THE ASSOCIATION OF NUTRITION ON BODY COMPOSITION AND METABOLIC DISEASE RISK IN RURAL SOUTH AFRICAN CHILDREN AND ADOLESCENTS

By

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Declaration

I, Titilola M. Pedro, declare that this thesis is my own original, unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted previously for any degree or examination at any university or institution.

Signed: ________________________________

on November 21, 2017.

Dedication

"To almighty Allah, the all Knowing, the Wise," who shows mercy to whomever He pleases. Glory and praises be to You, for all Your benevolence and for Your wits to accomplish this task.

To my late father. "Okelade Adeniyi Lawal," who strongly believed in a girl child being educated.

To my mother and my siblings, "Amudat Abeni Lawal," "Dr. Abimbola, Adesile Badmus and others," for their unwavering prayers.

To my husband, Professor "Jimoh O. Pedro, my teacher and a true friend over the years of being together. Your patience, guidance, coaching and understanding are limitless. You are always encouraging, supporting and never lost faith in me. "Ki Oluwa jeki a pe fun ara wa ni-inu ola-nla re Amin".

To my lovely children, "Omowunmi and Olanrewaju," for their understanding and patience and for reminding me always of the important things in life - GOOD HEALTH AND SUPPORTIVE FAMILY.

To my grandchildren, "Abdul-Roqeeb Ajijola-anabi (SAW) Yusuf and Sekinah Ajoke Yusuf."

ABSTRACT

Abstract

Background: The persistent burden of undernutrition, with increasing prevalence of obesity and metabolic disease risk among children and adolescents, has become a global public health problem. Research has shown that risk factors established in childhood and adolescence may contribute to the development of non-communicable diseases (NCDs) in adulthood. This is of particular concern in South Africa, given its rapid socio-economic, political and epidemiological transitions. Research into the trends of nutrition transition in rural children and adolescents, whose particular health needs have been under-served and poorly delineated in the past, provides a unique opportunity to study the effects of rapid health transitions on development.

Aim: To determine the association of nutrition, body composition and metabolic disease risk in rural South African children and adolescents.

Study design: Three cross-sectional studies were undertaken to address the overall aim of this research. The specific objectives of each study were: (1) to determine the association of nutrition on body composition and metabolic disease risk in children and adolescents; (2) to examine the associations between body mass index (BMI), disordered eating attitude and body dissatisfaction in female adolescents, and descriptive attributes assigned to silhouettes of differing body habitus in male and female adolescents; and (3) to investigate associations between diet and cardiovascular disease (CVD) risk factors in adolescents.

Method: One cross-sectional study, 3 analyses were nested within the Agincourt Health and Socio-demographic Surveillance System (HDSS) site, in the Bushbuckridge sub-district, Mpumalanga Province, South Africa. In 2009, a random sample of 600 children and adolescents, from age groups 7 to 8 years, 11 to 12 years and 14 to 15 years, were selected from 3489 children who had participated in a 2007 growth survey. These children and adolescents had to have lived in Agincourt at least 80% of the time since birth or since 1992, when enrolment into the Agincourt Health and Socio-Demographic Surveillance System (HDSS) began. Height and weight were measured to determine BMI. Age and sex-specific cut-offs for underweight and overweight/obesity were determined using those of the International Obesity Task Force. Body image satisfaction using Feel-Ideal Discrepancy (FID) scores, Eating Attitudes Test-26 (EAT-26), perceptual female silhouettes and pubertal assessment were collected through self-administered questionnaires. Blood pressure (systolic (SBP) and diastolic (DBP)) was measured, fasting blood sam-

ples were collected for the determination of glucose and lipids.

Waist to hip ratio cut-offs of (WHR) >0.85 for females, >0.90 for males, waist to height ratio (WHtR) of >0.5 for both sexes, and waist circumference (WC) of >80 cm for females and >94 cm for males were used to determine the risk of adiposity. For abnormal lipids: high density lipoprotein cholesterol (HDL-C) cut-offs of >1.03 mmol/l, low density lipoprotein-cholesterol (LDL-C) of >2.59 mmol/l, triglycerides (TGs) of >1.7 mmol/l and total cholesterol (TC) of >5.17 mmol/l were used. Pre-hypertension prevalence was computed using the average of 2 readings of SBP or DBP, being >90th but <95th percentile for age, sex and height. Dietary intake was assessed using semi-quantitative food frequency questionnaire. T-test and ANOVAs for normally distributed data and Wilcoxon-Mann-Whitney test was used to determine significant differences by sex and by pubertal stages for EAT-26 and EAT-26 sub-scores. Chi square tests were done to determine significant associations between the categorical variables. Bivariate linear regression was employed to test associations and significant tests were set at the $p<0.05$ level.

