stated
    b. 2 pts = yes or ref use of validated tool
    c. Possible score of 2 pts
6. Was the nutrient database used to code the FFQ specified or referenced?
    a. 0 pts = not stated
    b. 1 pt = yes
    c. Possible score of 1 pt
7. Was any measure of quality control described in the article?
    a. 0 pts = not stated
    b. **1 pt = any measure stated** [e.g. reviewing questionnaire for missing items, clarifying ambiguous responses, or spot checking by a second interviewer]
    c. Possible score of 1 pt
8. Was the FFQ focused on a recalled dietary period that was prior to diagnosis?

a. 0 pts = not stated or unclear
b. 1 pt = yes
c. Possible score: 1 pt

9. Was the survey time stated for either the FFQ or the whole questionnaire?
   a. 0 pts for not stated
   b. 1 pt = yes
   c. Possible score: 1 pt

Maximum points = 15

FFQ for BT20 participants score: 13

FFQ for WBS participants score: 11 (failed to meet no. 8)

Appendix IIIa: Approval letter from Birth to Twenty to use the data for the study.

DPHRU
MRC/Wits Developmental Pathways for Health Research Unit

University of the Witwatersrand
Private Bag 3, Wits, 2050, South Africa
Tel: +27 11 933 1122 Fax: +27 11 933 3424

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

3 August 2012

To whom it may concern,

Re: Access – Developmental Pathways for Health Research Unit/Birth to Twenty Data

This serves to confirm that the Developmental Pathways for Health Research Unit, Department of Paediatrics and Child Health, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg owns access to the Developmental Pathways for Health Research Unit data and that I have given Mr Clarence Yah permission to access the required data.

Yours faithfully,

Shane Norris (PhD)
Director and Associate Professor

DPHRU
MRC/Wits Developmental Pathways for Health Research Unit

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Appendix IIIb: University of the Witwatersrand Ethical Clearance Letter.

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Dr Clarence Suh Yah

CLEARANCE CERTIFICATE **M120862**

PROJECT The Association between Dietary Intake and Risk of Obesity among 17-year old Adolescents in Soweto Johannesburg, South Africa in 2007/2008

INVESTIGATORS Dr Clarence Suh Yah.

DEPARTMENT School of Public Health

DATE CONSIDERED 31/08/2012

DECISION OF THE COMMITTEE* Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 31/08/2012 **CHAIRPERSON** ....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Prof Tobias Chirwa

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...