To what extent have urban South African adolescents experienced the Nutrition Transition?

By

Chiedza Zingoni

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ABSTRACT

The nutrition transition is recognised as a change in dietary pattern from a low fat, high fibre diet to a high fat, high energy, low fibre diet. This change has been accompanied by an increase in nutrition related non-communicable diseases (NCDs) such as obesity, non-insulin dependant diabetes mellitus (NIDDM), and cardio-vascular disease (CVD). The impact on health is a rising concern because these NCDs are not confined to adults but are also being increasingly observed in children and adolescents in developing countries. The nutrition transition is driven by changing socio-economic conditions, food technology, distribution and marketing systems, and urbanization. The evidence on which the nutrition transition is based comes mostly from national aggregate data on adult samples and there is a dearth of information about the aetiology and characteristics of nutrition transition at a group or individual level in adolescents.

The aim of this study is to investigate the dietary intake and body composition outcomes, in a sample of South African urban adolescents in the context of the nutrition transition. These adolescents have been followed from birth within the Birth to Twenty birth cohort set in Soweto and Johannesburg. A pilot study was conducted to assess the quantitative food frequency questionnaire (FFQ) which was to be administered to measure usual dietary intake. Consequently, the FFQ was modified according to the findings from the pilot study. The modified FFQ was administered to a sample of 15-year-old adolescents (n=154) and demographic factors, physical activity, pubertal development, socioeconomic status (SES) and body composition were measured using routine cohort standard protocols. Bivariate and multivariate analyses were performed to investigate the associations of these factors with dietary intake (total energy intake (kcal), % fat, carbohydrate, sugar and protein intake) and body composition (body mass index, relative % fat and lean mass).

The macronutrient intake of the urban adolescent sample was 33.3% fat, 51.8% carbohydrate, 10.7% protein and 14% added sugar as a proportion of

total energy intake. The macronutrient composition of the current diet and the most commonly consumed foods suggests a transition towards the diet consumed by transitioned societies with a greater transition in the added sugar intakes. There were no significant predictors of energy intake in the linear regression analysis. No significant associations were observed between socioeconomic status (SES) and energy intake, % fat, carbohydrate or added sugar intake. However, SES was positively associated with % protein intake. Significant differences (p=0.015) in the prevalence of overweight and obesity between girls (24.7%) and boys (9.7%) were observed. The odds of being overweight or obese increased if the participant was female, had high SES and mature breast/genitalia development. None of the dietary intake variables had a significant association with the body composition outcomes.

A transition towards a typical 'western 'diet is evident suggesting that this sample of adolescents have a similar dietary risk for NCDs to their counterparts in transitioned societies. Possible intervention strategies are suggested in the light of the findings from this study.

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Abbreviations

AIDS: Acquired immune deficiency syndrome

ANC: Africa National Congress

ANOVA: Analysis of variance

BMI: Body mass index

BMR: Basal metabolic rate

BRISK: Black Risk Factor Study

Bt20: Birth To Twenty

CI: Confidence interval

CHD: Coronary heart disease

CHNS: China Health and Nutrition Survey

CHO: Carbohydrate

CORIS: Coronary Risk Factor Study

CV: Coefficient of variation

CVD: Cardiovascular diseases

DHS: Demographic Health Survey

DXA: Dual energy X-ray absorptiometry

EE: Energy expenditure

EI: Energy intake

FAO: Food and Agriculture Organization

FBS: Food balance sheets

FFQ: Food frequency questionnaire

FFM: Fat-free mass

FM: Fat mass

FPM: Food photo manual

GI: Glycaemic index

GNP: Gross National Product

HFCS: High fructose corn syrup

HIV: Human immunodeficiency virus

IDAF: International Defence Aid Fund

IDECG: International Dietary Energy Consultative Group

MET: Metabolic equivalent

MRC: Medical Research Council

MUFA: Monounsaturated fatty acid

NCDs: Non-communicable diseases

NIDDM: Non-insulin dependant diabetes mellitus

PAL: Physical activity level

PCA: Principal component analysis

PUFA: Polyunsaturated fatty acids

RDA: Recommended daily allowance

RDMX: Rand Daily Mail Extra

SAFOODS: South African Food Composition Database

SD: Standard deviation

SE: Standard error

SES: Socioeconomic status

SFA: Saturated fatty acids

TEE: Total energy expenditure

THUSA: Transition, Health and Urbanisation in South Africa

THUSA BANA: Transition, Health and Urbanisation in South African children

UNDP: United Nations Development Programme

UNU: United Nations University

USDA: US Department of Agriculture

VIGHOR: Vanderbiljpark Information Project on Health, Obesity and Risk Factors.

WHO: World Health Organisation

Chapter 1: Background to the study

1.0. Introduction

There is an increase in the prevalence of lifestyle related non-communicable diseases (NCDs) such as obesity, non-insulin dependant diabetes mellitus (NIDDM), and cardiovascular diseases (CVD) and mortality associated with these in developing countries (WHO, 2004; Popkin, 2003; Popkin, 2002a). The impact on health is a rising concern because these NCDs are not confined to adults but are also being increasingly observed in children and adolescents in developing countries (Popkin, 2003). These changes in the pattern of diseases are being attributed to changes in the dietary intake and physical activity patterns. This is termed the nutrition transition and is characterised by a shift from high physical activity levels and a diet high in carbohydrate, fibre and low in fat to more sedentary lifestyles and a diet with high fat, sugar, and processed foods (Popkin, 1994).The evidence on which this is based comes mostly from national aggregate data on adult samples and there is a dearth of information about the aetiology and characteristics of nutrition transition at a group or individual level in adolescents. The lack of data on children and adolescents are problematic because this is the time in the life course when eating attitudes and behaviours are being constructed (Kelder *et al.*, 1994; Moore, 1993; Nicklas, 1995), as well as a period that is important for the aetiology of some adult NCDs (McGill, 1997; Dietz, 1994; Power *et al.*, 1997). Understanding the dietary habits of adolescents will therefore enhance efforts to prevent NCDs by promoting healthy eating behaviours.

Economic, political, environmental, cultural, technological, social and demographic factors drive the nutrition transition (Tansey and Worsely, 1995). Accompanying the economic transition are changes in the dietary intake and physical activity levels (Popkin, 1998; Monteiro *et al.*, 2001a). South Africa has undergone major political changes and is undergoing a socio-economic transition. The aim of the current study is to determine to what extent South African urban adolescents have experienced the nutrition transition using individual dietary intake data. This study will investigate the urban South

African adolescent diet and body composition and the factors associated with these outcomes in a sample from the Birth To Twenty cohort in Soweto-Johannesburg. A brief historical background of South Africa is presented in the first section of this chapter to highlight the context in which the study is taking place. The nutrition transition is then described and the evidence that is available on this transition globally is critically reviewed. The various socio-economic factors that drive the nutrition transition are then discussed. The evidence available on the nutrition transition in South Africa is reviewed and the study aim and objectives stated. Finally the chapter concludes with a review of the dietary assessment tools used with adolescents and the selection of an appropriate tool for the current study.

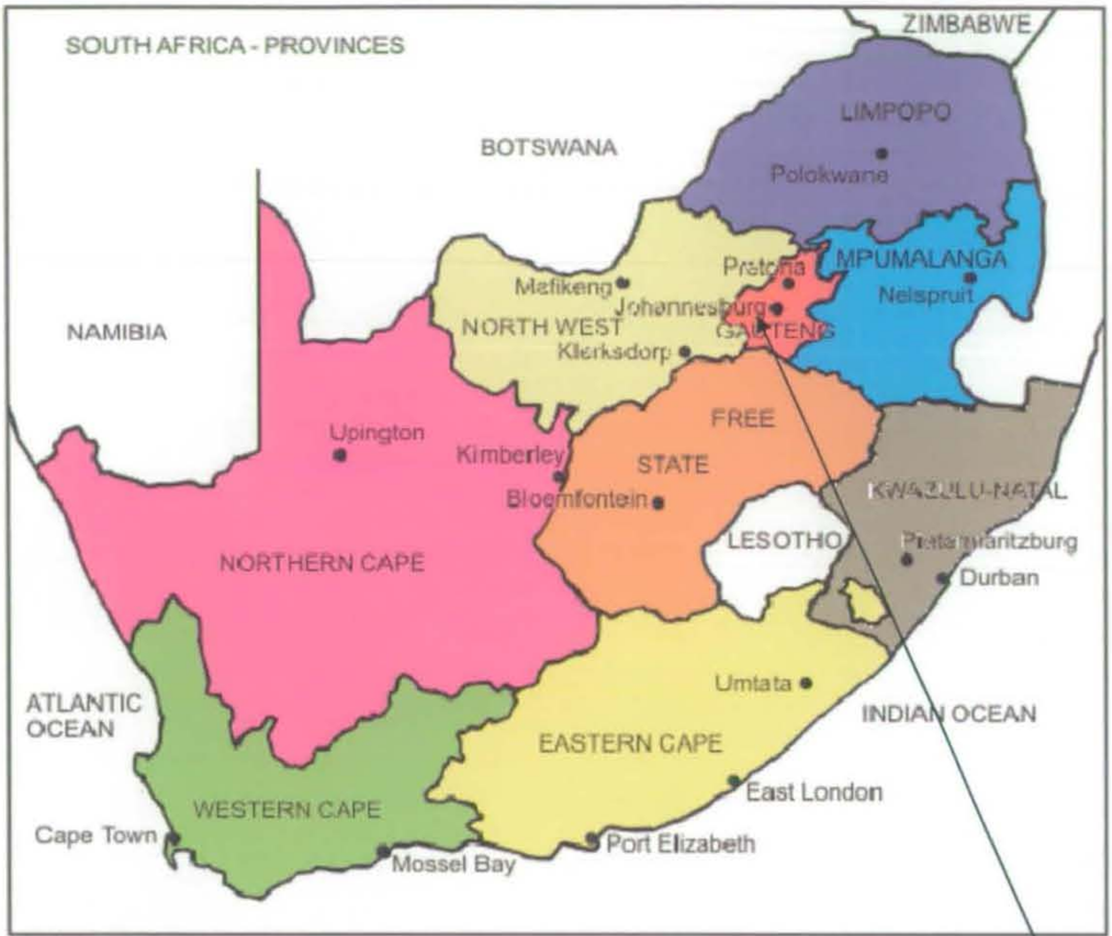
1.1. Historical background of South Africa

South Africa is located at the southern tip of the African continent. A map of South Africa showing its neighbouring countries is shown in Figure 1.1. It has a population of about 44.8 million people consisting of four ethnic groups. The proportions of these groups in the 2001 census were 79% Black, 9.6% White, 8.9% Coloured and 2.5% Indian[1] (Statistics South Africa, 2003). South Africa has a high burden of infectious disease accounting for 44% of the mortality in the year 2000 with 29% being attributed to HIV/AIDS. HIV/AIDS is taking a social and economic toll with a prevalence of 21.5% in 2003. The incidence of HIV/AIDS increased rapidly in the 1990s and places a strain on the health system. About 25% of public health spending is related to HIV/AIDS treatment. HIV/AIDS has also resulted in an increase in infant mortality and a decline in life expectancy to 42.73 years (Horton, 2005). Lifestyle related non-communicable diseases (NCDs) are on the increase accounting for 37% of the deaths in the year 2000 (Bradshaw *et al.*, 2003).

South Africa is classified by the World Bank as a middle income country and occupies a dominant economic position in Africa (World Bank, 2005). This country has one of the highest rates of income inequality in the world. About

[1] **Disclaimer**: The population groups identified by the Population registration Act were White, Black, Coloured (mixed descent) and Indian during the apartheid era. These terms are used in this work even though people are no longer required to register as such. This classification had a significant social and economic impact and therefore has been maintained as such.

Figure 1.1: Provincial map of South Africa



(ANC, 2004)

48.5% of the population are below the national poverty line. The income inequality was partly due to South Africa's apartheid history which resulted in skewed distribution of wealth, earning inequalities and high unemployment of the Blacks (UNDP, 2003). The daily per capita income (rands) was 10.7, 17.9, 30.0 and 85.8 for Black, Coloured, Indian and White population groups respectively in the year 2000 (Barbarin and Richter, 2001). The Whites earned eight times what the Blacks earned per day illustrating the high income inequalities. South Africa's history of apartheid is briefly described in the following section.

1.1.1. Apartheid (1948 -1994)

Apartheid is an Afrikaans word (South African language derived from Dutch) meaning apartness or separation. Apartheid was a national government policy introduced by the Afrikaner-dominated National Party after their victory in the 1948 parliamentary election that encouraged separate development of different population groups. Apartheid was used to describe the continuation of racial segregation since 1948 since this was already in place for almost 300 years. Before 1948 however most of the rules were informal but after the 1948 general election victory the race relations were enforced by law (Lapping, 1989). The white minority controlled the political and economic structure with the black majority providing cheap labour (Seidman, 1980). The argument of the ruling National Party was that separate development was in the interest of Blacks as it would enable them to govern themselves and to have their traditional institutions restored and respected in their homelands. The policy had been designed to have two stages whereby in the first, Blacks would be needed and allowed to work in towns followed by a stage where they all would be excluded. No date was specified for this total exclusion however.

Several laws were put in place to ensure this racial segregation and a legal basis for prosecuting those who broke these laws. Some of these laws which formed the backbone of apartheid are discussed briefly. The Native Land Act (1913) separated South Africa into Black and White areas. Under this act 13% of the land in the poorest and least productive parts was allocated to Blacks who formed the majority of the population (Seidman, 1980). These areas assigned to Blacks became known as the homelands. The Group areas Act (1950) empowered the government to mark off areas for residence by the different population groups and to move each group by force if there was defiance. The Population Registrations Act (1950) required all citizens to register as Black, White, Coloured or Indian. The population group in which a person was registered was the decisive indicator dictating where they could live, what they were allowed to do and what facilities they could access (Lapping, 1989). The restriction and regulation of the movement of Blacks in the country was facilitated by the introduction of Pass Laws in 1952. The Separate amenities Act (1953) created among other things separate buses, hospitals, schools, restrooms and drinking fountains for the different population groups (IDAF, 1991). In 1955 the Bantu Education Act transferred control of schools for Africans from provincial councils to the Department of Native Affairs. This provided poor quality education, the education curriculum was distorted, there were poor physical conditions, overcrowded classrooms, few textbooks and teachers who were not well trained. In 1975-76 the government allocated 2.88% of the budget for White, 0.53% Coloured, 0.22% Asian and 0.70% for Black education (RDMX, 1979).

With time the black majority began to radicalize and mobilize themselves to end this apartheid rule (Lapping, 1989). A defiance campaign was initiated in 1952 whereby the Africa National Congress (ANC)[2], Indians and Coloureds made a plan for defiance of unjust laws. They wrote to Malan, the prime minister to repeal the Pass Laws, Group Areas Act and Bantu Authorities Act. After there was no action volunteers were instructed by the ANC to non-violently court arrest in order to embarrass the government by making the prisons overcrowded. In 1955 the ANC adopted the Freedom Charter, demanding for equal political representation for all the races. There was growing national and international opposition to apartheid rule to which the South African government responded violently. This started a series of unrest and demonstrations. South Africa was facing economic sanctions from many companies and countries and was suspended from the United Nations in 1963 (Lapping, 1989; Glaser, 2001).

Nelson Mandela a leader of the ANC was imprisoned for life in 1964 after being accused of trying to overthrow the government (Mandela, 1994). A state of emergency was announced on the 12th of June 1986 as the strikes and violence continued to escalate. This stagnated the economy and hence changes needed to be effected to ensure an economic turnaround.

By the end of the 1980s, the National Party leaders concluded that white minority rule was incompatible with continued stability and long-run

[2] Africa National Congress is a South African political party and Black Nationalist organization founded in 1912. This organization spear-headed the fight against apartheid.

effectiveness of the state (Glaser, 2001). In 1986 the Prime Minister P.W. Botha announced that major constitutional changes should be made after consultation of all racial groups. F.W. de Klerk of the National Party became president in 1989 and opened negotiation with opposition parties removing the ban that had been imposed on them (Lapping, 1989). The end of apartheid was brought about by the will of the majority of the people who, by the end of the 1980s, were united in their desire to move on with a more equitable dispensation. Nelson Mandela was released in 1990 after 27 years in prison. The White government negotiated the end of minority rule and an interim democratic constitution was drawn up in 1993 and a transitional executive sat from 1993 to April 1994 (Glaser, 2001). Free and democratic elections were held in April 1994 and Nelson Mandela became the president on the 10th of May 1994 which marked the beginning of a new era (Mandela, 1994).

1.1.2. Post-apartheid

A number of social and economic reforms had to be initiated by the democratically elected government to alleviate the effects of apartheid. A legacy of economic and social inequality had been inherited by this new government. This included poor access to healthcare and education, inadequate housing, poor sanitation high levels of unemployment and poverty for the majority of the population (Nowak, 2005; Michie and Padayachee, 1997). This posed major challenges for the new government. Some of the health and socio-economic indicators from the most recent sources after 2000 are shown by population group in Table 1.1.2 illustrating the inequalities that were created by the apartheid rule.

Table 1.1.2: Health and socio-economic indicators

Indicator	Black	Coloured	Indian	White
[1]Infant mortality rate (per 1000 live births)	45	41.1	(24.8)	--
[1]Under five mortality	54.4	58.6	(34.4)	--
[2]Unemployment (%)	28.1	17.1	10.0	4.1
[2]Access to piped water (%)	80.3	97.6	99.2	99.3
[2]Toilet facility (%)				
Flush toilet	39.4	83.9	97.7	98.6
Pit and bucket latrine	41.2	9.5	1.3	0.5
Chemical toilet	2.5	0.6	0.2	0.1
None	16.9	6.0	0.8	0.7
[2]Refuse removal (%)				
Removed by local authorities	47.0	85.4	97.2	91.6
Communal refuse dump	1.9	2.0	0.3	0.7
Own refuse dump	40.0	11.3	2.1	7.2
No rubbish disposal	11.0	1.4	0.4	0.5
[2]Type of dwelling (%)				
Informal (shacks in/out of backyard)	20.4	7.4	1.1	0.5
[2]Selected goods (%)				
Radio	68.7	75.3	91.0	94.7
Television	44.2	73.6	91.0	92.6
Computer	1.8	9.4	27.9	46.0
Refrigerator	39.4	73.2	96.2	97.6
Telephone in dwelling	12.0	43.2	74.8	78.6
Cell-phone	24.6	31.0	58.9	74.6
[3]Literacy rate (1996) (%)	83.1	91.4	95.6	99.3

[1]Department of Health, 2004; [2]Statistics South Africa, 2003; [3]Statistics South Africa, 2001. -- figures were based on fewer than 250 cases and were suppressed and those in parenthesis () are based on 250 – 499 cases.

Childhood mortality rates are basic indicators of a country's socio-economic level and quality of life. Infant and under-5 year mortality rates were highest in the Black and Coloured population. No significant changes were observed at the national level when the mortality rates in Table 1.1.2 in the 2003 Demographic Health Survey were compared to the 1998 survey (Department of Health, 2004).

The overall unemployment rate is high at 24% for the whole population which is similar to the rate in 1994. There has been an increase in the employment growth but the labour force grew more rapidly. Between 1995-2003 employment increased by 1.25% whereas the labour force increased by 4% per annum. Racial inequalities in unemployment levels are still evident as shown in Table 1.1.2 with unemployment being more concentrated in the historically disadvantaged groups. The unemployment level for Blacks is almost seven times that of Whites. Blacks therefore made up approximately 80% of the total population and 90% of total unemployment (Arora and Ricci, 2005).

Inequalities in access to basic services were also evident. Almost all the Coloured, Indian and White households had access to piped water in their dwelling, on site or from a communal tap compared to 80.3% of Black households. About 39.4% of Black households had access to flush toilets compared to 98.6% for White households. A high proportion (16.9%) of Black households had no access to any toilet facilities in comparison to the other groups. Almost all the Indian and White households had their refuse removed by local authorities compared to about half of the Black households.

The proportion of the Blacks living in informal housing and the distribution of the selected goods illustrate the economic inequalities amongst these four population groups. The literacy rate for the Whites was almost 100% in 1996 compared to 83% for Blacks. The black majority had previously been deprived access to quality education resulting in differing literacy rates. Education standards have improved under the new government resulting in an increase in the literacy rates (Horton, 2005). An progressive increase in the literacy rate for the Blacks has been observed which was 66%, 77% and 83% in 1980, 1991 and 1996 respectively (Statistics South Africa, 2001).

South Africa's transformation initiated demographic, socio-political and economic transitions. Coupled with these transitions, there has been a rapid urbanization of Black South Africans with a consequent increase of informal housing (Lester and Binns, 2000). Urbanisation results in higher earning potential and protection from seasonal variation in food supply (Popkin, 1998). This increase in urbanization together with other socio-economic, technological and environmental changes are said to drive the nutrition transition (Tansey and Worsely, 1995). In developed countries, research has demonstrated that with increased urbanization there is an increase in the risk of nutrition-related NCDs because of a nutrition transition (Popkin, 1994). The nutrition transition and the available evidence are therefore reviewed to establish the progress of the nutrition transition in South Africa.

1.2. Nutrition Transition

1.2.1. Nutrition Transition Background

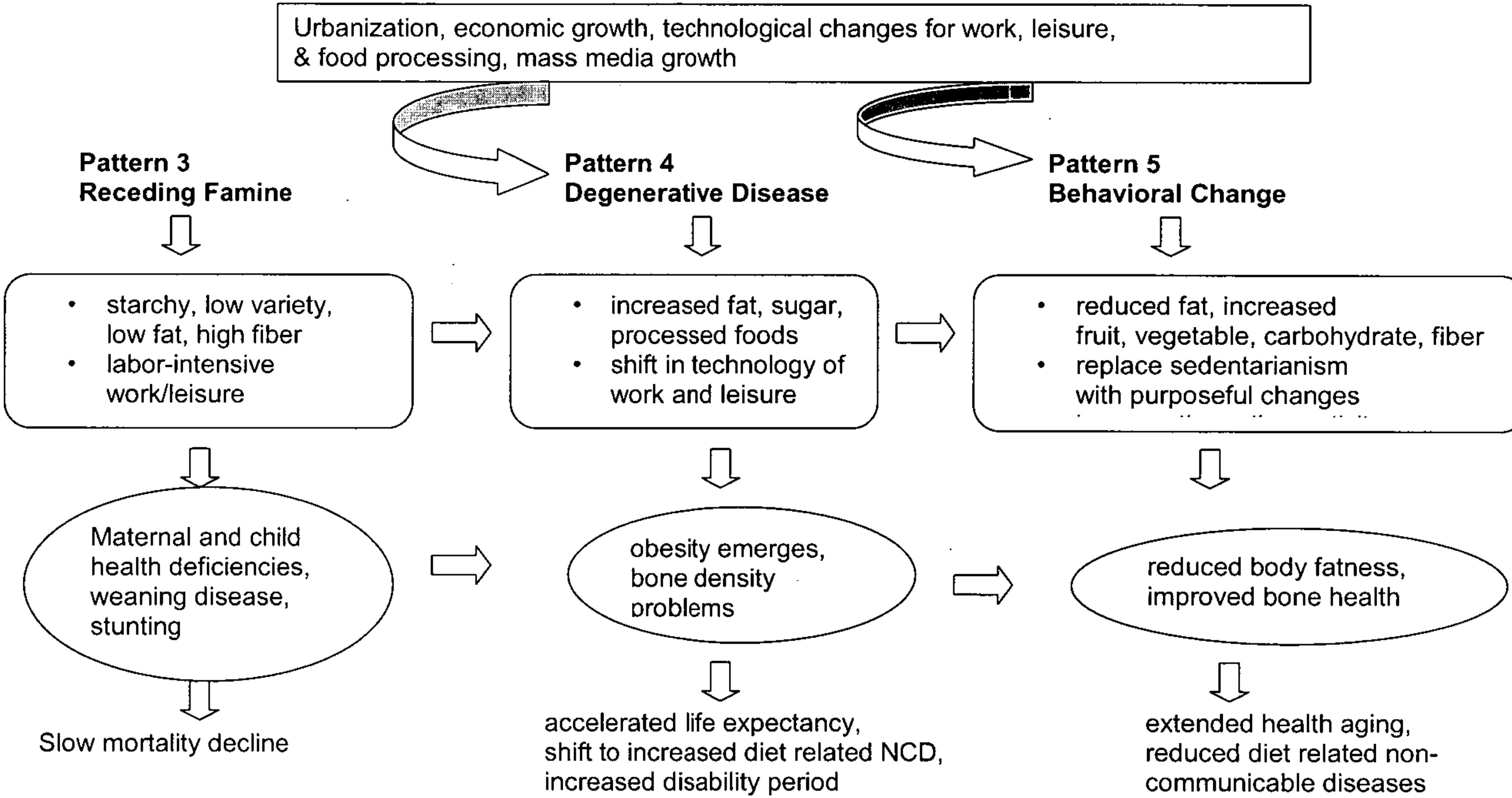
The nutrition transition is defined as a sequence of characteristic dietary and nutritional patterns associated with economic, environmental, cultural, technological, social and demographic factors (Tansey and Worsely, 1995; Popkin, 2003). Nutrition transition is occurring concurrently with the demographic and epidemiological transitions. These dietary changes are reflected in outcomes such as body size and composition changes (Popkin, 1994). The changes occurred over a long time in developed countries but developing countries are experiencing rapid changes (Monteiro, 2000; Popkin, 1998). Popkin has placed these dietary changes into five broad nutrition stages without any restriction to particular periods in human history as these changes are said to occur in the same sequence but at different times in different communities. These stages are (1) collecting food, (2) famine, (3) receding famine, (4) nutrition related non-communicable diseases (NCDs) and (5) behavioural change to reduce the degenerative diseases and prolong health (Popkin, 1994; Popkin, 2002b). The last three of these nutrition stages, which characterize the stage of transition for most countries at present are summarised in Figure 1.2.1. A brief account of all the nutrition stages follows:

(1) Stage of collecting food

This refers to the hunter-gatherer system that was in existence around 400 000 to 15 000 years ago. The diet was based on tubers, nuts, pulses, plants and wild game obtained through gathering, scavenging and hunting. About

50-80% of the diet was from plants whilst 20-50% was from animals resulting in high fibre and low fat intake (Harris, 1981; Popkin, 2002b). A large stature and lean body composition were characteristic of the hunter-gatherer population (Eaton *et al.,* 1988; Truswell and Hansen, 1976).

Figure 1.2.1: Stages of the nutrition transition



Source: Popkin, B. M. (2002b)

Infectious diseases were the major cause of morbidity and mortality whilst diet related NCDs were virtually absent (Cavalli-Sforza, 1981; O'Keefe and Cordain, 2004). The diet appeared to have a protective effect against a number of diseases associated with 'Westernised' communities such as atherosclerosis, coronary artery disease and some cancers (Walker, 1956). However, this could be because facilities in these populations did not allow for easy diagnosis of these conditions and most deaths were attributed to infections and deficiency diseases (Rose, 1972). The life expectancy was also low (Popkin, 1999), therefore they could have died before the chronic diseases manifested.

(2) Famine stage

The famine stage occurred during the peasant-agricultural system. The first Agricultural revolution occurred about 10 000 to 15 000 years ago and this resulted in settled communities who engaged in cereal cultivation and animal husbandry (Tansey and Worsely, 1995). In this system domestication of livestock made possible the development of dairy products causing a shift from plant foods to increased dairy foods consumption. There was also a reduction in the diversity of plant foods consumed. This resulted in a change in the disease ecology as deficiency diseases began to increase as diversity decreased. There were periods of famine when food was scarce because of seasonality. This nutrition transition stage is associated with a reduction in body stature (Eaton and Konner, 1985).

(3) Receding famine stage

From about the mid 18th century there was increased abundance of food as a result of the introduction of potatoes, legumes and maize as well as improved farming methods such as crop rotation and some degree of mechanization. These changes marked the second agricultural revolution (Tansey and Worsley, 1995).

There was increased consumption of meat as its production became faster. There were improvements in the storage of food with the advances in technology such as refrigeration, canning, freezing and radiation treatment (Popkin, 2001). There was therefore a lack of seasonal availability of foods. The body stature increased in this stage (Popkin, 1994).

(4) Stage of nutrition related non-communicable diseases

The Industrial revolution in the late 18th and early 19th century resulted in further dietary changes (Tansey and Worsley, 1995). It resulted in a diet with increased fat, sugar, salt, and highly processed foods that were low in fibre and characteristic of most present day societies. This diet has been termed the 'western' or 'affluent diet' (Popkin, 1994). Technological advances made the introduction of salt, sugar, and other additives simpler and less costly resulting in increased availability and consumption of these products. This food processing is said to have altered crucial nutritional characteristics of the hunter-gatherer diet increasing the risk of NCDs. These characteristics are the macronutrient composition, fatty acid composition, glycemic load, micronutrient density, acid-base balance, sodium-potassium ratio and the fibre content (Cordain *et al.*, 2005). Accompanying these changes was a transition to more sedentary lifestyles because food production, processing and preparation had become more mechanized. These changes saw a concurrent increase in the prevalence of obesity and diet related NCDs. This change happened slowly in developed countries, whereas in developing countries it has happened far more rapidly (Popkin, 2003).

(5) Behavioural change stage

Behavioural change occurs to a diet low in fat, processed foods, sugar and high in fruits and vegetables to prevent the occurrence of nutrition related NCDs in this stage. This stage can be influenced by government policy and changing consumer preferences as there is increased awareness of the risk factors of NCDs (Popkin, 1994).

The nature and extent of changes in these stages are not uniform among countries and even within a country as they are influenced by various factors.

Whilst the nutrition transition refers to all these stages it is commonly used to describe the transition from the receding famine to the degenerative disease stage (Kim *et al.*, 2000; Monteiro *et al.*, 2000; Popkin, 2003). In this work therefore the term nutrition transition will be used to refer to this shift from a diet high in unrefined carbohydrate and low in fat to a diet high in fat, processed foods and sugar with consequent increases in the obesity and NCD prevalence. It is important to look at the evidence on which this nutrition transition is based.

1.2.2. What is the evidence of the nutrition transition globally?

Popkin (1994) gives examples of the nutrition transition in different countries. These are based on national data from food balance sheets (FBS). FBS are a national account of the annual production of food, changes in stocks, imports and exports, and utilisation within a country (FAO, 2007). They show the pattern of a country's food supply and utilization during a specified reference period. This can be summarised in the equation below:

Stocks + production + imports = exports + feed + seed + waste + processing for food + other utilization + closing stock

FBS however have several shortcomings. They provide information on per capita food availability and not actual food consumption. The accuracy of FBS derived statistics are dependant upon the quality of the data which varies between countries (Kelly *et al.*, 1991). It should be noted that losses by pests and diseases are not usually available and production statistics may only be available for commercially important crops. Production from subsistence farming and home gardening are not included, some of the trade in both imports and exports may go unrecorded, and stock information may only be available from official marketing authorities and commercial establishments and not households. The amount of food actually consumed is likely to be lower than that estimated in FBS because household food losses during storage, preparation, plate waste, and that fed to domestic pets go unrecorded. Population counts may also be unreliable because some people who consume the food may be left out in the enumeration such as refugees, illegal immigrants and tourists. All these shortcomings will result in an inaccurate food availability figure (FAO, 2007).

FBS also do not give an indication of the differences that may exist in the diet consumed by different population groups such as people of different socio-economic status, ethnicities, or geographical zones within a country. Comparisons can not be made therefore between low and high socio-economic groups or urban and rural populations.

A study by Pomerleau *et al.*, (2003) revealed discrepancies of 5-270% when food availability data obtained from FBS were compared with actual food intake data from nutrition surveys. The FBS data overestimated intakes in 14 out of the 15 countries included in the study with great variations amongst the countries. This study however only looked at fruit and vegetable intake therefore it is not known whether the same discrepancies would be found with other food items. Lower variations would be expected with other foods such as cereals because fruits and vegetables are highly perishable therefore several losses may occur between production and their final destination, the consumer.

The discrepancies among countries could also be due to the fact that they used different methods with differing accuracies for measuring dietary intake. Some of the countries used one or two 24 hour recalls whilst others used one or seven day food records. The results would have been more comparable if the same dietary assessment methods had been used (Nelson and Bingham, 1997; Johansson *et al.*, 2001). Different age groups were also surveyed in the different countries. Extrapolations were made to make estimates for the groups which were not covered by the survey. This could be another source of error which would reduce the reliability of the study. Another important factor is that the food surveys were done at different times of the year in the different countries. Seasonality is important in determining food intake particularly fruits and vegetables as there are varying amounts available during different seasons. It is therefore possible that the observed discrepancies could have been lower if the food intake measurements were spread over the whole year as the FBS. It is good however that the FBS used for comparison were an average over three years reducing annual variation in food availability data and that these were matched with the period (years) of the dietary intake survey for each country. Generally this study illustrates that there are discrepancies between FBS data and measured dietary intake data but further studies are required to be able to determine the actual discrepancy as this study had several shortcomings.

Despite all these shortcomings FBS are useful for illustrating broad dietary changes by looking at overall trends in national food supply. They also give an indicator of social and economic change as the variety and amount of food change. FBS currently provide the only standardized data that permit international comparisons over time (FAO, 2004).

Inferences made about individuals based on aggregate FBS data are however vulnerable to ecological fallacy. For instance if a country has high fat per capita availability and an association is found with the overweight/obese prevalence inferences are sometimes made that high fat intakes are causing individuals to become obese. However the obese individuals may not necessarily be exposed to high fat intakes with other factors explaining the obesity. Disaggregating the data may reveal some variations and associations in individuals and population sub-groups that are not visible at the larger aggregate level.

It is therefore essential to obtain individual dietary intake data to analyse any associations with changes in body composition. Individual dietary intake assessment will also provide reliable dietary consumption data to enable comparisons of different population subgroups, socio-economic groups and geographical regions.

In the US, sugar, meat, and dairy product consumption is said to have risen whilst grain consumption declined in the first half of the twentieth century. This information was based on national food disappearance data compiled on a regular basis by the US Department of Agriculture (USDA) (Slattery and

Randall, 1988). Food disappearance data is food availability data calculated annually by the Economic Research Service in the US. The food available for domestic consumption is estimated as the residual after subtracting exports, industrial uses, seed, feed use and year end inventories from the sum of production, beginning inventories and imports. Food disappearance data typically overstates consumption just as the FBS due to losses which occur during distribution and processing.

Popkin and Nielson (2003) analysed food disappearance data from 103 countries in 1962 and 127 in 2000. In addition they also analysed data from three nationally representative surveys in the US. The results showed increased consumption of calories between 1962 and 2000. A 22% increase in consumption of calories was noted for the US. Whilst the food disappearance data can show trends in the availability of different foods the actual amounts that reach the consumer are unknown due to losses along the food chain. Actual consumption might therefore be much less or even more for those who practice subsistence farming and home gardening.

The nutrition transition in China has been described using data obtained from the routine China Health and Nutrition Surveys (CHNS) of adults aged 20-45 years (Popkin, 2003). This gives a clearer picture of the actual dietary changes taking place as they measured individual dietary intake. Random multistage cluster sampling was used to select a sample of about 16 000. The sample was followed up in 1989, 1991, 1993, 1997 and 2000. An average of three 24 hour recalls and household food consumption data were used to collect dietary information (Popkin, 2003). Dietary intake in g/capita/day for the years 1989 - 1997 is presented in Table 1.2.1. There is a decline in cereal and increased animal product consumption. Energy intake from fats increased to 27.3% in 1997 from 19.3% in 1989 whilst energy intake from carbohydrates declined. Energy density of the average diet increased by 13% between 1989 and 1997 (Popkin and Du, 2003).

Table 1.2.1: Changes in Chinese Dietary Consumption (grams/per capita/per day)

Food	1989	1997
Cereals	684	557
Meat and meat products	53	67.8
Eggs and egg products	11	22.7
Fish and seafood	25	27.9
Milk and milk products	1.3	1.7
Poultry and game	6.1	12.7
Plant oil	15	37.1
Fresh vegetables	377	345
Fresh fruit	15	21.7

Source: China Health and Nutrition Survey, 1989-1997 (Popkin, 2003)

Changes in the body composition have been observed in the CHNS (Popkin *et al.*, 1993; Du *et al.*, 2002). There was an overall shift in BMI to greater values. The prevalence of obesity and overweight increased from 3.5% (1982) to 14.1% (1997) (Du *et al.*, 2002).

Wang *et al.*, (1998) described the nutritional status and dietary patterns of Chinese adolescents aged 10-18 years using two cross sectional studies. These studies were conducted in 1991 and 1993 with 2236 and 2018 adolescents respectively. Three 24 hour recalls and household food consumption data were used to measure dietary intake. The sample was randomised and covered the whole week. This was good as it eliminates any weekend effects as dietary intake tends to be different on weekends. The household dietary data was used to identify any discrepancies with individual data and it also enabled ingredients added during cooking to be identified. This was therefore a good method of assessing dietary intake. Generally rural adolescents consumed more cereals and carbohydrates and less animal foods and total fat than their urban counterparts. Rural and urban adolescents obtained about 20-23% and 26-29% of their energy from fat respectively. These percentages had increased by 1993 in both groups whilst those for carbohydrates decreased. This study therefore shows evidence of a nutrition transition in Chinese adolescents. There is no mention of the time of year when the studies were conducted as this could have an influence on food availability and resultant food intake. There was no mention of any seasonal influences by the authors. This study is however useful as it stimulates further research in this age group and it also shows the association between urban environments and consumption of high fat foods.

Other evidence of the nutrition transition are based on obesity increases and body composition changes in different countries such as Thailand, New Delhi, Brazil, South Pacific islands and Chile (Ladda *et al.*, 1993; Chadha *et al.*, 1990; Monteiro *et al.*, 1995; Sichieri *et al.*, 1994; Atalah 1992). These studies have concluded that changes in dietary structure are reflected in nutritional outcomes such as stature and body composition. The studies do not usually have data on proximate determinants like diet or activity however. Griffiths and Bentley (2001) examine the nutrition transition in India using data from a nationally representative sample of 4032 women in Andhra Pradesh. 12% of the women were classified as overweight or obese. In the large cities where 4% of the population resides, the prevalence of overweight/obese was 37%. Logistic regression was performed to identify determinants of overweight/obese. There was very limited dietary information, with questions on frequency of eating milk/curd, pulses, green leafy vegetables, other vegetables, fruits, eggs, and meat/chicken/fish only. No quantities were given for the foods being consumed and there was therefore no indication of total energy intake which is important when studying overweight as it is the energy imbalance which results in weight gain. The authors' observation however was that the women who ate more fruits and vegetables were more likely to be overweight/obese. This was hypothesised to be because they were more likely to have resources to buy processed foods and consume diets high in fats and sugar.

Changes in stature, body size and obesity are well documented but there is need for evidence on the role of diet in effecting these body composition changes as most studies have not measured individual dietary intake. Evidence from the studies reviewed enables hypothesis generation of what is causing the obesity increases. Focus however, should be on measuring the determinants of the nutrition transition rather than the outcomes. Diet is important in outcomes such as obesity and NCDs but there could be other factors driving these changes such as early nutrition insults (Barker, 1994), changes in overall energy expenditure without any change in intake or unhealthy lifestyles such as smoking. Therefore a conclusion that diet is responsible for any obesity increases cannot be reached without actual data on the intake to test this hypothesis.

1.2.3. Economic and social factors of importance in the nutrition transition

Economic, political and cultural transitions accompany, facilitate and frame the nutrition transition. Factors driving the nutrition changes include population growth, urbanization, globalisation of food production and marketing, changes in work patterns to more sedentary occupations and mass media changes (Lang, 2002).

Urbanization has been shown to be strongly associated with dietary and activity changes. Rapid urbanization plays a major role in speeding up the nutrition transition. Drenowski and Popkin (1997) regressed the percentage of energy from each macronutrient on GNP (Gross National Product) per capita, urban population in that year and an interaction term between GNP per capita and proportion of urban residents using data from FBS from 1962-1990. All the variables were found to be highly significant ($p < 0.01$). Urbanization causes behavioural changes resulting in a shift of the dietary structure and physical activity at the national level. These changes are a decline in the physical activity due to better transportation, sedentary leisure activities such as watching television and playing video games as well as home electrification resulting in labour saving devices such as vacuum cleaners, washing machines and electric food mixers (Popkin *et al.*, 1995; Popkin, 2001). Urban residence is also associated with greater food availability with no seasonal fluctuations, increased consumption of convenience foods and away from home food consumption due to time constraints and increased marketing influences (Popkin and Bisgrove, 1988; Popkin *et al.*, 1995). It is however important to look at the individual level to ascertain the changes which actually take place. Rural and urban diets have been shown to differ significantly with increased consumption of polished grains such as rice, processed foods, and higher fat foods in urban areas (Popkin, 2002c). A clear link between urban residence and consumption of a higher fat, low fibre diet is evident. However this could be just a reflection of other socio-economic factors such as high income, higher education, cheaper food, increased accessibility and availability of food that are associated with urban populations.

In urban areas there is increased consumption of food prepared away from home which is usually higher in fat (Monteiro *et al.*, 2000; Popkin, 1998). Convenience and fast foods have larger quantities of fats and sugars to enhance stability and palatability. Nutrient control which is the degree to which one exercises some control over what goes into one's food diminishes when food is prepared outside of the home. Occupational patterns associated with modern lifestyles result in reduced compatibility with home food preparation (Tansey and Worsely, 1995; Popkin *et al.*, 2001; Nielsen *et al.*, 2002a). There is increasing penetration of Western style fast food outlets like McDonalds and Burger King in developing countries (Lang, 2002). This changing environment influences the dietary intake of the population, especially in urban areas where these restaurants first locate.

In the 1980s McDonalds introduced value meals, for example the 'Happy meal', which was made up of a high profit drink and fries plus low profit burger thereby increasing their profits whilst consumers increased their caloric intake (www.mcdonalds.com)). Portion sizes were also increased gradually, which resulted in further increases in calories eaten away from home. A study by Rolls *et al.*, (2002) showed that as portion sizes increased the study subjects consumed larger amounts. Male and female volunteers were served lunch on 4 occasions and reported the same hunger levels at the start of each meal. Each time the size of the main dish was increased from 500, 625, 750 to 1000g and the participants ate increasingly larger amounts.

Globalisation of mass media is another important factor influencing the nutrition transition (Popkin, 2002b). Advertising appears to encourage purchase of some 'unhealthy' foods which are high in fat/calories. Very few studies have however looked at the association between dietary shifts and changes in mass media advertisement of food. What has been studied is the level of TV ownership and viewing levels. These have been shown to be on the increase (Du *et al.*, 2002; Tudor-Locke *et al.*, 2003). Further studies are therefore required to establish the association of mass media and lifestyle changes to see if a significant association exists between mass media exposure and dietary patterns. Urban residents have greater access to mass media information therefore advertising potentially has a larger influence on their dietary choice. TV viewing not only results in sedentary behaviour but also increases snacking. It was positively associated with consumption of sodas, crisps, pastries, sweets and chocolates in a sample of 4211 Greek adolescents (Yannakoulia *et al.*, 2004).

International migration has been shown to have a significant effect on the diet of migrants. The movement of the Japanese to the US for example had a major impact on their diet and this is evident from the high obesity and nutrition related NCD prevalence in this population as compared to the same ethnic group residing in Japan (Marmot *et al.*, 1975). Among a sample of 3809 Japanese Americans classified according to the degree to which they retained a traditional Japanese culture the most traditional had coronary heart disease (CHD) prevalence as low as Japan whilst the ones most acculturated to the 'western' culture had 3-5 times this prevalence (Marmot and Syme, 1976). This was a cross sectional study and this has limitations as the people with CHD might have changed their dietary and lifestyle patterns after diagnosis of the diseases therefore this might introduce some bias by diluting the effects of the 'western' culture. The authors acknowledge this could have happened in this study as a high prevalence of CHD was found in the ex-smoker group who had preference for a Japanese diet lower in fat. Frisbie *et al.*, (2001) found in the 1992-1995 National Health Interview that the health of immigrants declined with increasing duration of their stay in the US. Health assessment was however based on self reports which are subject to bias.

Over the 20th century major changes in food production took place. Changes occurred in the types of products, processing, distribution and marketing technologies. In 1971 food scientists in Japan economically produced high fructose corn syrup (HFCS) a sweetener 6 times sweeter than cane sugar.

Apart from its use as a sweetener it also preserves, protects food against freezer burn, and increases palatability of products. This was convenient for producing cheap stable convenience and fast foods. The composition of Coke and Pepsi was changed from a 50:50 blend of sugar and corn syrup to 100% HFCS reducing production costs thereby increasing affordability of the product (Bray *et al.*, 2004). Fructose is said to bypass the normal metabolic pathway for sugar breakdown and arrives in the liver intact. It is then used as a building block for triglycerides. Soft drinks are therefore linked to increasing obesity as the triglycerides are building blocks for body fat (Bray *et al.*, 2004).