Results: Study component (1): Stunting levels were higher in the boys than in the girls in mid to late childhood and combined overweight and obesity prevalence was higher in girls than in boys. The girls' BMI was significantly greater at ages 11 and 12 years than that of the boys [girls: 18 ± 3.4, 95% confidence interval (CI): 17.33- 18.69; boys: 17 ± 2, 95% CI: 16.46-17.25; p-value 0.004] and at ages 14-15 years (girls: 22 ± 4.1, 95% CI: 20.82-22.47; boys: 19 ± 2.4, 95% CI: 18.39-19.38; p-value < 0.001). Prehypertension (defined as < 90th centile for age, sex and height) was higher in girls (15%) than boys (10%). Further, impaired fasting glucose was detected in 5.3% of girls and 5% of boys. High-density lipoprotein cholesterol (>1.03 mmol/l) concentrations were observed in 12% of the girls and 0.7% of the boys, which is indicative of cardiometabolic risk.

Study component (2): The prevalence of overweight and obesity was higher in girls than boys in early and mid to post pubertal stages. The majority (83.5%) of the girls reported body image dissatisfaction (a desire to be thinner or fatter). The girls who wanted to be fatter had a significantly higher BMI than the girls who wanted to be thinner ($p=0.001$). There were no differences in EAT-26 score between pubertal groups, or between boys and girls within the two pubertal groups. The majority of the boys and the girls in both pubertal groups perceived the underweight silhouettes to be "unhappy" and "weak" and the majority of girls in both pubertal groups perceived the normal silhouettes to be the "best".

Study component (3): Added sugar and sweets contributed 10% and maize meal and

bread contributed 7.2% to the total number of food items consumed respectively. Girls had higher intakes of total fat, saturated fat and cholesterol after adjusting for dietary energy intake and age (all $p<0.001$). The prevalence of combined overweight and obesity was 13.8% in girls and 3.1% in boys ($p<0.001$). In addition, indicators of adiposity were higher in females, abnormal waist circumference (WC) (6.7%), waist to hip ratio (WHR) (22.0%) and waist to height ratio (WHtR) (18.0%), compared to males, (0%), (3.1%) and (6.2%) respectively (all $p<0.001$). Girls had higher low-density lipoprotein (LDL) (12(9.3%) vs. 3(2.3%), $p=0.01$), total cholesterol (17(12.7%) vs. 5(3.5%), $p<0.001$) and were more pre-hypertensive (28(15.3%) vs.15(8.4%), $p=0.04$) than the boys. Furthermore, the bivariate associations between dietary intakes (total energy, total carbohydrate (CHO), total dietary fat and saturated fat) and anthropometric indices (BMI and WC) showed that body mass index (BMI) was associated with total energy ($p=0.05$) and BMI and WC were associated with total fat ($p=0.01$, $p=0.03$) and saturated fat ($p<0.001$, $p=0.02$) in females respectively.

Conclusions: In conclusion, this thesis highlights that girls in rural South Africa had a higher prevalence of combined overweight and obesity than did boys, stunting was more prevalent amongst boys than girls in mid to late childhood and metabolic risk factors that were associated with adiposity, and linked to diet, were higher in girls than in boys. This study has provided useful information for targeting critical health promotion intervention programmes to optimise child nutrition as part of a noncommunicable disease preventative strategy, especially, in remote areas in rapidly transitioning South Africa.

ACKNOWLEDGEMENTS

"AGBAJỌWỌ LAFII NGBE ẸRU DORI"
A YORUBA PROVERB
"COLLECTIVE EFFORTS MAKE SUBSTANTIVE DIFFERENCE"

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- Lastly, but the most important: My hearty gratitude to all the participants - who made this possible -**NKHOMU!!!**.

Thesis materials

Original publications

1. Pedro TM, Kahn K, Pettifor JM, Tollman SM, Norris SA Norris. Under- and over-nutrition and evidence of metabolic disease risk in rural black South African children and adolescents. *S Afr J Clin Nutr* 2014;27(4):194-200.