Generally as income increases, animal fat, animal protein and sugar increase whilst vegetable fat, vegetable protein and complex carbohydrate intake declines (Popkin *et al.*, 1995). In the Philippines income increases were associated with increasing high fat food consumption away from home. In China income increases resulted in increased meat consumption which constituted a major proportion of dietary fat intake (Popkin, 1989). Income increases have resulted in increased calorie consumption as estimated from FBS data (Rosen, 1999). As the years progress however income is having less effect on the national diet. Consumption of vegetable oil and sugar is increasingly becoming independent of national income due to increased mass production and a resultant reduction in price (Drenowski, 1998; Drenowski and Popkin, 1997).

Evidence from food balance sheet data for 1962-1990 revealed that fat consumption was less dependant on income as had been the case previously. Data for 98 countries with full datasets showed that low income nations had access to a relatively high fat diet. In 1962 a diet deriving 20% of energy from fat was associated with a GNP of $1475 but in 1990 the same diet was associated with only $750 (Drenowski and Popkin 1997).

Level of income and other factors determine socio-economic status (SES). Social class is almost universally related to health, relative economic power and access to education which in turn affects what people eat, choose and can afford. SES can be a broad composite measure combining income or proxies for income, education, occupation and place of residence or it can be measured using one of these indicators therefore it is difficult to compare studies on SES. It is however difficult to generalize studies using composite measures such as income and education as these may have independent and even antagonistic effects on dietary intake and physical activity patterns (Popkin *et al.*, 1995). Sobal and Stunkard (1989) show that in developed countries obesity tends to be greater in those of low SES whilst the converse is true for developing countries. In developing societies lower prevalence of obesity in low SES groups could be due to food inadequacy and high energy expenditure whilst in the high SES groups it could be because of increased availability and accessibility of food supplies, exposure to increased mass media advertising, access to fast foods outlets and reduced activity. In developed societies however the 'unhealthy' high fat food tends to be cheaper and therefore affordable for the low SES group whereas those with high SES can afford to buy 'healthier' foods and they tend to have better nutrition knowledge and therefore make more informed dietary choices. Large stature may be a sign of health and wealth in developing societies, the opposite of its meaning in developed countries (Sobal and Stunkard, 1989). These differing perceptions have implications for how the obesity epidemic might be experienced and opportunities for intervention in contrasting communities.

1.2.4. Nutrition transition and body composition

Researchers have shown that dietary and activity changes are related to body mass index (BMI) changes and increasing obesity prevalences (Popkin, 2003; Popkin and Doak, 1998; Bray and Popkin, 1998, Paeratakul *et al.*, 1998). Obesity is increasing rapidly in developing countries which is a major concern as problems of under-nutrition are still in existence (Wang *et al.*, 2002, Doak *et al.*, 2000; Martorell *et al.*, 2000, Steyn *et al.*, 1998; Popkin and Doak, 1998). There is therefore an interest in body composition, because obesity which is characterised by excessive body fat is a major health problem (Sokol, 2000; Must and Straus, 1999; Pi-Sunyer, 1993, Westrage and Deurenberg, 1989). Obesity is associated with NCDs such as non-insulin dependant diabetes mellitus, coronary heart disease, cancer, hypertension (Bray *et al.*, 1992; Steyn *et al.*, 1990; Colditz *et al.*, 1995; Beilin *et al.*, 1994).

Childhood and adolescence are critical periods in the development of obesity and therefore its prevention should be prioritised (Dietz, 1994; McGill, 1997). The impact of obesity during adolescence is not only physiological but also psychosocial being associated with poor body image, low self esteem, depression and poor school performance (Rogge *et al.*, 2004; Lee *et al.*, 2004; Puhl and Brownwell, 2001; Bronwell, 1984; Kaplan and Wadden, 1986).

The obesity risk factors are multifactorial including genetic, developmental, lifestyle and dietary factors (Haddad and Johnston, 1996). It has been reported that about 75% of the variation in % body fat and total fat mass is determined by lifestyle factors and culture with 25% being attributed to genetic factors (Bouchard and Perusse, 1988; Bouchard, 1991). Dietary and lifestyle factors are preventable therefore it is essential to study their impact on obesity and intervene appropriately. Fundamentally obesity is a result of chronic energy imbalance (Wang *et al.*, 2002; Weinsier *et al.*, 1998; Wells, 1998). Studies in South Africa have shown that as the population became more urbanized and ate a less prudent diet the prevalence of obesity increased (Vorster *et al.*, 2005; Bourne and Steyn, 2000; Steyn *et al.*, 1998). In the 1998 South Africa Demographic Health Survey 29.2% and 56.6% of men and women aged 15 or above were classified as overweight or obese (Puoane *et al.*, 2002). In the South Africa Youth Risk Behaviour Survey (n=9054) in 2002 17% and 4.2% of the adolescents were overweight or obese respectively (Reddy *et al.*, 2003). This is therefore an indication of the magnitude of the problem in South Africa. The current study will therefore investigate the association between dietary intake and body composition measures (BMI, % fat and lean mass).

1.2.5. Summary

A weak evidence base for the nutrition transition exists at an individual level. The evidence presented on previous pages shows that most of the information came from routinely collected data such as FBS, and food disappearance data. Routine data collection is subject to political influences and manipulation and this can therefore reduce reliability. These studies are open to ecological fallacy as the people in a generally exposed group are not necessarily exposed themselves. A relationship at a national level between food availability and outcomes such as diabetes and obesity does not establish them as being causally linked. Such studies may be confounded by a variety of factors which could explain the general relationship. The data is however valuable in generating hypotheses of areas which need further research. It is important to carry out studies which assess dietary intake, physical activity and body composition changes on an individual level to be able to relate any nutrition changes to changes in body stature. The shifts in diet and physical activity are a result of the economic transition which has led to industrialization resulting in dietary changes and a decline in energy expenditure as there is an increase in labour saving devices at home and work, motorized transport and physically undemanding leisure activities. Busy lifestyles, increased mass media exposure, and increased availability of fast food establishments have resulted in increased consumption of food away from home. This has resulted in inappropriate dietary patterns globally which has been related to the body composition changes.

The evidence reviewed suggests that economic, technological and social changes result in changes in the dietary intake and physical activity patterns. Rapid urbanization is accompanying the socio-economic transition occurring in South Africa, and an increase in the prevalence of NCDs is evident (Bradshaw *et al.*, 2003). This could possibly be because a nutrition transition is in progress. The evidence on the nutrition transition in South Africa is therefore reviewed in the following section to establish to what extent the nutrition transition has been experienced.

1.3. Nutrition transition in South Africa

A comprehensive narrative review of the nutrition transition in South African children was conducted. Searches were performed on Medline, Zetoc, ArticleFirst, Web of Science and Environmental Sciences databases using the following search terms: dietary/food/energy/macronutrient intake; South Africa; nutrition transition; children/adolescents/youths/teenagers; obesity; non-communicable diseases; nutritional status; food choice; nutrition knowledge. Literature was also identified through search engines on the internet using similar search terms. Additional sources of information were obtained from the bibliographies of the identified literature. Systematic reviews are known to be more objective as they are criterion based and therefore control bias and imprecision but they can also be limiting as they have a narrow focus. A narrative review was therefore chosen over a systematic review because it is comprehensive and covers a wide range of issues within a given topic (Collins and Fauser, 2005) which was desirable for the topic under investigation.

1.3.1. What is the evidence of the nutrition transition in South Africa?

In a narrative review by Bourne *et al.*, (2002) of the trend in the dietary intake of black adults from 1940-1992 there was a progressive shift towards higher fat and lower carbohydrate intakes even though intakes were still within the prudent dietary guidelines. Fat intakes increased from 16.4% to 26.2% and carbohydrate intakes decreased from 69.3% to 61.7% as a proportion of total energy among the black population aged 15-64 years over a 50 year period from 1940 to 1990 (Bourne, 1996). It would be interesting to know where this population stands on the nutrition transition 15 years after the end of apartheid rule which has been accompanied by socio-economic changes and increased urbanisation. The current study aims to investigate this nutrition transition with a focus on adolescents.

Food balance sheets between 1962 and 2001 have shown an increase in per capita food and energy availability in South Africa. An increase in energy supply of 318kcal was observed and a transition to increased fat intakes is evident (FAO, 2004). As a proportion of total energy intake the macronutrient composition was 21.2% fat, 68.3% carbohydrate and 10.5% protein in 1962 and 24.3% fat, 65.4% carbohydrate and 10.3% protein in 2001 (Steyn *et al.*, 2006a). These figures give an indication of the available food but not how they are distributed by age, gender or socioeconomic status (Steyn *et al.*, 2006a).

A study of five year old urban black South African children in 1984 and 1995 revealed a shift towards the 'western' diet. In 1984 a low fat diet (30% of total energy), and 61% carbohydrate was consumed and in 1995 this was 41% fat and 52% carbohydrate (MacKeown *et al.*, 1998). These dietary assessments were not done on the same sample therefore the difference in intakes could be a difference in the samples used and therefore do not reflect a real change.

The Black Risk Factor Study (BRISK) of the urban black population in the Cape Peninsula in 1990 revealed intakes of 27% fat, 64% carbohydrate and 13% protein in the 15 -18 year age group using the 24 hour recall (Bourne *et al.*, 1993). This sample had lower fat intake in 1990 than the study by MacKeown *et al.*, (1998) in 1984. This inconsistency showing a decline in fat intake could be because of the difference in the ages sampled and dietary intake tools.

The Coronary Risk Factor Study (CORIS) in 1979 administered a 24 hour recall to a white rural sample (n=1113) aged 15 - 64 years and mean fat, carbohydrate and protein intakes varied from 35-37%, 44.1-51.5% and 13.8-16.6% respectively , for the different age groups indicating that this group was already eating a 'western' diet in 1979 (Wolmarans *et al.*, 1988).

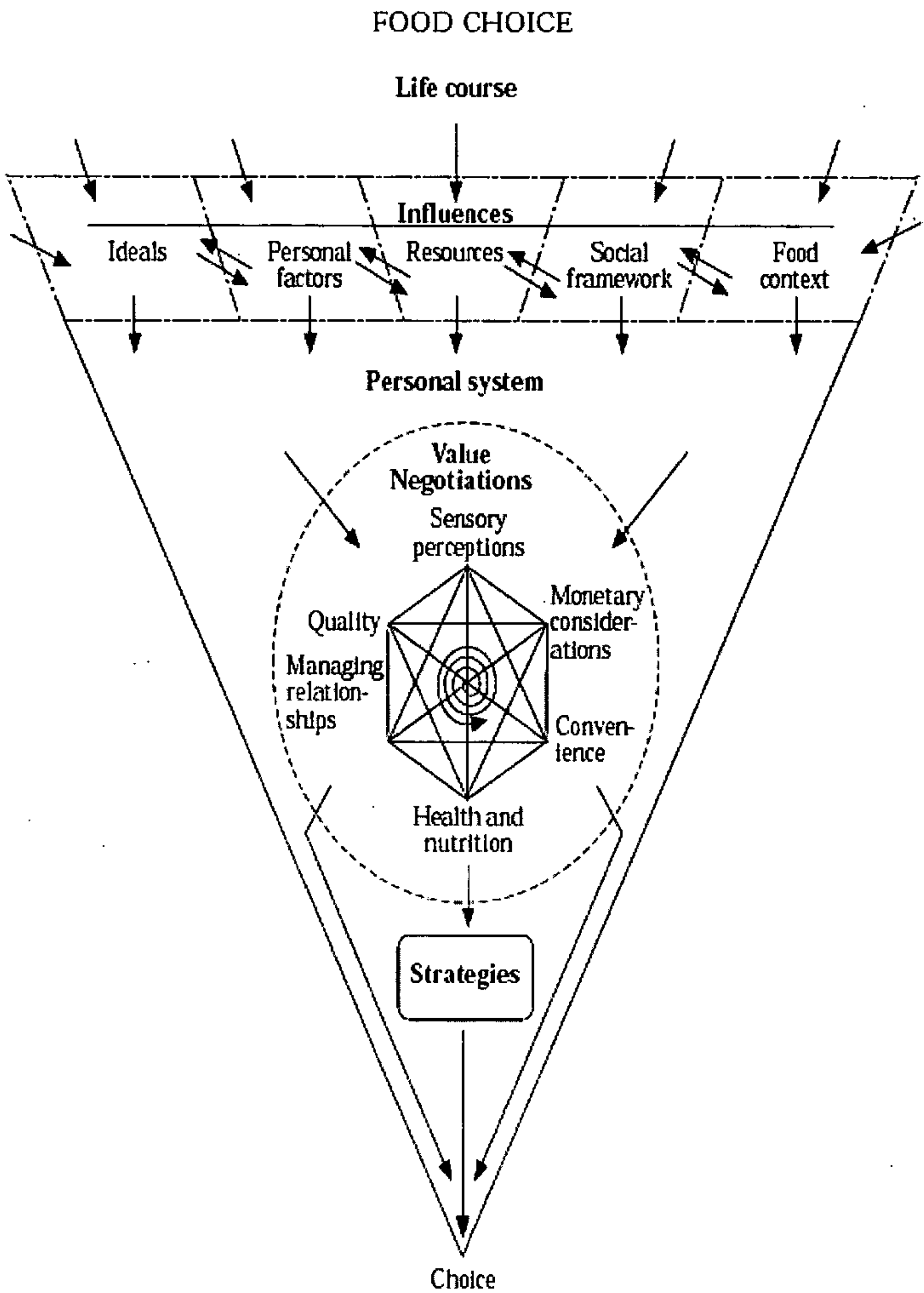
In a white urban sample aged 15 - 64 years in the Vanderbiljpark Information Project on Health, Obesity and Risk Factors (VIGHOR) study the macronutrient intake was 33.3-38.6%, 46.9-53.3% and 13.6-16.3 % fat, carbohydrate and protein respectively showing that this group had also transitioned (Vorster *et al.*, 1995).

In the THUSA study (Transition, Health and Urbanization in South Africa) conducted in 1996 and 1998 a quantitative FFQ was used to assess diet in a sample (n=1751) aged between 15 - 80 years and data is presented by gender and urbanization strata. The sample was selected by multi stage sampling from healthy adult volunteers. This selection could have introduced bias if the ones who volunteered were different from those who did not. There was no mention whether there were any significant differences between the volunteers and non volunteers. The authors acknowledge that the sample was not truly random due to logistic constraints such as availability of resources and accessibility to the volunteers. Dietary information was collected using a quantitative FFQ which was validated against a seven day weighed record in 4% of the participants. A change in diet composition was observed with increasing urbanization to decreased cereal and increased animal protein and fat consumption. The mean intake of the upper urban class stratum was 31% fat, 57% carbohydrate, and 13% protein of total energy intake. The rural, informal settlement and middle class urban strata were consuming 22% fat, 65% carbohydrate and 12% protein (MacIntyre *et al.*, 2002). This study shows the effect of urbanization in the shift towards a 'western diet' which is particularly important for many developing countries which are undergoing rapid urbanization. In the THUSA BANA (BANA means children) study in 2000 - 2001 dietary intake was assessed in 10-15 year-olds (n=1257) using a 24-hour recall. Fat intakes were between 26-27% of total energy intake for the different urbanization strata (Kruger *et al.*, 2005).

1.3.2. Food choice is important in the nutrition transition

It is important to understand why people eat what they do in order to be able to intervene appropriately to effect dietary change when needed. Food choice can be defined as the selection of foods for consumption resulting from the interaction of a variety of factors which include sensory, physiological and psychological responses of individuals and their interaction with social, cultural, environmental and economic influences (Buttriss *et al.*, 2004; Furst *et al.*, 1996; Mela, 1999). Food choice is therefore a complex process. Furst *et al.*, 1996 used a constructionist approach to build a conceptual model of food choice. This approach is designed to show the complexities of food choice rather than reducing information. In-depth interviews were conducted with 29 adults who were purposively sampled to ensure maximum variation in age, gender, socioeconomic status, family role and family situation. The study was not designed to be representative but to examine the range of factors in food choice among a group of diverse people. The verbatim transcripts were analysed using the constant comparative method. Original categories from the interviews were applied to the cumulative data and revised until group consensus was reached to develop a model (Furst *et al.*, 1996). The conceptual model that was developed is shown in Fig 1.4.

Figure 1.3.2: A conceptual model of the components in the food choice process



Source: Furst *et al.*, 1996, page 251

The major components were the life course, influences and personal system. The life course is the personal roles, social, cultural, and physical environment to which a person is exposed. The influences include factors such as resources (skills, money, knowledge, time), personal factors (age, gender, health status), ideals (beliefs and standards), food context (environment, availability, seasonality) and the social framework. The personal system involves value negotiations, that is weighing the different factors in making the final choice and strategies to effect this choice. The detailed description of these factors can be found in Furst *et al.*, (1996). It should however be noted that other populations may have other factors unique to them as this is a general model. Ideally the model should be examined further with a variety of participants in different settings.

My current study is based in South Africa in an adolescent age group therefore a review of factors influencing food choice in adolescents was conducted. In a study by Neumark-Sztainer *et al.*, (1999) the factors which influenced food choice in adolescents were taste, appearance, hunger and food cravings, time considerations, convenience, food availability, parental influence, benefits of food (health), mood, body image, habit, and cost. These findings were from 21 focus group discussions in a diverse racial/ethnic student population with an age range of 12-19 years. The factors were grouped into three levels on the basis of the frequency and extensiveness with which participants talked about them. Factors in the first level were appeal of food (taste and appearance, time considerations, convenience, hunger and food cravings. Other studies have also shown that the top factors considered by adolescents in their choice of food are taste, appearance, hunger, price, time, and convenience (Story *et al.*, 2002; Bauer *et al.*, 2004; French *et al.*, 1997, 1999, 2001; Horacek and Betts, 1998, Glanz *et al.*, 1998; O'Dea, 2003).

Cost has been shown to be an important influence in choosing food in some studies conducted in adults (Jetter and Cassady, 2006; Cade *et al.*, 1999). Focus group studies in adolescents also identified cost as an important factor in choosing food (Bauer *et al.*, 2004; O'Dea, 2003; French *et al.*, 1997) hence its inclusion in the questionnaire. Adolescents purchase ready meals and snacks from shops, vendors and at school when they are away from home. The cost of these foods may determine what an adolescent chooses to eat depending on their financial position. The term cost is defined in this study as the prices of the food which the adolescents purchase on their own. There were no data specific to South African adolescents regarding cost, however this factor was included as it appeared to be important in other population groups. Convenience or time taken to prepare foods is considered to be an important factor in urban environments. Unhealthy options are often chosen over healthy alternatives because they are less time consuming to prepare and consume (O' Dea, 2003). In a study by Bauer *et al.*, (2004) students cited that a major barrier to consuming nutritious meals at school was the short lunch break. Time was spent in a queue and as a result there was insufficient time to eat. They indicated that they would rather choose unhealthy foods from the snack cart. This is because of the busy lifestyles associated with this environment. The current sample is living in an urban environment and therefore a question was included on time considerations.

Based upon this review of the literature, the current study focuses on the following factors influencing food choice: taste, appearance, cost, hunger, time, as well as two other factors, health benefits and mood that did not appear as frequently in the other studies. Health benefits has been shown to be a minor factor in adolescents in food choice (Horacek and Betts, 1998) but was included because this is important in the current research as there is an increasing obesity prevalence in South Africa. This is also because a lack of a sense of urgency about personal health has been identified in some studies (Gracey *et al.*, 1996; Neumark-Sztainer *et al.*, 1999; Glanz *et al.*, 1998). Mood was also included because some studies have cited it as important in adolescents (Neumark-Sztainer *et al.*, 1999). Health benefits, mood and sensory appeal were the top food choice factors in a study of black students in South Africa (Peltzer, 2002). This strengthens the argument for their inclusion in the current study. As can be seen from the list from Furst *et al.*, (1996)'s conceptual model my list is not exhaustive but because of time limitations and study constraints I could only look at a few factors.

The food choice questions were not pilot tested because of these study constraints. Ideally a pilot should have been conducted to enable feedback to be obtained from the participants on difficult and ambiguous questions. This could have resulted in re-wording or discarding some of the questions. The questions asked on food choice where based on review of the literature and none of the studies were specific to South Africa therefore a potential problem could be that these might not have been the main factors influencing choice in this setting and therefore the questions on these factors might not provide valid responses. Any future research should therefore attempt to investigate factors of importance in that particular setting through focus group discussions or in-depth interviews. Pilot studies should then be conducted using the findings from the preliminary investigation before administering them to the whole sample.

1.3.3. Summary

The review on South Africa suggests that the Whites have transitioned to the 'western' diet and that the Blacks are in a transitional phase. Most of the nutrition transition literature however focuses on adults and we know comparatively less about children and adolescents. Adolescents are in the process of establishing their diets and are therefore an important group to study. The effects of the nutrition transition are already evident in this nation. Obesity is an increasing health concern with an overweight and obesity prevalence of 17.6% and 5.9% in adolescent girls and 5.3% and 2% in adolescent boys respectively in the 1998 Demographic Health Survey (Department of Health, 2002). Dietary intake patterns in this younger population group needs to be assessed using more robust dietary collection methods so as to inform future interventions that may counteract the negative consequences of a nutrition transition.

This study endeavours to add to the knowledge base on dietary intake in adolescents in South Africa. The study will use data from a sample from the Birth to Twenty cohort (Bt20) collected during adolescence to assess the dietary intake and its association with factors influencing food choice, socioeconomic status, physical activity and body composition. The Birth to Twenty (Bt20) Study is the largest and longest running study of child health and development in Africa. The cohort consists of 3273 children born between April to June 1990 following the release of Nelson Mandela from prison. These children were therefore born during a vital time in South Africa's history when it was undergoing a major socio-political transition. The aim of the Bt20 study was to document the survival, health, growth, and psychosocial development of children and adolescents in the urban setting of Soweto-Johannesburg (Richter *et al.*, 2004). Of the more than 5000 births which were identified in the seven week enrolment period, 74% were enrolled during the first 15 months of the study. Currently longitudinal data is available for 3273 children. There was a bias in the enrolment by population group membership, place of delivery and residential area. Of the eligible participants 78%, 86.5%, 69.5% and 38% of the Black, Colored, Indian and White population were enrolled respectively (Richter *et al.*, 1995). Details of the recruitment and sample characteristics have been described in detail elsewhere (Richter *et al.*, 1995; Yach *et al.*, 1991; Richter *et al.*, 2004). Whites were under-represented because of the difficulty of enrolling them through the private health facilities which they used and the higher attrition rate compared to the others as the study progressed (Richter *et al.*, 2007). Details of the sample used can be found in the Methods Chapter (pages 74-77). The study aims and objectives are described in the following sections.

1.4. Hypothesis, study aim and objectives

Hypothesis

A transitioned diet is one with at least a 5% difference in the percentage of fat as a proportion of total energy intake in comparison to the recommended fat intake (WHO/FAO, 2003). Fat intake is the most defining shift in diet from the 'traditional' to the 'western' or 'transitioned' diet characterizing nutrition transition (Popkin, 1994; Cordain *et al.*, 2005; Popkin, 2002c; Monteiro *et al.*, 2000). High fat intakes are associated with increasing obesity and non-communicable disease prevalence which are evident in South Africa (Bradshaw *et al.*, 2003). This suggests that a nutrition transition is in progress from a 'traditional' diet to a 'western' diet. Previous studies have simply defined the nutrition transition as a shift from a diet low in fat and sugar and high in unrefined carbohydrate to one with high fat, sugar and processed foods (Popkin, 1994). There is no proper definition to describe whether a transition has occurred. A review of the literature however revealed that fat intakes in transitioned societies averaged 35% or more of total energy intake (Lietz *et al.*, 2002; Robinson *et al.*, 1999; Feunekes *et al.*, 1998; Matthy *et al.*, 2003; Tur *et al.*, 2004; Paulus *et al.*, 2001). The recommended fat intake for the prevention of diet related chronic diseases is 15-30% of total energy intake (WHO/FAO, 2003). There is a 5% difference between the upper recommended intake and the average of transitioned diets. This was therefore chosen as a reasonable difference to indicate whether a transition had occurred for the current study. Fat intakes from previous studies in South Africa and transitioned societies will be compared with that of the current study to investigate the progress of the nutrition transition.

Aim

To investigate the dietary intake and body composition of urban adolescents in South Africa in the context of the nutrition transition.

Objectives

- To investigate the current dietary macronutrient composition and energy intake in a sample of the Birth to Twenty (Bt20) adolescents in Johannesburg/Soweto and compare it with the 'traditional' and 'western' (transitioned) diet.

- To describe the actual foods currently consumed in a sample of Bt20 adolescents in Johannesburg/Soweto and compare them with those consumed in a typical 'traditional' and 'western' diet.

- To establish the factors associated with dietary intake (i.e. energy intake, % fat, carbohydrate, protein and sugar intake) in a sample of Bt20 adolescents in Johannesburg/Soweto.

- To investigate the factors influencing food choice in a sample of urban Bt20 adolescents in Johannesburg/Soweto.

- To investigate in a sample of Bt20 Johannesburg/Soweto adolescents the factors that are associated with body composition (i.e. body mass index, relative % fat and lean mass).

To achieve these objectives an appropriate dietary assessment method had to be administered to determine the habitual dietary intake. A review of the dietary assessment methods is presented in the following section.

1.5. Dietary assessment

Dietary intake can be assessed through a variety of methods such as weighed or estimated food records, 24 hour recalls, food frequency questionnaires (FFQ) or dietary histories. The dietary assessment method chosen will depend on characteristics of study subjects, respondent burden, study objectives and available resources (Willet, 1990). In order to achieve the current study objectives there was a need to choose a dietary intake tool which measures habitual food intake. The various methods of assessing dietary intake are briefly described in Table 1.5.1.

According to Table 1.5.1 there is no ideal method for assessing intake as all the methods have their pros and cons. The dietary records and food diaries measure actual intake over a prescribed period. These have great respondent burden, require literate individuals and are more likely to alter the dietary behaviour to ease the recording process (Mahalko *et al.*, 1985; Block, 1982; Willet, 1990; Rockett *et al.*, 1995). A number of days are required to record usual intake and the compliance of participants and hence validity may decline with longer assessment periods (Mahalko *et al.*, 1985). In a study of 13-18-year-old participants (n=565) in Belgium, a 7 day estimated record was used to assess dietary intake and only 60.3% of these participants had complete records (Matthys *et al.*, 2003). This could be because of the participant burden and could introduce bias in the data collected.

Table 1.5.1 also shows that the 24 hour recall also requires several days to assess usual intake because of the daily variability in food intake and relies on memory. The 24 hour recall however has the advantage that large coverage can be achieved at a relatively lower cost. The assessment method has been used to assess intakes in adolescents (Bourne *et al.*, 1993; Wolmarans *et al.*, 1999; Faber *et al.*, 1999). No significant differences were observed between three 24 hour recalls and a FFQ for energy and total fat in a study of 14-18-year-old participants in Brazil. The FFQ in this study however overestimated carbohydrate and fibre intake whilst underestimating protein intake (Slater *et al.*, 2003). Good agreement between the 24 hour recall and FFQ

Table 1.5.1: Dietary intake assessment methods

Method	Brief description and use	Advantages	Disadvantages
Weighed food records	All food weighed on consumption, need literate and numerate respondents.	Accurate, measures actual intake.	Time consuming, costly, can alter eating pattern, several days required to determine usual intake.
Food diaries with estimated portion sizes	All foods recorded when eaten but portion sizes estimated.	Less respondent burden compared to weighed record, measures actual intake.	Accuracy depends on ability to estimate quantities, several days required to determine usual intake.
24 hour dietary recall	Recall of intake in the last 24 hours, estimation of portion sizes, suitable for average usual intake of population groups.	Inexpensive, high compliance, large coverage, quick method, less likely to alter eating pattern.	Relies on memory therefore subject to recall bias, multiple recalls needed to assess usual intake.
Dietary history	A 3-part assessment consisting of 24 hour recall, cross check food frequency list, 3 day weighed record.	Describes usual food intakes over a relatively long time period.	Highly trained interviewers required, labour intensive, unsuitable for large surveys, high respondent burden.
Food frequency questionnaire	Lists the foods, frequency of consumption and amount eaten over a specified period.	Low cost, low respondent burden, ease of use, determines usual consumption.	Subject to recall bias, tends to overestimate intakes.

(Willet, 1990; Block, 1982)

does not necessarily indicate validity. The agreement may be a reflection of similar errors in both methods.

The dietary methods assessing usual intake in Table 1.5.1 are the FFQ and dietary history. The FFQ has low participant burden and can assess intake over specified periods. This tool has been shown to reliable and valid in estimating nutrient intakes (MacIntyre *et al.*, 2000a; Rockett *et al.*, 1997; Frank *et al.*, 1992; Eck *et al.*, 1991). In a study by Lietz *et al.*, (2002) a FFQ and 7 day weighed record were compared in a UK sample (n=67) aged 11-13 years. Good correlations were observed between the two methods for macronutrients. The median spearman correlation coefficient was 0.31 and increased to 0.48 after adjusting for total energy intake. In another study comparing a FFQ and 7 day weighed record in 15-year-old Swedish participants (n=411) good correlations were also observed for the macronutrients though the FFQ tended to overestimate intakes (Samuelson *et al.*, 1996). Samuelson *et al.*, (1996) did not present the actual correlation coefficients or their significance.

The FFQ has been used by many researchers to describe the macronutrient intake (French *et al.*, 2001; Park *et al.*, 2004; Tur *et al.*, 2004). This tool has also been used to describe the foods that are commonly consumed by a population (Faber *et al.*, 1999; MacIntyre *et al.*, 2002). The dietary history is however, more labour intensive, has greater respondent burden and is costly compared to the other methods. It is therefore seldom used in research studies.

Following this review, the FFQ was chosen as the appropriate dietary intake tool for the current study as it has been used more frequently by other researchers for the adolescent population and has been shown to be valid using other dietary intake methods for comparison (Slater *et al.*, 2003; MacIntyre *et al.*, 2000a). The FFQ was also chosen because it is brief, inexpensive, easy to administer and less burdensome in comparison to other methods which is ideal for the study sample. The sample for the current study is part of the Birth to Twenty cohort in Johannesburg/Soweto. Details of this cohort have been presented previously (pages 46-47). Because of logistic and budget constraints dietary assessment had to be done when these participants came to the study site for their annual routine assessments. These routine assessments took about 3.5 hours therefore a dietary intake tool which did not have great respondent burden whilst measuring usual intake to meet study objectives was required. As these participants were part of an on going study it was crucial to maintain their motivation and not deter them from future visits. The FFQ has shown good correlation with other methods for measuring dietary intake for energy and macronutrient intake which are the nutrients of interest in this study therefore this method will capture the desired data (Slater *et al.*, 2003; Willet *et al.*, 1985; MacIntyre *et al.*, 2000a).

A FFQ which was developed for a South African population by the Medical Research Council (MRC) of South Africa (Steyn and Senekal, 2005) was identified for use in the current study. This is because the FFQ had a comprehensive list of food items consumed by all South Africans and not limited to one population group. A major difficulty in most dietary assessment studies is the estimation of portion size (Livingstone and Robson, 2000). The dietary aids (food pictures and flour models), used to estimate portion size for the MRC FFQ were tested in a sample of black and white (n = 92) children living in the same geographical area as the Birth to Twenty cohort, from which the current study sample comes. Significant and positive associations (see page 45) were observed between the actual and estimated nutrient intakes using the dietary aids (Steyn *et al.*, 2006b). This therefore gives assurance that portion sizes would be estimated with reasonable accuracy. The evaluation and subsequent modification of this tool is described in the following chapter.

Chapter 2: Developing an appropriate dietary intake tool

2.0. Introduction

As discussed previously in the review of dietary assessment methods in Chapter 1 (pages 40 - 43), the food frequency questionnaire (FFQ) developed by the South Africa Medical Research Council (MRC) (Steyn and Senekal, 2005) was selected as an appropriate tool to study to habitual dietary intake in an urban adolescent population. The FFQ had not been used previously in South African adolescents therefore it was essential to conduct a pilot study on a sample of the 15-year-olds before collecting data on the entire sample. Pilot studies are important as they highlight unique challenges encountered with a measurement tool, and therefore will inform broader research studies that wish to use it. The FFQ was administered to 8 participants (Pilot group) in the pilot stage of the research using the standard protocol (Steyn and Senekal, 2005). Consequently, the MRC recommended protocol was then modified according to practical experiences and logistical problems identified by the pilot study and applied to a further 8 participants and their primary caregivers (Validation group).

2.1. MRC Quantitative Food Frequency Questionnaire

The food list on the questionnaire was based on an analysis of dietary surveys conducted in South Africa since 1983. The list is comprehensive including all foods eaten by at least 3% of the population (Steyn *et al.*, 2003). The MRC FFQ is shown in Appendix A with the instructions for its administration on the first page.

The FFQ captures information regarding the amount of food eaten, food code which is a unique four digit number identifying each food and obtained from the MRC dietary analysis programme and frequency of consumption i.e. the number of times per day/week/month the food is eaten.

Additional questions on factors affecting food choice and fast food restaurant use were added (see questions 1-7 on the modified FFQ in Appendix B). This study is looking at the nutrition transition therefore it was important to ask these additional questions to investigate why the adolescents are choosing to eat the diet they have. Increased fast food restaurant use is associated with transitioned societies hence the inclusion of this question. A Likert scale where the respondents are asked to indicate their degree of agreement with a statement (Likert, 1932) on food choice factors was used. The 4-point Likert scale with the following response categories was used in the current study: strongly agree, agree, disagree and strongly disagree. There has been a great deal of research on the optimal number of response categories but this issue is still unresolved (Chang, 1994). Contradictory findings have been reported on the number of response categories that maximise reliability. Some researchers claim that reliability is independent of response categories (Boote, 1981; Brown *et al.*, 1991; Remington *et al.*, 1979). Others found that reliability is maximized by 3-point (Bendig, 1954a; 4-point (Bendig, 1954b), 5-point (Jenkins and Taber, 1977; Lissitz and Green, 1975) and 7-point (Cicchetti *et al.,* 1985; Ramsay, 1973). This suggests that there is no ideal number of response categories. The scale of choice will therefore depend on the research question, ease of understanding and interpretation by respondents. The 4-point scale was chosen for this study because it is relatively easier to understand. This scale does not have a neutral point thus forcing the respondents to make a choice. This is because people are rarely neutral or without opinion. However, forcing them to choose one way or another could artificially inflate the importance of the particular characteristic. Another argument is that the focus of number of response categories should be those that are meaningful to respondents i.e. categories that individuals typically use in making the particular choice (Viswanathan *et al.*, 2004) and four response categories appeared to be reasonable in this study.

It was decided to collapse the scale into a binary difference for analysis because the research was not interested in the extent to which the participants agreed with the statements but whether the factor was of importance to them or not. The other reason was because the study had a small sample size.

A food photo manual (FPM) and food flashcards developed by the MRC, food flour models and household utensils (teaspoon, tablespoon, serving spoon, glass, cup, mug, and bowl) were used to assist the participant to recall the foods eaten and amounts consumed. The set-up for the dietary intake interview is as shown in Figure 2.1a. The FPM has generic life-size sketches of food portions which show cups, mugs, glasses, bowls and spoons filled to different levels to determine portion sizes. An example of these is shown for a mug filled to ¼, half, ¾ and full in Figure 2.1b. There are also life-size portion pictures of some foods on the reverse side of the photos in the FPM to assist in portion size determination.

The food flour models were used to simplify recall of amount of certain foods such as pap (stiff maize porridge). Figure 2.1c gives an illustration of these flour models. The method of making these models is detailed elsewhere (Steyn and Senekal, 2005). Different sizes representing ¼, ½, ¾, 1 and 1½ cups were available.

The food pictures and food models have been shown to assess portion size with reasonable accuracy in adolescents. A study was conducted in adolescents aged 12-13 years living in Johannesburg. The sample consisted of 50 black and 42 white children recruited from relatively low and medium income schools respectively. Each participant was presented with a plate of food of a known weight and was required to select a 2-dimensional drawing and the 3-dimensional food model which closely resembled the portion size on the plate. There were significant ($p<0.0001$) positive linear associations between the calculated nutrients using the actual and estimated portion sizes using both the pictures and the food models. Correlations ranged from 0.842 to 0.994 for the 11 different food items that were tested (Steyn *et al.*, 2006b). The accuracy might be different in a dietary intake interview however because in this study the visual image of the plate of food is still fresh in their mind unlike being asked to recall the quantity consumed on another day.

A set of food flashcards representing all the foods on the questionnaire acted as visual aids for the participant to select foods eaten. Figure 2.1d shows an example of the food flash cards which are color coded to enable quick identification of the foods in the FPM e.g. dairy products are blue, and beans and lentils are a light green color. The food flashcards also helped participants to recall/identify the preparation method as the same food was shown using different cooking methods e.g. fried/boiled/roasted chicken.

The food code and weight were identified from the FPM and entered on the FFQ.

Figure 2.1a: Setup for dietary intake interview

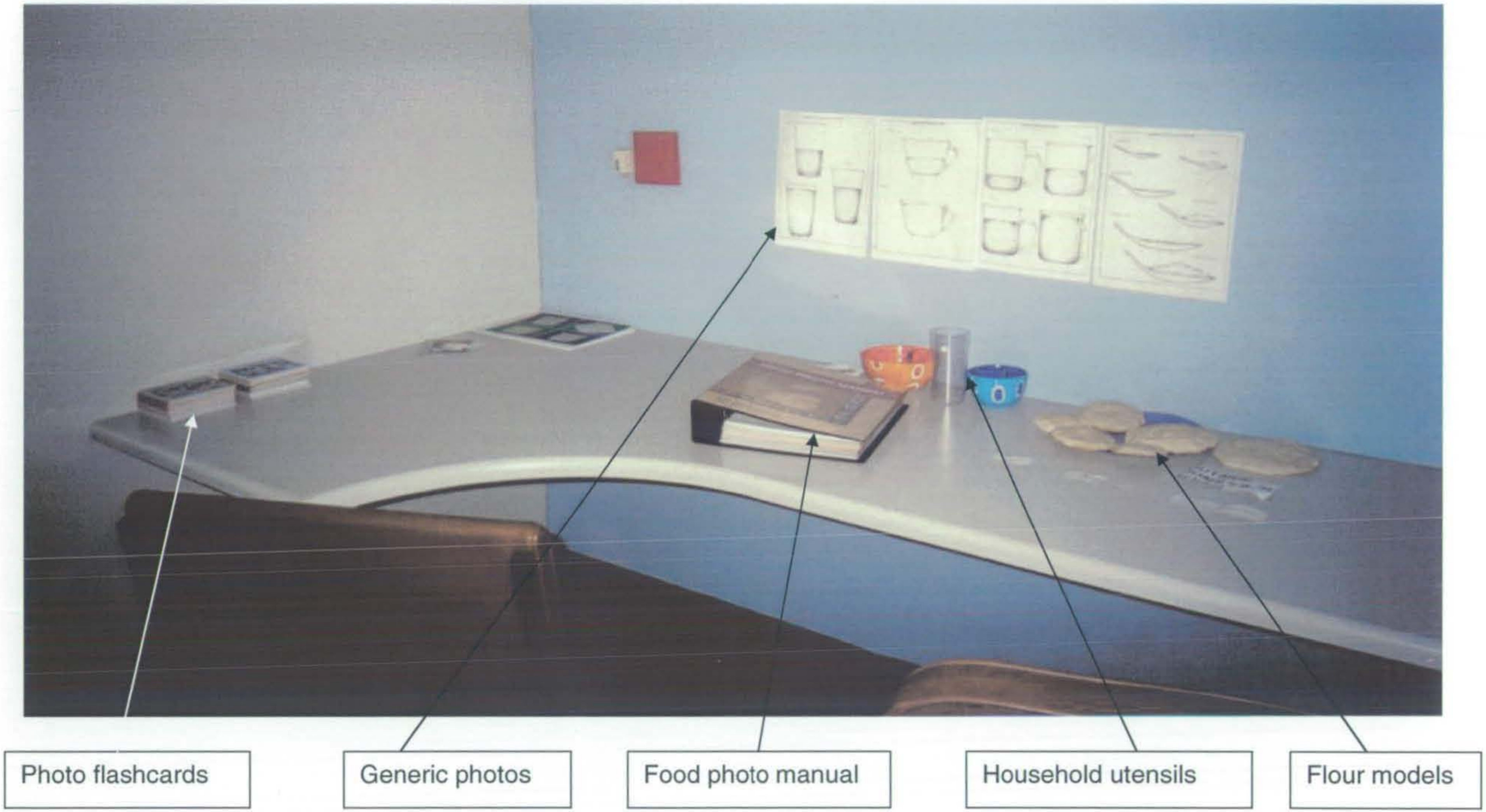


Figure 2.1b: Generic life-size sketches of a mug

(Steyn and Senekal, 2005)

Figure 2.1c: Food flour models

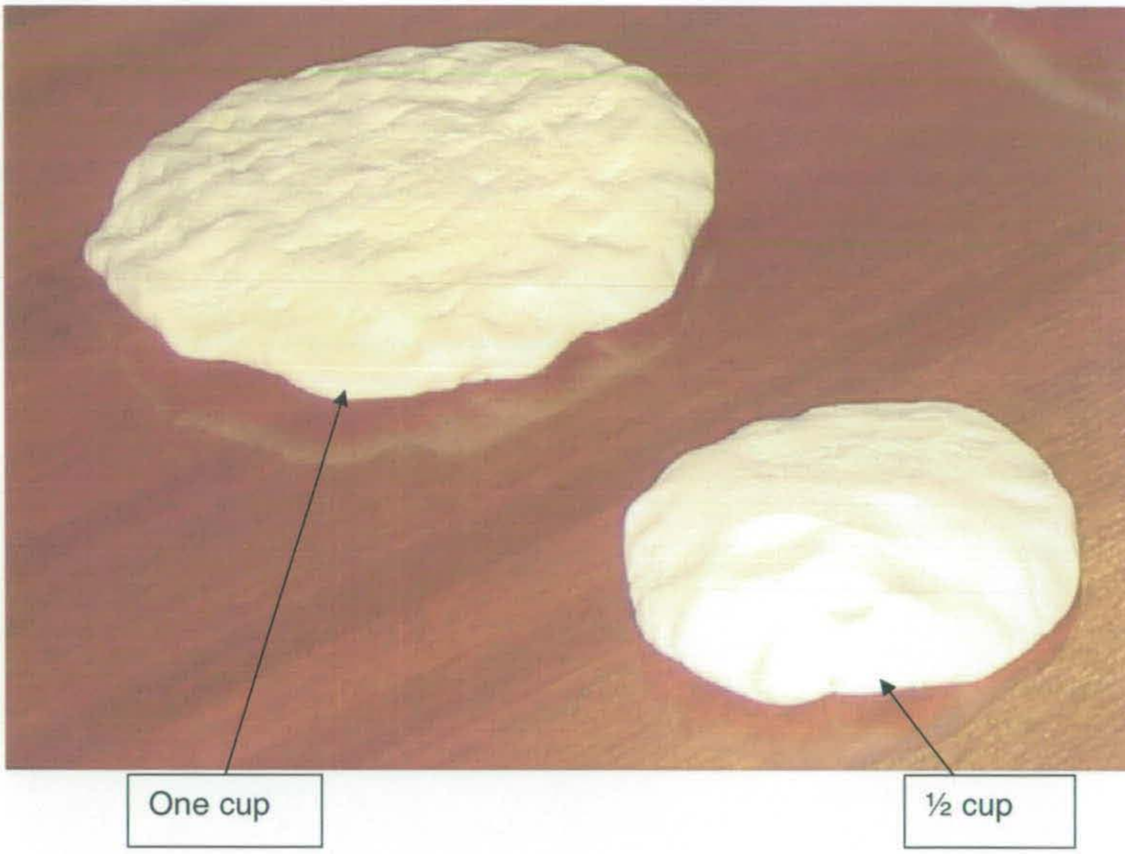


Figure 2.1d: Food flash cards

(Steyn and Senekal, 2005)

have been used throughout this thesis. Newer references have since been released (Torun, 2001) but for standardization and comparability with other previous South African Studies the 1989 standards have been used. The new references involved analysis of a number of studies with children and adolescents aged between 1-18 years in different parts of the world. The recommended energy intake for 14-15 year old boys and girls was 2990kcal and 2449kcal in the new references compared to 3000kcal and 2449kcal respectively for the 1989 references. The recommendation for boys is 0.3% lower whereas its 11.3% higher for girls. Use of either reference would not impact the results of the current study.

Accuracy of data input were checked by comparing every questionnaire to its printout from the Foodfinder dietary analysis programme and any necessary corrections made.

2.3. Results of the pilot study using the original MRC procedure

A sample of 8 male and female black 15-year-old participants took part in the pilot study. The sample consisted of 4 girls and 4 boys who were among the first children from the cohort to be scheduled for their annual assessment appointments for year 15 data collection.

Dietary assessment was carried out in addition to a 3.5 hour routine annual Bt20 assessment. Routine data collected for the Bt20 cohort included anthropometry, dual-energy X-ray absorptiometry scans (DXA), Tanner scaling for pubertal development, socio-economic status and physical activity assessment. The methods for the collection of routine data are described in detail in Chapter 3 . A nutritionist (CZ) conducted all the dietary interviews to minimize interviewer variability.

Time: The entire interview took on average 60 minutes to complete depending on the responsiveness of the participant. The length of the interview was too long considering the participants had already undergone 3.5 hours of routine annual assessments.

Motivation: By the end of the interview the adolescents appeared bored and a set response format developed, which could not be overcome with probing and encouragement from the interviewer.

Ability: An observation was made by the trained nutritionist (CZ) conducting the interview that some participants found it difficult to answer the FFQ and took more time before giving a response. The way the foods were arranged in food groups made it difficult for the adolescents to answer the FFQ. For example, participants tended to respond by saying 'I eat bread with butter and cheese'. Therefore, it was inefficient to ask about bread and then in a much later stage of the FFQ ask about spreads.

Quantification of added ingredients during cooking and food preparation was also a problem for the adolescents since they generally said they were not actively involved in food preparation. Some also indicated that they were not aware of the cooking methods.

The adolescents had difficulties in naming the brand/types of food eaten at home, for example, differentiating between skim and full cream milk, or margarine and butter. Some of them mentioned they just use the food available and do not look at the description, to quote one participant "I just use what is in the fridge".

Participants tended to say they ate certain food items everyday even though after probing it was clear that the food item was only consumed for 5 or 6 days a week. Such responses had to probed with questions such as 'so is it Sunday to Saturday?' This was a particular problem because it could result in overestimating intakes if the food was only eaten on 5 days but the participant reported that it was eaten daily.

Caregiver involvement: The caregiver was not involved in the dietary intake interview in the prescribed methodology, meaning that the caregiver was not available to clarify any information that the adolescent could not provide such as method of cooking (i.e. fried, roasted, boiled etc.), ingredients added during cooking and their quantities, and brand names of foods eaten at home.

Energy intakes, BMI and physical activity: The daily energy intakes, BMI and physical activity of the participants are shown in Table 2.3. The mean intakes for girls and boys were 3599kcal and 5979kcal respectively. The intakes as a percentage of the Recommended Dietary Allowance (RDA) averaged 163.5% and 199.3% for the girls and boys respectively [3](Food and Nutrition Board, 1989). Only two participants were overweight according to age adjusted Body Mass Index (BMI) cutoffs (Cole *et al.*, 2000) and yet the intakes of the other participants were well above the RDA apart from only one girl with 76.4% of the RDA. The physical activity average was 154.25met-hours per week for the whole group. One MET is defined as the energy expenditure for sitting quietly which is equal to 1kcal.kg-1.body weight.hour-1 for the average adult (Ainsworth *et al.*, 2000). Details of physical activity measurement are published elsewhere (Aaron *et al.*, 1995, Ainsworth *et al.*, 2000) and explained in the Methods chapter Section 3.3.6. Comments on the comparison of the pilot and validation group are on page 68.

Table 2.3.: Energy intakes, BMI and physical activity of the Pilot Group

Participant	Energy intake (kcal)	% [1]RDA	[2]BMI	[3]Met Score
Girl	1681	76.4	18.90	138.32
Girl	3309	150.4	22.04	230.40
Girl	5395	245.2	23.75	183.73
Girl	4009	182.2	25.80[4]	110.22
Mean	3599	163.5	22.61	165.67
Boy	6480	216.0	18.28	148.22
Boy	4692	156.4	21.91	100.28
Boy	6590	219.7	22.90	174.84
Boy	6152	205.1	24.89[4]	147.98
Mean	5979	199.3	22.00	142.82

[1]RDA - Recommended dietary allowance: boys = 3000kcal and girls = 2200kcal (Food Nutrition Board, 1989)
[2]BMI- body mass index = (weight (kg)/height (m)^2.
[3] Physical activity in met-hours per week.
[4] Overweight according to age adjusted BMI cut-offs (Cole *et al.*, 2000)

[3] The 1989 Food and Nutrition Board references are used as a standard by the Foodfinder dietary analysis programme used in this study hence the use of these references.

2.4. Modification of the MRC procedure

In order to overcome the problems encountered in the pilot study it was decided to pilot an additional interview with an adolescent together with her caregiver. The adolescent sorted the cards with the caregiver's help and they helped each other quantify the foods. The interview took 35 minutes to complete and both participants did not appear bored. However, this approach revealed that the adolescent might not have mentioned some of the foods consumed because of potential caregiver disapproval. This concern arose from the comment of a female participant in the Pilot group who mentioned that her mother would be very upset if she knew she was eating a lot of 'junk' food. This was in addition to the unspoken interaction between the adolescent and caregiver when going through the snacks and alcohol cards. Taking all of these findings into consideration the MRC standard procedure was modified.

Firstly to reduce the FFQ time it was decided to modify step 2 and 3 in the standard methodology shown in Appendix A to the following: *"Please look through these photographs and make three piles. One pile is for items, which you never eat/drink, one for those you eat/drink occasionally that is only once or twice a month and the other is for the foods you eat everyday or week."* Thereafter the nutritionist indicated the food items that were never and occasionally eaten/drunk by ticking the respective columns in the FFQ. Furthermore, instead of quantifying all of the foods, only foods eaten regularly were quantified as the foods not or rarely eaten would have made only a small contribution to overall macronutrient intake.

To counteract the problem of quantification of added ingredients during food preparation, and brand/types of foods consumed at home it was decided to involve the caregiver. The adolescent completed the food item sorting in the absence of the caregiver. The adolescent then sorted the usually eaten pile into foods eaten at home and outside the home (e.g. school, at friend's homes). The adolescent then quantified the foods consumed outside the home. Finally the caregiver assisted in quantifying the food items consumed at home.

It was also decided to change the structure of the questionnaire so that foods eaten together were grouped together. These were bread and spreads, porridge and milk, sugar, butter/margarine. This was adapted from the FFQ used by MacIntyre (1998) who grouped foods eaten together in her questionnaire. The questions in this questionnaire were structured as has been done on the modified FFQ for breakfast cereals as an example (Appendix B) where the type of breakfast cereal is put down and the participant asked whether milk and sugar were added to the cereal, if so they were asked to elaborate on the type and quantity. This gives a flow to the questionnaire and prevents monotony. There were other changes that would have been logical to make e.g. grouping main carbohydrate dishes such as stiff maize porridge (pap), rice or pasta with meat and vegetables as they are never eaten on their own. However it was not possible to restructure the entire questionnaire as the way it was arranged originally made it easier to use the Food Photo Manual which was colour coded with each colour representing different food groups and the foods within each section were also arranged alphabetically. To change these orderings would have made the original toolkit provided to be user unfriendly. Other changes made included inserting some of the food codes on the questionnaire and inserting prompts (see difference between the MRC FFQ and the modified FFQ) with some of the foods to minimize the time the interviewer spent looking for these in the FPM during the interview. An example : Pilchards and sardines (canned in water/tomato sauce, any mayonnaise added) , the prompts are included in smaller text in brackets next to the food item therefore the interviewer would remember to ask what substance the pilchards were canned in and whether the participant added anything like mayonnaise during consumption which would require quantification.

The interviewer also changed the way frequency questions were asked to avoid the adolescent getting into a pattern of answering. For example, asking which days they ate the food instead of just asking how many times they consumed the food. This also reduced the likelihood of the respondent answering everyday if they actually only consumed the food on five days of the week.

2.5. Results: Validation Group using the modified MRC procedure

The modified procedure was administered to the next 8 participants (4 females and 4 males) and the results are presented in this section.

Time: The adjustments resulted in the dietary interview taking a shorter time to complete. On average the interview took 45 minutes to complete (20 minutes with the adolescent and 25 minutes with the caregiver).

Motivation: The adolescents did not appear to get bored as time spent with them was minimal (i.e. 20 minutes in comparison to 60 minutes with the Pilot group).

Ability: In this group the participants answered the questionnaire with ease. Arranging the foods according to how they were eaten made it easier for the adolescent to recall what they ate.

Caregiver involvement: Involving the caregiver in the dietary interview shortened the time spent with the adolescent freeing them up for other Bt20 routine cohort assessments. The caregivers were knowledgeable about the brands of foods eaten at home as they were the ones involved in shopping for the food consumed at home. They were also actively involved in food preparation and knew what ingredients had been added to the food. It was difficult to get a usual preparation method as the caregiver would say "it differs from day to day, sometimes, I fry, boil, grill, it just depends". This was overcome by asking for the most frequently used method.

If the caregiver was hesitant or could not quantify any additions to food such as sugar in tea these were flagged and the adolescent asked again at a later stage. In a few cases where the caregiver said the food was never consumed at home it was noted and not quantified.

Caregivers also had a tendency to say they ate the food everyday if it was eaten frequently even though they had it for 4 days a week. They were therefore further probed as to which days of the week the foods were eaten on to avoid this problem.

Energy intakes, BMI and physical activity: Energy intakes, BMI and physical activity of the Validation group are shown in Table 2.5. The mean energy intakes were 2080kcal and 3218kcal for the girls and boys respectively. The intakes as a percentage of the Recommended Dietary Allowance (RDA) averaged 94.5% and 107.3% for the girls and boys respectively (Food and Nutrition Board, 1989). Mean energy intakes were lower and more reasonable in comparison to Pilot group intakes.

The average physical activity was 145.97 met-hours per week for the whole group. The Mann-Whitney test was used to test for significant differences between the two groups (Pilot and Validation) and there were no significant differences in the BMI ($U = 18.000$, $p=0.141$) and physical activity ($U = 28.000$, $p=0.674$) whilst significant differences existed for energy intake ($U = 10.000$, $p=0.021$). Based on this the Pilot group intakes appear to have been overestimated.

Table 2.5: Energy intakes, BMI and physical activity of the Validation group

Participant	Energy intake (kcal)	% [1]RDA	[2]BMI	[3]Met Score
Girl	1696	77.1	19.08	96.22
Girl	1353	61.5	19.13	140.38
Girl	1450	65.9	21.16	148.40
Girl	3820	173.6	22.57	133.10
Mean (girls)	2080	94.5	20.49	129.53
Boy	3179	106.0	16.91	110.06
Boy	4784	159.5	19.17	149.11
Boy	2787	92.9	20.04	225.09
Boy	2123	70.8	22.78	165.43
Mean (boys)	3218	107.3	19.73	162.43

[1]RDA-Recommended dietary allowance: boys 3 000kcal and girls = 2200kcal (Food Nutrition Board, 1989)
[2]BMI - body mass index = (weight (kg)/height (m)^2.
[3] Physical activity in met-hours per week

2.6. Discussion

Time is a significant factor in any study, but even more so when assessing children or adolescents. In order to avoid loss of participants in any longitudinal study it is important to take the shortest possible time to prevent boredom without jeopardizing data quality. The participants in this study are part of a birth cohort routinely assessed every year, therefore it was crucial not to deter them from coming to the next visit by using lengthy assessment tools. The methodology used in the Validation group reduced the time spent with the adolescent considerably and kept the caregiver occupied while waiting for the adolescent to finish further assessments, therefore reducing boredom.

The ability to answer the FFQ improved with the changes in the structure of the questionnaire. Grouping foods eaten together appeared to simplify recall and quantification. Participants think in terms of meals (MacIntyre, 1998) and not food groups. The MRC tool was structured in terms of food groups making it hard for participants to comprehend. Involvement of the caregiver meant that more information could be collected on food brands as well as ingredients added during cooking.

The energy intakes in the Pilot Group were much higher in comparison to those obtained in the Validation Group (p=0.021). The intakes in the Pilot Group suggested overestimation when they were compared with the BMI and physical activity of the participants as there were no significant differences in these in comparison to the Validation Group. The limitation of this study is however the small sample size of both my pilot and validation groups and that they were based on convenience sampling of participants coming for their annual appointments. Ideally cases should have been matched by sex, ethnicity, BMI and socio-economic status to see the effects of the two procedures but logistically this was not feasible.

Pilot Group energy intakes averaged 181% and the Validation Group 101% of the RDA. Intakes which exceed the energy requirement will result in positive energy balance and therefore overweight/obesity (WHO/FAO/UNU, 1985).

The Validation group intakes are comparable to intakes obtained in other studies with participants of a similar age in South Africa unlike those for the Pilot group. Percent RDAs reported in these previous studies range from 58.3 to 101.2% (See Table 6.1.1 pages 144) (Steyn *et al.*, 1986; Steyn *et al.*, 1989; Bourne *et al.*, 1993; Vorster *et al.*, 1997). Based on this information the procedure used in the Validation group suggests a more successful approach.

To contextualise the dietary intake findings of this study, the mean energy intakes obtained using the original MRC and the modified procedure are compared to those obtained in other South African studies in Table 2.6. The Validation group had lower intakes (mean intake 2649 kcal) in comparison to intakes obtained in a black (urban and rural) population (3248 kcal) using a FFQ in the THUSA study (MacIntyre *et al.*, 2002). Both studies used quantitative FFQs and similar methods of quantification using food portion photographs and common household utensils. The administration of the FFQ differed in that the current study involved the caregiver whilst the THUSA study did not which could partially explain the lower intakes in the current study as the combination of caregiver and adolescent appeared to enhance quantification. It was observed that in the Pilot Group that without caregiver involvement intakes were much higher (mean intake 4788 kcal). The difference in ages of participants could also explain the difference in energy intakes as the intake is given for 14-18-year-olds in the THUSA study in comparison to 15-year-olds in the current study. This could explain a higher intake for the older age group in the THUSA study. Data in the THUSA study was collected in 1996 and 1998 and the Bt20 data was collected in 2005 so higher energy intakes would have been expected in the Bt20 participant if a nutrition transition was in progress but this was not the case. Comparisons are however, limited by the small size of the current study.

Lower energy intakes were observed for both males and females in the other studies compared to the Validation group (Wolmarans *et al.*, 1988; Bourne *et al.,* 1993; Kruger *et al.*, 2005). It is however difficult to make comparisons among the various studies as the intakes could be real differences or could be a result of differing methods. Various other factors are of importance such as the actual nutrient composition of the diet, body composition of the participants and physical activity level and not just the absolute energy intakes. What is clear from observing Table 2.6 is that the energy intakes observed in the Validation Group in this study fit within the range of values obtained by other studies in this setting, whereas the energy values observed in the Pilot Group were much higher than the averages observed in the studies presented in the Table.

2.7. Limitations

Parents of adolescents have increasingly less control over what their children eat. The ability of the parents to answer the FFQ would differ according to household organization and the degree of independence of the adolescent. Some caregivers expressed concern that they now hardly notice what their adolescent consumes especially with foods such as fruits. When fruits are available in the house the caregiver reported that it is not always possible to track how much the adolescent eats. Further clarification from the adolescent for these types of food might further improve the accuracy of this procedure.

Ingredients added during cooking such as sugar and cooking oil were difficult to quantify even for the caregiver. The caregiver was asked the number of household members they were preparing the food for and the amount eaten by the adolescent was obtained by dividing the total quantity by the number of household members. This however assumes that all of them are getting equal portions of the dish, which is not necessarily true resulting in over or underestimation. It could help to ask the caregiver whether the adolescent normally eats an equal share.

It was not possible because of a lack of resources to validate the modified procedure with other dietary methodology, although this would be recommended before further use of the modified procedure.

Table 2.6: Comparison of absolute energy intakes for the current study with other South African studies of a similar age

Source	Age (years)	Sample Size	Sample characteristics	Dietary method	Energy intake (kcal) mean (SD)	BMI mean (SD)	Comments
Bt20 Pilot group	15	4 (M) 4 (F)	Black (urban)	FFQ	5979 (M) 3599 (F)	22.00 (M) 22.61 (F)	[1]One girl and one boy overweight
Bt20 Validation group	15	4 (M) 4 (F)	Black (urban)	FFQ	3218 (M) 2080 (F)	19.73 (M) 20.49 (F)	None of the participants overweight/obese
Bourne *et al.*, 1993 (BRISK study)	15-18	58 (M) 61 (F)	Black (urban)	24 hour recall	2035 (833) (M) 1525 (690) (F)	Not reported	Mean energy intakes fell below the RDA for both males and females.
Wolmarans *et al.*, 1988	15-19	96 (M) 91 (F)	White (urban & rural)	24 hour recall	3035 (1171) (M) 1721 (598) (F)	21.9 (2.4) (M) 22.8 (3.5) (F)	[2]9.4% males and 28.6% females overweight.
Kruger *et al.*, 2005 (THUSA Bana Study)	10 - 15	608 (M) 649 (F)	Black, White, Coloured and Indian (urban & rural)	24 hour recall	1915 (722) (M) 1767 (660) (F)	16.9 (3.0) (M) 18.0 (3.5) (F)	[1]5.6% males and 10% females overweight/obese
Steyn *et al.*, 2003	14-18	81 (both)	Black (urban and rural)	FFQ	3248 (1209)	Not reported	No breakdown by sex Data from THUSA study. Original paper (MacIntyre *et al.*, 2002) reports dietary intake for all adults up to >65years

[1] Cole et al., 2000 cut-offs; [2] BMI >= 25 in males and >= 24 in females used to define overweight; Bt20: Birth to Twenty; BRISK: Black Risk Factor study; THUSA Bana study: Transition and Health during Urbanisation of South Africans Children study; THUSA: Transition and Health during Urbanisation of South Africans; FFQ: food frequency questionnaire; M: males; F: females.

2.8. Conclusion

The modified protocol appeared to be more successful with this urban South African adolescent group. Further validation against other dietary intake methods is recommended. Standard dietary methods might need to be assessed and adapted to specific samples and environments.

Chapter 3: Methods

3.0. Introduction

This chapter describes the study participants, sample size and selection, and the Birth to Twenty (Bt20) routine data collection procedures. Routine data collection includes anthropometric, demographic, socio-economic status, physical activity and pubertal status assessment. The data processing and statistical analysis procedures are then described at the end of the chapter.

3.1. Ethical approval

Ethical approval for this study was obtained from the University of the Witwatersrand, South Africa (Reference number M980810) and Loughborough University, UK (Reference number R05-P81) ethical advisory committees. Informed consent and assent was sought from the caregiver and adolescent participant respectively.

3.2. Participants

Participants for this study were drawn from the Bt20 Study that has been described in Chapter 1. A random sub-sample (n=523) stratified by ethnic group (Black and White) and sex who were participating in the Bt20 cohort with complete data at 9 years of age were enrolled into a longitudinal sub-study (Bone Health Study). The Bone Health study investigates the factors which influence the acquisition of peak bone mass during childhood and adolescence (Cameron *et al.*, 2003; Vidulich *et al.*, 2006; McVeigh *et al.*, 2004). All the white children with complete longitudinal data were enrolled into this sub-study. This sub-sample consisted of only 19.7% white participants. To counter the under-representation of Whites, more Whites (n=151) were recruited in Year 10/11 of the study who were born during the same year as the Bt20 cohort from schools in the greater Johannesburg metropolitan area. Participants with chronic illness (juvenile rheumatoid arthritis, epilepsy or asthma) or on medication known to affect growth or bone mass (n=4) were excluded from the study (Vidulich *et al.*, 2006). Cross checks were performed to ensure that there were no significant differences between the Bt20 and Bone Health cohort for key demographic variables (residential area at birth, maternal age at birth, gravidity, gestational age and birth weight) (Vidulich *et al.*, 2006; McVeigh *et al.*, 2004). The final Bone Health Study had 683 participants, with 38.8% Whites and 49.9% females. The Bone Health study participants underwent more detailed body composition assessment in comparison to the rest of the Bt20 cohort in addition to the standard routine measures. The nutrition transition study sample was drawn from the Bone Health Study. This is because of the greater range of body composition measures available for this group that would enable the current study objectives to be met. The sample size calculation and selection is described in the following paragraphs.

3.2.1. Sample size and selection

The sample size was calculated based on the largest variation in fat intake observed in previous studies, as it is the most defining shift in diet from the 'traditional' to the 'western' diet characterizing the nutrition transition. From a review of studies using food frequency questionnaires in adolescents of a similar age group (Steyn *et al.*, 2000; Vorster *et al.*, 2000; Tur *et al.*, 2004; Feunekes *et al.*, 1998; Lietz *et al.*, 2002) the standard deviation (SD) of fat intake as a % of total energy intake varied from 4.4 to 7.5%. Sample size was calculated using the largest estimate of these variances based on a 2 sample unpaired t-test.

$$n = \frac{(z\alpha + z\beta)^2 \,.\, 2.s^2}{(d)^2}$$

$z\alpha$ = z value for alpha error (95% confidence level)

$z\beta$ = z value for beta error (80% power)

s^2 = variance (from other similar studies)

d = difference to be detected (Jekel *et al.*, 2001)

For a difference of 5% in fat intake

$$n = \frac{(1.96 + 0.84)^2 * 2 * (7.5)^2}{5^2}$$

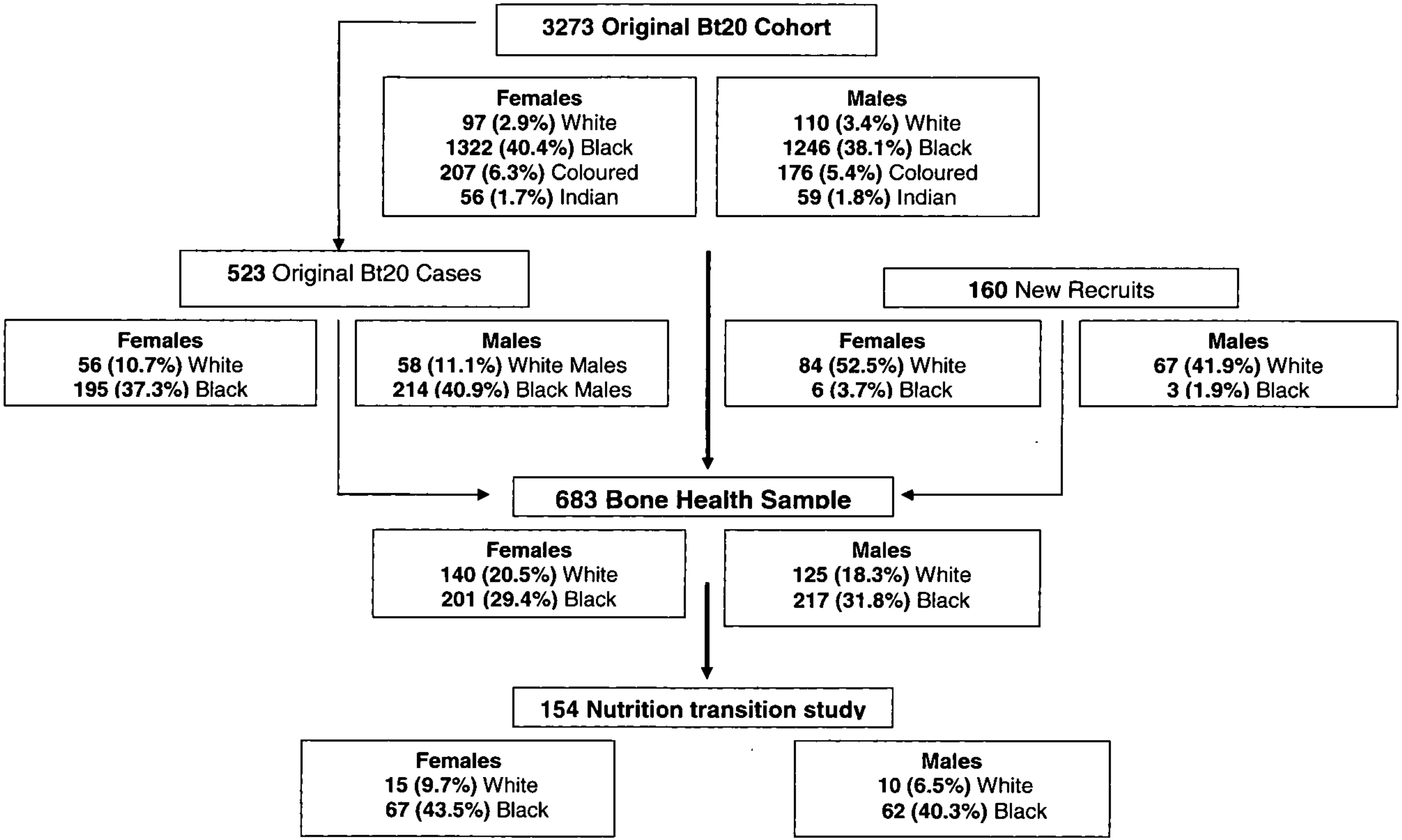
n = 4*36(white girls and boys, black boys and girls)

n = 144

A 5% difference in fat intake was chosen as the difference of interest because a review of the literature showed that fat intakes in transitioned societies averaged 35% or more (Lietz *et al.*, 2002; Robinson *et al.*, 1999; Feunekes *et al.*, 1998; Matthy *et al.*, 2003; Tur *et al.*, 2004; Paulus *et al.*, 2001) whereas the recommended range of population nutrient goals for the prevention of diet-related chronic diseases was 15-30% (WHO/FAO, 2003). Looking at the upper recommended and the average of the transitioned diets there is a 5% difference therefore this was chosen as a reasonable difference to use. To detect a 5% difference in fat intake 36 subjects were required per group i.e. white girls, white boys, black boys and black girls. It was decided to have 40 subjects per group to allow for any exclusion.

Practicalities/logistics resulted in insufficient numbers being obtained for the white sample therefore the black population was over sampled. The final sample consisted of 154 participants (15 white girls, 10 white boys, 67 black girls and 62 black boys). Convenience sampling of those coming for their annual appointments during the period of time the researcher was in South Africa was used. The study was conducted over a 5 month period. An attempt is made by the Bt20 study to see each participant around the same time each year. Initial appointments were based on date of birth for the white participants but black participants were all born in a 7 week window period therefore they were spread evenly throughout the whole year. The Whites are already under-represented and are spread throughout the whole year according to their birthdays, and a few were born during the period the researcher was in the field and therefore very few were booked for their annual appointments during this time. This explains why there were low numbers of white participants. The Bone Health Study has 38.8% white participants but the sample for the dietary intake study only had 16.2% Whites (n=25). A summary of the sample breakdown is shown schematically in Figure 3.2.1.

Figure 3.2.1: Summary of sample breakdown



3.2.2. External validity

External validity has been shown for the Bone Health participants versus the Bt20 cohort. It has however been shown that the Bone health sample is of a slightly higher socioeconomic status (SES) compared to the main Bt20 cohort (Griffiths *et al.*, awaiting publication). The external validity of the current sample versus the Bone Health participants was investigated by comparing some of the variables at year 10. Year 10 data was used because the data for the other years had not been cleaned ready for use. Independent t-tests and Pearson's chi-square tests were performed to see if any significant differences existed between a variety of anthropometric and body composition measures. The results of these tests are shown in Table 3.2.2. There were no significant differences observed amongst the participants who took part in the nutrition transition study and those who did not except for height (p=0.026) and the ethnicity distribution (p<0.001). The nutrition sample was shorter by about 1.6cm and there was a greater proportion of black participants in this sample. The height difference could be reflection of SES differences as the higher SES are generally taller compared to their lower SES counterparts (Tanner, 1989; Rosenbaum *et al.*, 1985). Rosenbaum *et al.*, (1985) found in a UK sample differences of about 2cm, 4cm and 3cm at 3 years, adolescence and young adulthood respectively between the height of boys with professional and managerial fathers and those with unskilled manual laborer fathers. The respective differences for girls were 1.5cm, 3cm and 2cm. As the Whites are predominantly high SES the higher proportion of Blacks in this current study sample means that the socio-economic status is not representative of the Bone Health cohort. The significant difference in height and ethnicity that were observed indicate some problems with external validity in relation to the rest of the Bt20 cohort.

Table 3.2.2: Comparison of the participants in the nutrition study sample and those who are not at Year 10

Variable	Bone Health sample mean(SD)[1]/(%)[2]	Nutrition transition sample mean(SD)[1]/%[2]	Test statistic (df)	p-value
Weight (kg)	34.37 (7.08)	33.85 (8.46)	0.662 (474)	0.509
Height (cm)	140.01 (7.09)	138.38 (6.31)	2.240 (474)	0.026*
BMI (kg/m^2)	17.42 (2.58)	17.55 (3.55)	-0.391 (167.034)	0.696
Waist circumference (cm)	59.14 (6.06)	58.64 (7.020	0.759 (474)	0.448
Hip circumference (cm)	73.57 (7.57)	73.09 (9.12)	0.562 (459)	0.574
Triceps skinfolds (mm)	11.76 (4.69)	11.83 (5.95)	-0.126 (172.601)	0.900
Biceps skinfolds (mm)	6.71 (3.24)	6.39 (3.55)	0.912 (468)	0.362
Sub scapular skinfolds (mm)	8.29 (4.91)	8.81 (6.35)	-0.913 (468)	0.362
Suprailliac skinfolds (mm)	10.37 (6.43)	10.58 (7.39)	-0.291 (468)	0.771
DXA % body fat	24.06 (6.67)	24.96 (7.76)	-1.226 (474)	0.221
DXA % body lean	72.94 (6.44)	72.05 (7.50)	1.254 (474)	0.211
Sex			0.807 (1)	0.369
Boys	78.8	21.2		
Girls	76.0	24.0		
Ethnicity			40.424 (1)	<0.001***
White	90.2	9.8		
Black	69.3	30.7		
Pubic hair development			6.289 (3)	0.097
Tanner stage 1	69.8	30.2		
Tanner stage 2	79.8	20.2		
Tanner stage 3	83.3	16.7		
Tanner stage 4	50.0	50.0		
Breast/genitalia development			5.510 (3)	0.125
Tanner stage 1	69.2	30.8		
Tanner stage 2	78.0	22.0		
Tanner stage 3	82.8	17.2		
Tanner stage 4	66.7	33.3		

[1]For continuous variables t-tests were used to assess statistical significance. [2]For categorical variables Pearson's chi-square tests were used to assess statistical significance, *p<0.05, **p<0.01, **p<0.001. DXA: dual-energy X-ray absorptiometry.

3.3. Data collection

The aim of the main study using the selected 154 participants was to investigate the current adolescent diet and body composition in the context of the nutrition transition and its association with socio-economic status and demographic variables. The collection of dietary intake, anthropometry, body composition, pubertal development, socio-economic status, and physical activity data is described in this section.

In this current study my responsibility was the dietary intake data collection, coding, entry and analysis. I selected the dietary intake tool, the food frequency questionnaire (FFQ) using my nutritionist expertise, and knowledge gained from reviewing the literature. This took into account the logistic and financial constraints. A pilot study whose details are in Chapter 2 was conducted, and the FFQ modified accordingly. Consequently this was administered to all the participants by myself. I also entered data for my participants for the other variables of interest that were routinely collected by the Bt20 cohort. This included anthropometry, body composition, pubertal development, socioeconomic status, physical activity and demographic data.

The Bt20 research team is committed to reliable and accurate data collection. The different operations, administration, laboratory staff and data managers report to the chief investigators on a weekly basis. This is in addition to the on-going quality control during the actual data collection (Richter *et al.*, 2007). The reliability and accuracy of the routinely collected Bt20 data is described in each of following sections.

3.3.1. Dietary intake

The modified food frequency questionnaire (FFQ) was administered as described in the previous chapter. The dietary data were exported to Excel from the FoodFinder programme (see details in section 2.2.). The energy contributed by each macronutrient was calculated using the Atwater factors, i.e. 4, 9, 4 and 7kcal/g for protein, fat, carbohydrate and alcohol respectively (Passmore and Eastwood, 1986). These general Atwater factors were used because they are the ones used by the Foodfinder dietary analysis programme. The % energy contribution of protein, fat and carbohydrate to total energy intake was calculated by dividing the total energy content of the diet by the energy provided by the macronutrient. Similarly the saturated, monounsaturated and saturated fat, added sugar, animal protein and plant protein were also expressed as a percentage of total energy intake. The data was then exported to SPSS version 13.0 for statistical analysis. Percent carbohydrate intake was recoded into two categories representing a prudent diet (>=55%) and a transitioned diet (<55%) intake based on the WHO/FAO (2003) recommended intakes. Percent fat intake was also split into two categories representing a prudent diet (=<30%) and a transitioned diet (>30%) intake based on the WHO/FAO (2003) recommended intakes. No tests of reliability or accuracy of the dietary intake were conducted. The pilot study (see Chapter 2) however gave an indication that the dietary data were reliable when energy intakes were compared to the BMI and physical activity of participants. The investigator had originally planned to conduct 24 hour recalls in addition to the FFQ but this could not be done due to logistic constraints.

3.3.2. Anthropometry

Weight was measured to the last completed 0.1 kilogram (kg) using a Holtain electronic scale. Height was measured using a Holtain stadiometer to the last completed centimetre (cm). The participants removed their shoes and wore light clothing for both measurements. Waist and hip measurements were done using a measuring tape to the nearest mm using standard procedures (Cameron, 1984). Skin fold measurements (sub scapular, supra-iliac, tricep, and bicep) were done using a Holtain caliper to the nearest 0.1mm. An average of three skinfold measurements were taken. Biepi condylar breadth of humerus and femur were also measured using a Holtain caliper to the nearest 0.1mm. Other measurements were the Body mass index (BMI) was calculated by dividing the weight (kg) by height $(m)^2$. BMI was categorized into two categories not overweight/obese and overweight/obese using Cole's international cut-offs (Cole *et al.*, 2000).

Trained research assistants recorded the data using the same equipment which are routinely checked and calibrated every three months (Vidulich *et al.*, 2006; McVeigh *et al.*, 2004). No adjustments were necessary to the calibrations of the equipment during the study therefore accurate measures were obtained. A reliability study of height measures using participants (n=20) from the same Bone Health study was conducted. An intra-observer reliability standard error of measurement of 0.29cm over two repeat measures and an inter-observer reliability standard error of measurement of 0.31cm was recorded for height (Griffiths *et al.,* unpublished). In another sub-study (n=369) of the Bone Health study at 9 years of age the intra-observer variation for the skinfold measurements ranged between 2.0% and 2.7% (Cameron *et al.,* 2004). No reliability studies were conducted during the current study data collection period but these earlier studies give an indication of the reliability and accuracy of collected data.

3.3.3. Body composition

Body composition was assessed using a fan-beam densitometer (model QDR 4500A; Hologic Inc, Bedford, MA) to obtain dual-energy X-ray absorptiometry (DXA) readings. Fat mass (kg) and lean tissue mass (kg) were assessed using software version 8.21(Hologic Inc) under standardized participant positioning and scan analysis (Cameron *et al.*, 2004). These assessments were conducted by a trained technician. A spine phantom was scanned daily to determine the intrinsic coefficient of variation of the machine (CV). In a sub-sample of the Bone health participants during the study period the CVs for bone mineral content, bone area and bone mineral density were 0.48%, 0.39% and 0.35% respectively. The intra-observer variation for that study was below 1% for all skeletal sites (Cameron *et al.*, 2004, McVeigh *et al.*, 2004). There is no facility to assess the quality control of the DXA machine in measuring lean and fat mass (Griffiths *et al.*, unpublished). A study by Well's *et al.*, 1999 however, observed a 'negligible mean error' in DXA measures of fat free mass relative to the criterion of the 4-compartment model in UK children aged 8 -12 years.

Previous studies have shown that there is poor validity of using the weight-for-height index, body mass index (BMI) as a measure of body fatness in healthy individuals (Warner, 2000; Wells, 2000; Ellis *et al.*, 1999). The use of BMI might not identify excess fat deposition (Wells *et al.*, 2001, 2002a), that has been shown to have adverse health consequences (Sokol, 2000; Must *et al.*, 1999). Weight can be separated into its fat mass (FM) and fat-free mass (FFM) components and hence BMI can be separated into a fat mass index and a fat-free mass index (van Itallie *et al.*, 1990; Wells *et al.*, 2001, 2002a). To overcome this major shortcoming of BMI not taking into account the actual composition it was decided to use a fat mass index and fat-free (lean) mass index.

An attempt was made to create a fat mass index and lean mass index using log-log regression as proposed by Wells *et al.*, (2002b) to determine the power to which height should be raised in the indices thereby controlling for height. In the original paper the log-log regression approach was used in 8-year-old children and this approach proved not to be applicable to the 15-year-old sample in the current study. The results of the log-log regression in the 15-year-olds are shown in Table 3.3.3.

Table 3.3.3: Results of the regression of log fat mass (kg) and log lean mass (kg) (dependant variable) on log height (m) (independent variable)

Participants	Coefficient	95% CI	P-value
Fat mass			
All (n=151)	-3.140	-4.866; -1.415	<0.001
Boys (n=71)	2.073	-0.288; 4.435	0.084
Girls (n=80)	-1.087	-3.592; 1.419	0.391
Lean mass			
All (n=152)	2.675	2.297; 3.054	<0.001
Boys (n=71)	2.574	2.013; 3.136	<0.001
Girls (n=81)	1.550	0.882; 2.219	<0.001

For the fat mass negative coefficients were observed in girls and both sexes combined. No significant associations between log fat mass and log height were observed for both girls and boys. Significant associations were however observed between log lean mass and log height in the whole sample and the separate sexes. Different adjustments of lean mass for height in boys and girls would however be required according to the results shown in Table 3.3.3.

The gradient of the regression line relating log lean mass to log height was 2.574 and 1.550 in boys and girls respectively. These results might have been achieved because Well *et al.*, (2002b)'s sample were pre-pubertal whereas the current study sample were pubertal. In a pre-pubertal sample not much variation is expected in height as well as the fat mass and fat free mass whereas the current adolescent sample is at differing stages of pubertal development and greater variation expected in height and body composition (Gou *et al.*, 1997; Siervogel *et al.*, 2003). There are significant differences between boys and girls in body composition during puberty with greater total body fat accumulation in girls (Siervogel *et al.*, 2000; Malina and Bouchard, 1991). Boys and girls attain peak height velocities at different ages resulting in variation in height in people of the same age. After puberty, the mean adult height difference is about 13cm higher in men compared to women whereas before puberty males are only slightly taller than females (Veldhuis *et al.*, 2005; Tanner, 1989). These sex differences during and after puberty could therefore explain the differing coefficients when the log-log regression was conducted for separate sexes in the current study compared to Well *et al.*, (2002b) who obtained similar results for both girls and boys.

It was therefore decided to determine the relative % fat and lean mass as follows:

% fat = fat mass without head/overall standing mass x 100

% lean = lean mass without head/overall standing mass x 100

The head tissue mass had to be subtracted as this measurement is based on an algorithm which has been shown to be inappropriate for children (the values are overestimated) (Lohman *et al.*, 2000; Roubenoff *et al.*, 1993; Brownbill and Ilich, 2005).

3.3.4. Pubertal development

Pubertal stage of development was assessed using a self completed questionnaire which uses Tanner scaling of pubic hair and breast/genitalia development (Tanner, 1962). This tool has been validated in Black South African adolescents by Norris and Richter (2005). Adolescents aged between

10-18 years (n=182) were recruited from a primary and secondary public school in Johannesburg-Soweto. The adolescents examined themselves in private in a secure room with a full length mirror. They were provided with drawings illustrating the Tanner stages of pubertal development. These drawings were accompanied by brief descriptions of each stage and these had been translated to isiZulu and seSotho the two most common languages in the area. The adolescents were required to circle the stage that reflected their stage of development. The health professional then examined the adolescent and did their own rating whilst being blinded from the adolescent's self assessment result. The adolescents' pubertal assessment was then compared to that of the same sex health professional. This study concluded that pubertal self assessment was a valid instrument as there were significant agreement between adolescents' and the health professional's assessment. In females the kappa coefficients were 0.71 and 0.76 ($p<0.0005$) for pubic hair growth and breast development respectively. In males the kappa coefficients were 0.63 and 0.60 ($p<0.0005$) for pubic hair growth and genitalia development respectively (Norris and Richter, 2005). The pubertal data collected for the Bt20 cohort is therefore reliable.

In the current nutrition transition study sample there were no participants in Tanner stage 1 for both pubic and breast/genitalia development. The participants were therefore classified as being in the early stages of development (Tanner stages 2 and 3) or late stages of development (Tanner stages 4 and 5).

3.3.5. Socio-economic status

A caregiver completed questionnaire was used to assess socio-economic status (SES). Variables used to determine SES in the year 15 questionnaire were number of childcare, disability and foster care grants; financial, goods and emotional support for the Bt20 child; current marital status; medical aid; type of house, number of rooms in the house, number of rooms used for sleeping; water facility (indoor/outdoor); toilet facility (indoor/outdoor); and occupation. The number of rooms in the house and the number of rooms used for sleeping were eliminated from the analysis as there was no information on the total number of people living in the house. Ideally the ratio of the people to rooms would give a relative measure of SES. The SES questionnaire was based on standard measures which are used in Demographic Health Surveys (DHS) that are routinely administered in low income settings (www.measuredhs.com). To ensure understanding of concepts, and an optimal layout of the questionnaire it was piloted in 30 caregivers who were not part of the cohort. No tests of reliability were however conducted by the Bt20 (Griffiths *et al.*, unpublished).

3.3.6. Physical activity

Physical activity was assessed using retrospective data collected in year 14. This data were used as there were no physical activity data for year 15 that had been collected at the time of the study. Physical activity was assessed by means of a structured, detailed questionnaire which asked about frequency and time spent sleeping or doing various formal/informal activities, domestic chores as well as transport to and from school over the previous 12 months. The physical activity questionnaire was based on questionnaires validated in previous studies (Gorden-Larsen *et al.*, 1999; Pate *et al.*, 1996) and modified appropriately for South African children (McVeigh *et al.*, 2004). Ideally further reliability tests should have been conducted for the Bt20 cohort but these are not available. The information was processed to get the metabolic equivalent (MET) score of the various activities using the Compendium of Physical activities (Ainsworth *et al.*, 2000). The Compendium presents a classification of physical activity by rate of energy expenditure (i.e. intensity). The intensity is defined as the ratio of work metabolic rate to a standard resting metabolic rate (MET). One MET is defined as the energy expenditure for sitting quietly which is equal to 1kcal.kg-1.body weight. hour-1 for the average adult. Activities are listed in the Compendium as multiples of the resting MET level. The energy costs of various activities were obtained from published and unpublished data (Ainsworth *et al.*, 1993). For each participant in the current sample the hours/week spent doing each activity was calculated as follows:

$$\frac{(\#\ \text{months/year}) \times (4.3\ \text{weeks/month}) \times ((\#\ \text{days/week}) \times (\#\ \text{minutes/day})}{(60\text{minutes/hour}) \times (52\ \text{weeks/year})}$$

The hours/week for each activity are then multiplied by the MET scores from the Compendium of Physical Activities (Ainsworth *et al.*, 2000) in order to weight each activity by a crude estimate of its relative intensity. These are then added to get the total MET hours/week for the past year (Aaron *et al.*, 1995). The kcal energy expenditure specific to the person's weight can be obtained by multiplying the duration of the activity (minutes) by the MET and body weight of the participant (Ainsworth *et al.*, 1993). The participants were categorized into relative high and low physical activity using the median split of the total MET score.

3.4. Statistical analyses

SPSS version 13.0 was used for the statistical analysis. The outcome variables being used to study nutrition transition in this study were dietary intake (total energy intake, fat, carbohydrate, protein and added sugar as a proportion of total energy intake) and body composition (BMI, relative % fat and lean mass). The data exploration of the dependant and independent variables, identification of outliers, bivariate and multivariate analysis methods are described in the sections which follow. Also included is the method used for creation of a general socio-economic linear index.

3.5. Data Exploration

The first step in the analysis was data exploration performed by running cross tabulations and frequency counts to identify any coding or data entry errors. Histograms which show the frequency of different scores were plotted and cases which were very different from the rest were examined to establish whether they were a true value or a data entry error. Normality checks to determine the distribution of the continuous variables were done by plotting histograms and looking at the shape of the distribution as well as skewness and kurtosis statistics. The Kolmogorov-Smirnov test of normality was also used and p-values >0.05 gave an indication that the distribution was not significantly different from a normal distribution.

3.6. Identification of outliers

The identification of outliers is described below for each outcome variable. Any identified outliers were investigated to see if they were real/possible values or were the result of measurement or data entry errors. This was done by comparing the variable with some witness variables where possible. When values were identified as outliers but plausible they were retained and included in the analysis.

3.6.1. Identification of energy intake outliers

This section will discuss how energy intake outliers were identified, whilst placing these in the context of criteria that have been commonly used by researchers in previous studies.

3.6.1.1. The Goldberg cut-offs

The ratio of energy intake (EI) to basal metabolic rate (BMR) is an objective method that has been used by most researchers to assess whether energy intakes are reasonable in terms of energy requirements (Goldberg *et al.*, 1991).

The derivation of the Goldberg cut-offs is briefly described here and detailed reports have been published elsewhere (Goldberg *et al.*, 1991, Black, 2000a). Two Goldberg cut-offs were derived. Cut-off 1 assessed whether reported energy intakes were a plausible measure of habitual diet. A value of 1.35BMR was suggested as the lowest value compatible with a normal lifestyle. This was taken as the mean of all the inactive calorimeter measurements and was set to be higher than the survival limit of 1.27BMR suggested by WHO/FAO/UNU (1985).

Cut-off 2 assessed whether the reported intake was a plausible measure of the actual diet during the measurement period. Cut-off 2 was calculated as the 95% confidence limits of EI/BMR at a given physical activity level (PAL).