   Student's role in managing the field work

   The student worked as a research manager in the field and I collected high quality primary data and the lessons I learned in the field significantly contributed to my doctoral work.

   Student's contributions to publication

   The student was responsible for the literature search, conceptualised the paper, conducted the data analysis, drafted and revised the manuscript.

2. Pedro TM, Micklesfield LK, Kahn K, Pettifor JM, Tollman SM, Norris SA Norris. Body image satisfaction, eating attitudes and perceptions of female silhouettes in rural South African adolescent boys and girls. *PLoS ONE*, 2016; 11(5):e0154784.

   Student's role in managing the field work

   The student worked as a research manager in the field and I collected high quality primary data and the lessons I learned in the field significantly contributed to my doctoral work.

   Student's contributions to publication

   The student conceptualised the paper, did the literature survey, analysed the data, wrote and revised the manuscript.

3. Pedro TM, Pisa PT, Kahn K, Pettifor JM, Tollman SM, Norris SA. Associations between dietary intakes and cardiovascular disease risk factors in rural black South African adolescents (*Submitted to Nutrition, Metabolism and Cardiovascular Diseases*).

   Student's role in managing the field work

   The student worked as a research manager in the field and I collected high quality primary data and the lessons I learned in the field significantly contributed to my doctoral work.

Student's contributions to the coding of data

The student solely coded the dietary data and has contributed to my doctoral work.

Student's contributions to publication

The student's contributions included conceptualisation, literature survey, management of the data, drafted and wrote the manuscript. Statistical support for Paper 3 was provided by Dr PT Pisa.

Conference proceeding

Oral presentation:

"The prevalence of Overnutrition and Metabolic Disease Risk Factors in Rural South African Children University of the Witwatersrand Faulty of Health Sciences // Biennial Research Day and Postgraduate Expo, September 2012, Johannesburg, South Africa".

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PREFACE

"EDUCATION IS THE MOST POWERFUL WEAPON WHICH YOU CAN USE TO CHANGE THE WORLD"

Nelson Mandela

A journey to an unknown wilderness “BREAKING NEWS- Some decades ago, there was famine in one African country; the majority of the victims were children with emaciated and sunken eyes. They never had the last energy to cry again and eventually succumbed to the ultimate-DEATH”. So sad indeed thought a young African lady from West Africa and studying Food Science and Technology in a foreign land. ’Wait a minute,’ she paused, there is more than enough land in Sub-Saharan Africa, and so, there should be enough food for the continent’.

This propelled her into changing her course to Human Nutrition. If there were to be adequate nutrition for every person living in Sub-Saharan Africa, we could begin to solve the mountain of other problems plaguing our land. The more she ventured into the field of nutrition, the more unknown wild trees she encountered, having their roots deeply embedded into other unknowns and shooting their branches with deadly thorns.

A slice of the scenario was witnessed as a lecturer and a consultant in a nutrition rehabilitation centre in West Africa, where “plump mothers presented their emaciated children as sick”. Nutritional advice was given and during a home visit, the grave of an emaciated child was presented. This nave, but maturing, African lady is still looking to change, and/or solve, African nutritional problems, by pursuing a PhD.

Admittedly, the problem is complex, multifactorial and involves several key holders, thus, we cannot solve these problems with just ordinary naked eyes. We need to untangle the interwoven tree branches and seek sophisticated microscopes, in order to see the unknown under the wild trees’ roots. However, I just hope this PhD will give some insight for other boys and girls to continue this journey. Reflection of a PhD Student.

Fig. 0.1: An African Tree

Structure of the thesis

This PhD thesis is presented with publications, and contains three manuscripts. Two journal papers have been published and one manuscript is under review in a peer-reviewed journal. Following the abstract, acknowledgement and preface, the thesis is structured as follows: **Part 1 (Chapter 1):** A brief introduction of the conceptual framework on which this thesis was based is given in Part 1 (Chapter 1) and followed by literature review.
Part 2 (Chapter 2): Comprises the method section and outlines the detailed information about the study site. A brief description of the data collection procedures, the questionnaires used, data quality and ethical approval and consent were discussed.
Part 3 (Chapters 3 to 5): Includes three papers that holistically answer the objectives for this thesis. Each specific chapter is described below in brief:

- **Chapter 3:** This paper describes under - and over-nutrition and evidence of metabolic disease risk in rural black South African children and adolescents.