Physical activity level (PAL) is calculated by dividing the total energy expenditure (EE) by BMR. Values below the lower limit are unlikely to indicate plausible intakes for weight maintenance (Livingstone and Black, 2003). Cut-off 2 is based on the equations below that equate energy intake to energy expenditure.

Energy intake (EI) = Energy expenditure (EE) ± changes in body stores (changes at a group level are ignored)
EE/BMR = PAL therefore
EI/BMR = PAL

The derivation of cut-off 2 is shown in Appendix C. Illustrative tables for Cut-off 2 are presented at different sample sizes and days of dietary assessment using a PAL value of 1.55 by Goldberg *et al.*, (1991).

3.6.1.2. Application of Goldberg cut-offs

The major constraint of using EI/BMR is that it is dependant on a valid value for BMR and the activity factor to be applied to result in an accurate assessment.

BMR is the amount of energy expended at complete rest in a thermo-neutral environment in a post-absorptive state (12 hours fasting) and accounts for about 70% of total energy expenditure (James and Schofield, 1990). BMR is influenced by a variety of factors including age, gender, body composition, health, environmental temperature, stress and hormones (FAO/WHO/UNU, 1985). The Schofield equations have been commonly used by most researchers to predict the BMR. These predictive equations from the 1981 FAO/WHO/UNU expert consultation (WHO, 1985) have been previously said to have shortcomings in over- or under-prediction of BMR because of a lack of ethnic and geographical representation in the data questioning their adequacy and accuracy for universal use. A recommendation was made to expand and refine the earlier BMR database at the International Dietary Energy Consultative Group (IDECG) (Scrimshaw *et al.*, 1996). The findings of the reanalysis at the IDECG 1997 meeting were inconclusive. In the FAO/WHO/UNU 2001 Expert consultation of Human Energy Requirements a recommendation was made to re-analyse the old and new databases with inclusion of other datasets previously not available (FAO/WHO/UNU, 2004). Sophisticated analyses were conducted with 13 910 BMR data points and there were no significant improvement in the equations. The original equations in the 1985 are therefore reasonably accurate for predicting BMR for different geographical regions and population groups (FAO/WHO/UNU, 2004). The BMR value in the Goldberg cut-offs can therefore be predicted with reasonable accuracy.

The activity factor to be applied to is however seldom known. Most researchers have used the illustrative tables of cut-offs for universal applications which were calculated using a PAL value of 1.55 (Goldberg *et al.*, 1991) which is not how they are meant to be used. In order to maximise the sensitivity and specificity of the cut-off each element of the equation should be fitted with values appropriate for each study (Black, 2000b). The PAL of the study population should also be known. The original PAL of 1.55 is said to be a conservative cut-off as most groups have higher physical activity in comparison to this (Black *et al.*, 1996). The Goldberg cut-off has poor sensitivity for defining under- and over–reporters at an individual level. The actual physical activity level should be known and individuals assigned to low, medium and high and the appropriate PAL values. To do this the energy expenditure should be well documented or measured. Applying a single cut-off for all individuals fails to identify under-reporters among those with high energy requirements as well (Black, 2000a). The Goldberg cut-offs were derived using data from adults from affluent societies with sedentary lifestyles. This is unlikely to be representative of an African adolescent population. When a single Goldberg cut-off for physical activity of 1.55 was used in a study by Black (2000b) the sensitivity and specificity was 0.50 and 1.00 in men and 0.52 and 0.99 in women respectively. Sensitivity is the proportion of under-reporters correctly classified and specificity is the proportion of non-under-reporters correctly identified. Classification of subjects into low, medium and high PALs and use of cut-offs for the different PALs improved sensitivity to 0.74 and 0.67 and specificity became 0.97 and 0.98 in men and women respectively. These data were obtained from individuals from 21 studies in which BMR were measured in calorimeters and energy expenditures were measured by the doubly labelled water technique. Of the 21 studies, fifteen used weighed diet records, five used estimated diet records and one used the diet history to assess energy intake. The sample was aged 18 - 90 years and the individuals were from affluent societies (Black, 2000b). Whether the same sensitivity and specificity would be obtained in an adolescent sample from an African population whose diet was assessed using a food frequency questionnaire is unknown.

The actual PALs of the current Bt20 sample are not known to enable derivation and use of cut-off 2. Goldberg's Cut-off 1 of <1.35 could have been used but its derivation is not satisfactory as it was based on measurements of sedentary subjects and it does not account for any variations which may occur in the BMR, energy intake and physical activity as in Cut-off 2.

Although the Goldberg cut-offs have been used by many researchers they have not always been correctly applied (Black, 2000a). A summary of 25 studies has been presented by Livingstone and Black (2003) that examined the characteristics of low energy reporters and the criteria used to identify them. Table C1 in Appendix C shows more studies that have been identified on under and over-reporters. The range of cut-offs for EI/BMR for under-reporters for all these studies were <0.92 to <1.56 (Mendez *et al.*, 2003; McGowan *et al.*, 2001; Okubo and Sasaki, 2004; Ferrari *et al.*, 2002; Azizi *et al.*, 2005; Fletcher *et al.*, 2004; Bedard *et al.*, 2004; MacIntyre *et al.*, 2000a; Mennen *et al.*, 2000). The percentage of under-reporters ranged from about 6% to 68% in these studies using the different cut-offs.

The value of 2.4 for identifying over-reporters has been adopted from Black *et al.*, (1996) as the maximum physical activity level which can be sustained over extended periods. The data used to derive this value were limited in that most of the participants led relatively sedentary lifestyles and were from affluent societies (Black *et al.*, 1996).

In using the equation EI = EE the changes in body stores are ignored but when the cut-offs are applied to an individual this should be taken into account. EI does not necessarily equate to EE because energy may be stored resulting in weight increases. A subject can thus be classified as over-reporting because of a high EI/BMR ratio but there is a possibility that excess energy is being converted to body stores. The Goldberg method does not allow this factor to be taken into account when identifying over-reporters.

The high levels of under-reporting obtained in previous studies using the Goldberg method also cast doubt on the reliability of the method. If such high levels of under-reporting were obtained, it brings into question whether the criteria are suitable and whether the data of the so called 'plausible reporters' were valid. A conclusion was reached that the use of the Goldberg cut-offs were inappropriate for the current study.

3.6.1.3. Use of z-scores to identify energy intake outliers

Data were therefore checked for energy outliers using z-scores. In a normal distribution it is expected that 95%, 5% or less, 1% and 0% of the energy intakes should be =<1.96 >1.96, >2.58 and >3.29 absolute z-scores respectively. Data points >3.29 z-scores are said to be significant outliers (Field, 2005). The distribution of the z-scores in this sample is shown in Table 3.6.1.3a.

Table 3.6.1.3a: Distribution of energy intake z-scores

	Frequency	Percent
Absolute z-score =< 1.96	147	95.5
Absolute z-score >1.96 &=< 2.58	3	1.9
Absolute z-score >2.58	4	2.6
Absolute z-score >3.29	0	0
Total	154	100

Of the 5% expected to be >1.96, 2.5% are meant to be >+1.96 and 2.5% <-1.96. There were however 4.5% absolute z-scores > +1.96. The z-scores >2.58 were also more than the expected 1% but there were no significant outliers. The cases >+1.96 (n=7) therefore warranted further investigation. Table 3.6.1.3b compares the weight, height and BMI of these participants at Year 14 and 15. The dietary intake is at Year 15 and refers to diet over the previous 12 months therefore high energy intakes are expected to result in increased weight and BMI. All the cases show positive increases in weight and BMI but cannot tell whether these are significant increments or not in relation to the intake. All cases that were not overweight/obese and those that were overweight/obese at Year 14 remained in the same category.

Participants 1, 2 and 7 also had high physical activity which could partially explain the reason why the BMI had not shifted to an overweight category. Participant 5 and 6 who were obese had low physical activity. Participant 3 had low activity and a high energy intake and would be expected to have an increment in the BMI. The physical activity data was however collected in Year 14 for the previous 12 months and was not collected concurrently with the intake data therefore a possibility that activity levels could have changed exists.

A one sample t-test was performed to investigate whether there was a difference in the mean energy intake including all participants 2990 (1192) kcal and excluding the seven cases 2851(1023) kcal and there was no significant difference (p=0.101) on a group level.

When the absolute energy intakes for both girls and boys were plotted together the resulting distribution was not normally distributed (Kolmogorov-Smirnov p-value = 0.019) violating the requirement for a normally distributed dependant variable for the linear regression analysis. Four extreme values with energy intakes >6335 kcal were identified using the box and whisker plots. Exclusion of these cases resulted in a normal distribution (Kolmogorov-Smirnov p-value = 0.200). Analyses were therefore performed excluding these four cases.

The strength of using z-scores is that it is a method that can be adopted easily by various studies enabling universal comparisons. This method does not use many different variables like the Goldberg cut-offs (Goldberg *et al.*, 1991) that uses many different variables that have their own measurement error. The values of these extra variables such as PAL are seldom known because of the financial burden and logistical constraints. Therefore potentially the error of misclassification is reduced by using z-scores.

This method however has a limitation that there is no way of verifying whether the ranges of intakes in the sample are plausible because of the individual variations in energy requirement and thus intake.

Z-scores are calculated using the mean and standard deviation including all of the data points. Therefore if there are any outliers present these will influence the tool that will be used to make the evaluation. If any of the points are outliers the standard deviation is likely to be inflated, therefore the outlier may no longer be >3.29 z-score and will be retained as a possible value. Therefore excluding data on this basis could be unsatisfactory.

Table 3.6.1.3b: Characteristics of participants identified as energy intake outliers

Participant	Energy Intake (kcal)	Year 14 weight (kg)	Year 15 weight (kg)	Year 14 height (cm)	Year 15 height (cm)	Year 14 BMI (kg/m2)	Year 15 BMI (kg/m2)	Physical Activity
1. Black girl	5275	48.2	49.8	160.6	161.1	18.69	19.19	High
2. Black boy	6335	43.8	46.4	153.4	157.6	18.61	18.68	High
3. Back girl	5272	46.9	48.8	150.6	150.6	20.56	21.40	Low
4. Black girl	5336	78.0	Missing	156.8	Missing	*31.73	Missing	Low
5. Black girl	6359	89.6	90.4	159.0	1605	*35.44	*35.09	Low
6. Black girl	6423	56.0	57.0	161.8	1618	21.39	21.77	Missing
7. White boy	6397	53.2	59.2	167.9	1735	18.87	19.67	High

*obese according to Cole *et al.*, (2000) cut-offs

3.6.2. Identification of body mass index (BMI) outliers

Using z-scores there were 6.54%, 3.27% and 1.31% of participants with z-scores >1.96, >2.58 and >3.29 respectively. This distribution did not follow that expected for a normal distribution and all cases with >1.96 z-scores were investigated. According to the witness variables in Table 3.6.2 there was no reason to exclude any cases as outliers because the skin fold measurements were also large.

Table 3.6.2: Comparison of BMI outliers with their skinfolds measurements

Participant	z-score	BMI	Tricep	bicep	sub scapular	suprailliac
Black girl	1.99	31.66	32.53	19.67	19.40	18.33
White girl	2.46	33.87	28.87	17.07	32.00	19.07
Black girl	2.65	34.73	24.60	18.50	30.30	24.90
Black girl	2.73	35.09	24.87	10.93	20.37	21.73
Black girl	4.23	42.09	26.73	18.30	30.37	32.97
[1]Mean		22.39	17.32	9.89	13.56	15.65
(SD)		(4.66)	(6.25)	(3.97)	(5.94)	(6.32)
White boy	2.14	27.87	12.93	6.00	12.20	16.33
Black boy	2.37	28.69	27.93	14.93	25.93	27.33
Black boy	2.37	28.71	21.00	12.47	22.37	27.30
Black boy	3.14	31.52	23.33	12.33	23.53	21.80
Black boy	4.06	34.85	30.07	12.67	33.87	26.33
[2]Mean		20.05	10.23	5.60	9.38	8.89
(SD)		(3.65)	(5.45)	(2.56)	(5.32)	(5.90)

[1] Mean for all girls in study sample (n = 82)
[2] Mean for all boys in study sample (n = 72)

3.6.3. Identification of relative % fat and lean mass outliers

Investigation of the z-scores for relative % fat and lean mass estimated from dual-energy X-ray absorptiometry revealed 6.5% cases (n=10) with z-scores >1.96 that are shown in Table 3.6.3. Of the 10 cases 7 are the same cases which were identified as potential BMI outliers. The remaining cases all had z-scores <3.29 therefore were not significant outliers. There is therefore a relation between % body fat and BMI as expected and therefore there is no basis for their exclusion. All the cases in Table 3.6.3 are either overweight or obese apart from one female participant with a BMI of 16.34. This participant has 14.86% body fat which corresponds to the expected association therefore all cases were retained for analysis.

Table 3.6.3: Comparison of % body fat and lean tissue outliers with BMI

Participant	BMI	% body fat z-score	% lean tissue z-score
Black girl	31.66	2.02	-2.07
Black girl	34.73	2.63	-2.61
Black girl	42.09	2.70	-2.65
Black girl	16.34	-2.02	2.16
Black boy	28.71	2.30	-2.10
Black boy	28.69	2.55	-2.56
Black boy	31.52	3.06	-2.99
Black boy	34.85	3.46	-3.49
Black boy	25.97	2.24	-2.24
White boy	26.42	2.53	-2.36

3.7. Descriptive statistics

Descriptive analysis was performed to determine the averages (mean/median) and spread of the data (standard deviation/inter-quartile ranges) for continuous variables or frequencies for categorical variables. Differences in mean dietary intakes between sex-ethnic and socio-economic groups were tested using the independent t-test and the Mann-Whitney test. The independent t-test is a parametric test which is used to compare the statistical significance between the means of two independent groups on the same independent variable. This test assumes that the data is from normally distributed populations, measured at least at interval level, roughly equal variances and independent. The null hypothesis is that there no difference in the means of the groups whilst the alternative hypothesis is that a difference exists. The null hypothesis was rejected if $p < 0.05$ (Field, 2005). The independent t-test was therefore performed when these criteria were met. However, SPSS allows for adjustments to be made if equal variances cannot be assumed. Levene's test for equality of variances is performed when the independent t-test is run. The output from the t-test has two rows, one in which equal variances is assumed and another in which it is not. If the significance of Levene's test is <0.05 then the 'equal variances not assumed' results are used otherwise the 'equal variances assumed' are used. The Mann-Whitney test is the non-parametric equivalent of the independent t-test. This was used when the data were not normally distributed.

For body composition, differences in proportions of participants in BMI, % fat and lean mass categories between sex-ethnic groups were tested using the Pearson's chi-square test. The Pearson's chi-square test is used to establish whether a significant relationship exists between two categorical variables by comparing observed frequencies to those expected by chance in the categories. The chi-square assumes that each person will contribute to only one cell of the contingency table and that expected frequencies should be greater than 5. If $p<0.05$ the null hypothesis that there is no association is rejected and accept the hypothesis that there is a relationship between the variables (Field, 2005).

3.8. Bivariate analysis

Bivariate analyses were performed to test the association of socioeconomic status, ethnicity, puberty, physical activity, dieting behaviors, food choice factors and anthropometric measures with the outcome variables. The tests employed were dependant on the type of variable and their distribution. For continuous outcome variables (energy intake, % fat, carbohydrate, protein, and added sugar intake), independent t-tests and one way ANOVA were used to assess statistical significance for categorical, whilst Pearson's correlation coefficients were used for continuous independent variables. For the categorical outcome variables (BMI, % body fat, % lean tissue, categorised fat and carbohydrate intake) Pearson's chi-square tests were used to assess statistical significance for the independent categorical variables, and independent t-tests were used for the continuous independent variables. Significant variables with a p-value <0.05 were retained for inclusion in the multivariate analysis.

3.9. Creation of a socioeconomic status (SES) index

There were too many SES variables for the current study sample size to perform multivariate analysis. There was also high correlation between some of the SES variables meaning that there would be a problem of multicollinearity if they were all entered into a regression model. It was therefore necessary to combine the SES measures into a general linear SES index to overcome this problem. Principal Component Analysis (PCA) is a data reduction technique for extracting from a set of variables a few linear combinations that capture the common variance most successfully. The first component of a set of variables is the linear index of all the variables that captures the largest amount of information that is common to all variables (Filmer and Pritchett, 2001). PCA was therefore used to derive a linear SES index. This technique was chosen because it works best when variables are correlated as well as when the distribution of variable varies across cases. The variables that are unequally distributed between cases are given more weight in PCA (McKenzie, 2003) hence only the measures that were significantly associated with any of the outcomes in the bivariate analysis were used in the PCA analysis. If all cases exhibit a certain characteristic or not there would be no variation between cases and would be of little use in differentiating SES (Vyas and Kumaranayake, 2006). Use of a single proxy for SES is unreliable whereas an aggregation of several weighted indicators is more reliable (Bollen *et al.*, 2002). PCA was also chosen because compared with other techniques it is computationally easier and the resulting indices allow for comparison across different studies provided they are calculated using similar variables (Jobson, 1992). The limitation is that the variables included in the analysis are limited to those for which data is collected in the study. For the current study there were no data collected on ownership of consumer durables for the year 15 questionnaire hence they are not included. Ideally an indicator of SES should include all measures of relevance to SES. Table 3.9.1 shows the distribution of the available socioeconomic status measures.

Table 3.9.1: Distribution of socioeconomic status variables

Variable	n	%
Child grant	**149**	
No	94	63.1
Yes	55	36.9
Disability grant	**149**	
No	136	91.3
Yes	13	8.7
Foster care grant	**150**	
No	144	96.0
Yes	6	4.0
Financial support from mother	**150**	
No	54	36.0
Yes	96	64.0
Financial support father/partner	**150**	
No	99	66.0
Yes	51	34.0
Financial support from grandparent	**150**	
No	137	91.3
Yes	13	8.7
Financial support from caregiver	**150**	
No	132	88
Yes	18	12
Goods/Financial support from others	**150**	
No	133	88.7
Yes	17	11.3
Goods support from mother	**150**	
No	44	29.3
Yes	106	70.7
Goods support from father/partner	**150**	
No	106	70.7
Yes	44	29.3
Goods support from grandparent	**150**	
No	137	91.3
Yes	13	8.7
Goods support from caregiver	**150**	
No	133	88.7
Yes	17	11.3
Emotional support from mother	**149**	
No	24	16.1
Yes	125	83.9
Emotional support from father/partner	**149**	
No	119	79.9
Yes	30	20.1

Table 3.9.1 continued

Variable	n	%
Emotional support from grandparent	**148**	
No	131	88.5
Yes	17	11.5
Emotional support from caregiver		
No	128	85.9
Yes	21	14.1
Water and toilet facility	**149**	
Both indoor	81	54.4
Mixed (Indoor and outdoor)	34	22.8
Both outdoor	34	22.8
Medical aid	**150**	
No	109	72.7
Yes	41	27.3
Marital status	**150**	
Alone (single, divorced, widowed)	90	60.0
With someone (married, living with partner)	60	40.0
House description	**150**	
Shack/room/garage/hostel	13	8.7
House/flat/cottage	137	91.3
Employment status	**150**	
Employed	101	67.3
Unemployed	49	32.7

Significant SES predictors from the bivariate analysis ($p<0.05$) with the dietary intake and body composition outcomes were used to create the index. PCA enables the weights of the measures in the index to be determined. The results of the significant bivariate predictors for each outcome are shown in detail in Appendix D in Tables D1 – D7. There were no significant SES associations with

- Energy intake (boys only)
- % fat intake (whole sample)
- % carbohydrate intake (whole sample)
- % added sugar (whole sample)
- Categorised % fat intake

There were 14 variables which had significant associations with at least one of the outcome variables and were therefore included in the PCA analysis. These are

- Child grant
- Foster care grant
- Financial support from father/partner
- Goods support from father/partner
- Goods/financial support from others
- Emotional support from father/partner
- Medical aid
- Water-toilet facility
- Marital status
- Employment status
- Emotional support from mother
- Financial support from caregiver
- Goods support from caregiver
- Emotional support from caregiver

The Kaiser-Meyer-Olkin measure of sampling adequacy, a test that assesses the amount of variance in the data that can be explained by the factors was 0.775. This is an acceptable value as 0.5 is considered to be poor, 0.6 is good and a value closer to one is desirable. Bartlett's test of sphericity had a chi-square = 1267.158, df = 91 and p<0.001 indicating that the data is factorable (Brace *et al.*, 2003). Three factors were extracted but most of the variables loaded strongly on component 1. The factor loadings of Component 1 for the unrotated solution are shown in Table 3.9.2. The caregiver is important in this SES index as the highest factor loadings are for financial support from caregiver (0.748), emotional support from caregiver (0.746) and goods support from caregiver (0.745). Component 1 which explained 30.3% of the variance was used to create the linear index.

The resulting factor scores from Component 1 had a skewed distribution (range -1.449 to 2.970) as was shown by the histogram, skewness and kurtosis statistics. The Kolmogorov-Smirnov test had a p-value of <0.001 indicating a deviation from normality. The factor scores were split into tertiles which represented relatively low, medium and high SES.

Table 3.9.2: Factor loadings of Component 1

Variable	Factor loading
Child grant	0.393
Foster care grant	0.445
Financial support from dad/partner	0.686
Financial support from caregiver	0.748
Goods/financial support from others	0.416
Goods support from dad/partner	0.620
Goods support from caregiver	0.745
Emotional support from mother	0.597
Emotional support from dad/partner	0.593
Emotional support caregiver	0.746
Medical aid	0.388
Water and toilet facility	0.296
Employment status	0.556
Marital status	0.456

3.10. Multivariate analysis

The criteria for inclusion into the multivariate analysis were variables with two tailed p-value <0.05 in the bivariate analysis. Other variables known to be predictors of the outcome variable under investigation from past research such as sex and pubertal stage of development were also included in the regression analysis even if they were not significant in the bivariate analysis. A p-value <0.05 indicated significance in the multivariate analysis. Linear regression was used for the continuous variables total energy intake and % protein intake. Logistic regression was performed for BMI, % fat and lean mass. This approach was used because BMI was split into two categories not overweight or obese and overweight or obese using the international classification of Cole *et al.*, (2000), and a median split was used to assign participants to relative high or low % fat and lean mass (see pages 144,149).

The variables that had to be controlled for were all entered in the first block in the first step using the Enter method for both linear and logistic regression. The other significant predictors from the bivariate analysis were then added individually to the initial model using the Enter method. These were either retained or discarded if they were significant or not respectively at each step and the next variable entered. The model building process is shown for each of the outcome variables with significant bivariate predictors.

3.10.1. Linear regression with energy intake as outcome variable

Sex and pubertal stage of development were controlled for in the linear regression model. Males have higher energy requirements in comparison to their female counterparts with the same age and weight resulting mainly from the differences in their body composition (WHO, 1985) hence the need to control for sex. Pubertal stage of development significantly influences energy requirements which could be explained mainly by the alterations in fat-free mass and fat mass which occur (Molnar and Schutz, 1997, Bitar *et al.*, 2000, Clavien *et al.*, 1996).

Step 1: sex, breast/genitalia development and pubic hair development.
Step 2: sex, breast/genitalia development, pubic hair development and height.
Step 3: sex, breast/genitalia development, pubic hair development and biepi condylar breadth of humerus.
Step 4: sex, breast/genitalia development, pubic hair development and biepi condylar breadth of femur.
Step 5: sex, breast/genitalia development, pubic hair development and SES.
Step 6: sex, breast/genitalia development, pubic hair development and multivitamin use.
Step 7: sex, breast/genitalia development, pubic hair development and food choice factor 'mood'.
Step 8: sex, breast/genitalia development, pubic hair development and food choice factor 'hunger level'.
Step 9: sex, breast/genitalia development, pubic hair development and food choice factor 'health benefits'.

3.10.2. Linear regression with % protein intake as outcome variable

Step 1: ethnicity.
Step 2: ethnicity and age.
Step 3: ethnicity and SES.
Step 4: ethnicity, SES and multivitamin use.

3.10.3. Logistic regression with BMI as outcome variable

Pubertal development influences body composition, and males biologically tend to have higher lean mass than their female counterparts (Tanner, 1989). Pubertal development and sex were therefore controlled for in the logistic regression.

Step 1: sex, breast/genitalia development and pubic hair development.

Step 2: sex, breast/genitalia development, pubic hair development and SES.

3.10.4. Logistic regression with % body fat as outcome variable

Pubertal development and height were controlled for in this analysis. Height needs to be controlled for because of its correlation with fat free mass and fat mass (Wells *et al.*, 2002). Sex was not controlled for in the multivariate analysis as equal numbers of boys and girls were placed into relative high and low % body fat using the median split. Biologically females have a higher % body fat therefore if the variable had been continuous sex would have been controlled for.

Step 1: breast/genitalia development, pubic hair development and height.

Step 2: breast/genitalia development, pubic hair development, height and SES.

3.10.5. Logistic regression with % lean tissue as outcome variable

Similar variables as for % body fat were controlled for.

Step 1: age, breast/genitalia development, pubic hair development and height

Step 2: age, breast/genitalia development, pubic hair development, height and socioeconomic status

3.11. Identification of influential cases and multicollinearity

The models were checked for accuracy by investigating whether there were any outliers or influential cases. Outliers were identified by looking at the standardized residuals and those with values > 3 or <-3 were investigated. Influential cases were identified using Cook's distance and leverage values. Cook's distance measures the influence a case has over the whole model and values greater than 1 were regarded as a cause for concern (Cook and Weisberg, 1982) and therefore investigated further. Leverage measures the influence of the observed values over the predicted values. Average leverage = ((k+1)/n) where k=number of predictors. Cases with three times the average leverage were considered to be influential (Stevens, 1992).

Multicollinearity was checked by looking at the correlation matrix, tolerance, VIF and the collinearity diagnostics. Predictors with r >0.9 are collinear and were therefore investigated and where possible combined to form one variable. Tolerance values <0.1 indicates a collinearity problem (Menard, 1995). VIF values which were greater than 10 were investigated as these are indicative of a collinearity problem (Myers, 1990). The collinearity diagnostics indicate a problem of collinearity if there are large variance proportions on the same small Eigen values.

The models were also checked for the assumptions of independent errors and normally distributed residuals. Independent errors were checked using the Durbin-Watson statistic which should be close to 2 if the assumption is met. The recommended range is 1-3 (Field, 2005). The residuals' distribution was investigated by plotting histograms and probability plots of the residuals which should be a bell shaped curve or straight line respectively for a normal distribution (Field, 2005).

Chapter 4: Adolescent diet in South Africa: energy and macronutrient intake

4.0. Introduction

This chapter begins by describing the characteristics of the sample being studied. The daily energy and macronutrient (fat, carbohydrate and protein) intake of the sample are then reported by gender and ethnicity and compared with recommended intakes (WHO/FAO, 2003). Results of the bivariate and multivariate associations of the dietary intake variables with various demographic, socioeconomic and food choice factors are then presented.

4.1. Sample characteristics

The characteristics of the 154 adolescent participants are shown in Table 4.1. The proportion of overweight or obese girls and boys is 24.7% and 9.7% respectively. Boys have significantly higher waist-hip ratio ($p<0.001$), height ($p<0.001$), physical activity ($p=0.024$) and a lower prevalence of overweight/obesity ($p=0.015$) than their female counterparts. There are also significantly more boys in the late Tanner stage for pubic hair development ($p=0.009$).

4.2. Outliers

Details of the identification of outliers are described in detail in the methods chapter (Section 3.6.1)). The skewness, kurtosis, and Kolmogorov-Smirnov statistics revealed that the energy intake data was normally distributed for boys and girls. No significant outliers (>3.29 z-scores) (Field, 2005) were identified. Further investigation of the seven participants that had z-scores >1.96 revealed that their intakes were plausible and therefore all the cases could be retained for analysis.

When the energy intake data for both girls and boys were combined and plotted the data were not normally distributed with 4 extreme values according to the box and whisker plots. Removal of these resulted in a normal distribution (Kolmogorov-Smirnov p-value = 0.200). Analysis was performed with and without these four cases. No significant differences were observed with and without these four cases therefore results are reported without these cases.

Table 4.1: Characteristics of the adolescent sample by sex

	Boys	Girls
[1]**Number of participants**	46.8(72)	53.2(82)
[1]**Ethnicity**		
Black	86.1(62)	81.7(67)
White	13.9(10)	18.3(15)
[2]**Age (years)**	15.38 ± 0.08	15.37± 0.10
[1]**Pubertal development**		
Breast/genitalia Tanner stage		
Early stage (2&3)	29.6(21)	27.8(22)
Late stage (4&5)	70.4(50)	72.2(57)
Pubic hair Tanner stage**		
Early stage (2&3)	19.7(14)	39.2(31)
Late stage (4&5)	80.3(57)	60.8(48)
[2]**Waist-hip-ratio*** **	0.79±0.04	0.72 ±0.05
[3]**Weight(kg)**	54.6 (48.3-61.0)	53.4 (48.3-60.0)
[2]**Height(m)*** **	1.67±0.08	1.58±0.06
[3]**BMI (kg/m2)**	19.4 (17.8-21.2)	21.63 (19.3-24.4)
[1]**BMI status***		
Not overweight/obese	90.3(65)	75.3(61)
Overweight	4.2(3)	16.0 (13)
Obese	5.6(4)	8.6(7)
[1]**Physical activity***		
Low	39.4(26)	58.2(46)
High	60.6(40)	41.8(33)

Data expressed as [1]% (n), [2]mean ± SD, and [3]median (inter-quartile range).
Cole *et al.*, (2000) cut-offs for overweight and obesity.
*p<0.05, **p<0.01, ***p<0.001

4.3. Energy and macronutrient intake by gender and ethnicity

Table 4.3.1 shows the mean energy and macronutrient intake of the sample (n=150) by gender and ethnicity. The average energy intake as a percentage of the recommended dietary allowance (RDA) averaged 103% for boys and 124% in girls. 47.1% and 33.8% of boys and girls respectively had intakes below the RDA (Food and Nutrition Board, 1989). Table 4.3.2 shows the significance of the difference in the different sex-ethnic groups. Black girls consumed significantly more saturated fat (p=0.001) and added sugar (p= 0.016) and less plant protein (p<0.001) and dietary fibre (p= 0.015) than black boys. For the white participants, boys had higher energy intakes (p=0.015) and lower fat intakes ($p=0.040$) than their female counterparts. Comparison of black and white boys revealed significant differences in total protein ($p=0.002$), plant protein ($p=0.001$), animal protein ($p<0.001$), saturated fat ($p=0.014$) and polyunsaturated fat ($p=0.007$). The white boys had higher total protein, animal protein and saturated fat than the black boys. Black girls had higher energy intakes ($p=0.007$), carbohydrate ($p=0.020$) and lower total protein (0.001), animal protein ($p=0.001$) and saturated fat ($p=0.015$) than white girls. Whites therefore consumed more proteins especially animal proteins and saturated fat compared to blacks. Because of the small white sample the analysis was rerun for the comparison of boys and girls by ethnicity using the non-parametric Mann-Whitney tests. Similar results were observed apart from the % carbohydrate intake between girls, where the difference between the two groups was no longer statistically significant ($p=0.062$).

Table 4.3.1: Daily energy and macronutrient intake by gender and ethnicity

Variable	Whole sample (n=150)	White girls (n=15)	White boys (n=9)	Black girls (n=65)	Black boys (n=61)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Energy (E) (kcal)	2900 (1069)	2227 (643)	3148 (1070)	2845 (1105)	3087 (1061)
Total protein (g)	75.5 (28.5)	65.9 (18.7)	93.1 (27.6)	73.0 (31.6)	77.9 (26.1)
Total Protein (% E)	10.7 (1.9)	12.3 (2.4)	12.3 (20)	10.4 (1.9)	10.4 (1.6)
Plant protein (% E)	4.7 (0.9)	4.1 (0.8)	4.2 (0.9)	4.4 (0.9)	5.2 (0.8)
Animal protein (% E)	5.6 (1.9)	7.4 (1.8)	7.4 (1.3)	5.6 (1.9)	5.0 (1.7)
Total fat(g)	109.5 (45.2)	86.2 (22.4)	103.9 (31.4)	110.0 (49.0)	115.6 (45.7)
Total fat (%E)	33.3 (5.3)	34.9 (5.1)	30.0 (5.7)	33.6 (5.3)	33.0 (5.2)
Saturated (%E)	10.0 (2.1)	11.6 (1.4)	10.6 (1.9)	10.4 (2.2)	9.1 (1.6)
Monounsaturated (%E)	11.4 (2.4)	11.3 (1.9)	9.9 (2.4)	11.4 (2.3)	11.5 (2.6)
Polyunsaturated (%E)	8.9 (2.6)	8.5 (2.5)	6.9(2.2)	8.8 (2.5)	9.4 (2.7)
Total carbohydrate (g)	369.7 (140.4)	268.9 (94.8)	419.4 (182.1)	358.8 (132.7)	398.6 (140.5)
Total Carbohydrate (% E)	51.9 (5.6)	48.3 (5.6)	52.9 (7.0)	52.0 (5.5)	52.4 (5.3)
Added sugar(% E)	14.0 (5.6)	12.3 (8.2)	14.4 (7.0)	15.2 (5.6)	13.0 (4.5)
Dietary fibre (g)	28.3 (12.6)	25.8 (14.5)	36.1 (15.0)	25.8(12.2)	30.5(11.6)

See Table 4.3.2 (page 111) for results of the significance of the difference in the different sex-ethnic groups.

Table 4.3.2: Comparison of differences[1] in macronutrient intake by gender and ethnicity

Variable	BB[2] versus BG[3]	WB[4] versus WG[5]	WB versus BB	WG versus BG
Energy (kcal)	t = 1.252 , df =124	t = 2.649*, df =22	t = -0.160, df = 68	t = 2.870**, df = 35.906
Total protein (%)	t = -0.006, df =124	t = 0.014, df =22	t = -3.192**, df = 68	t = -3.335**, df =78
Plant protein (%)	t = 5.406***, df =124	t = 0.254, df =22	t = 3.582**, df = 68	t = 1.257, df =78
Animal protein (%)	t = -1.964, df =124	t = -0.024, df =22	t = -4.084***, df = 68	t = -3.315**, df =78
Total fat (%)	t = -0.577, df =124	t = -2.179*, df =22	t = 1.629, df = 68	t = -0.852, df =78
Saturated fat (%)	U = 1306.000**, n_1 = 61, n_2= 65	U = 45.000, n_1 = 9, n_2 = 15	U = 134.000*, n_1 = 9, n_2 = 61	U = 290.000*, n_1= 15, n_2 = 65
Monounsaturated fat (%)	t = 0.304, df =124	t = -1.528, df =22	t = 1.709, df = 68	t = 0.160 , df =78
Polyunsaturated fat (%)	t = 1.419, df =124	t = -1.669, df =22	t = 2.771**, df = 68	t = 0.351, df =78
Total carbohydrate (%)	t = 0.471, df =124	t = 1.803, df =22	t = -0.257, df = 68	t = 2.366*, df =78
Added sugar (%)	t = -2.453*, df =124	t =0.643, df =22	t = -0.816, df = 68	t = 1.312, df =17.108
Dietary fibre (g)	U =1486.000*, n_1 = 61, n_2 = 65	U = 36.000, n_1 = 9, n_2 = 15	U = 221.000, n_1= 9, n_2 = 61	U = 461.000, n_1= 15, n_2 = 65

*$p<0.05$; **$p<0.01$;***$p<0.001$, [2]BB- black boys, [3]BG – black girls, [4]WB – white boys, [5]WG – white girls

[1]Independent t-tests and Mann-Whitney tests were used to test for significant differences between groups. See Table 4.3.1 (page 110) for the means and SDs for each group.

4.4. Recommended nutrient intakes

The recommended nutrient intakes for preventing diet-related chronic diseases are shown in Table 4.4.1 (WHO/FAO, 2003). Total carbohydrate contributed 51.8%, protein 10.7% and fat 33.3% of the total daily energy intake for the whole South African sample. Protein intake as a proportion of total energy intake is higher for the Whites in comparison to the Blacks but still within the recommended range for both groups. Added sugar is over the recommended limit for all groups and is highest in the black females at 15.3% of energy intake. All of the groups met the recommended dietary fibre intake.

Table 4.4.1: Range of population nutrient intake goals for preventing diet-related chronic diseases

Dietary factor	Goals(% of total energy)
Total fat	15-30%
Saturated fatty acids (SFAs)	<10%
Polyunsaturated fatty acids (PUFAs)	6-10%
Monounsaturated fatty acids (MUFAs)	total fat-(SFAs+ PUFAs+ transFA)
Total carbohydrate	55-75%
Free sugars(added plus sugars naturally present in honey, syrup, fruit juices)	<10%
Protein	10-15%
Dietary fibre	25g/day

(WHO/FAO, 2003)

The macronutrient intake of the sample is compared to the recommended WHO/FAO (2003) intakes in Figures 4.4.1 - 4.4.4. None of the participants are consuming fat intakes below the recommended intake. The majority (66.7% – 80%) for the different sex-ethnic groups are consuming fat intakes greater than 30%. Most of the participants are consuming carbohydrates below the recommended range. However added sugar is being consumed above the recommended intake by the majority with the most extreme intakes observed among black girls where 84.6% are consuming more than the recommended 10%. Protein intake shows almost equal numbers of black girls and boys consuming protein below and within the recommended range. In contrast, the majority of the Whites are within the recommended protein intake range.

Figure 4.4.1: Percentage of the sample achieving WHO/FAO guidelines for fat intake by sex and ethnic group

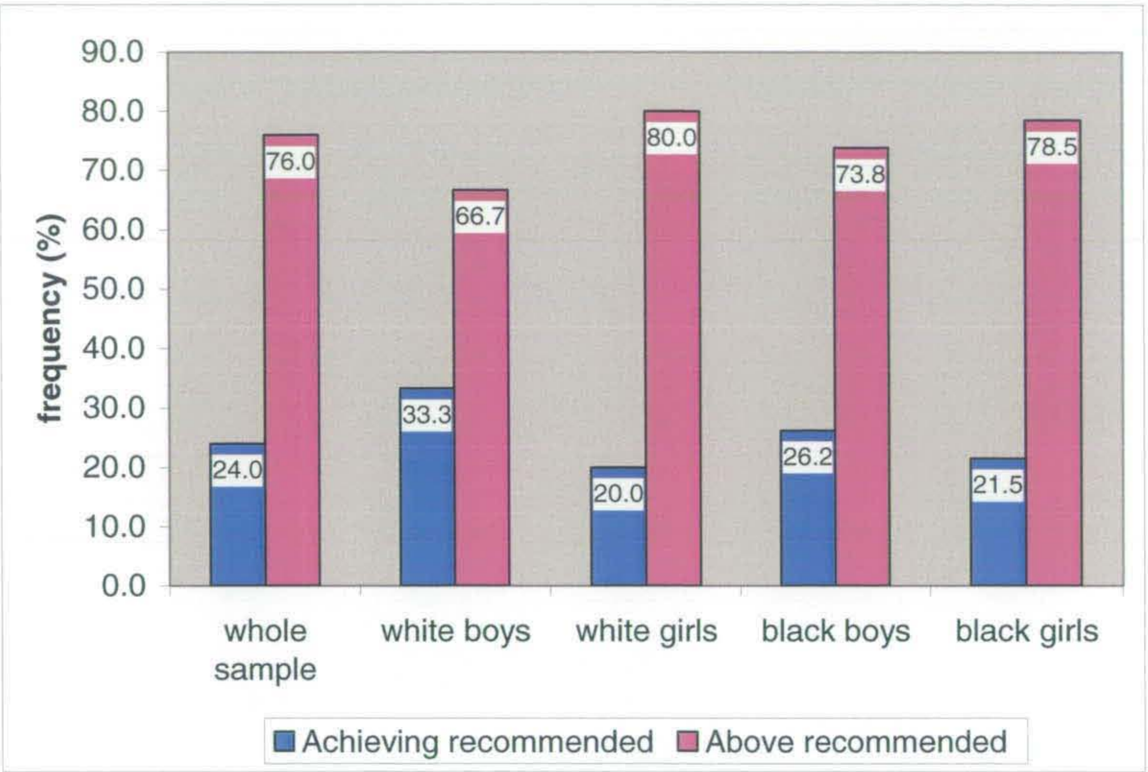


Figure 4.4.2: Percentage of the sample achieving WHO/FAO guidelines for carbohydrate intake by sex and ethnic group

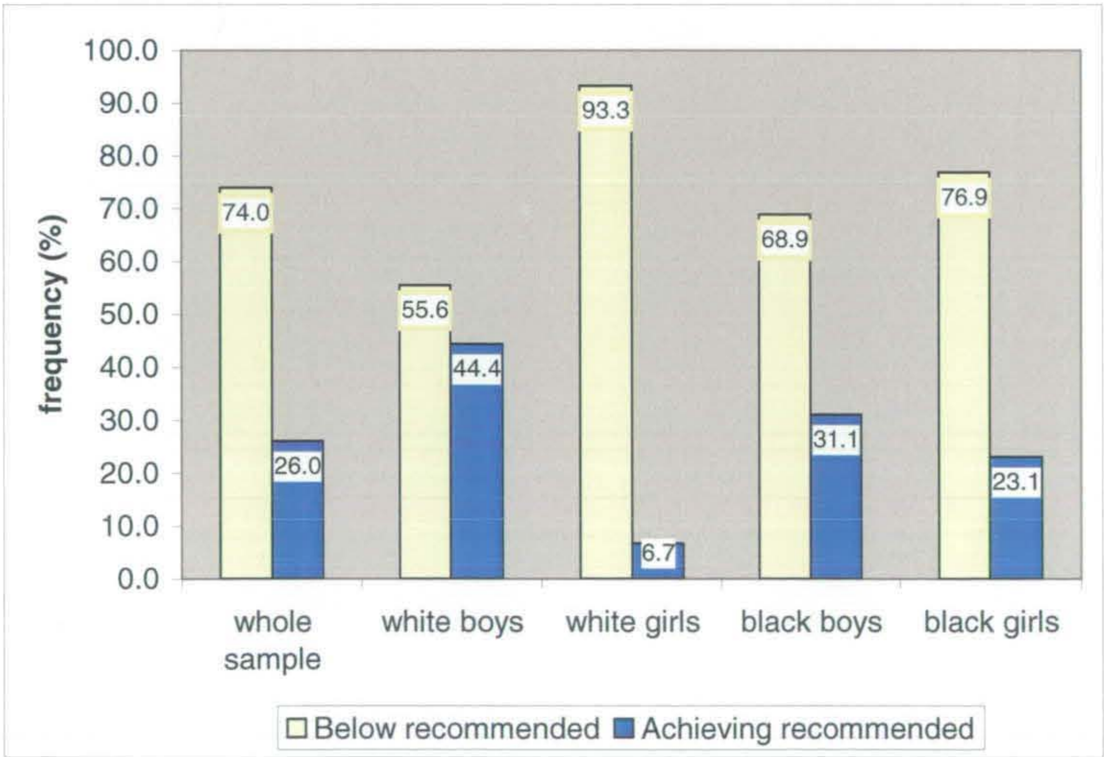


Figure 4.4.3: Percentage of the sample achieving WHO/FAO guidelines for added sugar intake by sex and ethnic group

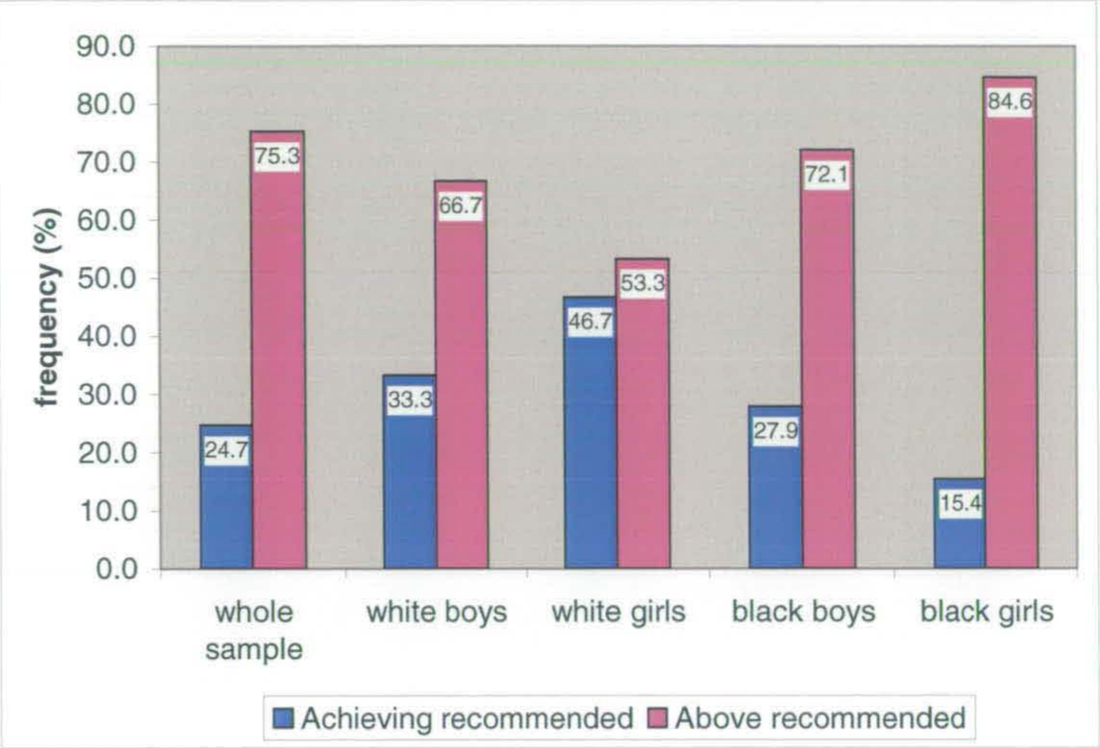
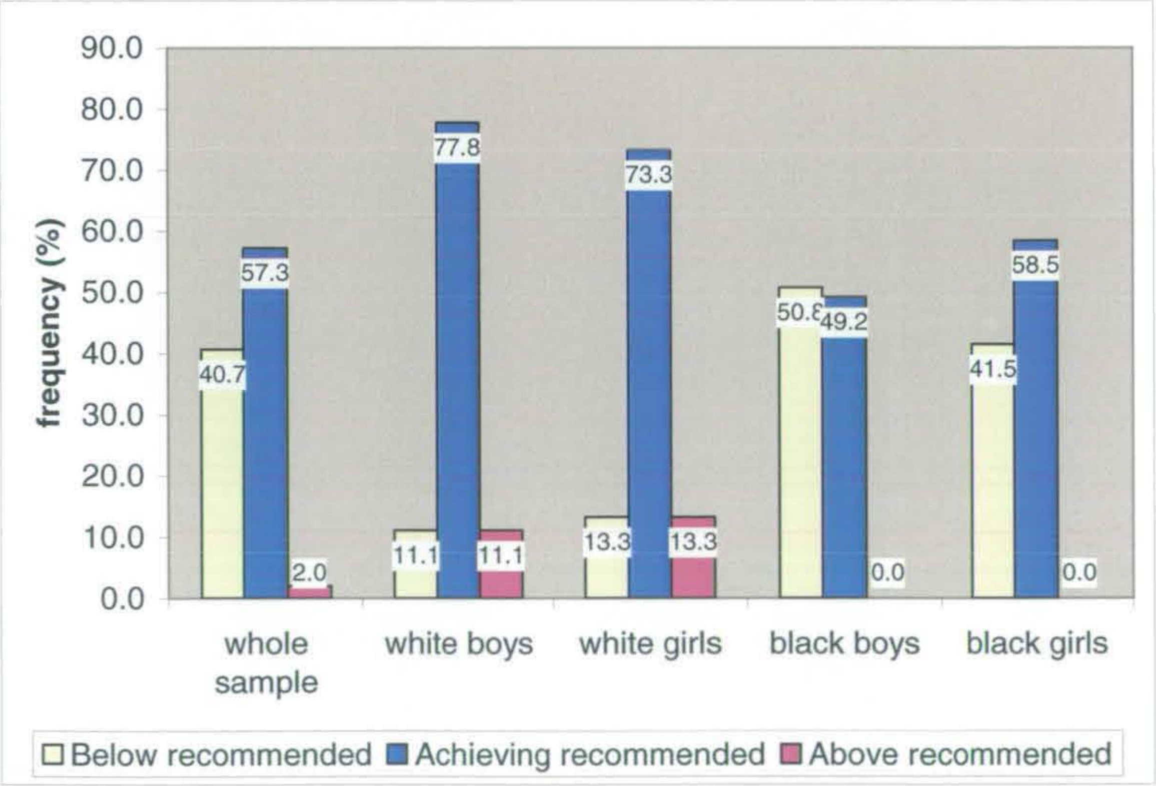


Figure 4.4.4: Percentage of the sample achieving WHO/FAO guidelines for protein intake by sex and ethnic group



4.5. Fat and protein constituents as a proportion of total energy intake

The contributions of the fat constituents to energy intake are shown in Figure 4.5.1 which shows that the Whites and black girls have a slightly higher saturated fat intake compared to the recommended (<10%) whereas black boys meet the requirement (WHO/FAO, 2003).

Protein breakdown into animal and plant protein is shown in Figure 4.5.2. All of the groups have higher animal protein than plant protein intake except for black boys who have slightly higher plant protein intake as a proportion of total energy.

Figure 4.5.1: Fat constituents as a proportion of total energy intake by sex and ethnic group

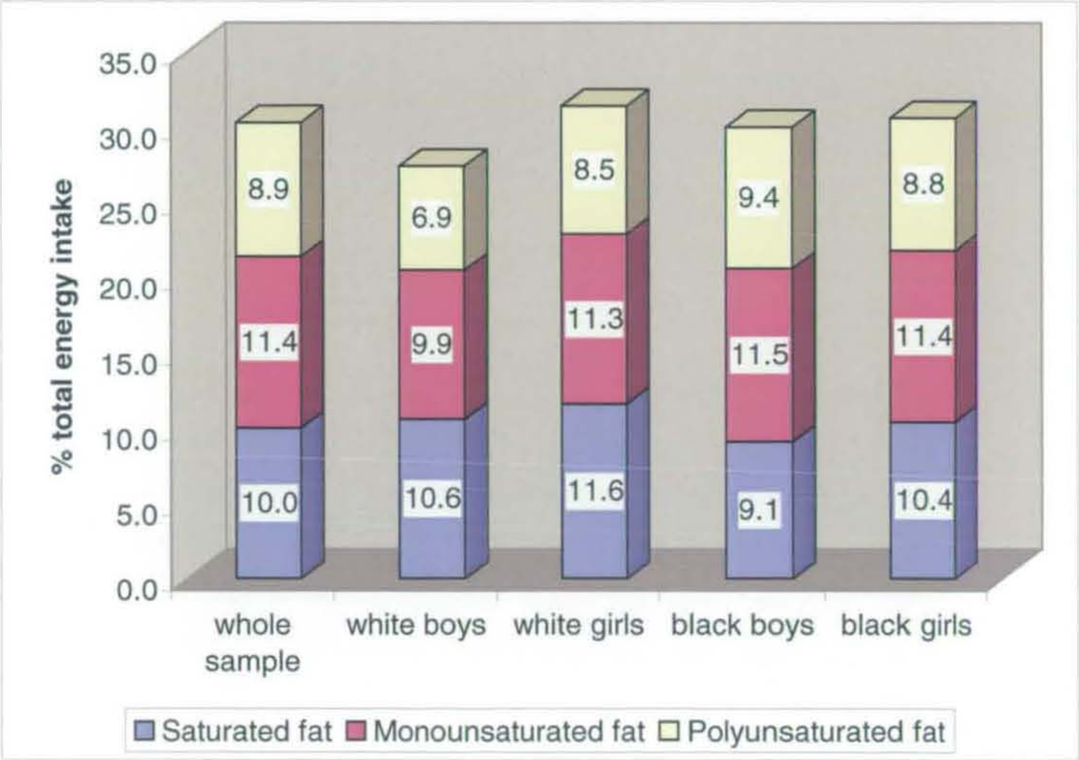
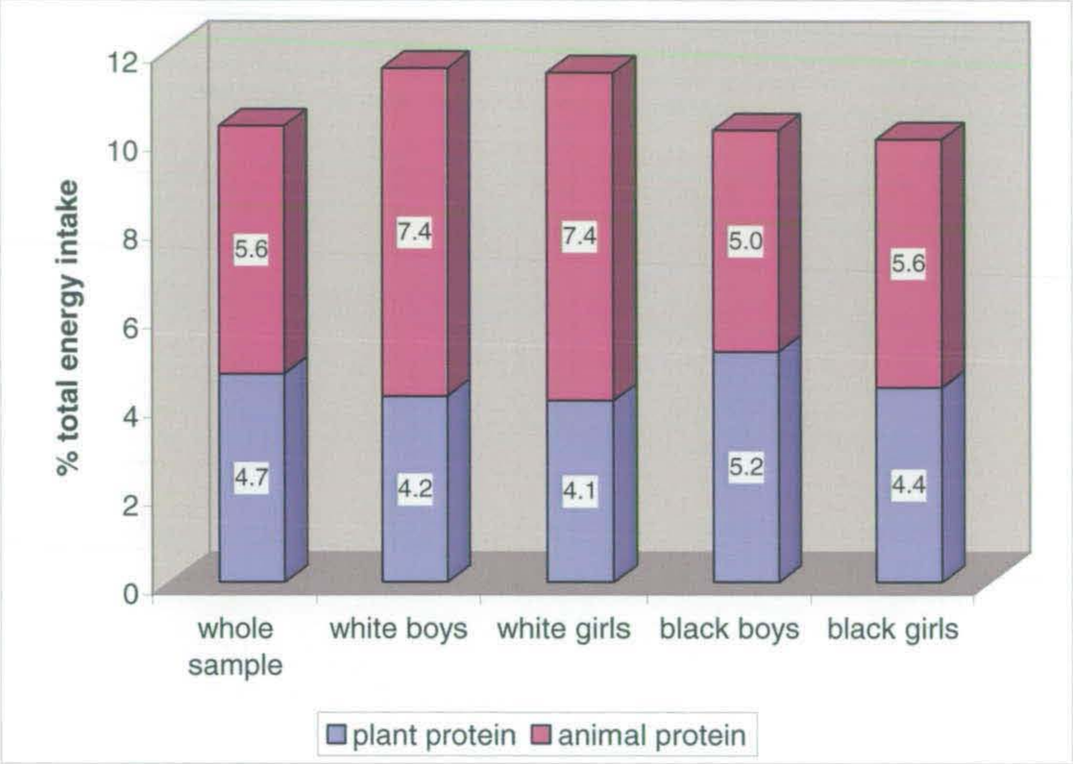


Figure 4.5.2: Protein constituents as a proportion of total energy intake by sex and ethnic group



4.6. Socioeconomic status (SES) and dietary intake

The energy and macronutrient intake by SES is shown in Table 4.6.1 (see how participants are allocated to an SES category in the methods chapter (Section 3.9). Table 4.6.2 shows the significance of the difference in the socioeconomic groups. The high SES group consumed significantly higher % total protein, animal protein and % saturated fat and lower % plant protein and % polyunsaturated fat in comparison to the low and medium SES groups. The high SES also had significantly lower energy intake in comparison to the medium SES group. The only significant difference between the low and medium SES group was in plant protein which was lower in the latter.

Table 4.6.1: Mean (SD) energy and macronutrient intake by socioeconomic status

Variable	Low SES (n=48)	Medium SES (n=50)	High SES (n=49)
Energy (E) (kcal)	3001 (1177)	3090 (1029)	2599 (975)
Total protein (g)	76.0 (31.8)	77.0 (27.3)	73.3 (26.8)
Total Protein (% E)	10.3 (1.7)	10.2 (1.8)	11.6 (2.1)
Plant protein (% E)	5.0 (0.8)	4.6 (0.9)	4.5 (1.0)
Animal protein (% E)	5.0 (1.7)	5.3 (1.8)	6.6 (2.0)
Total fat(g)	114.4 (51.1)	117.0 (42.0)	97.2 (41.0)
Total fat (%E)	33.2 (4.5)	33.6 (5.1)	33.2 (6.2)
Saturated (%E)	9.5 (2.0)	9.6 (1.8)	10.8 (2.1)
Monounsaturated (%E)	11.3 (2.2)	11.6 (2.4)	11.3 (2.7)
Polyunsaturated (%E)	9.4 (2.4)	9.2 (2.6)	8.1 (2.5)
Total carbohydrate (g)	383.5 (144.2)	394.2 (139.7)	329.3 (134.9)
Total Carbohydrate (% E)	52.5 (4.8)	51.8 (5.3)	51.2 (6.6)
Added sugar(% E)	14.1 (4.9)	14.4 (5.6)	13.7 (6.4)
Dietary fibre (g)	29.8 (13.8)	29.3 (11.1)	25.5 (12.5)

See Table 4.6.2 (page 118) for results of the significance of the difference in the different socioeconomic groups.

Table 4.6.2: Comparison of differences[1] in macronutrient intake by socioeconomic status

Variable	Low vs. medium SES	Low vs. high SES	Medium vs. high SES
Energy (E) (kcal)	t = -0.399, df =96	t = 1.833, df =95	t = 2.435*, df = 97
Total Protein (% E)	t = 0.302, df =96	t = -3.546**, df =95	t = -3.804***, df = 97
Plant protein (% E)	t = 2.101*, df =96	t = 2.654**, df =95	t = 0.627, df = 97
Animal protein (% E)	t = -0.978, df =96	t = -4.352***, df =95	t = -3.386**, df = 97
Total fat (%E)	t = -0.421, df =96	t = 0.045, df =95	t = 0.402, df = 97
Saturated (%E)	U = 1117.000, n_1 = 48, n_2 = 50	U = 691.000***, n_1 = 48, n_2 = 49	U =796.000**, n_1 = 49, n_2 = 50
Monounsaturated (%E)	t = -0.703, df =96	t = -0.064, df =95	t = 0.570, df = 97
Polyunsaturated (%E)	t = 0.329, df =96	t = 2.666**, df =95	t = 2.235*, df = 97
Total Carbohydrate (% E)	t = 0.674, df =96	t = 1.105, df =95	t = 0.507, df = 97
Added sugar(% E)	t =-0.315, df =96	t = 0.300, df =95	t = 0.567, df = 97
Dietary fibre (g)	U = 1189.000, n_1 = 48, n_2 = 50	U = 942.500, n_1 = 48, n_2 = 49	U = 921.500*, n_1 = 49, n_2 =50

*p<0.05; **p<0.01;***p<0.001

[1]Independent t-tests and Mann-Whitney tests were used to test for significant differences between groups. See Table 4.6.1 (page 117) for the means and SDs for each group

4.7. Usual food consumption of the adolescent sample

The foods commonly consumed by at least one third of the sample are shown in Table 4.7.1 in descending frequency of consumption and the average amount consumed per day. The average amount of each food consumed is calculated excluding the non-consumers. The top 15 most commonly consumed foods were white rice, white sugar, apples, stiff maize meal porridge (pap), sweets (hard boiled and soft jelly type) carbonated cold drinks, white bread/rolls, oranges, fried potato chips/French fries, bananas, full fat milk, full fat milk powder, cold diluted squash drinks, roasted chicken (with skin) and beef stew with vegetables.

Snacks are commonly consumed by this sample i.e. sweets (hard boiled and soft jelly type) (74.7%), fizzy drinks (73.3%), popcorn (45.3%), savoury snacks e.g. Niknaks (44%), vetkoek (this is deep fried dough balls which can be served with savoury fillings such as mince meat or sweet fillings like honey and syrup) (39.3%) and sweets (chocolate coated bar) (38%). On average the adolescents consumed 237.2g and 151.8g per day of carbonated cold drinks and squash respectively. A commonly mentioned food item consumed at school was bunny chow which consists of a quarter bread, frankfurters, polony (another name for Bologna sausage), French fries and tomato sauce which are all commonly consumed by at least a third of the sample.

62.7% consume whole full fat milk, 23.3% low fat milk whilst only 3.3% consume skim milk. In the fats and oils group, a large percentage consume polyunsaturated margarine (45.3%) followed by peanut butter (40%) and brick margarine (31.3%). The most commonly consumed fish and seafood item is pilchard in tomato sauce (18%). The most commonly consumed vegetables are mashed potatoes (50%), carrots (41.3%), French salad (41.3%) and beetroot salad (35.3). There is a high consumption of apples (82%), oranges (68%), bananas (65.3%), pears (55.3) and naartjies (South African citrus fruits also known as satsumas, tangerines or mandarins in other countries) (46%). The data for the food items consumed by less by one third of the sample are presented in Table E1 in Appendix E.

The most commonly consumed foods are also presented by sex in Table 4.7.2 and 4.7.3. Nine out of the top ten commonly consumed foods are the same for boys and girls but the ordering is different. For example sweets (hard-boiled or soft jelly type) are the third most commonly consumed food for girls whereas sweets are ranked in eighth position for the boys. The tenth food commonly consumed by girls and boys which is different is raw tomato and banana respectively.

Table 4.7.1: Food items consumed frequently by at least a third of the whole adolescent sample (n=150)

Food item	Average amount consumed per day (g)	% of sample consuming the item
Rice, White, Cooked	40.2	87.3
Sugar, White, Granulated	29.0	83.3
Apple, Raw	93.4	82.0
Maize Meal, Cooked, Stiff Porridge	155.0	80.0
Sweets, Hard Boiled And Soft Jelly Type	26.1	74.7
Cold Drink, Carbonated, Average (e.g. Cola, Cream Soda, Tonic)	237.2	73.3
Bread/rolls, White	92.2	71.3
Orange, Raw (peeled)	106.2	68.0
Potato Chips/French Fries, Fried In Sun Oil	59.6	66.7
Banana, Raw (peeled)	42.5	65.3
Milk, Full Fat / Whole, Fresh	137.3	62.7
Milk Powder, Full Fat (Vitamin A, D & Fe added)	6.7	62.7
Chicken, Skin, Fresh, Cooked - Dry	30.8	60.7
Cold Drink, Squash, Diluted	151.8	60.0
Stew, Beef, With Vegetables	40.9	59.3
Beef, Mince (regular), Savoury (tomato, Onion)	25.8	58.0
Bread/rolls, Brown	104.8	58.0
Pear, Raw	65.8	55.3
Sauce, Tomato	16.9	54.7
Sausage, Beef & Pork / Boerewors, Grilled	16.1	53.3
Coffee, Brewed/ Instant	171.5	50.7
Potato, Mashed (whole Milk, Brick Margarine)	29.7	50.0
Tea, Brewed	258.3	48.7
Naartjie/tangerine, Raw (peeled)	50.1	46.0
Polony / Bologna, Beef & Pork	9.1	45.3

Table 4.7.1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Popcorn, Plain	17.7	45.3
Margarine, Polyunsaturated	21.1	45.3
Chicken, Skin, Fresh, Cooked - Moist	28.2	44.7
Snack, Savoury, Average, e.g. Niknaks, Fritos, Ghost Pops	20.8	44.0
Yoghurt, Fruit, Low Fat, Sweetened	47.9	43.3
Egg, Fried In Sun Oil	42.7	41.3
Carrot, Boiled (flesh And Skin)	19.5	41.3
Salad: French (lettuce, Tomato, Cucumber, No Dressing)	23.3	41.3
Tomato And Onion, Stewed (no Sugar)	51.8	41.3
Cheese, Cheddar	22.6	40.7
Peanut Butter; Smooth Style	15.8	40.0
Vetkoek, Homemade (cake Flour, Water)	60.5	39.3
Frankfurter, Beef & Pork	14.7	38.0
Sweets, Chocolate Coated Bar	22.0	38.0
Salad: Beetroot	19.7	35.3
Avocado, Raw (peeled)	38.7	34.7
Breakfast Cereal- Corn Flakes, Plain	21.0	34.0
Tomato, Raw	42.9	34.0

Table 4.7.2: Food items consumed frequently by at least a third of the adolescent girls (n=80)

Food item	Average amount consumed per day (g)	% of sample consuming the item
Rice, White, Cooked	34.9	85.0
Sugar, White, Granulated	23.3	78.8
Sweets, Hard Boiled And Soft Jelly Type	24.9	77.5
Apple, Raw	86.8	76.3
Maize Meal, Cooked, Stiff Porridge	115.6	75.0
Cold Drink, Carbonated, Average (e.g. Cola, Cream Soda, Tonic)	238.9	75.0
Bread/rolls, White	75.5	70.0
Orange, Raw (peeled)	108.7	63.8
Potato Chips/French Fries, Fried In Sun Oil	63.5	63.8
Tomato, Raw	37.8	63.8
Chicken, Skin, Fresh, Cooked - Dry	31.6	62.5
Banana, Raw (peeled)	44.8	61.3
Milk, Full Fat / Whole, Fresh	104.9	60.0
Cold Drink, Squash, Diluted	147.9	60.0
Stew, Beef, With Vegetables	40.0	58.8
Beef, Mince (regular), Savoury (tomato, Onion)	24.7	57.5
Bread/rolls, Brown	80.7	57.5
Potato, Mashed (whole Milk, Brick Margarine)	29.2	53.8
Sausage, Beef & Pork / Boerewors, Grilled	16.8	52.5
Sauce, Tomato	17.0	52.5
Pear, Raw	64.3	52.5
Coffee, Brewed/ Instant	160.4	52.5
Popcorn, Plain	14.6	51.3
Yoghurt, Fruit, Low Fat, Sweetened	47.4	50.0
Tea, Brewed	246.3	48.8

Table 4.7.2 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Margarine, Polyunsaturated	18.6	47.5
Naartjie/tangerine, Raw (peeled)	60.8	46.3
Salad: French (lettuce, Tomato, Cucumber, No Dressing)	28.4	46.3
Tomato And Onion, Stewed (no Sugar)	38.6	46.3
Cheese, Cheddar	24.1	43.8
Frankfurter, Beef & Pork	15.6	41.3
Sweets, Chocolate Coated Bar	25.6	41.3
Chicken, Skin, Fresh, Cooked - Moist	25.6	41.3
Snack, Savoury, Average, e.g. Niknaks, Fritos, Ghost Pops	27.7	40.0
Carrot, Boiled (flesh And Skin)	21.7	40.0
Cookies, Commercial, Plain	20.4	36.3
Patty, Beef, Frozen, Grilled	16.6	35.0
Avocado, Raw (peeled)	35.8	33.8

Table 4.7.3: Food items consumed frequently by at least a third of the adolescent boys (n=70)

Food item	Average amount consumed per day (g)	% of sample consuming the item
Rice, White, Cooked	46.0	90.0
Sugar, White, Granulated	34.8	88.6
Apple, Raw	99.8	88.6
Maize Meal, Cooked, Stiff Porridge	194.4	85.7
Orange, Raw (peeled)	103.8	72.9
Bread/rolls, White	110.7	72.9
Cold Drink, Carbonated, Average (e.g. Cola, Cream Soda, Tonic)	235.1	71.4
Sweets, Hard Boiled And Soft Jelly Type	27.6	71.4
Banana, Raw (peeled)	40.1	70.0
Potato Chips/French Fries, Fried In Sun Oil	55.1	70.0
Milk, Full Fat / Whole, Fresh	171.1	65.7
Stew, Beef, With Vegetables	41.9	60.0
Cold Drink, Squash, Diluted	156.3	60.0
Beef, Mince (regular), Savoury (tomato, Onion)	27.0	58.6
Bread/rolls, Brown	131.8	58.6
Pear, Raw	67.3	58.6
Chicken, Skin, Fresh, Cooked - Dry	30.0	58.6
Sauce, Tomato	16.8	57.1
Polony / Bologna, Beef & Pork	10.0	54.3
Sausage, Beef & Pork / Boerewors, Grilled	15.3	54.3
Vetkoek, Homemade (cake Flour, Water)	72.7	48.6
Snack, Savoury, Average, e.g. Niknaks, Fritos, Ghost Pops	14.2	48.6
Tomato And Onion, Stewed (no Sugar)	62.7	48.6
Coffee, Brewed/ Instant	185.3	48.6
Tea, Brewed	272.1	48.6

Table 4.7.3 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Chicken, Skin, Fresh, Cooked - Moist	30.8	48.6
Egg, Fried In Sun Oil	41.8	45.7
Naartjie/tangerine, Raw (peeled)	37.7	45.7
Potato, Mashed (whole Milk, Brick Margarine)	30.4	45.7
Margarine, Polyunsaturated	24.3	42.9
Carrot, Boiled (flesh And Skin)	17.1	42.9
Peanut Butter; Smooth Style	22.6	41.4
Popcorn, Plain	22.5	38.6
Margarine, Brick/hard	30.5	38.6
Salad: Beetroot	21.1	38.6
Cheese, Cheddar	20.4	37.1
Breakfast Cereal- Corn Flakes, Plain	22.5	37.1
Yoghurt, Fruit, Low Fat, Sweetened	48.8	35.7
Avocado, Raw (peeled)	41.8	35.7
Mixed Vegetables, Frozen, Boiled (carrot, Corn, Peas, Green Beans, etc)	14.4	35.7
Salad: French (lettuce, Tomato, Cucumber, No Dressing)	15.7	35.7
Stew, Mutton, With Vegetables	37.4	34.3
Frankfurter, Beef & Pork	13.4	34.3
Tomato, Raw	48.7	34.3
Sweets, Chocolate Coated Bar	17.1	34.3

4.8. Factors influencing food choice

Table 4.8 shows the results relating to the questions on food choice which were asked. The numbers of participants agreeing with each of the questions asked are shown in descending order. The majority (92.5%) agreed that they considered taste when choosing their food. Cost did not appear to be a major influential factor in choosing food as only 28.6% of the participants said they considered it.

Table 4.8: Factors influencing food choice

Question	Agree n (%)
I choose to eat certain foods because they taste good **(taste)**	92.5 (136)
I consider whether a food is good for my health before eating the foods **(health benefits)**	72.8 (107)
My hunger level determines what type of food I eat **(hunger level)**	61.2 (90)
I choose to eat certain foods because it looks good **(appearance)**	52.4 (77)
I choose foods which are not time consuming to prepare **(preparation time)**	49.0 (72)
The food I choose to eat differs according to my mood(i.e. happy/sad) **(mood)**	42.2 (62)
The food I eat depends on whether it is expensive **(cost)**	28.6 (42)

4.9. Determinants of dietary intake

The bivariate and multivariate results for total energy, fat, carbohydrate, protein and added sugar intake as a proportion of total energy intake are presented in this section.

4.9.1. Energy Intake

In addition to sex and puberty that were entered as potentially confounding factors, the criterion for including variables into the multivariate analysis was a p-value <0.05 in the bivariate analysis. Table 4.9.1a shows the variables that had p-values <0.05 from the bivariate analysis in their association with total energy intake as well as sex and pubertal development. There were too many socio-economic status (SES) variables for the relatively small sample size to perform a multivariate analysis including all significant factors. Furthermore there was a problem of multicollinearity for some measures. It was therefore necessary to combine the SES measures into a general linear SES index. Principal component analysis was used to create the index and the details of how this index was constructed are presented in the methods chapter (see Section 3.9.). The bivariate association of energy intake and SES was not significant but has been included in Table 4.9.1a because of its importance to the hypothesis being tested in this thesis.

The bivariate results show that boys are consuming significantly more energy than their female counterparts. A significant positive correlation is observed between energy intake and height, biepi condylar breadth of humerus, and biepi condylar breadth of femur. The biepi condylar breadth of humerus and femur are measures of skeletal size (Hennerberg *et al.*, 2001) and this was hypothesised to influence energy requirements hence it inclusion in the analysis. Participants who did not use multivitamins and those that disagreed that mood, hunger level and health benefits influence their food choice had significantly higher energy intakes. When the bivariate analysis was run separately for boys and girls no significant associations were observed for boys and ethnicity (p=0.007), mood (p=0.009) and hunger level (p=0.030) were significant for girls.

Linear regression was performed with energy intake as the dependant variable and the results of the model building steps are shown in Table 4.9.1b.

Table 4.9.1a: Variables associated with total energy intake (kcal) in bivariate analysis (whole sample n=150)

Independent variable	Mean intake (SD)	Test statistic	P-value
*Sex	Boys 3095(1055); Girls 2729 (1059)	t = 2.114, df =148	0.036
Breast/genitalia	Late 2876 (1046), Early 2901 (1047)	t = -0.128, df = 144	0.898
Pubic hair	Late 2890 (1057); Early 2868 (1019)	t = 0.114, df =144	0.909
*Height		r = 0.167	0.042
* biepi condylar breadth of humerus		r = 0.190	0.021
* biepi condylar breadth of femur		r = 0.193	0.018
*Multivitamin use	No 2965 (1071) ; Yes 2425 (949)	t = 2.030, df =148	0.044
Socioeconomic status[1]	Low 3001 (1177); Medium 3090 (1029); High 2599 (975)	F= 2.979, df =146	0.054
*Mood	Disagree 3044 (1000); Agree 2647 (1088)	t = 2.286, df =145	0.024
*Hunger level	Disagree 3117 (1097); Agree 2725 (1001)	t = 2.229, df =145	0.027
*Health	Disagree 3181 (1061); Agree 2763 (1032)	t = 2.171, df =145	0.032

*p<0.05; **p<0.01;***p<0.001

For categorical variable, independent t-tests and ANOVA were used to assess statistical significance.

For continuous variables, Pearson's correlation coefficients were used to assess statistical significance.

[1]SES index contains the following variables child grant, foster care grant, financial support from father/partner, goods support from father/partner, emotional support from father/partner, goods/financial support from others, emotional support from mother, financial support from caregiver, goods support from caregiver, emotional support from caregiver, medical aid, water-toilet facility, marital status and employment status.

Table 4.9.1b: Linear regression with total energy intake as the outcome variable

Variable (n)	Model 1 B(SE)	Model 2 B(SE)
Step 1		
Constant	2679.957 (141.238)	
Sex		
Girls (ref) (80)		
Boys (70)	390.544 (177.577)*	
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-16.989 (218.531)	
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.781 (222.488)	
Step 2		
Constant	2679.957 (141.238)	1166.440 (1961.628)
Sex		
Girls (ref) (80)		
Boys (70)	390.544 (177.577)*	305.133 (209.317)
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-16.989 (218.531)	-12.898 (218.904)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.781 (222.488)	102.489 (224.564)
Height (149)		9.526 (12.314)
Step 3		
Constant	2679.957 (141.238)	1758.551 (1291.495)
Sex		
Girls (ref) (80)		
Boys (70)	390.544 (177.577)*	266.104 (248.394)
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-16.989 (218.531)	-5.635 (219.476)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.781 (222.488)	101.418 (224.716)
Biepi condylar breadth humerus (149)		15.651 (21.806)

*p<0.05; **p<0.01; ***p<0.001

Table 4.9.1b continued

Variable (n)	Model 1 B(SE)	Model 2 B(SE)
Step 4		
Constant	2679.957 (141.238)	1202.961 (1141.706)
Sex		
Girls (ref) (80)		
Boys (70)	390.544 (177.577)*	242.124 (210.573)
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-16.989 (218.531)	64.053 (226.685)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.781 (222.488)	74.503 (221.994)
Biepi condylar breadth femur (149)		17.368 (13.322)
Step 5		
Constant	2679.349 (144.198)	2857.049 (207.329)
Sex		
Girls (ref) (80)		
Boys (70)	400.931 (180.993)*	378.883 (179.414)*
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-34.068 (221.400)	-73.981 (220.652)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	69.352 (225.923)	37.522 (225.170)
Socioeconomic status		
Low (ref) (48)		
Medium (44)		-7.483 (217.208)
High (46)		-421.452(217.197)
Step 6		
Constant	2679.957 (141.238)	2778.485 (149.851)
Sex		
Girls (ref) (80)		
Boys (70)	390.544 (177.577)*	351.698 (177.334)*
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-16.989 (218.531)	8.539 (217.134)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.781 (222.488)	-10.601 (226.089)
Multivitamin use		
No (ref) (132)		
Yes (18)		-491.528 (265.903)

*p<0.05; **p<0.01; ***p<0.001

Table 4.9.1b continued

Variable (n)	Model 1 B(SE)	Model 2 B(SE)
Step 7		
Constant	2680.476 (142.774)	2825.027 (163.390)
Sex		
Girls (ref) (80)		
Boys (70)	367.766 (179.100)*	331.486 (178.906)
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-6.535 (219.003)	24.278 (218.027)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.584 (223.076)	65.120 (221.550)
Mood		
Disagree (ref) (85)		
Agree (62)		-311.106 (175.127)
Step 8		
Constant	2680.476 (142.774)	2898.668 (190.281)
Sex		
Girls (ref) (80)		
Boys (70)	367.766 (179.100)*	329.318 (179.262)
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-6.535 (219.003)	23.402 (218.184)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.584 (223.076)	20.318 (224.290)
Hunger level		
Disagree (ref) (57)		
Agree (90)		-308.664 (179.518)
Step 9		
Constant	2680.476 (142.774)	2939.066 (197.858)
Sex		
Girls (ref) (80)		
Boys (70)	367.766 (179.100)*	371.276 (177.534)*
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	-6.535 (219.003)	-39.436 (217.787)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	80.584 (223.076)	150.368 (224.240)
Health benefits		
Disagree (ref) (40)		
Agree (107)		-368.817 (197.218)

*p<0.05; **p<0.01; ***p<0.001

All the significant bivariate variables lost their significance when they were included in the regression model individually after controlling for sex and pubertal development. The initial model with sex, breast/genitalia development and pubic hair was not significant p=0.185 explaining only 3.3% of the variance in energy intake. When the SES dummy variables (reference: low SES) were added to the model in the fifth step the high SES and medium SES had p-values of 0.054 and 0.973 respectively.

4.9.2. % Fat Intake

The food choice factor 'taste' was the only variable (t = -1.989, df =145, p=0.049) associated with % fat intake as a continuous variable. There was a 3.3% difference in fat intake between those that agreed (33.6%) that they considered taste when choosing their food and those who did not (30.3%). There was no significant association between % fat intake and SES (F=0.111, df = 146, p = 0.895). Sex and pubertal stage are not known to be potential confounders of % fat intake therefore they were not controlled for in this association.

Splitting % fat intake into two categories representing a prudent diet (=<30%) and a transitioned diet (>30%) intake based on the WHO/FAO (2003) recommended intakes resulted in no significant bivariate associations as well. Because of the lack of significant bivariate associations with fat intakes no multivariate analysis was performed for this variable.

4.9.3. % Carbohydrate intake

For % carbohydrate intake the food choice factor 'taste' (t = -2.021, df = 145, p=0.045) was the only variable associated with % carbohydrate intake as a continuous variable. Participants who considered taste in their choice of food had a 3.5% lower carbohydrate intake than those who did not. There was no significant association between % carbohydrate intake and SES (F=0.648, df = 146, p = 0.525). Sex and pubertal stage are not known to be potential confounders of % carbohydrate intake therefore they were not controlled for in this association.

When % carbohydrate intake was recoded into two categories representing a prudent diet (>=55%) and a transitioned diet (<55%) intake based on the WHO/FAO (2003) recommended intakes there were also no significant bivariate associations. No multivariate analyses were performed with % carbohydrate intake as an outcome.

4.9.4. % protein intake

The significant % protein bivariate predictors are shown in Table 4.9.4a. There was a positive correlation between age and % protein intake. White participants, those who used multivitamins, and those in the high socioeconomic status (SES) group had significantly higher protein intakes. The results of the linear regression analysis with the significant retained variables are shown in Table 4.9.4b.

In the final model (model 3) the variables associated with % protein intake are high SES and multivitamin use. Ethnicity loses its significance on addition of multivitamin use. Having high SES and taking multivitamins increases the protein intake by 0.807 and 1.115% compared to those with low SES and no multivitamin use respectively. There were no variables correlated highly with each other ($r > 0.9$), VIF range 1.382 – 1.650, tolerance range 0.606 – 0.724 and there were no variables with high variance proportions on the same small eigen value therefore no collinearity problem was evident. There were no standardised residuals >3.0 and no influential cases were identified using Cook's and Leverage statistics, The Durbin-Watson statistic was 1.935 therefore the assumption that the residual terms were independent was met. The final model ($p=0.045$) explained 20% of the variance in protein intake.

The final linear regression equation is
Protein intake (%) = 10.228 + 0.860 (ethnicity) + 0.807 (High SES) – 0.229 (Medium SES) + 1.115 (multivitamin use).

The average predicted reported % protein intake for low, medium and high SES respectively from the linear regression analysis were 10.23%, 10.00% and 11.04% for the black and 11.09%, 10.86% and 11.9% for the white participants who did not use multivitamins respectively. This shows that the high SES groups have higher protein intakes.

4.9.5. % added sugar

The only variable associated with % added sugar was the food choice factor 'health benefits' ($t = 2.490$, $df = 145$, $p=0.014$). Participants who considered the health benefits of the food had lower added sugar intake 13.3% compared to those who did not 15.8%. Sex and pubertal development were not controlled for in this association as they are not known to be potential confounders of this association. There was no significant association between % added sugar intake and SES ($F=0.111$, $df = 146$, $p = 0.895$). No multivariate analysis was therefore performed for % added sugar as the dependant variable.

Table 4.9.4a: Variables associated with % protein intake from bivariate analysis (whole sample n=150)

Independent variable	Mean intake (SD)	Test statistic	P-value
***Ethnicity	Black 10.38 (1.75); 12.28 (2.20)	t = -4.653, df = 148	<0.001
*Age		r = 0.173	0.034
***Socioeconomic status	Low 10.27 (1.94); Medium 10.17 (1.75); High 11.63 (2.06)	F = 9.617, df = 146	<0.001
***Multivitamin use	No 10.44 (1.75); Yes 12.51 (2.38)	t = -4.498, df = 148	<0.001

*p<0.05; **p<0.01;***p<0.001
For categorical variable, independent t-tests and ANOVA were used to assess statistical significance.
For continuous variables, Pearson's correlation coefficients were used to assess statistical significance.

Table 4.9.4b: Linear regression with % protein intake as the outcome variable

Variable (n)	Model 1 B(SE)	Model 2 B(SE)	Model 3 B(SE)
Constant	10.400 (0.164)	10.274 (0.257)	10.228 (0.256)
Ethnicity			
Blacks (ref) (126)			
Whites (24)	1.856 (0.415)***	1.414 (0.440)**	0.860 (0.514)
Socioeconomic status			
Low (ref) (48)			
Medium (44)		-0.275 (0.364)	-0.229 (0.361)
High (46)		0.864 (0.393)*	0.807 (0.390)*
Multivitamin use			
No (ref) (132)			
Yes (18)			1.115 (0.551)*

*p<0.05; **p<0.01; ***p<0.001
Model 1, 2 and 3 explain 12.1%, 17.7% and 20% of the variance in % protein intake. The respective model significance were p <0.001, p = 0.009 and p = 0.045.

Chapter 5: Body Composition

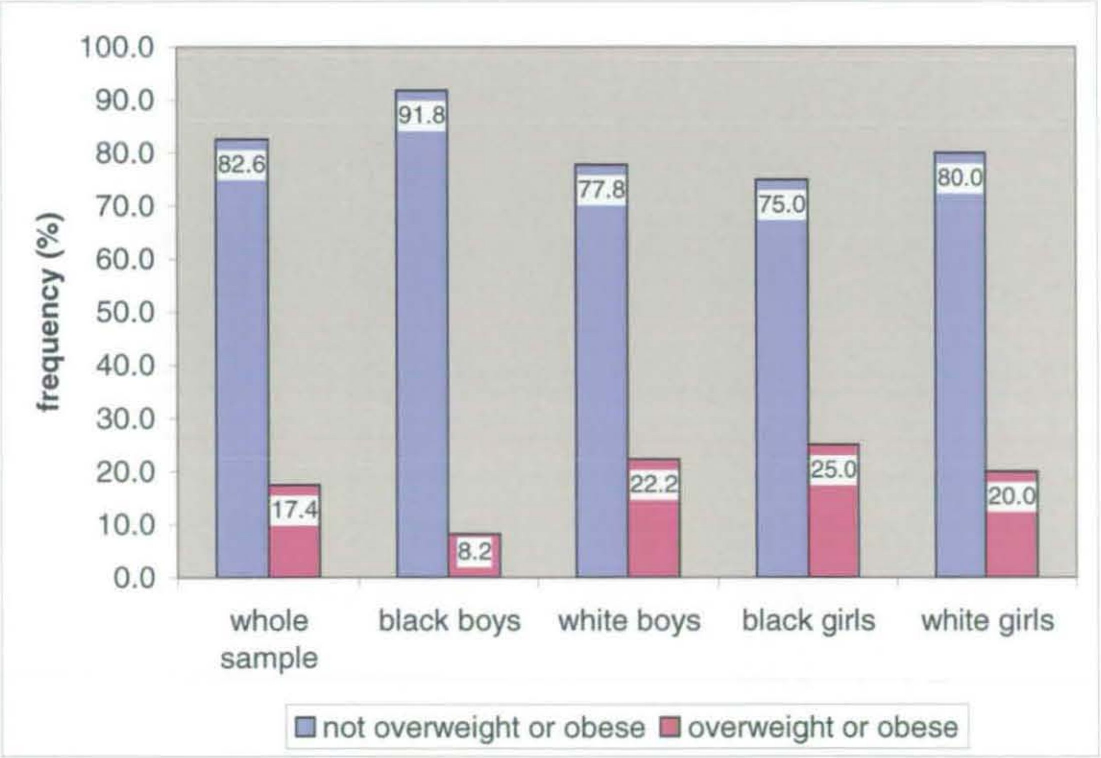
5.0. Introduction

This chapter will examine the body composition of the sample in terms of body mass index (BMI), % body fat and % lean tissue. Descriptive data will be presented and then the results of bivariate and multivariate analyses to show the association with demographic and socio-economic factors.

5.1. Body mass index (BMI)

BMI was categorised into not overweight/obese and overweight/obese using the classification of Cole *et al.*, (2000). 24.1% and 10% of the girls and boys respectively were overweight/obese. The median BMI was 21.6 and 19.4 for girls and boys respectively. The distribution of overweight and obese participants is shown by gender and ethnicity in Figure 5.1. The differences in the proportion of participants who were not overweight/obese and those who were overweight/obese were tested. Significant differences were only observed between black boys and girls (chi-square statistic = 6.309, df = 1, p=0.012).

Figure 5.1: Distribution of BMI category by gender and ethnicity



5.1.1. Factors associated with BMI

The criteria for including variables in the multivariate analysis was a p-value <0.05 from the bivariate analysis with the outcome variable. Table 5.1.1 shows the variables that had p-values <0.05 in their association with BMI in the bivariate analysis. Variables that need to be controlled for in the multivariate analysis i.e. breast/genitalia and pubic hair development (see page 93) are also included in Table 5.1.1 even if they did not have p-values <0.05 in the bivariate analysis with the outcome variable. The bivariate results suggest that females, participants in the late (mature) stage of breast/genitalia development and with higher socio-economic status (SES) are more likely to be overweight/obese. None of the dietary intake and physical activity measures had any association with BMI.

Logistic regression was performed with BMI as the dependant variable using the approach described in the methods chapter. The results of the final model are shown in Table 5.1.2.

Table 5.1.1: Variables associated with BMI from the bivariate analysis

Independent variable (n)	Not overweight/obese (%)	Overweight/obese (%)	[1]Test statistic (degrees of freedom)	Two tailed p-value
*Sex			5.087 (1)	0.024
Boys (70)	90.0	10.0		
Girls (79)	75.9	24.1		
Pubertal Development				
**Breast genitalia			6.856 (1)	0.009
Early Tanner stage (2 & 3) (42)	95.2	4.8		
Late Tanner stage (4 & 5) (104)	76.9	23.1		
Pubic hair			0.619 (1)	0.432
Early Tanner stage (2 & 3) (43)	86.0	14.0		
Late Tanner stage (4 & 5) (103)	80.6	19.4		
*Socioeconomic Status			8.848 (2)	0.012
Low (48)	91.7	8.3		
Medium (44)	85.7	14.3		
High (46)	69.4	30.6		

[1]Pearson's chi-square tests were used to assess statistical significance.
p<0.05*, p<0.01**, p<0.001***

Table 5.1.2: Odds ratios and 95% confidence intervals for BMI from the logistic regression analysis

Predictor	Model 1 Exp (B) (95% C.I.)	Model 2 Exp (B) (95% C.I.)
Sex		
Boys (ref) (70)		
Girls (79)	3.141 (1.166; 8.461)*	2.831 (1.031; 7.772)*
Pubertal development		
Breast/genitalia development		
Early Tanner stage (2 & 3) (ref) (104)		
Late Tanner stage (4 & 5) (42)	5.950 (1.205; 29.386)*	5.687 (1.080; 29.959)*
Pubic hair development		
Early Tanner stage (2 & 3) (ref) (103)		
Late Tanner stage (4 & 5) (43)	1.048 (0.330; 3.331)	0.777 (0.227; 2.664)
Socioeconomic status		
Low (ref) (48)		
Medium (44)		1.436 (0.371; 5.559)
High (46)		3.786 (1.066; 13.449)*

$p<0.05^{*}$, $p<0.01^{**}$, $p<0.001^{***}$

In the final model (Model 2) the variables significantly associated with being overweight/obese were sex, breast/genitalia development and high SES. The odds of being overweight/obese increased by a factor of 2.831, 5.687 and 3.786 if the participant was female, in the late stages of breast/genitalia development and belonging to the high SES group respectively.

Table 5.1.3 presents the significance of each model, the amount of variation explained, and the percentage of participants correctly classified by each model. The final model explained between 12.8% and 20.9% of the variation in BMI status and the model was significant (p=0.001). The Hosmer and Lemeshow's goodness of fit test statistic indicated no significant differences between the predicted and observed values and 81.1% of the participants were correctly classified.

Table 5.1.3: BMI logistic regression model parameters

Parameter	Model 1	Model 2
-2log-likelihood (-2LL)	121.815	116.005
Model significance (p-value)	0.003	0.001
Cox and Snell R square	0.092	0.128
Nagelkerke R square	0.150	0.209
Correctly classified cases	81.8	81.1
Hosmer and Lemeshow p-value	0.813	0.851

Collinearity was checked following the regression analysis. There were no correlation coefficients >0.9, the tolerance range was 0.721 - 0.952 and the VIF range was 1.051 – 1.388. There were no variables with high variance proportions on the same small eigen value therefore no collinearity problem was evident.