- **Chapter 4:** This manuscript presents body image satisfaction, eating attitudes and perceptions of female silhouettes in rural South African adolescent boys and girls.

- **Chapter 5:** This paper describes the associations between dietary intakes and cardiovascular disease risk factors in rural Black South African adolescents.

Part 4 (Chapter 6): The summary of the main findings from the published and submitted papers and the key points are outlined and consolidated in this discussion chapter. The contextual relevance, limitations, future research areas and the overall conclusion are discussed in this section.
Part 5 (Appendices): The appendices contain (1) student's plagiarism declaration form, (2) declaration by student and co-authors agreement for published papers, (3) University of the Witwatersrand ethical clearance certificate, (4) Mpumalanga Provincial Government ethical clearance certificate and (5) questionnaires used in this thesis. The structural flow of this thesis is presented in Fig. 0.2.

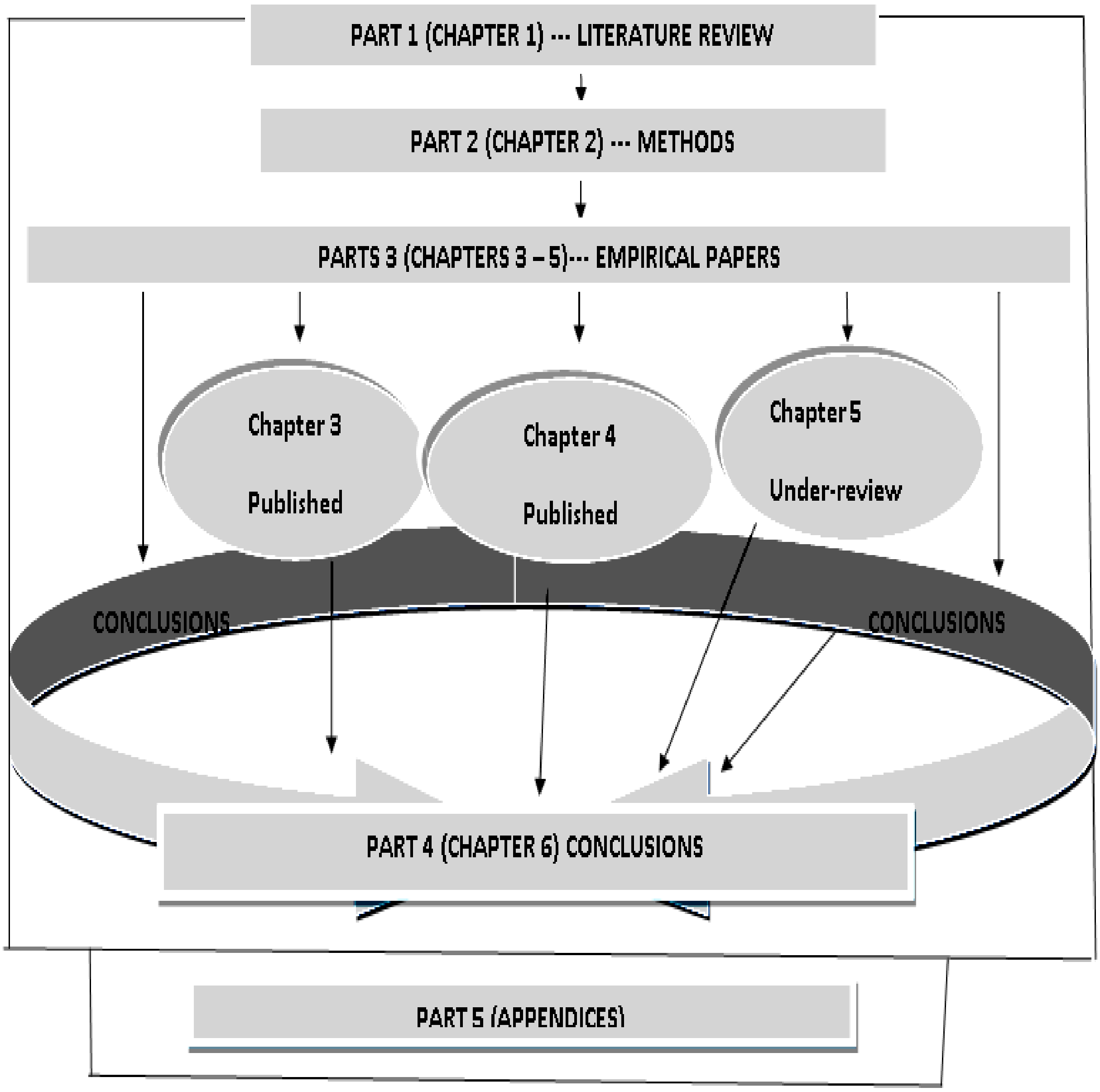

Fig. 0.2: Structure of the thesis

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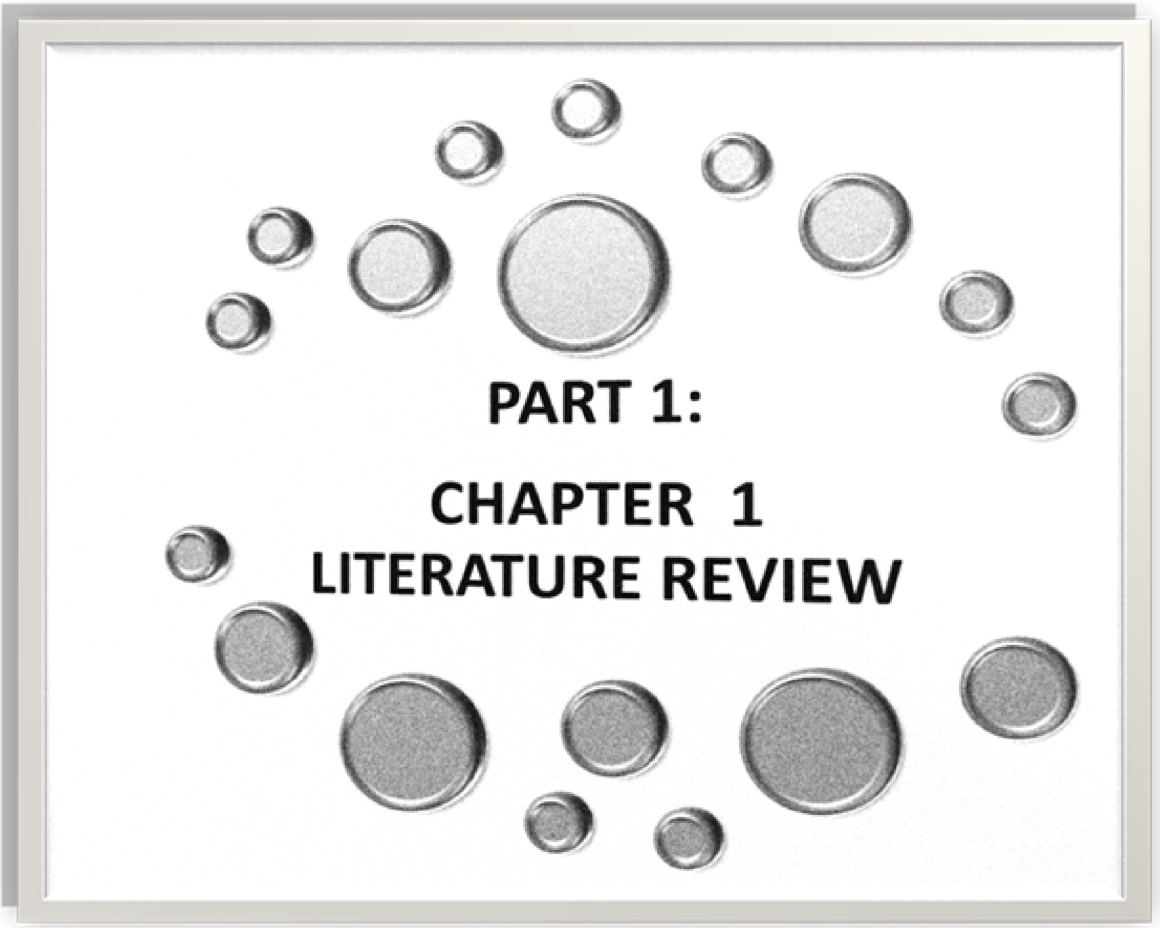
List of Abbreviations and Acronyms