Cases with standardised residuals greater than 3.0 (see Table 5.1.4) were investigated to see whether they were influential cases. All the cases with standardised residuals >3.0 were overweight or obese. None of these cases had Cook's and DfBeta statistics greater than 1. The expected leverage value was 0.042 and none of the cases had leverage values greater than three times the expected. It was concluded that none of these cases were exerting undue influence on the final model therefore all cases were retained.

Table 5.1.4: Examination of influential cases in BMI logistic regression

Case	Standardised residual	BMI category	Cook's statistic	Leverage
11	3.033	Obese	0.255	0.027
53	3.033	Obese	0.255	0.027
63	4.541	Overweight	0.693	0.033
78	3.033	Overweight	0.255	0.027

The probability of the outcome occurring is calculated using the following equation and the corresponding beta coefficients in the final model:

$$P(Y) = \frac{1}{1 + e^{-(b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n)}}$$

(Field, 2005)

Probability (overweight/obese) =

$$\frac{1}{1 + e^{-(-4.067 + 1.041(\text{sex}) + 1.738(\text{breast/genitalia}) - 0.252(\text{pubic hair}) + 0.362(\text{Medium SES}) + 1.331(\text{High SES}))}}$$

The probability of being overweight/obese if the participant is in the late stages of pubertal development is shown by SES status in Table 5.1.5. As SES increases the probability of being overweight/obese also increases.

Table 5.1.5: Probability of being overweight/obese by socioeconomic status

Socioeconomic status	Girls (n=72) Probability (%)	Boys (n=66) Probability (%)
Low	0.177 (29.1)	0.070 (40.9)
Medium	0.235 (40.3)	0.098 (22.7)
High	0.448 (30.6)	0.227 (36.4)

5.2. % Body fat

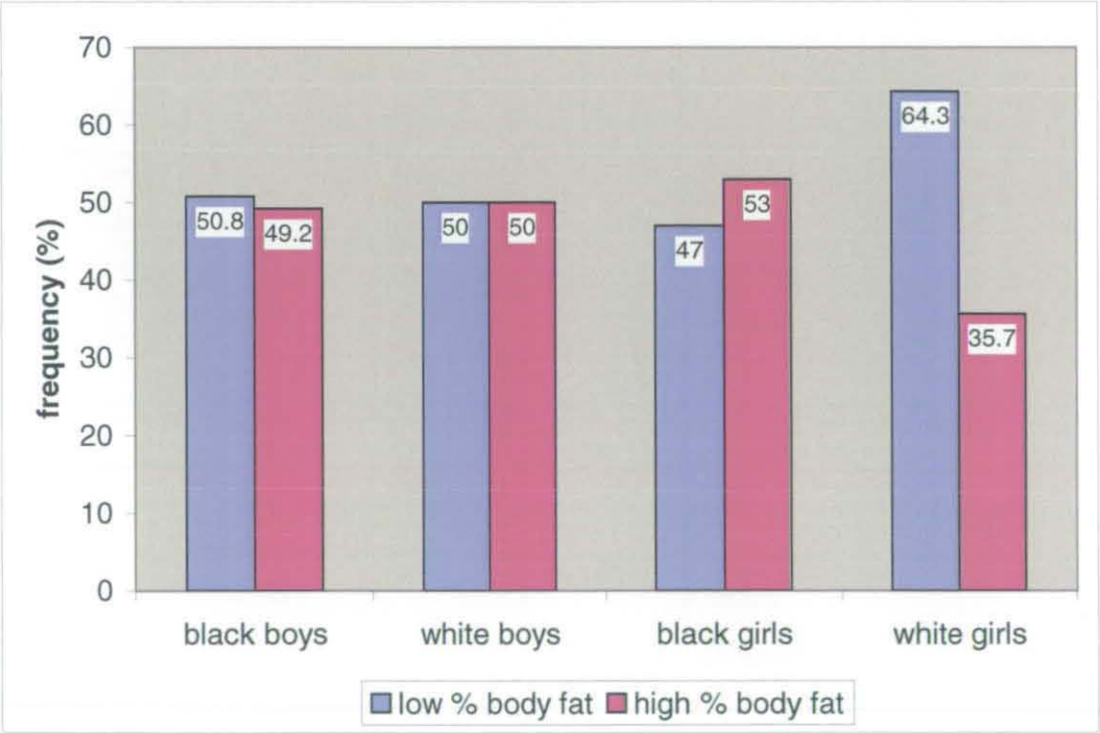
Percent body fat is shown by sex in Table 5.2. Girls have a higher % body fat compared to boys. The distribution is skewed for the boys and normal for the girls as was shown by the histogram, skewness and kurtosis statistics and the Kolmogorov–Smirnov test.

Table 5.2: % body fat distribution by sex

	Girls (n=78)	Boys (n=69)
Mean (SD)/ median (IQR)	29.66 (7.32)	12.48 (6.15)
Minimum	14.86	7.65
Maximum	49.41	37.34
Skewness (standard error)	0.264 (0.269)	1.734 (0.285)
Kurtosis (standard error)	0.063 (0.532)	2.901 (0.563)
Kolmogorov-Smirnov p-value	0.200	<0.001

Participants were split into two categories using the respective median for boys and girls to represent relative low and high % body fat. Figure 5.2 shows the fat distribution by gender and ethnicity. No significant differences were observed between black girls and white girls or their male counterparts.

Figure 5.2: % body fat distribution by gender and ethnicity



5.2.1. Factors associated with % body fat

Table 5.2.1 shows variables significantly associated with % body fat ($p<0.05$) from the bivariate analysis as well as variables to be controlled for in the multivariate analysis. High SES is significantly associated with high % body fat. The physical activity and the dietary intake variables had no significant association with % body fat.

A approach similar to that used for BMI was used in the logistic regression with % body fat as the dependant variable. Sex was not controlled for as an equal number of boys and girls were assigned to low or high % body fat by use of the median split. The results of the final model are shown in Table 5.2.2.

Table 5.2.1: Variables associated with % body fat from the bivariate analysis[1]

Independent variable (n)	Low body fat %/mean(SD)	High body fat %/mean(SD)	[2]Test statistic (degrees of freedom)	Two tailed p-value
Sex			0.005 (1)	0.946
Girls (78)	51.3	48.7		
Boys (69)	50.7	49.3		
Pubertal development				
Breast/genitalia development			2.109 (1)	0.146
Early Tanner Stage (2 & 3) (42)	61.0	39.0		
Late Tanner Stage (4 &5) (104)	47.6	52.4		
Pubic hair development			2.625 (1)	0.105
Early Tanner Stage (2 & 3) (43)	61.9	38.1		
Late Tanner Stage (4 & 5) (103)	47.1	52.9		
Height (m) (150)	1.63 (0.08)	1.61 (0.09)	1.660 (145)	0.099
*Socioeconomic status			6.417 (2)	0.040
Low (48)	66.0	34.0		
Medium (44)	47.9	52.1		
High (46)	40.8	59.2		

*p < 0.05, **p < 0.01, ***p < 0.001

[1]When height was controlled for in the bivariate analysis pubic hair development became significant (p=0.034). The significance of the remaining variables was unchanged.

[2]Pearson's chi-square and independent t-tests were used to assess statistical significance

Table 5.2.2: Odds ratios and 95% confidence interval for % body fat from the logistic regression analysis

Predictor	Model 1 Exp (B) (95% C.I.)	Model 2 Exp (B) (95% C.I.)
Pubertal development		
Breast/genitalia development		
Early Tanner stage (2 & 3) (ref) (42)		
Late Tanner stage (4 & 5) (104)	1.352 (0.575; 3.182)	1.196 (0.498; 2.871)
Pubic hair development		
Early Tanner stage (2 & 3) (ref)(43)		
Late Tanner stage (4 & 5) (103)	2.140 (0.882; 5.191)	1.948 (0.787; 4.825)
Height (149)	0.947 (0.907; 0.988)*	0.950 (0.909; 0.992)*
Socioeconomic status		
Low (ref) (48)		
Medium (44)		1.743 (0.722; 4.205)
High (46)		2.457 (1.019; 5.925)*

p<0.05*, p<0.01**, p<0.001**

The significant variables in the final model were height and socioeconomic status. A unit increase in height decreased the odds of having high % body fat by a factor of 0.950. The odds of having high % body fat increased by a factor of 2.457 if the participant had a high SES compared to low SES.

Table 5.2.3 presents the significance of each model, the amount of variation explained, and the percentage of participants correctly classified by each model. The final model (model 2) explained between 9.4% and 12.5% of the variance in % body fat and was significant (p=0.016). There were no significant differences between the observed and predicted values as shown by the Hosmer Lemeshow statistic.

Table 5.2.3: % body fat logistic regression model parameters

Parameter	Model 1	Model 2
-2log-likelihood (-2LL)	185.495	181.380
Model significance (p-value)	0.020	0.016
Cox and Snell R square	0.067	0.094
Nagelkerke R square	0.090	0.125
Correctly classified cases	58.2	58.2
Hosmer and Lemeshow p-value	0.438	0.252

There were no cases with standardised residuals >3.0. There were no correlation coefficients >0.9, the tolerance range was 0.733 - 0.944, the VIF range was 1.059 – 1.365 and there were also no variables with high variance proportions on the same small eigen value therefore no collinearity problem was evident.

Using the beta coefficients in the final model the regression equation is:

Probability (high % body fat) =

$$\frac{1}{1 + e^{-(7.196 + 0.179\,(\text{breast/genitalia}) + 0.667(\text{pubic hair}) - 0.052(\text{height}) + 0.899\,(\text{High SES}) + 0.556\,(\text{Medium SES}))}}$$

The probability of having high % body fat if in the late stages of pubertal development and assuming average height for girls and boys respectively is shown in Table 5.2.4. This table shows that as SES increases the probability of having high % body fat increases with girls having higher probabilities than boys.

Table 5.2.4 Probability of having high % body fat by socioeconomic status

Socioeconomic status	Girl (n=72) Probability (%)	Boy (n=66) Probability (%)
Low	0.457 (29.1)	0.345 (40.9)
Medium	0.594 (40.3)	0.479 (22.7)
High	0.674 (30.6)	0.564 (36.4)

5.3. % lean tissue

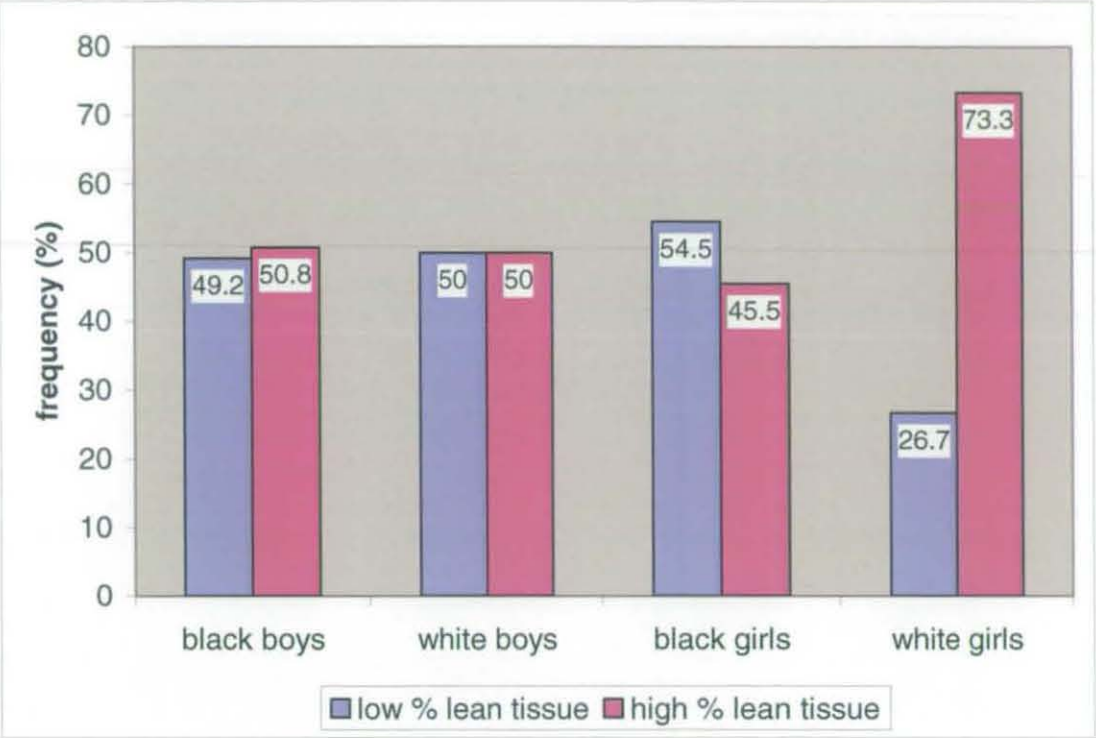
The boys had a skewed distribution and more % lean tissue in comparison to girls as shown in Table 5.3.

Table 5.3: % lean tissue distribution by sex

	Girls (n=79)	Boys (n=69)
Mean (SD)/ median (IQR)	61.13 (6.29)	76.66 (5.78)
Minimum	44.44	55.28
Maximum	74.72	81.99
Skewness (standard error)	-0.214 (0.267)	-1.628 (0.285)
Kurtosis (standard error)	0.014 (0.529)	2.678 (0.563)
Kolmogorov-Smirnov p-value	0.200	<0.001

Similarly as for % body fat, participants were split into two categories using the respective median for boys and girls to represent relative low and high % lean tissue. No significant differences were observed between black girls and white girls or their male counterparts.

Figure 5.3: % lean tissue distribution by gender and ethnicity



5.3.1. Factors associated with % lean tissue

Table 5.3.1 shows the association of pubertal development and socioeconomic status with % lean tissue in the bivariate analysis. When height was controlled for in the bivariate analysis, age and SES became significant hence their inclusion in Table 5.3.1.

A approach similar to that used for the % body fat was used to build the model controlling for the same variables, pubertal development and height. Sex was not controlled for as an equal number of boys and girls were assigned to low or high % lean tissue by use of the median split. The results of the logistic regression are shown in Table 5.3.2.

Table 5.3.1: Variables associated with % lean tissue from the bivariate analysis[1]

Independent variable (n)	Low lean tissue %/mean(SD)	High body tissue %/mean(SD)	[2]Test statistic (degrees of freedom)	Two tailed p-value
Age (150)	15.39 (0.09)	15.36 (0.09)	1.930 (146)	0.055
Sex			0.020 (1)	0.887
Girls (79)	48.1	51.9		
Boys (69)	49.3	50.7		
Pubertal development				
Breast/genitalia			2.454 (1)	0.117
Early Tanner Stage (2 & 3) (42)	38.1	61.9		
Late Tanner Stage (4 & 5) (104)	52.4	47.6		
Pubic hair			1.008 (1)	0.315
Early Tanner Stage (2 & 3) (43)	41.9	58.1		
Late Tanner Stage (4 & 5) (103)	51.0	49.0		
Height (150)	1.61 (0.09)	1.63 (0.08)	-1.341 (146)	0.182
Socioeconomic status			5.805 (2)	0.055
Low (48)	34.0	66.0		
Medium (44)	53.1	46.9		
High (46)	57.1	42.9		

[1]When height was controlled for in the bivariate analysis age (p=0.045) and high socioeconomic status (0.026) became significant and the significance of the remaining variables was unchanged.
[2]Pearson's chi-square and independent t-tests were used to assess statistical significance.

Table 5.3.2: Odds ratios and 95% confidence interval for % lean tissue from the logistic regression analysis

Predictor	Model 1 Exp (B) (95% C.I.)	Model 2 Exp (B) (95% C.I.)
Age (years) (150)	0.008 (0.0001; 0.505)*	0.014 (0.0002; 1.080)
Pubertal development		
Breast/genitalia		
Late Tanner stage (4 & 5) (ref) (104)		
Early Tanner stage (2 & 3) (42)	1.618 (0.678; 3.858)	1.497 (0.622; 3.603)
Pubic hair		
Late Tanner stage (4 & 5) (ref) (103)		
Early Tanner stage (2 & 3) (43)	1.578 (0.643; 3.876)	1.434 (0.575; 3.576)
Height (149)	1.051 (1.006; 1.097)*	1.047 (1.002; 1.094)*
Socioeconomic status		
High (ref) (46)		
Medium (44)		0.969 (0.412; 2.277)
Low (48)		1.757 (0.704; 4.387)

p<0.05*, p<0.01**, p<0.001***

The only significant variable in the final model (model 2) was height. A unit increase in the height increased the odds of high % lean tissue by a factor of 1.047. Age lost its significance and SES was not significant when placed in the regression model.

Table 5.3.3 shows the model significance, amount of variation explained by the models, percentage of correctly classified cases and the Hosmer and Lemeshow statistic. The final model therefore explains between 9.7 and 12.9% of the variance in % lean tissue status and has a significance p=0.025. This model predicted 64.1% of the cases correctly and the Hosmer and Lemeshow's goodness of fit test statistic indicated no significant difference between the predicted and observed values.

Table 5.3.3: % lean tissue logistic regression model parameters

Parameter	Model 1	Model 2
-2log-likelihood (-2LL)	184.280	182.162
Model significance	0.015	0.025
Cox and Snell R square	0.083	0.097
Nagelkerke R square	0.111	0.129
Correctly classified cases (%)	57.0	64.1
Hosmer and Lemeshow p-value	0.444	0.783

There were no cases with standardised residuals >3.0. There were no correlation coefficients >0.9, the tolerance range was 0.714 - 0.905, the VIF range was 1.105 – 1.400 and there were no variables with high variance proportions on the same small eigen value therefore no collinearity problem was evident.

Chapter 6: Discussion

6.0. Introduction

The aim of this study was to investigate the dietary intake and body composition of urban South African adolescents living in Soweto-Johannesburg and to put this in the context of the nutrition transition. The study also sought to find out the various demographic, socioeconomic and pubertal development factors influencing that association.

A quantitative food frequency questionnaire (FFQ) was used to assess usual dietary intake and factors influencing food choice. Body composition was assessed using anthropometrical measurements and double electron x-ray absorptiometry (DEXA) scans to provide values for body mass index (BMI) and relative % fat and lean mass.

The macronutrient intake of the urban adolescent sample was 33.3% fat, 51.8% carbohydrate, 10.7% protein and 14% added sugar as a proportion of total energy intake. Amongst the top commonly consumed foods reflecting the macronutrient composition, were white rice, stiff maize meal porridge (pap), white sugar, sweets, white bread, carbonated sweetened drinks, fried chips and full fat milk. The composition of the current diet suggests a transition towards the diet consumed by transitioned societies. The majority of the participants were consuming fat and added sugar intakes above the recommended (WHO/FAO, 2003) intakes. About half of the Blacks did not meet the recommended protein intakes. There were no significant energy intake predictors in the linear regression analysis. No significant association was observed between socioeconomic status (SES) and energy intake, % fat, % carbohydrate or % added sugar intake. However, % protein intake was positively associated with SES.

Significant differences (p=0.015) in the prevalence of overweight and obesity between girls (24.7%) and boys (9.7%) were observed. The odds of being overweight or obese increased if the participant was female, had high SES and mature breast/genitalia development. None of the dietary intake variables had a significant association with the body composition outcomes (BMI, relative % fat and % lean mass).

This chapter discusses these findings in the context of the nutrition transition. The energy and macronutrient intake of the current study sample are compared to research conducted in South Africa in previous years and food balance sheet data to establish the extent to which the adolescent sample have experienced the nutrition transition. Dietary intake of the sample is also compared to the FAO/WHO (2003) recommended nutrient intake goals. Foods commonly consumed by the South African adolescent sample are compared with the traditional South African diet and the implications of consuming these foods are discussed. Various food selection factors related to dietary intake are also discussed with regard to the adolescent sample studied. Nutrition transition is driven by various factors (demographic, socioeconomic, technological, environmental, and cultural) (Tansey and Worsely, 1995) therefore a section of this discussion is devoted to the determinants of dietary intake. Macronutrient composition and energy balance are important in the nutrition transition and influence body composition therefore the determinants of body composition are also discussed. The study strengths and limitations are then highlighted. The chapter concludes by giving possible intervention strategies in the light of the findings from this study.

6.1. Energy and macronutrient intake

The % recommended dietary allowance (RDA) (Food and Nutrition Board, 1989) of energy intake in the current study is compared with other studies in Table 6.1.1. The current study has a higher % RDA (101.2 -129.3%) in comparison with the other studies (range 58.3 – 101.2%) but is still within reasonable limits as the energy RDA is the mean requirement for a group. The high % RDA in the current study in comparison to the other studies suggests an increase in the absolute energy intakes. The differences with other studies could also be partially explained by the use of a FFQ in the current study which is known to overestimate energy intakes (Willet, 1990; Hernández-Avila *et al.*, 1998) whereas the rest of the studies in Table 6.1.1

used 24 hour recalls. The comparison between the current study and the other studies is therefore made difficult by use of different methods. However, the errors associated with both the FFQ and 24 hour recall are correlated i.e. perception of serving sizes and memory (Willet, 1990). Significant correlations ranging from 0.32 to 0.56 for macronutrients have been observed between the FFQ and 24 hour dietary recall (Sichieri *et al.*, 1998 and Hernández-Avila *et al.*, 1998). Differing age groups and communities could also explain some of the differences. It was difficult to compare the % RDA with studies which also used the FFQ as these used different and wide age ranges which made it impossible to calculate the % RDA.

Despite the high average % RDA there was a high proportion of participants below the RDA. More boys (47.1%) than girls (33.8%) had intakes below the RDA. These figures were an improvement when compared to the intakes of a sample from the same cohort at 10 years in the year 2000, where 74% of the participants fell below the RDA for energy (MacKeown *et al.*, 2003). This could be a reflection of changes in energy consumption reinforcing the suggestion that energy intakes are increasing or could be a result of different dietary assessment tools. MacKeown *et al.*, (2003) used a semi-quantitative FFQ and standardised portion sizes in their study. The authors acknowledged that this could introduce inaccuracy at an individual level as portion sizes vary from person to person.

Table 6.1.1: Comparison of % RDA of energy obtained in studies in South African adolescents

Source	Age (years); ethnicity (sample size)	Location	Dietary intake tool	Energy Intake (E)(kcal)	% RDA
Steyn *et al.*, 1986	12 years; White (197), Black (196), Coloured (255), Indian (195)	Urban, Cape Town	24 hour recall	2528 (WB);1543 (BB); 2016 (CB); 2049 (IB); 2077 (WG); 1642 (BG); 2035 (CG); 2094 (IG)	61.8 - 101.2
Steyn *et al.*, 1989	11 years; White (163), Black (94), Coloured (167)	Urban, Western Cape	24 hour recall	2387(WB); 2062(BB); 1806(CB); 2006(WG); 1955(BG); 1527(CG)	69.4 – 95.5
Bourne *et al.*, 1993	15-18 years; Black (119)	Urban, Cape Peninsula	24 hour recall	2035 (BB); 1525 (BG)	67.8 – 69.3
Vorster *et al.*, 1997 (SANSS)	11-15.9 years; White (524), Black (290), Coloured (595) and Indian (195)	Urban, Meta-analysis of studies in various locations.	24 hour recall	2392 (WB); 1755 (BB); 1888 (CB); 2049 (1B); 1985 (WG); 1726 (BG); 1819 (CG); 2094 (IG)	58.3 – 94.8
Current Birth to Twenty study (2007)	15 years; Black (126) and White (24)	Urban, Soweto-Johannesburg	Food frequency questionnaire	3148 (WB); 3087 (BB); WG (2227); 2845 (BG)	101.2 -129.3

SANSS: South African Nutrition Survey Study Group; WB: white boys; BB: black boys; CB: coloured boys; IB: Indian boys; WG: white girls; BG: black girls; CG: coloured girls; IG: Indian girls.
RDA: recommended dietary allowance (Food and Nutrition Board, 1989)

The energy contribution of fat, carbohydrate and protein are important in determining the progression of the nutrition transition. The energy and macronutrient intake of the current study is compared with previous dietary intake studies in urban South Africa by ethnicity in Tables 6.1.2 (Blacks), Table 6.1.3 (Whites) and Table 6.1.4 (mixed). The studies are put in the tables in ascending order of study period.

Comparison of the absolute energy intake in Table 6.1.2 reflects an increase in energy consumption in black South Africans from 1974 to 2005 for both males and females (Manning *et al.*, 1974; Steyn *et al.*, 1986, 1989; Bourne *et al.*, 1993; Vorster *et al.*, 1997 (SANSS); MacIntyre *et al.*, 2002 and the current Birth to Twenty study). Vorster *et al.*, (1997) reports data from the South African Nutrition Survey Study group (SANNS) who conducted a meta-analysis of data from 1975 -1996 in South Africa. 55 studies met their inclusion criteria with regards to the age and ethnic subgroups, randomisation and the database used for nutrient analysis. The meta-analysis covered both rural and urban populations but this study has extracted data on the urban population only.

The energy intake results for Whites in Table 6.1.3 do not show a consistent pattern as the years progress with the energy intakes being relatively similar. Compared to all previous studies however the energy intakes of Whites in the current study have risen. The current study however had a small white sample (n = 24). A study by Kruger *et al.*, (2005) in 2001 did not breakdown the energy intake by ethnicity (Table 6.1.4) but the mean intakes are lower than the intakes for the current study.

The increasing energy intakes suggest that a transition in the diet towards that of 'westernised' diets is in progress. It cannot be ascertained however how much of this increment can be explained by the different dietary intake methods used across studies, as well as the different communities and age groups studied. Food balance sheets between 1962 and 2001 have also shown an increase of 318kcal in per capita energy availability (Table 6.1.4) (Steyn *et al.*, 2006a; FAO, 2004). These figures however just show

Table 6.1.2: Comparison of macronutrient intake of Blacks

Source	Age (years); sex (n)	Location, period of study	Dietary method	Energy Intake (E)(kcal)	Total fat (% E)	SFA (% E)	PUFA (% E)	CHO (% E)	Free sugar (% E)	Protein (% E)
Manning *et al.*, 1974	80 families	Cape Town, 1974	Dietary survey-unspecified		15-20			62-70		11-13
Steyn *et al.*, 1986	12 years, B(68), G(128)	Cape Town	24 hour recall	1543 (B), 1642 (G)	29(B), 29(G)			59(B), 59(G)		12(B), 12(G)
Steyn *et al.*, 1989	11 years, B(47), G (47)	Western Cape	24 hour recall	2062(B), 1955(G)	28(B), 31(G)			58(B), 55(G)	9(B), 9(G)	12(B), 13(G)
Bourne *et al.*, 1993 (BRISK)	15-18 years, M(58), W(61)	Cape Peninsula, 1990	24hour recall	2035 (M) 1525 (W)	27.4(M), 28.3(W)	9.1(M) 8.5(W)	6.0(M) 7.2(W)	64.3(M) 63.7(W)	10.7(M) 14.6(W)	13.6(M) 13.1(W)
Vorster *et al.*, 1997 (SANSS 1975-1996)	11-15.9 years B(115), G(175)	Meta-analysis, various locations	24 hour recall	1755 (B) 1726 (G)	29.1(B) 30.1(G)			57.6 (B) 56.9 (G)	11.9 (B); 12.1 (G)	12.1 (B); 12.6 (G)
MacInytre *et al.*, 2002 (THUSA)	15-80 years, M (83), W(106)	Upper class strata, NW province, 1996 &1998	FFQ	2347 (M); 2037 (W)	30.6(M); 31.8(W)	9.5(M)1 0.7(W)	6.6(M) 6.6 (W))	57.3(M); 55.6 (W)		13.2(M); 13.4 (W)
MacKeown *et al.*, 2003	10 years, B & G(163)	Soweto-Johanessburg 2000	Semi-quantitative FFQ	1752 (all)	25.7 (all)			63.0 (all)	15.2 (all)	12.6 (all)
Current Bt20 Study (2007)	15 years, boys (61), girls (65)	Soweto-Johannesburg, 2005	FFQ	3087 (B) 2845 (G)	33 (B) 33.6(G)	9.1 (B) 10.4(G)	9.4 (B) 8.8(G)	52.4(B) 52(G)	13.0(B) 15.2(G)	10.4 (B) 10.4 (G)

SFA: saturated fat; PUFA: polyunsaturated fat, CHO: carbohydrate; B: boys; G: girls; M: men; W: women; FFQ: food frequency questionnaire: BRISK: Black Risk Factor Study; SANSS: South African Nutrition Survey Group; THUSA: Transition and Health during Urbanisation of South Africans Study; Bt20- Birth to Twenty Study.

available energy for the nation and not how it was actually distributed by age, gender, region or socioeconomic status. Losses along the food chain through processing, storage, delivery and home utilization are not accounted for in this aggregate data and food available through subsistence farming and home gardening is not included. To establish whether a transition is indeed in progress the macronutrient intake is used because of the different methods, samples and age groups of the different studies.

The macronutrient composition of the Blacks in the current study was also examined in comparison to the diets in previous South African studies. Table 6.1.2 in Blacks show that the % fat intake ranged from 15 - 30 % between 1974 and 1996. In 1996 and 1998 these had risen to 30.6% and 31.8% in men and women respectively. The current study conducted in 2005 shows further increases to 33 and 33.6% in boys and girls respectively. This is a difference of about 13% when compared to the 1974 study (Manning *et al.*, 1974) suggesting a transition to a more 'westernised' diet. In the Blacks not all studies break down fat into their constituents. The available data on the three studies which breakdown fat into its constituents suggest an increase in the saturated fat intake. Girls had higher saturated fat intake than the recommended (<10%) in 1996 and 1998 (MacIntyre *et al.*, 2002) and the current Bt20 study. Even though a progressive increase in the total % fat intake is evident as the years progress, it was not possible to ascertain whether these increments were significant or not. This is because the macronutrient intakes in the majority of the papers were presented in grams. This research therefore derived the % intakes by converting these intakes to kcal and dividing by the overall energy intake. There were therefore no standard deviations for % intakes to enable calculation of confidence intervals to establish significance.

Carbohydrate intakes show a decline from about 62 - 70% of the total energy intake in 1974 to about 52% in the current study. Nevertheless added sugar intakes have increased from about 9% in 1989 to a high of 15.2% in black girls in 2005.

The protein intakes have remained relatively similar between 1974 and 2005. They ranged from 11 - 13% in 1974 and are 10.4% in the current study.

In a sample from the Bt20 (from where the current sample was drawn) at 10 years (n=163) in 2000 the macronutrient composition was 25.7% fat and 63.0% carbohydrate, added sugar 15.2%, and 12.6% protein (MacKeown *et al.*, 2003). The macronutrient intakes were not broken down by sex. The results are for the true longitudinal sample at 4 interceptions i.e. at 5, 7, 9 and 10 years. The fat intakes for these interceptions were 41.7, 28.1, 30.1 and 25.7% respectively. A decline is observed but this could be because of bias in the data of the longitudinal group. Initially data was available for 1475 children at 5 years, 1096 at 7 years, 550 at 9 years and only 365 in 2000. There is no indication as to whether those that were lost to follow up were significantly different from the true longitudinal group. The use of a semi-quantitative questionnaire also introduces error because an assumption is made that participants consumed standardised portion sizes. Because of these shortcomings this study is not very valuable in investigating whether a transition is in progress. The current Bt20 study however suggests a transition towards a diet high in fat and sugar and low in carbohydrate typical of transitioned societies when compared to the other studies.

The results in Table 6.1.3 from 1986 -1996 show that the Whites had fat intakes as high as 39%. The current study has lower intakes for boys (30%) whereas girls (35%) have similar intakes to the previous studies. Saturated fat intakes are higher than the recommended <10% in the VIGHOR study (Vanderbijlpark Information Project on Health) (See Table 6.1.3) and the current Bt20 study. Carbohydrate intakes are all <55% in the studies shown whilst high sugar intakes (>10%) are observed. Protein intakes are lowest in the current study (12.3%) with the others ranging from 13 - 16.3%. These studies therefore suggest that Whites in South Africa have been consuming a western diet for the last three decades.

As a proportion of total energy intake the macronutrient composition was 21.2% fat, 68.3% carbohydrate, and 10.5% protein in 1962 and 24.3% fat, 65.4% carbohydrate, and 10.3% protein in 2001 for the food availability data from the food balance sheets for South Africa as a whole (Steyn *et al.*, 2006a and FAO, 2004). This data is for the whole country, meaning that it is not possible to make comparisons between urban and rural areas or different ethnic groups.

Table 6.1.3: Comparison of macronutrient intake of Whites

Source	Age (years); sex (n)	Location, period of study	Dietary method	Energy Intake (E)(kcal)	Total fat (% E)	SFA (% E)	PUFA (% E)	CHO (% E)	Free sugar (% E)	Protein (% E)
Steyn *et al.*, 1986	12 years, boys (100), girls (97)	Cape Town	24 hour recall	2528 (B), 2077 (G)	37(B), 39(G)			50(B), 48(G)		13(B), 13(G)
Steyn *et al.*, 1989	11 years, boys (78), girls (85)	Western Cape	24 hour recall	2387(B), 2006(G),	35(B), 37(G),			49(B), 48(G)	13(B), 13(G),	15(B), 14(G),
Vorster *et al.*, 1995 (VIGHOR)	15-64 years, 317			1405 – 2976	33.3-38.6	12.2-14.6	5.6-7.8	46.9-53.3	13.0-18.6	13.6 - 16.3
Vorster *et al.*, 1997 (SANSS)	11-15.9 years boys (263), girls (261)	Meta-analysis, various locations.	24 hour recall	2392(B); 1985(G);	36.3 (B); 37.4 (G)			48.3 (B); 48.2 (G)	13.7 (B); 14.2 (G)	
Current Bt20 Study (2007)	15years, boys (9), girls (15)	Soweto-Johannesburg	FFQ	3148 (B) 2227 (G)	30 (B) 34.9 (G)	10.6(B) 11.6 (G)	6.9 (B) 8.5(G)	52.9 (B) 48.3 (G)	14.4 (B) 12.3 (G)	12.3 (B) 12.3 (G)

SFA: saturated fat; PUFA: polyunsaturated fat, CHO: carbohydrate; B: boys; G: girls; M: men; W: women; FFQ: food frequency questionnaire; VIGHOR: Vanderbijlpark Information Project on Health, Obesity and Risk Factors; SANSS: South African Nutrition Survey Group; Bt20: Birth To Twenty Study.

Table 6.1.4: Comparison of macronutrient intake of all ethnicities

Source	Age (years); sex (n)	Location, period of study	Dietary method	Energy Intake (E)(kcal)	Total fat (% E)	SFA (% E)	PUFA (% E)	CHO (% E)	Free sugar (% E)	Protein (% E)
WHO/FAO 2003					15 -30	<10	6 -10	55 -75%	<10	10-15
FAO, 2004 , Steyn *et al.*, 2006a		Whole of South Africa, 1962	Food balance sheets	2603	21.2			68.4		10.5
FAO, 2004 , Steyn *et al.*, 2006		Whole of South Africa, 2001	Food balance sheets	2921	24.3			65.5		10.3
Kruger *et al.*, 2005 THUSA BANA	1257, 10-15years, Blacks, Whites, Indians & Coloureds	North West Province, 2000-2001	24hour recall,	1915 (M), 1767 (W)	26.5 (M), 27.1 (W)					
Current Bt20 Study (2007)	15 years, boys (70), girls (80)	Soweto-Johannesburg, 2005	FFQ	3095(B) 2729(G)	32.7(B) 33.8(G)	9.3(B) 10.6(G)	9.1 (B) 8.7(G)	52.5(B) 51.3(G)	13.2(B) 14.7(G)	10.6(B) 10.7(G)

SFA: saturated fat; PUFA: polyunsaturated fat, CHO: carbohydrate; M: men; W: women; BRISK: Black Risk Facto Study; THUSA BANA: Transition and Health during Urbanisation of South Africans Study in Children; Bt20- Birth to Twenty Study.

6.2. To what extent has the current study sample experienced the nutrition transition?

The differing dietary assessment methods, communities from which the samples were drawn, and specific age groups make direct comparisons of the studies difficult. Nevertheless the combined evidence from these aggregate data, the findings from the current study and other previous studies in the South African context suggest that nutrition transition is in progress. This is reflected by the higher energy intakes, increased fat and sugar and lower carbohydrate intakes in the black South Africans. However, the Whites appear to have experienced nutrition transition at least as early as the 1970's. Table 6.2.1 summarises and compares the current diet with the 'traditional' and 'western' diet. Fat and carbohydrate intakes are only 2% lower and higher respectively than those in transitioned societies. Fat and carbohydrate alone make up about 85% of the diet therefore a decline in one component will result in an increase in the other. There is a difference of about 8% in fat intake between the 'traditional' and current diet suggesting that a transition has occurred.

Table 6.2.1: Comparison of current diet with 'traditional' and 'westernised' diet

	[1]'Traditional'	Current (Bt20 sample)	[2]'Western' (transitioned)
% fat	15-25	33	35-40
% carbohydrate	>=70	52	45-50
% protein	11-14	11	15-20
% sugar	7 – 9	14	14-20
Prevalence of NCDs	Virtually absent	Increasing prevalence	High prevalence

[1]'Traditional' diet: (Lubbe, 1971; Walker and Walker, 1984; Richter *et al.*, 1984; Labadarios *et al.*, 1996. Faber *et al.*, 2001).
[2]'Westernised' diet: (Matthys *et al.*, 2003; Tur *et al.*, 2004; Robinson *et al.*, 1999; Paulus *et al.*, 2001; Lietz *et al.*, 2002 and Feunekes *et al.*, 1998; Nielsen *et al.*, 2002b).

The way the transition occurs varies from place to place. The findings from the current study show that the sugar intakes of these adolescents (14%) have already transitioned to that of a 'western' diet (14-20%) whereas the other macronutrients are still transitioning. This could explain the observed variation in occurrences of nutrition-related diseases as the nutrition transition progresses in different countries. China and India for example are both experiencing the nutrition transition but its progression is different (Popkin *et al.*, 2001). Generally both countries are consuming more fat and refined cereals but the Chinese consume less added sugar, more edible oil and meat compared to the Indians (Popkin *et al.*, 2001; Popkin *et al.*, 1993; Hanchate and Dyson, 2000). The disease profile is also different with China having more hypertension, coronary heart disease (CHD), stroke and some cancers (Eastern Stroke and Coronary Heart Disease Collaborative Research Group, 1998) whereas in India there is more adult on-set diabetes, and cardiovascular diseases (ischemic heart disease being predominant) (Reddy and Yusuf, 1998; King *et al.*, 1998).

In Sub-Saharan Africa (includes South Africa) there have been major increases of hypertension, diabetes and cerebrovascular disease in the urban population and slight increases in the coronary heart disease prevalence (Walker *et al.*, 2002; Walker and Segal, 1997; Walker, 1996; Betrand, 1995). The International Diabetes Federation and WHO have predicted that the number of diabetes cases in the world will increase from 194 million in 2003 to 330 million in 2030. Of these cases 75% will be living in developing countries (WHO, 2003). In contrast the more developed regions high prevalence of coronary heart diseases has been observed (CDC, 2001). Generally the CHD mortality rises with increasing saturated fat consumption when population diets are compared with the death rates from CHD (Webb, 1995).

This shows that the nutrition transition in each country is unique and different dietary elements might explain the varying NCDs profile and their relative increases. The food items associated with these increases will also differ between countries and need to be identified to enable appropriate interventions. However, dietary factors alone do not explain the differences between countries. Other factors such as smoking, physical activity, and family history also play a role in the aetiology of NCDs (Passmore and Eastwood, 1986). Diet should not therefore be considered in isolation but the other factors have to be taken into account.

Another variation in the progression of the nutrition transition in South Africa is the protein intakes. The protein intakes of the current study are similar to traditional values and 4% below that of transitioned societies though they are within the recommended range (FAO/WHO, 2003). The transition of protein is not similar to that of fat and carbohydrate, possibly because protein is more expensive compared to fat and carbohydrate (Drenowski, 1998; Drenowski and Popkin, 1997). An important source of protein, legumes is relatively cheaper compared to animal protein (meat, fish) but have longer cooking times. This also increases the fuel expense and is not compatible with busy urban lifestyles (Popkin *et al.,* 1999). The current protein intake of the whole sample is however still within the recommended WHO/FAO (2003) range therefore no adverse consequences are anticipated because of this level of intake.

The macronutrient composition presented in Table 6.2.1 is a reflection of the actual foods making up the diet. The foods that are commonly consumed by the current study sample are therefore compared to other studies in the following section.

6.3. Commonly consumed foods

The top commonly consumed food items in the current Birth To Twenty study (Bt20) are compared to those commonly consumed in the THUSA study (Transition, Health and Urbanization in South Africa) which was conducted in the North West Province in 1996 and 1998 in Blacks aged 15 – 80 years. This consisted of healthy adult volunteers from 37 randomly sites representing health districts in the North West Province. Authors acknowledge that the sample was not truly random due to accessibility of sites to participants and researchers and resource availability. Participants from five urbanization strata were selected (rural, farm, informal settlement, middle urban class and upper urban class). The foods consumed by at least 85% of the sample in the upper class urban stratum for both men and women were white sugar, white rice, maize meal porridge, cooked onion, cooked tomato, sunflower oil, whole fresh milk, apple, cooked pumpkin, hard margarine, white bread and boerwores (MacIntyre *et al.*, 2002). The similar foods in the top 15 commonly consumed foods in the Bt20 study and those in the THUSA study are maize porridge, white rice, white sugar, apple, whole fresh milk and white bread. The current study however also had sweets, fried chips, carbonated drinks and cold diluted squash drinks in the top commonly consumed foods. These foods reflect the macronutrient composition data discussed previously of very high sugar levels and increased fat intakes in the current Bt20 compared to the THUSA study. The Bt20 adolescent diet more closely resembles that reported by studies of adolescents in developed country environments. For instance a national survey of the diet of children aged 13-14 years in the UK revealed that the most popular foods were confectionary, crisps, chips and soft drinks showing a close resemblance to the current study (Hackett *et al.*, 1997).

The differences in food items consumed in the THUSA and Bt20 studies could be a reflection of the differences in the age groups studied. However this could be because of the nutrition transition which is in progress as the THUSA study was conducted in 1996 and 1998 whereas the current study was in 2005. It could be that the environment is becoming more obesogenic with increased availability of refined, high fat and high sugar foods in urban environments that are rapidly transitioning. For instance, Kruger *et al.*, (2005) reported similar findings to the Bt20 study that there was a high consumption of white rice, bread, maize meal porridge and empty kilojoule snack foods such as cheese curls and cold drinks in a sample of 1257, 10 -15-year-olds of all ethnic groups in the North West Province in South Africa in 2001. The actual quantities of the foods consumed were however not presented in this paper.

One commonly cited food item purchased from street vendors in the current study was 'bunny chow' which consists of a ¼ loaf of bread, with a hole drilled in the middle filled with fried potato chips, greasy sausages, tomato sauce and polony (Bologna sausage). Bunny chow is normally served with a carbonated soft drink. These foods were eaten mostly as a school snack as discovered in the dietary assessment. In the dietary interview the adolescent was asked about foods eaten at home (which the caregiver helped quantify) and those eaten at school (quantified by adolescent). Bunny chows were consistently consumed at school and not at home. Bunny chows are sold by street vendors therefore these play a major part in shaping the diets of the adolescents in the Bt20 study. Street vendors are easily accessible being located just outside school premises. There are also cafeterias/tuck shops on the school premises and some vendors obtain permission from the school principals to sell foods like bunny chows, vetkoeks (this is deep fried dough balls which can be served with savoury fillings such as mince meat or sweet fillings like honey and syrup) and fizzy drinks on the school premises (personal communication – Martin Manyike (Bt20 staff member)). No evidence has however been identified on the role of street vendors and schools on the dietary choices of South African adolescents. The role of informal street vendors in influencing the South African adolescents' dietary intake should therefore be investigated further.

Increased intakes of sugar-sweetened soft drinks and sweets may play a major role in increasing energy intake and replacing nutrient dense foods in the diet. This can be evidenced by the reduction in the relative amount of maize-meal porridge (a traditional food item) when the THUSA (1996 - 98) and current study are compared. The average amount consumed in the upper urban class was between 193g (women) and 300g (men) in the THUSA study and this compares to 115.6g (girls) and 194.4g (boys) in the current study. The average daily intake of carbonated sweetened drinks were 213g and sweets 24g in more than 70% of the participants in the Bt20 study suggesting that these may replace some of the energy from the main staple of maize-meal as well as adding additional energy as intakes are higher in the current study. The amount of carbonated drinks and sweets were not presented in the THUSA study making comparisons with the current study impossible.

Drinks which have high sugar levels are said to reduce appetite control resulting in higher food consumption and therefore increased energy intake promoting a positive energy balance (Rolls, 1997; Ludwig *et al.*, 2001). The glycemic index (GI) of sweets and carbonated sweetened drinks is high and may therefore stimulate overeating and contribute to weight gain (Kruger et *al.*, 2005; Ebbeling *et al.*, 2002). The GI ranks carbohydrates according to their effect on blood glucose levels in the first two hours after consumption. It is calculated by dividing the area under the blood glucose response curve after consuming a fixed amount of carbohydrate by the area under the curve of the standard (usually glucose which is given a GI of 100) (Brouns *et al.*, 2005). Refined grain products and potatoes generally have high GI whilst most fruits and vegetables have low GI (Ludwig, 2000). The effects of consumption of high GI foods are hunger stimulation, lower levels of circulating metabolic fuels and the favouring of storage of fat which promotes weight gain. This has an implication for the current study's finding because it is not only the overall caloric intake that should be the focus but also the type of calories to counter the physiologic drives to overeat (Ludwig, 2000). The current study participants' high consumption of sweets and carbonated sweet drinks suggest that they are consuming a high GI diet which could promote weight gain. Interventions therefore should not only focus on the total energy intake but also specific food items which could raise the GI.

The commonly consumed foods in the current study show a transition from the traditional South African diet. Commonly consumed foods in the traditional diet were sorghum *vulgare*, millet, maize, jugo and mung beans, groundnuts, cowpeas, pumpkin, wild fruits (sour plum, prickly pear, monkey apple), insects (caterpillars, beetles, locusts), wild birds and small game. Beverages consumed were sour milk, home brewed beer (maphapfe) and a thin fermented maize porridge (mahewu/mabundu) (Labadarios *et al.*; 1996; Lubbe, 1971; Richter *et al.*, 1984; Franz, 1971; Ndaba and O'Keefe, 1985; Bourne *et al.*, 1994). These foods were unrefined, high in carbohydrates and dietary fibre and low in fat and sugar. With the traditional diet NCDs were virtually absent (Truswell and Hansen, 1976) (see Introduction Chapter pages 22). The current diet shows a transition to foods consumed in 'westernized' societies (Matthys *et al.*, 2003; Robinson *et al.*, 1999; Nielsen *et al.*, 2002a; Lietz *et al.*, 2002; Feunekes *et al.*, 1998; Hackett *et al.*, 1997).

In order to develop effective nutrition interventions to counter this nutrition transition from the 'traditional' foods to foods consumed by 'westernized' societies it is important to understand the factors influencing food choice. The findings from this study are discussed in the following section.

6.4. Factors influencing choice

In a study investigating factors influencing food choice in adolescents using focus group discussions the following factors were identified: hunger, food cravings, availability, convenience of food, parental influence (culture, religion), health benefits, mood, body image, habit, cost, and advertising (Neumark-Sztainer *et al.*, 1999). Additional factors identified by other studies include peer pressure (Doyle and Feldman, 1997; Cullen *et al.*, 2000). The current study managed to investigate seven of these food choice factors (see Table 4.8). The majority of the current Birth to Twenty sample considered taste when choosing their food (92.5%). This is similar to a study by Shannon *et al.*, (2002) in 289 students in grades 10-12 in a high school in the USA in which 93.7% of the participants said they considered taste when choosing food from a school cafeteria. This suggests that efforts to promote low fat, low sugar foods need to address the taste of these healthy options and deter the adolescents from high consumption of unhealthy foods. No studies have been identified which have taken this approach but studies which have looked at barriers to healthy eating have identified taste as a major factor deterring children and adolescents from eating healthy foods (O'Dea, 2003; Bauer *et al.*, 2004).

Health benefits were the second most important factor influencing diet that was reported by the adolescents. It would have been interesting to know what the adolescents' definition of health benefits was, i.e. were they just thinking of under-nutrition rather than over-nutrition. This was however not investigated in this study but future research should try and find out what the perceived health benefits are in the South African context. Peltzer (2002) found the top three food choice factors to be health, sensory appeal and mood in a study in black students in South Africa. The sample consisted of 213 second year social science university students (20 – 40 years) and 199 secondary school students (14 -19 years). Increasing nutrition knowledge regarding the health benefits of foods consumed by the adolescents might improve their choice of foods. In a meta-analysis conducted by Axelson *et al.*, (1985) many studies did not find significant associations between nutrition knowledge and dietary behaviour. This however could be due to various confounding factors such as food availability, accessibility, cost, and community influence. If interventions address these other factors a positive association could be seen between nutrition knowledge and healthy eating. Other studies have however shown a significant positive association between healthy dietary habits and nutrition knowledge (Wardle *et al.*, 1997).

Food appearance, preparation time and mood were important factors for half of the current sample. Sensory appeal (appearance, taste, and smell) was the most important factor in selecting food in a study in secondary school black students in South Africa (Peltzer, 2002). This suggests that healthy eating can be promoted by making the healthy alternatives appealing with regards to the appearance, taste and smell of the food. Mood was the third most important factor in the study by Peltzer (2002) after sensory appeal and health benefits. It is unclear what effect mood has on choosing healthy options and this factor would need further exploration. The modern lifestyles associated with urbanisation have resulted in reduced compatibility with home food preparation (Tansey and Worsely, 1995; Popkin *et al.*, 2001 and Nielsen *et al.*, 2002a). Industry should therefore endeavour to reduce the preparation time of healthy options as half the participants in the current study considered the preparation time that could result in them choosing unhealthy options which take less time to prepare (Nielsen *et al.*, 2002a).

Only a third of the participants in the current study considered cost in choosing their food. This could be because the sample consists of adolescents and this age group might be less cost aware because they are still dependant on their caregivers to provide resources. Cost has not been found to be an important factor in other studies in children and adolescents (Shannon *et al.*, 2002). Studies in adults however have shown that cost determines selection of healthy foods. Jetter and Cassady (2006) conducted a market-basket survey in 25 stores in Los Angeles and Sacramento between September 2003 and June 2004. Each store was surveyed three times. They found that the healthier food basket ($230) was significantly more expensive than the standard market basket ($194) using a 2 week shopping list. The higher costs were due to the whole grains, lean ground beef and skinless poultry. In another study in the UK Women's cohort study, 15191 women's dietary intake was assessed using a FFQ and a healthy diet indicator was developed using the WHO recommendations. The difference between the healthy and unhealthy diet was £540 $year^{-1}$ (Cade *et al.*, 1999). No evidence in South Africa was identified with regards to the extent of the difference of the cost between a healthy and unhealthy diet. A similar association would however be expected in the urban areas. Any interventions to encourage people to eat more healthy diets should acknowledge the cost incurred with healthier choices and develop measures to counter this barrier.

6.5. Factors that affect nutrition transition

The nutrition transition is driven by various factors which include urbanisation, socioeconomic, technological, environmental, and cultural factors (Popkin, 2003). A common feature of urban environments is increased consumption of food prepared away from home (Monteiro *et al.*, 2000). The transition to higher energy, fat and sugar intakes in South Africa could be facilitated by the increasing penetration of international fast food establishments such as McDonalds, KFC and Wimpy and other local franchises such as Black Steers, Steers and Nandos (Lang, 2002). Earlier penetration of into South Africa was prevented because of the Apartheid politics. For, example McDonalds had identified South Africa as a potentially significant market and had registered its trademark there in 1968 but only began to do business there in the early 1990s (www.gblaw.com). Fast foods provide relatively cheap energy dense foods. For example a 30cm pizza will cost between R35 and R45 (£2.69 and £3.46), whist 3 McDonalds burgers (a hamburger, cheese burger and chicken burger) can be purchased for just under R17 (£1.30). Fast food establishments are especially important to consider when studying nutrition transition in adolescents because they are popular in this age group (French *et al.*, 2001; Lin *et al.*, 1999).

In the current Bt20 study no association with energy or % fat intake was observed between those that went to fast food outlets and those who did not. This could possibly be because adolescents regard eating out as the "in thing". This could result in over-reporting of frequency of eating out because it is the socially acceptable behaviour. However there might also be under-reporting as fast food is generally perceived as unhealthy eating which adults might not approve of. Therefore, the adolescents may not want to report this behaviour to the researcher. A study by French *et al.*, (2001) however concluded that fast food restaurant use was positively associated with total energy intake, % energy from fat, daily servings of soft drinks and was inversely associated with daily servings of fruits and vegetables in a sample of 4746 adolescent students in the US. The average daily caloric intake for those who ate at a fast food restaurant 0, 1-2, and >=3 times a week was 1952, 2192 and 2752 kcal respectively. Frequency of restaurant use was based on self reports and therefore subject to bias. A semi-quantitative FFQ was used and since not all foods were quantified the reported energy intakes might lack accuracy.

Globalisation of mass media is an important factor known to drive the nutrition transition (Popkin, 2002b) and this could also explain the energy and fat intakes observed in the current study. Unfortunately this study did not look at the media influence on dietary intake of the adolescents. Advertising appears to encourage intake of some 'unhealthy' foods high in fat and calories. What has been mostly studied is the level of TV ownership and viewing levels. These have been shown to be on the increase (Du *et al.*, 2002; Tudor-Locke *et al.*, 2003) and therefore increased exposure to advertising. TV viewing not only results in sedentary behaviour but is associated with increased snacking. Data on TV ownership was not available in the current sample for Year 15. However, a previous study in a sample (n=281) from the same cohort from where the current sample came TV ownership was almost 80% (Griffiths *et al.*, unpublished). This suggests that most of the participants in the current study are exposed to adverts on TV. In a study of 4211 Greek adolescents, TV viewing was positively associated with consumption of sodas, crisps, pastries, sweets and chocolates (Yannakoulia *et al.*, 2004). The study of the association between dietary shifts and changes in mass media advertisement of food is an area that needs further research in South Africa.

6.6. Gender and ethnicity differences in energy and macronutrient intake

Excess dietary energy intake is likely to be a major contributing factor to the increasing obesity prevalence in South Africa. Girls had energy intakes averaging 124% RDA which aids us in understanding their higher prevalence of overweight and obesity in comparison to the boys whose average RDA was 103%. There was no significant difference in the energy intakes between black boys and girls. For Whites, boys had significantly higher energy intake than the girls. However this was expected as the RDA for 15-year-old girls and boys is 2200kcal and 3000kcal respectively.

Black girls had significantly higher saturated fat and added sugar and lower dietary fibre intakes compared to their male counterparts. This places them at higher risk for NCDs than boys. The pattern of higher total fat, saturated fat and sugar in females is similar to that observed in other studies (Bourne *et al.*, 1993; Vorster *et al.*, 1995; Vorster *et al.*, 1997 and MacIntyre *et al.*, 2002). These findings suggest that girls may be at greater risk for nutrition-related NCDs and hence that the transition will consequently result in more adverse outcomes for females.

Comparison of the current diet observed in this study with the recommended WHO/FAO (2003) intakes (Fig 4.4.1- 4.4.4 page 112 - 113) shows that the majority of the participants are exceeding the recommended fat and sugar intakes. There is therefore a clear need for interventions to try to alter the diet so that these recommendations can be met. Possible interventions are suggested on pages 174-176. However whilst there is a transition in the fat and added sugar intake there is not much change in protein intakes in the Blacks. This is a cause for concern as about half of them are not meeting the recommended requirements. Adequate protein intake is essential for growth, repair of body tissue, regulation and maintenance of body functions. If requirements are not met then the normal body functions can be affected. Unlike fat and carbohydrates which can be derived from dietary carbohydrates and protein respectively protein synthesis is dependant on the proteins from the diet (Passmore and Eastwood, 1986). The low intakes could possibly be because of increased cost of meat and meat products. In China income increases were positively associated with animal product consumption. Using data from the China Health and Nutrition Survey the amount of animal foods consumed were 77.6; 123.2 and 191.7g $person^{-1}$ day^{-1} for the low, middle and high income respectively (Du *et al.*, 2001; Popkin, 2003). Higher protein intakes in Whites in this study could be because they are predominantly higher socio-economic status than their black counterparts and therefore can afford to buy more relatively expensive protein i.e. meat and meat products. The likely impact of a low protein diet in combination with high fat and sugar needs to be investigated as no evidence was identified on this.

Dietary fibre intakes met the recommended intake for all sex-ethnic groups suggesting that the sample is probably consuming adequate amounts of fruit and vegetables. This is positive because this is protective against some NCDs (WHO/FAO, 2003).

6.7. Determinants of dietary intake

Changing socioeconomic conditions are associated with a transition in the diet (Popkin, 2003). The high energy, fat and sugar diet of the urban adolescent sample under study could be a reflection of factors such as cheaper food, increased accessibility and availability of food, and no seasonality effects associated with the urban environment. Social class is almost universally related to health, relative economic power and access to quality education. This in turn affects what people choose and can afford to eat. The association of socioeconomic status (SES) with dietary intake was therefore investigated.

The bivariate results showed that high SES was associated with significantly higher % total protein, animal protein, and saturated fat intake and lower plant protein and PUFA when compared to low SES. These results suggest that the higher SES group is at higher risk of developing NCDs because of the higher saturated fat intake. However no significant differences were observed in the total energy intake which together with physical activity determines whether energy balance is achieved which is critical to the development of obesity.

None of the significant bivariate predictors of energy intake i.e. height, biepi condylar breadth femur, biepi condylar breadth humerus, multivitamin use, and food choice factors (mood, hunger level and health benefits) remained significant in the stepwise linear regression after controlling for sex and pubertal stage of development. Furthermore there were no significant bivariate predictors for boys unlike for girls when examined separately, explaining, perhaps why none of the factors were significant after controlling for sex. SES was not a significant predictor of energy intake ($p = 0.054$).

Percent fat and carbohydrate intake both had a significant bivariate association with the food choice factor 'taste'. Those who considered taste had higher fat intakes and lower carbohydrate intakes which has implications that high fat options are being chosen because of their palatability. Therefore to curb increases in fat intake the taste of healthy options should be addressed as previously suggested in the section on factors influencing food choice to enhance their palatability. Fats are said to increase the palatability of foods by increasing the juiciness and tenderness of the food (Cotton and Blundell, 1994; French and Robinson, 2003). SES was again not significantly associated with both % fat and % carbohydrate intake. The % fat and carbohydrate intakes in the current study were fairly homogenous which could explain why an association was not identified. Even when the % fat and carbohydrate intake were categorised into those achieving and not achieving recommended WHO/FAO (2003) intakes no significant associations were observed.

Multivitamin use and high SES were significant predictors in the linear regression with % protein outcome. Multivitamin use could be a proxy for high SES. This suggests that not everyone can afford to transition to the protein intakes observed in the westernised diet because of the relative high cost of protein. Increasing income is associated with an increase in animal fat, animal protein, sugar and a decline in vegetable fat, vegetable protein and carbohydrate intakes (Popkin *et al.*, 1995). In China the intake of animal foods were positively associated with income levels (Popkin, 2003)

The food choice factor health benefits was the only variable associated with added sugar intakes with those considering health benefits having a lower sugar intake (13.3%) compared to those not considering its benefits (15.8%). This therefore has important implications in the reduction of added sugar in the diet as increased knowledge of the health benefits might help reduce intakes.

The lack of significant associations between the % fat, carbohydrate and sugar intakes with demographic and socio-economic variables could be because the intakes were fairly homogenous. If the range of intakes is narrow this could result in associations between variables being weakened (Hebert and Miller, 1990; Kushi *et al.*, 1992). Although SES was not significantly associated with diet possibly due to the small sample size, a consistent positive association was observed for % animal protein and saturated fat intake. An inverse association was observed for % carbohydrate, plant protein and polyunsaturated fat intake (see Table 4.6.1, page 105). These associations are typical of developing countries undergoing a nutrition transition.

6.8. Determinants of body composition

The prevalence of overweight or obesity was significantly higher in girls (24.7%) than boys (9.7%) in the current study which reflects the findings of other recent studies in South Africa (Department Of Health, 2002; Puoane *et al.*, 2002). In the 1998 Demographic and Health Survey an overweight and obesity prevalence of 19.2% and 6.2% in adolescent girls and 7.5% and 3.0% in boys was observed in the urban areas (Department Of Health, 2002). The % body fat levels regarded as being too high for pubertal boys and girls are 25% and 35% respectively (Westrate and Deurenberg, 1989). 8.7% and 24.4% of the boys and girls respectively had high % body fat using these cut-offs showing the extent of the problem. In the current study boys had significantly higher physical activity levels compared to their female counterparts. Kruger *et al.*, (2005) found an overweight/obese prevalence of 10% and 5.6% in girls and boys respectively aged 10 -15 years in 2000 - 2001. There were white, black, coloured and Indian participants in this sample from informal settlements, urban and rural areas in the North West Province of South Africa. Boys also had significantly higher physical activity compared to their female counterparts in this study.

The prevalence of overweight and obesity observed in this study suggest that this is an increasing problem among adolescents in South Africa and could be a result of the nutrition transition which is in progress. Obesity increases the risk of NCDs which results in increased healthcare costs, and deterioration in the quality of life (WHO/FAO, 2003).

The occurrence of the nutrition transition has been paralleled by increases in the prevalence of obesity and non-communicable disease in some countries (WHO, 1990; Popkin *et al.*, 1995; Popkin, 1994). One of the objectives of the current study was to investigate whether dietary, demographic and socioeconomic factors influence body composition in the urban Bt20 adolescents. The determinants of body composition are therefore discussed in the following section.

The stepwise logistic regression analysis compared overweight and obese participants with those who were not overweight or obese in the current study. The odds of being overweight or obese were increased if the participant was female, had mature breast/genitalia development and high SES, explaining 12.8 -20.9% of the variance in BMI status. These results are similar to other studies in other developing countries where associations have been found between obesity and being female and having a high SES (Walker *et al.*, 2001, 2002; Depeuch and Maire 1997; Kruger *et al.*, 2002). Sobal and Stunkard (1989) in their review of the literature also found that in developing countries a positive association was evident between SES and obesity. A barrier in trying to combat the problem of being overweight or obese is that big stature is perceived to be associated with high social status and being healthy in non-Caucasian groups (Williamson, 1998; Wildes *et al.*, 2001). In South

Africa qualitative research revealed that being overweight was said to reflect beauty, affluence, health, a negative HIV/AIDS status, and a husband's ability to provide for his family (Clark *et al.*, 1999; Mvo *et al.*, 1999; Puoane *et al.*, 2002 and Caradas *et al.*, 2001). Body size perception was however not investigated in the adolescents in the current study but one study has shown that South African adolescent blacks desired significantly larger body sizes in comparison to their fellow whites (Caradas *et al.*, 2001).

A participant with mature breast/genitalia development in the current study had increased risk of being overweight or obese (OR = 5.7, 95% C.I. 1.08; 30.0). This could be due to the effect of pubertal development on total energy intake. In a study of 193 adolescents aged 9 - 19 years in Geneva, Switzerland the total energy intake was significantly associated with pubertal development for both girls and boys. In this study dietary data was assessed using a 5 day diet record. As a proportion of total energy intake the macronutrient composition however remained constant throughout pubertal development (Clavien *et al.,* 1996). Increases in energy intake are not often met with subsequent increases in energy expenditure as adolescents tend to decrease their physical activity during adolescence (Adams, 2006; Barsony *et al.*, 1997). This could therefore result in positive energy balance resulting in an increased risk of being overweight or obese. This is particularly so for females as activity decreases whilst there is acceleration in fat accumulation during puberty (Barsony *et al.*, 1997; Malina and Bouchard, 1991). The Cole *et al.*, (2000) cut-offs for overweight and obesity were used in the current study. These standards use chronological age which might be inappropriate for this age group. Significant differences in timing of puberty have been observed for different populations (Proos, 1993). BMI has been found to be higher in individuals in advanced pubertal stages (Cole *et al.*, 2007; Woodruff and Duffield, 2002; Sandhu *et al.*, 2006). This could result in misclassification therefore references adjusting for the pubertal development could be more reliable.

The risk of having high % body fat was also associated with high SES but there was no significant SES association with % lean tissue in the current study. These results are similar to those obtained by Griffiths *et al.*, (unpublished) in a sample from the same Bt20 study. This study assessed the association of SES at birth and at 9/10 years with fat and lean mass index at 9/10 years in 281 participants (83.3% Blacks and 16.7% Whites). SES at 9/10 years was only positively associated with the fat mass index and not lean mass index after controlling for potentially confounding factors but SES at birth was associated with only lean mass index. An SES index was created as for the current study using principal component analysis but with different SES measures because of availability of different SES variables at the earlier ages in the study. Comparison of the effect of SES across studies is therefore complicated by use of different composite measures. Their findings suggested that the late childhood SES environment has a stronger association with fat mass than the SES environment at birth. The implication of this is that the environmental SES factors of the adolescents play a role in determining the risk of developing NCDs, because fat mass is most strongly associated with SES at the end of childhood, and this association continues into adolescence. It is unclear what brings about this association between high SES and increased overweight and obesity.

In the current study none of the dietary intake variables had an association with SES in the multivariate analysis. However other studies have shown that as SES increases in developing countries the excess income is used in purchase of unhealthy foods (Alderman, 1986). As income increases the following dietary changes occur: sugar, animal fat, and animal protein increase whilst vegetable fat, vegetable protein and carbohydrate decreases. These changes are paralleled by increases in the obesity prevalence (Popkin *et al.*, 1995; Popkin, 2003). In countries where income levels are high an inverse association between income and obesity, diets high in total and saturated fat is evident (Popkin *et al.*, 1995; Jeffery *et al.*, 1989; Laurier *et al.*, 1992). A review conducted by Monteiro *et al.*, (2004) showed that as the country's GNP increases a reversal occurs with the lower SES groups having a higher burden of obesity. This scenario could therefore occur in South Africa with time if the GNP rises.

The association could also be explained by differences in lifestyle factors such as physical activity with the high SES groups leading more sedentary lifestyles. Because the physical activity in the current study was not concurrent with the dietary intake and body composition measures the contribution of physical activity is unknown. The results of the current study suggest that the high SES groups are at risk of NCDs such as NIDDM, heart disease and hypertension. Therefore, future research could investigate what it is about high SES groups that cause an increase in the overweight and obesity prevalence and the role of diet in this urban adolescent population.

In this current study no significant associations were observed between the dietary intake and body composition outcomes (BMI, % body fat and % lean tissue). Possible explanations for a lack of association could be because the dietary intake has not yet had sufficient time to impact the body composition significantly. Ideally body composition should have been measured initially at year 14 then and compared with that at year 15 as the dietary intake data refers to this one year period and any changes could then be related to the dietary intake. The cross-sectional nature of this study therefore makes it difficult to identify associations. With a cross-sectional design the sequence of events cannot be distinguished and causality cannot be established. There is a possibility that the participants who were overweight or obese could have changed their dietary intake to try and lose weight for instance. The lack of an association could also be because of inadequate physical activity data which was reported for a different time period. Physical activity data was collected for age 13 (collected in year 14 for the previous year) whereas dietary intake was collected in year 15 for 14 year olds. Activities could have changed in a one year period. In the US Risk behaviour study logistic regression analysis was used to assess the overall change in being active or inactive in each survey year. Significant decreases in the odds of being active were observed in the adolescents (grade 9 -12) between 1993 and 2003 (Adams, 2006). The energy balance exerts an effect in the body stores. Therefore if the energy expenditure data is insufficient and cannot be controlled for it could result in some associations not being identified. Studies which examine dietary intake should therefore strive to collect concurrent physical activity data.

Body composition measures are more objective in comparison to the dietary intake and physical activity data which are more subjective because they depend on personal reporting (Ainsworth *et al.*, 1993; Hackett *et al.*, 1985). Hackett *et al.*, (1985) found out that the day of the week, survey fatigue, learning effect and the participant's knowledge of the study's objectives influenced the dietary assessment. In terms of physical activity the way the activity is classified by a participant as "brisk" or "slow" varies from individual to individual influencing the energy cost assigned to the activity (Ainsworth *et al.*, 1993). Therefore associations which would otherwise have been observed if physical activity and dietary intake data were objectively measured might not have been observed because of errors in reporting.

The energy requirements of a group of people of the same age and gender follow a normal distribution. This suggests wide variation in the intakes that can be expected. The difference between the obese and normal weight participants in their intakes therefore could be small as some normal weight individuals will have high intakes according to the distribution curve. This could therefore result in no significant differences between the intakes of normal and overweight and obese participants. The FFQ has limitations in its assessment of dietary intake as it has been known to overestimate nutrient intakes when compared to dietary records. However, the differences were minimal when the macronutrient composition as a proportion of total energy intake was calculated (Lietz *et al.*, 2002). Z-scores were used to identify energy outliers in this current study but there is no way of being certain that the remaining intakes are plausible as individual requirements vary. The measurement errors associated with dietary intake assessment could therefore influence the associations observed with explanatory variables such as dietary intake. If for instance overweight or obese participants systematically under-reported their intakes this would result in no association between intake and overweight/obesity.

Inconsistent results have been found between energy and fat intake with BMI. Some studies show no associations and others show negative or positive associations between obesity and energy intake (Braitman *et al.*, 1985; Fehily *et al.*, 1984, Kromhout, 1983; Romieu *et al.*, 1988; Colditz *et al.*, 1990). The inconsistencies in the associations could be because of confounding factors such as genetic predisposition to obesity, metabolic efficiency and physical activity (Popkin *et al.*, 1995) as well as the aforementioned difficulties in accurately recording diet. There are also differing opinions as to whether the % fat intake plays a role in raising overweight and obesity prevalence. Some studies show inverse, positive or no associations between obesity and fat intake (Colditz *et al.*, 1990; Fehily *et al.*, 1984; Klesges *et al.*, 1992; Kromhout, 1983 and Romieu *et al.*, 1988). Willet (1998a) in his review of ecologic studies and randomized trials of varying % fat intakes concluded that high fat diets are not the primary cause of overweight. Therefore reducing dietary fat was not the solution. Bray and Popkin (1998) however refuted his conclusion after a review of 28 clinical trials that studied the effects of a reduction of the energy from fat in the diet. They concluded that fat plays a role in increased risk of obesity as a 10% reduction in the % fat was associated with a reduction in weight of 16g/day. This argument was later refuted by Willet (1998b) as he said that the association observed was only marginal (p=0.05) and the studies included were short term studies. Willet suggests that longer term studies have been shown to have no effect on weight change. Willet also highlighted that a major study by Knopp *et al.*, (1997) was omitted by Bray and Popkin in their review which showed no significant differences in obesity in one year. What these arguments suggest therefore is that the effect of dietary intake of fat are either small or non-existent and larger long term trials need to be conducted to determine the association. However this might not be feasible due to ethical concerns of assigning some people to high fat diets which up to date have been regarded as unhealthy. However the focus should be more on the total energy intake as it is the energy balance which is of importance and the effect of high fat diets is to increase the energy density and hence total caloric intake.

Poor association between diet and overweight has also been identified in a study of 1040 women volunteers aged 15 – 70 years in the THUSA study in the North West Province of South Africa. Weak positive correlations were found between BMI and fat intake (r=0.050, p=0.05) and energy intake (r=0.054, p=0.04) after controlling for age, smoking and household income. The prevalence of obesity (BMI >30) was 28.6%. Women in the highest tertile of physical activity were less likely to be obese with an odds ratio of 0.38 (95% confidence interval 0.22-0.66) (Kruger *et al.*, 2002). Kruger *et al.*, (2005) did not find any significant differences in the diets of overweight or obese children and those with normal weight. Percent body fat was calculated using the sum of skinfold thicknesses in that study. In the stepwise regression analysis the number of household members and physical activity over weekends were negatively associated with % body fat for boys but only age was positively associated with % body fat for girls.

6.9. Limitations

The current study assessed dietary intake in adolescents, a very important group which is undergoing several changes. The adolescent behaviours are likely to become adult lifestyle behaviours (Kelder *et al.*, 1994) and research suggests that it easier to influence behaviours at this stage than later in life (Singer *et al.*, 1995). A pilot study was conducted for the dietary assessment tool resulting in subsequent modification of the tool to meet the needs of the Birth to Twenty adolescent group which many studies fail to do. The commonly consumed foods were identified and not just the macronutrient intake which enables interventions to be appropriately targeted. Food based dietary recommendations are easier to comprehend than just nutrient intake levels. This study managed to achieve its objectives despite a few limitations described in this section. These limitations are highlighted so that results can be interpreted accordingly and to inform future research.

Only one method, the FFQ was used for assessing dietary intake and no validation or reproducibility study was conducted. Ideally a combination of methods is more useful than a single one. Another method would have enabled the validity of the FFQ to be established, i.e. whether it measured what it had been designed to measure (Willet, 1990). Because there is no perfect dietary assessment tool the other method chosen should have errors that are independent. This implies that dietary records would have been the appropriate method of choice. This is because dietary records are not subject to recall bias, difficulties in portion size estimation or limited to a fixed list of foods. However, this was not feasible in the current study because of financial and time constraints. This would have also increased the participant burden. As the participants are part of an ongoing study it was important not deter them from attending future data collection phases.

The comparison between Blacks and Whites is limited in this study because of the relatively small sample size of the Whites. Inadequate numbers for white participants were obtained according to the sample size and power calculations. The overall small study sample could have resulted in insufficient power to identify significant associations in some analyses. The Whites are predominantly high SES. Other previous studies suggest that this group has already transitioned with higher energy, fat and sugar intakes. This suggests that potentially an effect of SES on dietary intake could have been identified in the multivariate analysis if there were more Whites in the sample.

This study also used a small sample size therefore this could also explain some of the observed results. The sample size could have been inadequate in detecting some significant differences. SES was not a significant predictor of energy intake, but was close to significance in the linear regression analysis possibly because of insufficient power due to the small sample size. No significant predictors for categorised fat and carbohydrate intake (categories were those achieving or not achieving WHO/FAO (2003) recommended intakes) were observed. This could also have been a sample size issue as a small proportion of the participants were in the category of those achieving the recommendations.

The cross-sectional design of this study means causality between dietary intake and body composition outcomes could not be established. This is because of confounding factors such physical activity, attempts at losing weight and other lifestyle factors like smoking. Causality could have been established if the participants had baseline body composition measures then followed up over a known period. During this follow up period physical activity and dietary intake should ideally be measured using dietary and physical activity records. Again, these methods exert undue participant burden therefore this could result in changing behaviour patterns and results which do not reflect the true picture.

These limitations are not unusual as they represent the challenges faced by many researchers conducting dietary assessments. Despite these limitations this study has enhanced our understanding of the extent to which the adolescent urban sample has experienced the nutrition transition and factors associated with both dietary intake and body composition. This enables possible intervention strategies to be suggested.

6.10. Intervention strategies to counter the nutrition transition

The dietary behaviour of an individual is linked to social, environmental, cultural and individual psychosocial factors therefore a single approach to counter the effects of the nutrition transition will not be effective (Ammerman *et al.*, 2002). For intervention success there is therefore a need for inter-sectoral collaboration. This section suggests interventions to curb the transition to a 'westernised' diet and increasing overweight and obesity prevalence considering the findings of the current study.

6.10.1. Compulsory physical activity classes

Girls had significantly lower physical activity levels compared to their male counterparts in the current study. These girls had increased risk of being overweight and obese compared to their male counterparts. Interventions to increase activity should be introduced with a special focus on girls. Compulsory physical activity classes could be introduced in all schools and made part of the school curriculum. Barriers to physical activity change in an American sample were competition, bullying, safety, and time (Bauer *et al.,* 2004). Similar barriers might be found in South Africa. The school staff should therefore be educated and encouraged to get rid of competitiveness and make classes more enjoyable. Different classes for girls and boys could be set up to encourage the females to participate more and to avoid competitiveness. Culture sensitive dancing classes could also be introduced as part of school activities to increase activity. Another way to increase activity in South African adolescents would be to encourage walking or cycling to school. However there might be issues concerning personal safety as there is a high crime rate. Cycling and walking might therefore become an option if the country manages to tackle its crime problem.

6.10.2. Product development: Creation of healthy tasty low fat options

In a study by (O' Dea, 2003), 38 focus groups were held in Australia in children and adolescents aged 7 – 17 years and some barriers to healthy eating identified were taste, convenience, peer pressure and a lack of sense of urgency to personal health. In the current study a large proportion (92.7%) considered taste in their selection of foods. The food industry could therefore be encouraged with the government's support to develop products which are tasty but healthy. Many studies have shown that reducing fat in foods by using a fat substitute such as sucrose polyester can reduce the fat and energy intake without changing the control of appetite (Cotton and Blundell, 1994). No studies have been identified which have intervened in this way. However, many studies have been identified that suggest that high fat foods are more palatable (Cotton and Blundell, 1994). Therefore this intervention has great potential if healthy tasty low fat alternatives can be produced.

6.10.3. Nutrition education

The food choice factor health benefits was associated with added sugar intakes with those considering health benefits having a lower mean sugar intake 13.3% compared to 15.8% in those not considering its benefits. Nutrition education which highlights the benefits of a low sugar diet might therefore help to reduce added sugar intakes. In the current study those in the high SES group were at increased risk of being overweight or obese. Interventions should therefore specifically target this group. The cost of healthy options is probably not an issue for this group. The implication is that other lifestyle factors are probably at play or they are not well informed about the consequences of following a certain diet. Future research should investigate what it is about the high SES group that puts them at greater risk of being overweight or obese. Unfortunately the nutrition knowledge of this sample was not investigated. However, in the current study a high proportion considered the health benefits (72.8%) of foods in their selection but it is unknown how they interpreted health benefits i.e. was it just in terms of under-nutrition or both? If the health benefits of following a healthy diet and lifestyle are communicated this could result in improved dietary behaviour. It is suggested that as the nutrition transition progresses the people with high SES who are usually more educated will respond to nutrition messages and reduce their risk of obesity (Monteiro *et al.*, 2000; Monteiro *et al.*, 2001b). Therefore, people need to be given clear messages of the practical means to change their diet and lead healthy lifestyles to reduce the incidence of overweight and obesity. There is also a need to facilitate environmental change to ease selection of healthy options. If the food environment is ignored nutrition education programs may be ineffectual.

6.10.4. Investigate role of street vendors and schools in the diet of adolescents

Some of the commonly consumed foods in the current study contributing to high fat and sugar intakes were bunny chows, fried chips, carbonated sweetened drinks and sweets which are mostly eaten as school snacks. When these foods are consumed at schools they are usually bought from the street vendors (Martin Manyike – Bt20 member of staff). This suggests that these vendors potentially play an important role in shaping the diet of the current adolescent urban sample. Bauer *et al.*, (2004) held focus groups and interviews of students (13 -14 years), staff and some key informants in a study which aimed to identify factors which compete with initiatives to improve nutrition. 80% of the 26 students participating were White and 20% were Asian American or African American. Some of the identified barriers to healthy eating were the presence of vending machines in the schools and hence easy access to non-nutritious snacks and lack of appealing healthy options in the cafeteria. To quote one of the students: "*And you know, our principal tells us how healthy we should stay, and its like, How can we stay healthy when you are throwing all this in front of us*" (Bauer *et al.*, 2004 page 41). This shows that teaching messages about healthy eating without changing the environment will not be effective therefore if the street vendors play an important role they should be prohibited from selling their merchandise at schools. Schools are an ideal place for targeting the adolescents as the large proportion of the day is spent in school. Interventions targeting the environment may potentially be more effective in changing dietary behaviours as they change the context creating conditions which support healthy choices (Stokols, 1996). However this might be met with resistance as this is a source of livelihood for these vendors and would create another problem of unemployment.

6.11. Conclusion

It is important to understand what urban South African adolescents are consuming in this transitioning environment because adolescence is a critical stage in the aetiology of some adult nutrition related non-communicable diseases. A food frequency questionnaire (FFQ) developed by the Medical Research Council of South Africa was used to assess habitual dietary intake. A pilot study identified some problems with using the MRC FFQ protocol with the 15-year-olds from the Bt20 cohort. There were potential overestimations of energy intakes due to difficulties in recalling brand names, food preparation techniques, and boredom with the lengthy procedure. The FFQ was consequently modified resulting in more reasonable intakes, shorter time spent completing the FFQ, reduced boredom and an improvement in the adolescent's ability to respond to the questionnaire. The modified protocol therefore appeared to be more successful with this group, although cautioning that validation with other dietary intake methods is still warranted. Researchers exploring dietary intake might need to assess and adapt standard methodologies to their specific research sample and environment.

The macronutrient intake and foods commonly consumed by the adolescent participants in the Birth to Twenty study in comparison with other earlier studies in South Africa showed that there is a transition towards the diet consumed by transitioned societies with high energy, fat and sugar and low carbohydrate intakes. The macronutrient intake also did not meet the FAO/WHO (2003) recommendations. Added sugar intakes are very high in this adolescent sample with the majority (75.3%) consuming more than the recommended <10%. Black females had the highest added sugar intakes (15.3%) in the current study. The high added sugar intake could be a result of high consumption of carbonated sweetened soft drinks, sweets and table sugar as shown by the commonly consumed foods. This sample is already consuming sugar intakes comparable to those in the transitioned societies. This could have implication on the NCD profile in South Africa. 76% of the sample had total fat intakes above the recommended whilst 74% were below the recommended carbohydrate intake. No transition was observed in protein intake as a proportion of total energy intake towards 'westernized' intakes.

About half the black sample had intakes below the recommended (10 -15%). The current dietary intake and transition towards a 'western' diet is an increasing health concern. Therefore, preventative strategies to stop further deterioration in the diet should be implemented. This is because accompanying this nutrition transition is a rise in the prevalence of non-communicable diseases (NCDs) such as obesity, non insulin dependant diabetes mellitus and cardiovascular diseases. These NCDs accounted for 37% of the total mortality in South Africa in the year 2000 (Bradshaw *et al.*, 2003). This is in addition to the existing high burden of infectious diseases, under-nutrition and injuries (Steyn *et al.*, 2006a).

The results showed that there is an association between being female, mature breast/genitalia development and high SES and the risk of being overweight or obese. The food choice factors, taste, and health benefits have been shown to be particularly important in influencing food selection. No association was observed between diet and body composition measures possibly due to the cross-sectional study design, confounding factors which could not be controlled for adequately and measurement errors associated with dietary intake assessment.

There is a need to identify national strategies to counteract the negative consequences of the nutrition transition. The government needs to recognise the problems related to dietary transition and offer as much support to nutritionists, healthcare personnel and organizations trying to tackle this problem. The dietary choices are an interaction of various factors including personal preferences, cost, food environment, nutrition literacy, motivation, government policy, parental influence and the community. Collaboration among various sectors is therefore required to successfully change the dietary behaviour. Some of the possible intervention strategies suggested bearing in mind the results of the current study are nutrition education, increased physical activity especially for girls, and development of tasty healthy alternatives. Further research is needed on the role of street vendors in influencing the dietary intake of these urban adolescents.

Longitudinal research is needed to better understand the interaction between diet, body composition, physical activity and the environment. In-depth qualitative studies are also required to investigate dietary behaviour in the context of social networks to enhance the understanding of why the people are consuming the food they eat. This will enable development of interventions which are culturally and contextually appropriate.

The current study has shown that a transition towards a typical 'western' diet is evident suggesting that this generation of adolescents have a similar dietary risk for non-communicable diseases to their counterparts in transitioned societies.

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APPPENDICES

Appendix A: MRC food frequency questionnaire

MRC QUANTIFIED FOOD FREQUENCY QUESTIONNAIRE (FFQ)

NAME OF THE PARTICIPANT..

PARTICIPANT'S CODE

BIRTH DATE

D	D	M	M	Y	Y	Y	Y

INTERVIEWER NAME & CODE..

<u>Steps for the interviewer to follow when interviewing each participant</u>

Step 1: The interviewer can start the interview by saying the following: "I *want you to think back over the past ....months about the foods and drinks you ate/drank. Then I want you to try to remember how much you usually have of each item.*"

Step 2: Give the participants the Food Flash cards with the following instruction: "*Please look through these photographs and make 2 piles. One pile is for items, which you hardly ever or never ate/drank in the past ..... months. The other pile is for those items that you did eat/drink in the past ..... months.*" Put away the pile of cards that were not eaten/drank.

Step 3: Now ask the participant to do the following. "Once *again make 2 piles of cards. The one pile should include items. Which you eat/drink nearly every day. The second pile should include those items that are eaten/drank less frequently, i.e. once a fortnight or once a month.*"

<u>Steps 4 and 5 are completed together, for each food item, before moving on to the next item:</u>
Step 4: Now proceed through each item of the frequently eaten pile with the participant. Ask about how often the item is usually eaten per day/week. This amount should be entered in the appropriate column in the FFQ. For example, if white bread is usually eaten once a day, every day, **fill in a '1' in the E column (eaten daily). Items eaten every week (but not every day) should be filled in column F according to the number of days per week eaten**. After the frequently eaten pile, do the same with the less frequently eaten pile, which will involve completing column G. Do this until all the cards are accounted for. The following examples have been entered in the questionnaire example on page ......
"Coffee was usually drunk twice a day every day of the week."
"Maas was usually drunk once a day on the weekend (Saturdays and Sundays)."
"Oats was usually eaten once in the morning, three times a week."
"White rice is only eaten once a week on a Sunday."
"Tub margarine is used twice a day every day of the week."
"Butter is used about twice a month."

Step 5: The next step is to determine the usual portion size of each item. **This is done per item as you work through the commonly eaten foods' step above**. This must be done for each item directly after the frequency of intake was determined (Step 4). The FPM and any other available aids must be used to determine the portion sizes. Please note that each item has a number that corresponds to the number and colour of the photos in the manual. Identify the appropriate food code from the FPM and enter it in column C on the FFQ.

FOOD FREQUENCY QUESTIONNAIRE RECORDING SHEET

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten (g) Generic/amount =g	E. Eaten every day	F. Eaten every week	G. Eaten at least once a month
				Times/ day	Days/ week	Times/ month
DAIRY-BLUE						
1. Tea						
1. Coffee	coffee	4037	1 tea cup = 200	2	7	
1. Sugar in tea/ coffee						
2. Milk in tea/coffee						
2. Milk with porridge						
3. Buttermilk/maas	maas	2787	1 s/s carton =350	1	2	
4. Milk drinks						
5. Yoghurt						
6. Cottage cheese						
7. Hard cheese						
8. Processed cheese						
9. Ice-cream & lollies						
STARCH-BROWN						
1. Brown bread/rolls						
1. White bread/rolls						
2. Traditional bread/roti						
2. Fat cakes						
3. Breakfast cereals						
4. Maize porridge soft						
4. Maize porridge stiff						
4. Mabele/maltabella soft						
4. Mabele stiff						
4. Oats	oats	3239	1 full shallow bowl = 250	1	3	
5. Pasta without sauce						
6. Pasta dishes						
7. Rice	white	3247	1 heaped serving spoon = 60	1	1	
7. Samp/mealie rice						
7. Wheat rice						
8. Pizza & savoury tart						
FATS-TAN						
1. Brick margarine						
1. Tub margarine	Rama	3496	Thick spread =10	2	7	
1. White margarine						
1. Butter	butter	3479				2
2. Animal fat, i.e. lard						
3. Cream & substitutes						
4. Oils						
5. Salad dressing						
5. Mayonnaise						
SPREADS-PINK						
Cheese spread						
Fish paste						
Honey/syrup						
Jam						
Marmite						
Meat spread i.e. Bovril						
Peanut butter						
Sandwich spread						

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten (g) Generic/ amount =g	E. Eaten every day	F. Eaten every week	G. Eaten at least once a month
				Times/ day	Days/ week	Times/ month
EGGS-YELLOW						
Boiled						
Fried						
Omelette						
Scrambled						
FRUIT- ORANGE						
1. Apples						
2. Bananas						
3. Berries						
4. Figs/prickly pears						
5. Fruit salad						
6. Grapes						
7. Guavas						
8. Mango/paw paw						
9. Melons						
10. Naartjies						
11. Oranges						
12. Peaches						
13. Pears						
14. Pineapple						
15. Plums						
16. Dry fruit						
17. Fruit juice						
SOUPS, LEGUMES & NUTS						
1. Soups						
2. Beans & Lentils						
3. Nuts & seeds						
FISH & SEAFOOD – BEIGE						
1. Fried fish						
2. Grilled/smoked/dried fish						
3. Pilchard & sardines						
3. Tuna						
MEAT –RED						
1. Beef and Ostrich						
2. Patties & mince						
3. Burgers & takeaways						
4. Chicken & turkey						
5. Cold meat						
6. Meat fillings						
7. Meat pies						
8. Mutton						
9. Pork						
10. Sausage and Viennas						
11. Traditional and organ meats						
12. Vegetarian products						
13. Dry sausage and Biltong						

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten (g) Generic/ amount =g	E. Eaten every day	F. Eaten every week	G. Eaten at least once a month
				Times/ day	Days/ week	Times/ month
VEGETABLES – GREEN						
1. Asparagus						
2. Avocado						
3. Baby marrows						
4. Beetroot						
5. Butternut & pumpkin						
6. Broccoli/cauliflower						
7. Cabbage						
8. Carrots						
9. Gem Squash						
10. Green Beans						
11. Mealies						
12. Mixed vegetables						
13. Mushrooms						
14. Peas						
15. Potatoes						
16. Potato chips						
17. Salad vegetables						
18. Spinach/marog						
19. Sweet potatoes						
20. Tomatoes						
BISCUITS, CAKE & PUDDING						
1. Biscuits/cookies						
2. Biscuits/savoury						
3. Buns/muffins/scones						
4. Cakes & tarts						
5. Doughnuts/éclairs						
6. Pancakes/waffles						
7. Puddings & Custard						
8. Rusks						
9. Special breads						
SNACKS, SWEETS & COLD DRINKS – PINK						
1. Carbonated cold drinks						
1. Diet cold drinks						
2. Energy drinks						
2. Squashes						
3. Crisps & popcorn						
4. Sweets/chocolates						
SAUCES & CONDIMENTS –GREY						
1. Cheese and white sauces						
2. Chakalaka/Atjar						
2. Tomato sauce & other						
3. Salt, spices & seasoning						
ALCOHOLIC DRINKS – GREY						
1. Beer & cider & coolers						
2. Wine						
3. Spirits						
4.Liquers & fortified wine						

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten (g) Generic/ amount =g	E. Eaten every day	F. Eaten every week	G. Eaten at least once a month
				Times/ day	Days/ week	Times/ month
OTHER						

END

Appendix B: Modified food frequency questionnaire

FOOD FREQUENCY QUESTIONNAIRE (FFQ)

Bone Health ID ☐☐☐

Birth To Twenty ID ☐☐☐☐☐☐☐

Gender | F | M |

Date...

Interviewer's name.......................................

Interviewer instructions (**more detailed instructions in Food Photo Manual**)

Step 1: Ask the adolescent the questions in the food habits section.

Step 2 (with adolescent): Start the interview by saying "I want you to think back over the past few months about the foods and drinks you usually ate/drank."

Step 3: Give the **adolescent** the Food Flash Cards which have been grouped into their respective colours with the following instruction: "Please look through these photographs and make three piles. One pile is for items, which you never ate/drank , one for those you ate/drank occasionally that is only once/twice a month and the other is for the foods you eat everyday or week". Put away the pile of cards that were not eaten or drunk. Indicate the foods that were eaten occasionally and those never eaten by ticking the respective columns (**G** and **H**).

Step 4: Ask the **adolescent** to sort the usually eaten pile into those eaten at home and outside the home (e.g. school, takeaways where caregiver is not present).

Step 5: Go through the pile of foods eaten outside the home with the **adolescent**. Ask how often the item is usually eaten per day/week and enter the amount in the appropriate column. For example, if white bread is usually eaten once a day, every day fill in a '1' in **column E** (eaten daily). Items every week (but not every day) should be filled in **column F** according to the number of times per week eaten. Do this until all the cards are accounted for.

Step 6: Now determine the portion size of each item. Do this directly after determining the frequency of intake of each item (Step 5).The FPM and any available aids must be used to determine the portion size. Enter the amount consumed in **column D**. Please note that each item has a number that corresponds to the number and colour of the photos in the manual. Identify the appropriate food code from the FPM and enter it in **column C** on the FFQ (*the code can be entered after the interview and weight in grams if not readily available*).

Step 7: Now proceed through each item of the foods eaten regularly at home pile with the **adolescent's caregiver**. Determine frequency of consumption and portion size using the same procedure as for the adolescent in steps 5 & 6.

Food habits

1. Are you on a special diet that has been prescribed for you e.g. by a doctor or one that you have adopted from someone e.g. a TV star/magazine?

YES	1
NO	0

2. If NO, go to question 4.
   If YES, describe what kind of diet you are on and where you got the diet from?

____

____

3. How long have you been on that diet?__________months/years.

4. Do you currently take any vitamin and mineral supplements?

YES	1
NO	0

IF YES, what do you take?

	Name of product	Amount/day
Vitamins/vitamins and minerals		
Tonics		
Health foods		
Body building preparations		
Dietary fibre supplement		
Other: specify		

5. Which meals do you skip almost on a daily basis?

Breakfast	1
Lunch	2
Evening meal	3
None	4

6. Is salt added to your food while it is being cooked?

Always	1
Sometimes	2
Never	3
Don't know	4

7. There are some factors which influence the choice of foods we eat. Which of the following statements are true for you?

	Strongly agree	Agree	Disagree	Strongly Disagree
I choose to eat certain foods because they taste good	1	2	3	4
The food I eat depends on whether it is expensive	1	2	3	4
I choose to eat certain foods because it looks good	1	2	3	4
The food I choose to eat differs according to my mood (i.e. happy/sad)	1	2	3	4
My hunger level determines what type of food I eat.	1	2	3	4
I choose foods which are not time consuming to prepare	1	2	3	4
I consider whether a food is good for my health before eating the food.	1	2	3	4

8. Do you ever eat outside the home e.g. at fast food shops such as Nandos, KFC and Steers?

YES	1
NO	0

9. If YES, in an average month how often do you eat at the following places?

	Frequency of visits	
	Times/week	Times/month
Nandos		
Spur		
Macdonalds		
Steers		
KFC		
Chicken Licken		
Debonaire's Pizza		
Romans		
Anat		
Wimpy		
Something fishy		
Fontana		
Chinese takeaway		

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
DAIRY-BLUE							
1.Tea	Ordinary:	4038					
	Herbal	4053					
	Rooibois	4054					
1. Sugar in tea	Brown	4005					
	White	3989					
2. Milk in tea (is milk real dairy or blend?)	Type:						
1. Coffee		4037					
2. Milk in coffee (is milk real dairy or blend?)	Type:						
2. Sugar in coffee	Brown	4005					
	White	3989					
2. Milk (is milk real dairy or blend?)							
3. Buttermilk/maas (what is the fat content)	Buttermilk	2713					
	Maas	2787					
4. Milk drinks (fat content of milk, was water used to make drink, was sugar added?)							
5. Yoghurt (fat content, is it sweetened)							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
9. Ice cream and lollies (fat content, dairy/sorbet, diabetic/low sugar							
ASK ABOUT TYPE OF BREAD,THICKNESS OF SLICES AND THE SPREAD							
1. Bread/rolls	White						
	Brown						
	Whole wheat						
	Traditional bread/roti						
Do you spread anything on the bread? Yes=1 No=0. If yes what do you spread?							
1. Brick/tub margarine (hard/soft, regular/low fat/light)							
1. Butter							
Cheese spread		2730					
Fish paste		3109					
Honey/syrup		3988					
Jam	Jam/marmalade	3985					
	Jam/marmalade diabetic	4025					
Marmite		4030					
Meat spread i.e. Bovril		4029					
Peanut butter		3485					
Sandwich spread		3522					
Cold meats							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
6.Cheese							
2. Fat cakes							
3. Breakfast cereals (is it sweetened)	Brand name:						
Do you pour milk on your cereal? Yes =1 No=0 If yes, what type of milk do you use ________________							
If yes, how much milk?							
Do you pour sugar on your cereal? Yes =1 No=0							
If yes, how much sugar?							
4. Maize porridge stiff							
4. Maize porridge soft (was butter/margarine etc added)							
Do you pour milk on your soft porridge? Yes =1 No=0 If yes, what type of milk do you use ________________							
If yes, how much milk?							
Do you add anything to your soft porridge? (e.g. sugar/butter) Yes =1 No=0							
If yes, what & how much?							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
4. Mabele/maltabella stiff							
4. Mabele soft (was butter/margarine etc added)							
Do you pour milk on your soft porridge? Yes =1 No=0 If yes, what type of milk do you use ________________							
If yes, how much milk?							
Do you add anything to your soft porridge? (e.g. sugar/butter) Yes =1 No=0							
If yes, what and how much?							
4. Oats							
Do you pour milk on your oats? Yes =1 No=0 If yes, what type of milk do you use ________________							
If yes, how much milk?							
Do you add anything to your oats? (e.g. sugar/butter) Yes =1 No=0							
If yes, what and how much?							
5/6. Pasta/Pasta dishes (if sauce eaten ,how much sauce, any additions: cheese/butter margarine/lard)							

A. Food items (with FPM numbers)	**B.** Description of food item	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten once/twice a month	**H.** Never eaten
				Times/ day	Times/ week		
7. Rice (white/brown & with/without fat/oil)							
7. Samp/mealie rice (with/without fat/oil)							
7. Samp and beans (with/without fat/oil)							
7. Wheat rice (with/without fat/oil)							
8. Pizza (toppings: quantify, pizza crust)							
8. Savoury tart							
EGGS-YELLOW							
Boiled							
Fried							
Omelette (filling and quantity)							
Scrambled							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
FRUITS-ORANGE							
1. Apples (peeled or not)							
2. Bananas (peeled or not, is it fried)	Fresh	3540					
	Fried in HM	3611					
3. Berries (fresh/canned/candied)							
4. Figs/prickly pears (fresh or candied)							
5. Fruit salad (fresh or canned in syrup/juice							
6. Grapes	Grapes average raw	3550					
	Grapes, sultanas (not dried)	4224					
7. Guavas(fresh or canned in syrup/juice							
8. Mango/paw paw (fresh or canned in syrup/juice							
9. Melons							
10. Naartjies	Mineola raw	4227					
	Naartjie raw	3558					
	Naartjie canned in syrup	3635					
11. Oranges	Orange, raw, peeled	3560					
	Grapefruit raw	3546					

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
12. Peaches(fresh or canned in syrup/juice							
13. Pears(fresh or canned in syrup/juice							
14. Pineapple(fresh or canned in syrup/juice							
15. Plums(fresh or canned in syrup/juice							
16. Dry fruit							
17. Fruit juice (fresh/pure, was it sweetened/unsweetened)							
SOUPS, LEGUMES, NUTS							
1. Soups (homemade with what or commercial)							
2. Beans and lentils (anything added)							
3. Nuts and seeds							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
FISH & SEAFOOD- BEIGE							
1. Fried fish (type of fat/oil, crumbed or not, any sauce)							
2. Grilled/smoked/dried fish (fat/oil added, any sauce)							
3. Pilchards & sardines (canned in water/tomato sauce, any mayonnaise added)							
3. Tuna (canned in oil/water, any mayonnaise added)							
MEAT- RED							
How do you like meat 1= with fat 2= fat trimmed							
1. Beef/mutton/pork (state whether with bone or not)							
1.Ostrich/Turkey							
2. Patties (crumbed or not)							
2.Mince (regular/lean)							
3.Burgers (takeaway/fast food) homemade-crumbed or not)							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
Do you eat chicken skin? Yes=1	**No=0**						
4. Chicken (takeaway/fast food or homemade)							
5.Cold meat (specify)							
6. Meat fillings							
7. Meat pies (homemade or commercial)							
10. Sausages/viennas (state whether beef/pork/mutton/chicken)							
11. Traditional & organ meats (state type of meat and organ e.g. chicken feet)							
12.Vegetarian products							
13. Dry sausages & biltong	Sausages, beef dry	2949					
	Biltong	2912					
VEGETABLES-GREEN							
1. Asparagus (any fat/sauce added)	Asparagus, green, boiled	3695					
	Asparagus, white, canned	4094					

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
2. Avocado	Avocado, raw, peeled	3656					
3. Baby marrows(any fat/sauce added)							
4. Beetroot (grated/sliced, any sugar/vinegar added)	Boiled	3698					
	Beetroot salad	3699					
5. Butternut & pumpkin (any sugar, breadcrumbs/fat added)							
6. Broccoli/cauliflower(any fat/sauce added)							
7.Cabbage (was it fried, anything added)							
8.Carrots (was it fried, anything added)							
9. Gem squash (any sugar, fat/ sauce added)	Boiled	3760					
	Boiled with sugar	3754					

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
10. Green beans (any fat, sauce, potato, onion added)							
11. Mealies (any fat added)							
12. Mixed vegetables (which vegetables, any fat/sauce)							
13. Mushrooms (any fat/sauce added)							
14. Peas (any fat/sauce added)							
15. Potatoes (any milk/fat added to mashed potatoes)							
16. Potato chips (takeaway or homemade: (any mayonnaise eaten with chips)	Fried in Sun oil	3740					
	Chips baked in oven	3945					
17. Salad vegetables (any mayonnaise or salad dressing. See FAT 5)							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
18. Spinach/marog (any fat, sauce, potato, onion added)							
19. Sweet potatoes (any fat/sugar added)							
20. Tomatoes (raw/cooked sun dried tomatoes, any onions added, fried in fat)							
FATS-TAN							
2. Animal fat i.e. lard	Where used						
	Number of spoons						
	Number in family						
1. White margarine (type of fat)							
3. Cream and substitutes (real dairy/plant fats)							
4. Oils	Where used						
	Number of spoons						
	Number in family						
5. Salad dressing (homemade/bought, type of oil)							
5. Mayonnaise (homemade/bought, type of oil	Where used						
	Number of spoons						
	Number in family						

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
BISCUITS, CAKE & PUDDING							
1. Biscuits/cookies (homemade or bought)							
2. Biscuits/savoury (any spread)							
3. Buns/muffins/scones (any spread)							
4. Cakes and tarts (was cake iced)							
5. Doughnuts/éclairs (plain or filled with jam/cream/custard)							
6. Pancakes/waffles (any spread)							
7. Puddings & custard (any custard/cream/sauce added to pudding)							
8. Rusks (white/whole-wheat, commercial/homemade)							
9. Special breads (any spread)							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
SNACKS, SWEETS & COLD DRINKS-PINK							
1. Carbonated cold drinks e.g. coke		3981					
1. Diet cold drinks e.g. diet coke		3990					
2. Energy drinks							
2. Squashes							
3. Crisps & popcorn							
4. Sweets/chocolates							
SAUCES & CONDIMENTS-GREY							
1. Cheese & white sauces (which fat was used to make sauce and what type of milk)							
2. Chakalaka/Atjar							
2. Tomato sauce & other							

A. Food items (with FPM numbers)	B. Description of food item	C. Item code	D. Amount usually eaten(g) Generic/amount = g	E. Eaten every day	F. Eaten every week	G. Eaten once/twice a month	H. Never eaten
				Times/ day	Times/ week		
ALCOHOLIC DRINKS-GREY							
1. Beer & cider & coolers (regular/low alcohol)							
2. Wine							
3. Spirits (any carbonated drink e.g. coke added)		4035					
4. Liqueurs & Fortified wine							
OTHER							

Appendix C: Under and over-reporting in dietary assessment studies using EI/BMR ratio

Goldberg cut-offs

Cut-off 2 calculated as follows

Lower limit : PAL x exp (z-score_{min} x (S/100)/√n)

Upper limit : PAL x exp (z-score_{max} x (S/100)/√n)

Where

PAL = mean PAL for population under study

z-score_{min} is -2 for 95% or -3 for 99% lower confidence limit

z-score_{max} is +2 for 95% or +3 for 99% upper confidence limit

n is the number of participants

S is the factor that takes account of the variation in take, BMR and energy requirements.

$S = \sqrt{(} CV^2_{EI}/d + CV^2_{BMR} + CV^2_{tPAL}$

Where

EI = within subject coefficient of variation of energy intake

d = number of days of dietary assessment

BMR = coefficient of variation of repeated BMR measurements or precision of estimated compared with measured BMI

tPAL = total variation in PAL

(Goldberg *et al.*, 1991)

Table C1 : Under and over-reporting in dietary assessment studies.

Source	Participants	Setting/location	Cut-offs (EI/BMR)	Results
Mendez *et al.,* 2003	n=891 adults aged 25-75 years, random selection, FFQ, BMR (Schofield equations)	Spanish Town neighbouring the capital city of Kingston, Jamaica. Between 1993 and 1995	UR<1.35 OR >2.4	UR : 38.6% women; 22.5% men. OR: 16% women; 23.7% men. UR positively associated with obesity, special diets, smoking and age. Response rate 60%, unclear whether non-response may have affected findings
McGowan *et al.*, 2001	n=1379,adults aged 18-64years, random from electoral register, 7 day food diary	Northern Ireland and Republic of Ireland	UR <1.53	Mean EI/BMR =1.38 suggesting energy under-reporting occurred. 63% of eligible sample participated.
Okubo and Sasaki, 2004	n=1889 female university students, 18-20 years, enrolled in dietetics courses, diet history questionnaire	Japan, April 1997	UR<1.56 OR > 2.4	UR: 68% OR: 2% 37% below the minimum survival level of 1.27 BMI, body weight and BMR decreased significantly with increase in EI/BMR.
Ferrari *et al.*, 2002	n=35955 men and women , aged 35-74 years, EPIC calibration sub-studies, 24 hour dietary recall	Europe (10 countries participating in the European Prospective Investigation into Cancer and Nutrition (EPIC))	PAL of1.55 at aggregate level (reference) and Goldberg's cut-offs used	Extreme under-reporters 13.8% women and 10.3% men. Mean EI/BMR in women and men were 1.36 and 1.44 respectively. Overweight subjects more likely to underestimate energy intake.

EI: energy intake; BMR: basal metabolic rate; FFQ – food frequency questionnaire, UR-under-reporters, OR- over-reporters, BMI – body mass index.

Table C1 (continued)

Source	Participants	Setting/location	Cut-offs (EI/BMR)	Results
Azizi *et al.*, 2005	n= 947 (415 males and 532 females),mean age 37.3 ± 14.6 yrs for men and 32.9± for women two 24 hour recalls	Tehran, Iran	UR: < 1.35 OR : >=2.4	UR: 31% (men 19% and women 40%) OR :5% (men 7% and women 3%) Mean EI/BMR 1.72±0.44 (men) and 1.27± women. UR were older and higher BMI than normal reporters Smoking more prevalent in over-reporters.
Fletcher *et al.*, 2004	n= 424 children, aged 11-12years, two 3 day estimated food records	Northumberland, Britain, year 2000	UR <1.1	UR : 23% (boys) and 18% (girls).
Bedard *et al.*, 2004	n=246 adults, aged 18-82 years, semi-quantitative FFQ	Montreal, Canada . Administered between 2000 and 2001	UR: Goldberg statistical cut-off	UR; 43%. This was 54% and 35% in men and women. Mean EI/BMR was 1.26 for men and 1.32 for women. Underreporting higher in men, and individuals who were older, heavier, higher BMI and low educational level
MacIntyre *et al.*, 2000	n=890, aged 15-65 years, quantitative FFQ	North West Province , South Africa	UR :<1.2	UR : 43%.
Mennen *et al.* 2000	n=743 rural Cameroon, n=1004 urban Cameroon, n=857 Jamaica, n=243 African-Caribbeans in the UK	Four populations African populations	UR : 3 Goldberg cut-offs 1.15, 1.32 and 1.48 corresponding to PALs of 1.55, 1.78 and 2.00 respectively.	Using lowest cut-off for the four samples respectively men(women)%: 6(6); 5(4); 19(24); 39(28). Intermediate: 9(8); 9(7); 30(34); 53(46). Highest:11(9); 14(13); 37(47); 66(60). Physical activity was not assessed in any of these populations. Assumption rural Cameroonians are very active and UK sample very inactive and the others intermediate.

EI: energy intake; BMR: basal metabolic rate; FFQ – food frequency questionnaire, UR-under-reporters, OR- over-reporters, BMI – body mass index.

Appendix D: Significant SES bivariate associations

Dietary intake

Table D1: SES váriables associated with total energy intake (kcal) from the bivariate analysis (whole sample n=150)

Independent variable	Mean intake (SD)	[1]Test statistic	P-value
Child grant	No 2671 (981) ; Yes 3291 (1118)	t (147) = -3.531	0.001
Goods support from father/partner	No 3044 (1087); Yes 2553 (951)	t (148) = 2.606	0.010
Goods/financial support from others	No 2833 (1026) ; Yes 3425 (1274)	t (148) = -2.177	0.031
Medical aid	No 3019 (1120); Yes 2584 (854)	t (148) = 2.250	0.026
Water/toilet facility	Indoor 2677 (966); Mixed 3022 (1195); 3285 (1076)	F (148) = 4.373	0.014

[1]For categorical variables, independent t-tests and ANOVA were used to assess statistical significance

Table D2: SES variables associated with total energy intake from the bivariate analysis (girls only n=80)

Independent variable	Mean intake (SD)	[1]Test statistic	P-value
Child grant	No 2469 (845) ; Yes 3240 (1253)	t (78) = -3.260	0.002
Foster care grant	No 2786 (1036) ; Yes 1273 (426)	t (78) = 2.509	0.014
Financial support from father/partner	No 2907 (1098) ; Yes 2380 (897)	t (78) = 2.156	0.034
Goods support from father/partner	No 2924 (1090) ; Yes 2181 (745)	t (78) = 2.889	0.005
Medical aid	No 2921 (1155) ; Yes 2306 (650)	t (74.271) = 3.017	0.003
Water/toilet facility	Indoor 2406 (947) ; Mixed 3160 (1160) ; Outdoor 2997 (998)	F (78) = 4.530	0.014

[1]For categorical variables, independent t-tests and ANOVA were used to assess statistical significance

Table D3: SES variables associated with % protein intake from the bivariate analysis (whole sample n=150)

Independent variable	Mean intake (SD)	[1]Test statistic	P-value
Child grant	No 10.99 (2.09) ; Yes 10.13 (1.56)	t (138.096) = 2.828	0.005
Financial support from father/partner	No 10.24 (1.73) ; Yes 11.55 (2.07)	t (148) = -4.100	<0.001
Goods support from father/partner	No 10.35 (1.78) ; Yes 11.48 (2.13)	t (148) = -3.340	0.001
Emotional support from father/partner	No 10.39 (1.75); Yes 11.94 (2.16)	t (147) = -4.106	<0.001
Medical aid	No 10.33 (1.72) ; Yes 11.63 (2.20)	t (148) = -3.818	<0.001
Water/toilet facility	Indoor 11.05 (2.09) ; Mixed 10.28 (1.98) ; Outdoor 10.23 (1.37)	F (148) = 3.144	0.046
Employment status	Employed 10.91 (2.01); Unemployed 10.23 (1.74)	t (148) = 2.026	0.045

[1]For categorical variables, independent t-tests and ANOVA were used to assess statistical significance

Table D4: SES variables associated with % carbohydrate (WHO guidelines) from the bivariate analysis (whole sample n=150)

Independent variable	<55% (westernised) (%)	55-75% (prudent)(%)	[1]Test statistic	P-value
Goods support from caregiver			4.419 , df=1	0.044
No	76.7	23.3		
Yes	52.9	47.1		
Water/toilet facility			9.298	0.010
Indoor	72.8	27.2		
Mixed	58.8	41.2		
Outdoor	91.2	8.8		

[1]For categorical variables Pearson's chi square tests were used to assess statistical significance

Body Composition

Table D5: SES variables associated with BMI from the bivariate analysis (whole sample n=150)

Independent variable (n)	Not overweight/obese (%)	Overweight/obese (%)	[1]Test statistic (degrees of freedom)	Two tailed p-value
Financial support from father/partner			5.384 (1)	0.020
No (98)	87.8	12.2		
Yes (51)	72.5	27.5		
Goods support father/partner			4.183 (1)	0.041
No (105)	86.7	13.3		
Yes (44)	72.7	27.3		
Emotional support father/partner			9.478 (1)	0.002
No (118)	87.3	12.7		
Yes (300	63.3	36.7		
Marital status			5.924 (1)	0.015
Alone (89)	88.8	11.2		
With someone (60)	73.3	26.7		
Employment status			9.058 (1)	0.003
Employed (100)	76.0	24.0		
Unemployed (49)	95.9	4.1		

[1]For categorical variables Pearson's chi square tests were used to assess statistical significance

Table D6: SES variables associated with % body fat from the bivariate analysis (whole sample n=150)

Independent variable (n)	Low body fat (%)	High body fat (%)	[1]Test statistic (degrees of freedom)	Two tailed p-value
Financial support from father/partner			4.355 (1)	0.037
No (96)	57.3	42.7		
Yes (51)	39.2	60.8		
Goods support from caregiver			4.131 (1)	0.042
No (131)	48.1	51.9		
Yes (16)	75.0	25.0		
Employment status			8.051 (1)	0.005
Employed (100)	43.0	57.0		
Unemployed (47)	68.1	31.9		

[1]For categorical variables Pearson's chi square tests were used to assess statistical significance

Table D7: SES variables associated with % lean tissue from the bivariate analysis (whole sample n=150)

Independent variable (n)	Low lean tissue (%)	High lean tissue (%)	[1]Test statistic (df)	p-value
Financial support from caregiver			4.851 (1)	0.028
No (131)	51.9	48.1		
Yes (17)	23.5	76.5		
Goods support from caregiver				
No (132)	52.3	47.7	6.419 (1)	0.011
Yes (16)	18.8	81.3		
Emotional support from mother			4.205 (1)	0.040
No (24)	29.2	70.8		
Yes (123)	52.0	48.0		
Emotional support from caregiver			5.033 (1)	0.025
No (127)	52.0	48.0		
Yes (20)	25.0	75.0		
Employment status			10.793 (1)	0.001
Employed (100)	58.0	42.0		
Unemployed (48)	29.2	70.8		

[1]For categorical variables Pearson's chi square tests were used to assess statistical significance

Appendix E: Foods commonly consumed by less than a third of the adolescent sample

Table E1: Food items consumed by less than a third of the whole adolescent sample

Food item	Average amount consumed per day (g)	% of sample consuming the item
Mixed Vegetables, Frozen, Boiled (carrot, Corn, Peas, Green Beans, etc)	16.9	32.7
Stew, Mutton, With Vegetables	32.1	32.0
Cookies, Commercial, Plain	25.2	32.0
Maize Meal, Cooked, Soft Porridge	68.9	31.3
Margarine, Brick/hard	25.5	31.3
Jam/marmalade	14.1	31.3
Salad: Potato (mayonnaise, Egg)	22.3	28.0
Patty, Beef, Frozen, Grilled	15.8	27.3
Pumpkin, Boiled	14.9	27.3
Peach, Raw	68.3	26.7
Creamer (coffee & Tea) / Non Dairy Powder	8.1	25.3
Grape, Average, Raw	94.2	25.3
Cold Drink, Clifton, Reconstituted	153.7	25.3
Atchar, Mango	44.4	24.7
Oats, Rolled Or Oatmeal, Cooked	47.8	24.7
Spinach (Swiss Chard), Cooked With Potato, Onion, Sunflower Oil	24.3	24.7
Snack, Savoury, Potato Crisps/chips	22.9	24.0
Orange Juice, Liquifruit/ceres	200.7	24.0
Milk, Low Fat / 2% Fat, Fresh	150.8	23.3
Cookies, Commercial, With Filling	32.7	23.3
Cabbage, Boiled	13.4	23.3
Maas / Sour Milk	50.5	22.7
Beans, Dried, Canned In Tomato Sauce (baked Beans)	24.5	22.7
Macaroni/spaghetti, Cooked	36.3	22.0
Peanuts, Roasted, Salted	20.5	21.3

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Plum, Raw	19.2	21.3
Beef, Brisket, Cooked - Moist	23.9	21.3
Muffin, Plain	9.9	20.7
Mango, Raw (peeled)	72.7	20.7
Sugar, Brown	29.2	20.7
Squash, Butternut, Boiled	22.9	20.0
Maltabella, Cooked	96.6	19.3
Spaghetti Bolognaise (regular Mince)	40.4	19.3
Peas, Frozen, Boiled	13.9	19.3
Egg, Chicken, Whole, Boiled / Poached	28.6	18.7
Samp And Beans, 1:1	44.4	18.7
Pilchard In Tomato Sauce	24.8	18.0
Ice Cream, Rich (16% Fat)	43.8	18.0
Liver, Chicken, Cooked (simmered)	20.2	17.3
Salad Dressing, Mayonnaise	10.3	17.3
Carrot, Raw (flesh And Skin)	28.3	17.3
Nectarine, Raw	61.8	17.3
Custard, Whole Milk (Custard Powder)	31.6	16.7
Patty, Chicken, Crumbed / Breaded, Fried	17.4	16.7
Apricot, Raw	13.6	16.7
Green Beans, Boiled	11.2	16.7
Tea, Rooibos, Brewed	241.0	16.7
Ham, Sliced / Canned, Lean	9.4	16.0
Spinach (small Leaved), Boiled	20.4	16.0
Cabbage, Sautéed In Sunflower Oil	19.0	14.7
Vienna Sausage, Beef & Pork, Canned	13.1	14.0
Pie, Steak & Kidney, Commercial, Baked	23.2	14.0

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Cucumber, Raw (flesh And Skin)	25.8	14.0
Fish, Low Fat, Fried In Sun Oil	10.1	12.7
Hot Cross Bun	14.1	12.7
Grapefruit, Raw (peeled)	43.8	12.7
Orange Juice, Canned, Unsweetened	120.2	12.7
Cold Drink, Lucozade	83.1	12.7
Sweets, Chocolate, Kit Kat	16.9	12.7
Giblets, Chicken, Cooked (simmered)	29.3	12.0
Breakfast Cereal- Weet-bix	30.9	12.0
Doughnut, With Icing	10.4	12.0
Strawberry, Raw	14.6	12.0
Pineapple, Raw (peeled)	17.0	12.0
Feet, Chicken, Raw	22.9	11.3
Raisins, Thompson Seedless, Raw	18.3	11.3
Milk, Flavoured, Low Fat	73.2	10.7
Sausage Roll, Commercial, Baked	13.1	10.7
Salad: Coleslaw (mayonnaise)	16.5	10.7
Pizza, With Cheese, Tomato And Olives	54.4	10.0
Fruit Salad, Fresh, Without Sugar (pawpaw, Orange, Banana)	25.8	10.0
Broccoli, Boiled	12.7	10.0
Potato, Roasted In Sunflower Oil	24.8	10.0
Head, Chicken, Raw	33.7	9.3
Medium Fat Spread, Polyunsaturated, Floro Light	18.7	9.3
Watermelon, Raw (peeled)	42.4	9.3
Litchi, Raw (peeled)	17.7	9.3
Egg, Fried In Polyunsaturated margarine	32.0	8.7
Sausage, Beef, Dry	32.2	8.7

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Fish, Low Fat, Grilled	13.0	8.7
Scone, Plain (low fat milk, hard margarine)	15.8	8.7
Ice Cream, Soft Serve (13% Fat)	43.9	8.7
Cold Drink, Low-cal/ Artificial Sweetened/ Diet Squash, Diluted	102.6	8.7
Sausage, Pork, Grilled	12.2	8.0
Provita	12.1	8.0
Guava, Raw (peeled)	31.4	8.0
Bacon, Cured, Pan-fried/grilled	4.3	7.3
Cream Cracker	9.1	7.3
Scone, Plain (whole milk, hard margarine)	25.3	7.3
Eclair, With Chocolate Icing And Fresh Cream Filling	31.0	7.3
Potato, Boiled Without Skin	29.3	7.3
Sweet Potato, Boiled Without Skin	35.3	7.3
Mahewu/magou, Liquid	68.0	7.3
Mixed Vegetables, Frozen, Raw (carrot, Corn, Peas, Green Beans, Etc)	18.7	7.3
Cheese, Gouda (edam, Swiss)	9.7	6.7
Offal, Cooked (tripe, Brawn, Brain, Tongue)	19.8	6.7
Apple Juice, Liquifruit/ceres	152.2	6.7
Potato, Baked In Skin (flesh Only)	29.9	6.7
Nesquik, Powder	2.8	6.0
Fish Finger/stick, Fried/frozen, Crumbed, Reheated	28.4	6.0
Chutney, Tomato	22.3	6.0
Squash, Gem, Boiled (flesh Only)	11.0	6.0
Potato, Boiled With Skin (flesh And Skin)	43.7	6.0
Yoghurt, Drinking, Low Fat, Flavoured, Sweetened	68.8	5.3
Egg, Fried In hard margarine	45.3	5.3

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Biltong, Game	7.4	5.3
Tuna, Canned In Water (drained Solids)	15.7	5.3
Soup, Pea, Split (with Pork And Vegetables)	31.3	5.3
Sandwich Spread	8.1	5.3
Paw Paw, Raw (peeled)	17.9	5.3
Fruit Salad, Canned In Fruit Juice	33.4	5.3
Beetroot, Boiled With Skin (flesh Only)	39.0	5.3
Cheese Spread, Full Fat	12.0	4.7
Custard, Low Fat Milk (custard Powder)	25.5	4.7
Mutton, Loin, Grilled (chop)	11.5	4.7
Pie, Chicken, Commercial, Baked	20.0	4.7
Pork, Spareribs, Braised	30.6	4.7
Breakfast Cereal- All Bran Flakes	18.5	4.7
Breakfast Cereal- Rice Crispies	17.1	4.7
Rusk, Commercial, Bran	24.0	4.7
Spaghetti Bolognaise (lean Mince)	37.6	4.7
Mango And Orange Juice, Liquifruit	208.7	4.7
Cauliflower, Boiled	16.9	4.7
Mushroom, Sautéed In Sunflower Oil	18.3	4.7
Mixed Vegetables, Frozen, Boiled (cauliflower, Carrot, green Beans, etc)	11.6	4.7
Salad: Greek (lettuce, Tomato, Cucumber, Olive, Feta, No Dressing)	75.6	4.7
Salami, Beef / Pork (also Russians)	10.3	4.0
Ham, Sliced / Canned, Regular	5.6	4.0
Fish Cake, Commercial, Fried	11.9	4.0
Rice, Brown, Cooked	40.7	4.0
Margarine, 50% Polyunsaturated, Floro	17.1	4.0
Salami, Beer (bierwurst), Pork	3.4	4.0

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Cheese, Cottage, Low Fat	12.4	3.3
Yoghurt, Plain, Low Fat	34.3	3.3
Milk, Skim, Fresh	109.6	3.3
Malted Milk Beverage (low fat milk, No Sugar) e.g. Milo	88.9	3.3
Dairy-fruit Juice Mix	114.3	3.3
Batter Dipped, Fried Chicken (e.g. Kentucky)	15.1	3.3
Soup, Minestrone, Commercial, Prepared With Water	33.9	3.3
Pancake/crumpet, Plain, (whole milk, Sun Oil)	10.9	3.3
Cake, Chocolate, Plain, Homemade (whole milk, hard margarine)	25.6	3.3
Bread, Pita	28.3	3.3
Pancake/crumpet, Plain (low fat milk, Sun Oil)	36.7	3.3
Macaroni Cheese, Egg Custard Type (low fat milk)	44.3	3.3
Peach, Dried, Raw	13.9	3.3
Sweets, Chocolate, Milk	27.3	3.3
Spirit, Brandy/ Gin, Whisky/ Cane/ Vodka/ Rum(alc43%v/v,36%w/w)	83.0	3.3
Milk Shake, Vanilla, Purchased	89.3	2.7
Egg, Scrambled (whole milk only)	48.2	2.7
Mutton, Leg (meat & Fat), Roasted	9.7	2.7
Pie, Cornish, Commercial, Baked	22.7	2.7
Meatball (regular Mince, With Egg)	36.4	2.7
Cottage Pie (regular Mince, whole milk, hard margarine)	15.7	2.7
Sauce, Cheese, Medium (whole milk, hard margarine, Cheese)	8.9	2.7
Chutney, Fruit	32.9	2.7
Macaroni Cheese, Egg Custard Type (whole milk)	37.5	2.7
Noodles, Egg, Cooked	93.0	2.7
Samoosa, With Mutton Filling	16.5	2.7
Breakfast Cereal- Puffed Rice, Sweetened (coco pops)	14.2	2.7

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Samoosa, With Vegetable Filling	10.5	2.7
Lasagne (lean Mince, Cheese Sauce - low fat milk, hard margarine)	42.9	2.7
Orange Juice, Fresh	221.0	2.7
Mango Juice, Ceres	130.4	2.7
Mealie, Sweetcorn, Boiled	27.7	2.7
Cabbage, Cooked With Potato, Onion And Sunflower Oil	27.0	2.7
Potato, Mashed (skim Milk, Polyunsaturated Margarine)	11.2	2.7
Sweets, Chocolate, Assorted Centres	22.5	2.7
Squash, Baby Marrow, Boiled	9.1	2.7
Sausage, Beef, Grilled	17.7	2.7
Malted Milk Powder e.g. Milo, Horlicks	10.2	2.0
Cheese, Mozzarella	34.3	2.0
Pork, Loin, Grilled (chops)	24.3	2.0
Fish, Low Fat, Battered/crumbed, Fried In Sun Oil	13.3	2.0
Soup, Vegetable, Vegetarian, Commercial, Prepared With Water	110.9	2.0
Breakfast Cereal- Muesli, Commercial	55.7	2.0
Pudding, Trifle	23.1	2.0
Scone, Plain (skim milk, Sun Oil)	11.2	2.0
Noodle Salad	27.1	2.0
Pudding, Baked, Plain Batter, No Syrup (low fat milk, hard margarine)	20.0	2.0
Breakfast Cereal- Pronutro Great Start	49.3	2.0
Melon, Orange Flesh, Raw (peeled)	26.2	2.0
Peach, Canned In Fruit Juice	26.2	2.0
Fruit Punch (alcohol-free)	187.5	2.0
Peach Juice, Ceres	100.0	2.0
Sweet Potato, Baked With Skin (flesh Only)	45.2	2.0
Jelly, Dessert, Prepared With Water	20.0	2.0

Table E1continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Syrup, Golden	20.4	2.0
Bovril, Meat & Vegetable Extract	2.3	2.0
Marmite, Yeast Extract	4.1	2.0
Mineola, Raw (peeled)	20.0	2.0
Raisins, Hanepoot, Seedless, Raw	11.4	2.0
Cheese, Processed, Full Fat	13.9	1.3
Fruit Juice, Average	89.3	1.3
Egg, Scrambled (whole milk, Sun Oil)	9.7	1.3
Egg, Scrambled (low fat milk, Sun Oil)	16.1	1.3
Curry, Mutton	17.9	1.3
Tuna, Canned In Oil (fish And Oil)	6.3	1.3
Calamari/squid/octopus, Fried (flour, Oil)	2.4	1.3
Sauce, Cheese, Medium (low fat milk, hard margarine, Cheese)	5.5	1.3
Sauce, White, Medium (whole milk, hard margarine)	5.4	1.3
Soup, Mushroom Cream Commercial, Prepared With Water	52.9	1.3
Beans, Sugar, Dried, Cooked	26.8	1.3
Bread/rolls, Whole-Wheat	61.4	1.3
Koeksister	71.5	1.3
Doughnut, Plain	23.6	1.3
Lasagne (regular Mince, Cheese Sauce - whole milk, hard margarine)	85.7	1.3
Pudding, Instant (whole milk)	31.1	1.3
Cake, Madeira, Commercial	7.9	1.3
Roti, Made With Sun Oil	45.0	1.3
Pudding, Instant (low fat milk)	19.3	1.3
Cake, Chocolate, Plain, Homemade (low fat milk, hard margarine)	13.5	1.3
Banana Loaf (low fat milk, hard margarine)	8.6	1.3
Mixed Nuts (almond, Cashew, Peanuts, Hazel, Brazil)	8.6	1.3

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Sunflower Oil	0.3	1.3
Olive Oil	4.1	1.3
Guava Juice, Sweetened	178.6	1.3
Orange Juice, Canned, Sweetened	264.3	1.3
Blueberry, Raw	27.2	1.3
Guava Juice, Liquifruit/ceres	250.0	1.3
Kiwifruit, Raw (peeled)	17.2	1.3
Peach And Orange Juice, Liquifruit	71.4	1.3
Mealie, Sweetcorn, Cream Style, Canned	53.2	1.3
Mushroom, Sautéed In Brick Margarine	6.8	1.3
Salad: Mixed Fresh Vegetables (carrot, Tomato, Lettuce, No Dressing)	9.3	1.3
Sweets, Liquorice Allsorts	9.7	1.3
Tea, Herb, Brewed	340.0	1.3
Mealie, Sweetcorn, Frozen, Boiled	20.4	1.3
Mealie, Sweetcorn, Baby, Whole, Fresh/frozen, Boiled	19.3	1.3
Mushroom, Oyster, Boiled	25.4	1.3
Mopanie Worm, Dried	16.8	1.3
Fruit Salad, Fresh, Without Sugar (melon, Orange, Banana)	22.5	1.3
Drinking Chocolate, Reconstituted	107.2	1.3
Milk, Evaporated, Full Fat, Unsweetened	20.0	0.7
Custard, Skim Milk (Custard Powder)	17.9	0.7
Custard, Whole Milk (egg), Plain Baked / Sauce	41.4	0.7
Malted Milk Beverage (whole milk, No Sugar) e.g. Milo	71.4	0.7
Milk, Soy	115.7	0.7
Cheese, Feta	4.3	0.7
Cheese, Parmesan	2.1	0.7
Milk Powder, Blend, Medium Fat (numel)	12.0	0.7

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Drinking Chocolate, Powder	4.3	0.7
Omelette, Plain (whole milk, Fried In Sun Oil)	6.4	0.7
Chicken, Meat And Skin, Frozen, Roasted	17.1	0.7
Beef, Rib, Wing, Cooked - Dry	25.7	0.7
Meatball (regular Mince, Without Egg)	34.3	0.7
Stew, Chicken (with Skin), Tomato And Onion	17.9	0.7
Schnitzel, Pork Chop (crumbed)	11.4	0.7
Frankfurter, Chicken	2.9	0.7
Biltong, Beef (cured, Dried)	1.7	0.7
Haddock, Smoked, Steamed	10.0	0.7
Sardine, Canned In Tomato Sauce (drained)	37.1	0.7
Tuna, Canned In Oil (drained Solids)	34.3	0.7
Sardine, Canned In Oil (drained Solids)	6.0	0.7
Fish Paste	2.0	0.7
Sauce, White, Medium (low fat milk, Polyunsaturated margarine)	9.5	0.7
Peas, Split, Cooked	17.9	0.7
Beans, Haricot, Dried, Boiled	7.1	0.7
Chick Peas, Dried, Cooked	6.1	0.7
Lentils, Whole, Cooked	6.4	0.7
Cake, Butter, Plain, Homemade (whole milk, butter)	7.9	0.7
Pudding, Baked, Plain Batter, No Syrup (whole milk, hard margarine)	40.0	0.7
Tart/pie, Jam, Short Crust - hard margarine	20.0	0.7
Rye, Crisp bread Ry-vita, Ry-king	35.7	0.7
Maize, Samp/rice, Cooked (white)	71.4	0.7
Noodles, Egg & spinach Cooked	115.7	0.7
Pudding, Baked Custard E.g. Bread-/sago- /rice- (whole milk, hard margarine)	140.0	0.7

Table E1 continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Cake, Sponge, With Jam, Commercial (e.g. Swiss Roll)	10.0	0.7
Cheese Cake, Baked (egg And Cream)	10.7	0.7
Macaroni/spaghetti, Whole-wheat, Cooked	102.9	0.7
Pudding, Instant (skim milk)	20.7	0.7
Crackers, Average Refined, High Fat e.g. Tuc, Bacon Kips	2.4	0.7
Macaroni & Cheese (low fat milk, Hard margarine)	28.6	0.7
Tart/pie, Apple, Short Pastry - Polyunsaturated margarine	7.9	0.7
Popcorn, Sugar Coated/candied	3.7	0.7
Almond, Dried, Blanched	1.1	0.7
Salad Dressing, Salad Cream	0.4	0.7
Ice Cream, Sorbet / Non Dairy (8% Fat)	22.9	0.7
Orley Whip (no Sugar Added)	1.1	0.7
Cream Canned	4.6	0.7
Apricot, Dried, Raw	0.9	0.7
Apricot Nectar	5.0	0.7
Guava, Canned In Syrup	9.6	0.7
Prickly Pear, Raw (peeled)	32.1	0.7
Fruit Salad, Canned In Syrup	40.0	0.7
Pear, Dried, Raw	10.3	0.7
Apple, Dried, Raw	3.6	0.7
Apricot Juice, Liquifruit	128.6	0.7
Peach Nectar	107.1	0.7
Strawberry Juice, Liquifruit	85.7	0.7
Grape/hanepoot Juice Liquifruit/ceres	171.4	0.7
Strawberry And Banana Juice, Liquifruit/ceres	142.9	0.7
Squash, Butternut, Boiled, With Sugar	7.5	0.7

Table E1continued

Food item	Average amount consumed per day (g)	% of sample consuming the item
Potato, Baked In Skin (flesh And Skin)	51.4	0.7
Carrot, Boiled, With Polyunsaturated Margarine	5.7	0.7
Potato, Sautéed In Sunflower Oil	68.6	0.7
Springroll, Fried In Sun Oil	3.3	0.7
Salad: Mixed Green (lettuce, Cabbage, Cucumber, Apple, No Dressing)	6.5	0.7
Potato Chips/French Fries, Frozen, Heated In Oven	10.0	0.7
Bean Sprouts, Lentils, Raw	11.4	0.7
Leaves, Amaranth, Boiled	2.6	0.7
Sweets, Peppermint	15.0	0.7
Wine, Red/white/rose Dry/semi-sweet/spark (alc 12%v/v;9,4%w/w)	35.7	0.7
Beer, Sorghum (alc 2-3%w/w)	35.7	0.7
Cider, Sweet (alc 3,7%v/v; 2,9%w/w)	600.0	0.7
Cucumber, English, Raw (flesh And Skin)	25.7	0.7
Mushroom, Canned (drained Solids)	9.5	0.7
Grape, Sultana, Raw	17.9	0.7
Mixed Vegetables, Frozen, Raw (cauliflower, Carrot, Green Beans, Etc)	10.7	0.7
Worcestershire Sauce	5.0	0.7
Cheese, Brie	40.0	0.7
Veal, Breast, Cooked - Moist	34.3	0.7
Beef, Silverside, Cooked - Moist	4.3	0.7
Fish, Low Fat, Steamed (hake)	10.0	0.7