AIDS	Acquired Immune Deficiency Syndrome
BMI	Body Mass Index
Bt20	Birth to Twenty Cohort Study
CDC	Centers for Disease Control
CDV	Cardiovascular disease
CDF	Community Development Forum
CHO	Carbohydrate
CI	Confidence Interval
Cm	Centimetre
CVD	Cardiovascular Diseases
DALYs	Disability-Adjusted Life Years
DBP	Diastolic Blood Pressure
DHS	Demographic and Health Survey
DoH	Department of Health
DoHAD	Developmental Origins of Health and Disease
EAT-26	Eating Attitudes Test-26
FAO	Food and Agriculture Organization
FG	Fasting Glucose
FID	Feel-Ideal Discrepancy
Kg	Kilogram
HAZ	Height-for-Age Z-Scores
HC	Hip Circumference
HDL-C	High Density Lipoprotein Cholesterol
HDSS	Health and socio-Demographic Surveillance System
HIV	Human Immunodeficiency Virus
IDF	International Diabetes Federation
IFG	Impaired Fasting Glucose
IQR	Inter-quartile range
IOTF	International Obesity Taskforce
IQR	Inter-Quartile Range
LDL-C	Low Density Lipoprotein Cholesterol
MDG(s)	Millennium Development Goals

LINC	Learning, Information Dissemination and Networking with Communities
LMICs	Low-and Middle-Income Countries
M	Metre
MetS	Metabolic Syndrome
MRC	Medical Research Council
NCEP ATP III	National Cholesterol Education Program-Third Adult Treatment Panel
NCDs	Non-Communicable Diseases
NCHS	National Center for Health Statistics
NFCS	National Food Consumption Survey
NHANES	National Health and Nutrition Examination Survey
PhD	Doctor of Philosophy
QFFQ	Quantitative Food Frequency Questionnaire
SAVACG	South African Vitamin A Consultative Group
SBP	Systolic Blood pressure
SD	Standard Deviation
SES	Socio-economic Status
TG	Triglyceride(s)
TC	Total Cholesterol
TV	Television
UK	United Kingdom
UNICEF	United Nations Children's Fund
USA	United States of America
WAZ	Weight-for-Age Z-Scores
WC	Waist Circumference
WHR	Waist to Hip Ratio
WHO	World Health Organization
WHtR	Waist-to-Height Ratio
WHZ	Weight-for-Height Z-Scores
YRBS	Youth Risk Behaviour Survey
ZAR	South African Rand

1. PART 1: CHAPTER 1 – LITERATURE REVIEW



1.1 Introduction

> ***"All countries are searching for answers about how to reverse the rising tide of adult and childhood obesity" –[3].***

The global prevalence of overweight and obesity has increased by 39% in adults (aged 18 years and above), with 47.1% of children also affected, between 1980 and 2014 [1, 2]. Simultaneously, the steep rise in the prevalence of childhood obesity from low-and middle-income countries (LMICs) is a serious public health concern because obesity is the major contributor of non-communicable diseases (NCDs) [2–8]. Of the estimated 38 million global deaths caused by NCDs per year, almost three quarters (28 million), occur in LMICs and it has been suggested that this will be associated with increasing prevalence in the young [9, 10].

Studies by WHO have shown that 90% of all deaths due to NCDs are occurring in LMICs [9]. It has also been noted that 170 million children (aged < 18 years) worldwide were classified as overweight and obese [5], but of greater importance and concern is the steep rise of childhood obesity in developing countries [6, 11–15].

In 2011, the political declaration of the United Nations held a meeting regarding the escalating prevalence of NCDs worldwide. The outcome was to prevent and control the escalating rise in NCDs, which has been associated with premature mortality. National governments were encouraged to collaborate with other sectors including civil society, academia and other private sectors [3]. In response to this, in May 2012, the World Health Assembly endorsed the new health global goal in order to reduce the prevalence of NCDs by 25% by 2025 (the 25 by 25 goal) [16].

School-aged children (5 - 10 years) have been defined as a disparate group because they remain under the care of their parents and teachers at home and/or at school [17]. Adolescence (aged between 10 - 19 years), however, is a period of transition from childhood to adulthood and is characterised by psychological, physical, environmental and social changes [18, 19]. A number of studies have shown that adolescence is characterised by increased vulnerability and exposure to inappropriate diets, which could be a major determinant of obesity and subsequent development of NCDs in adulthood [17, 19–21].

Unfortunately, there are limited data on the association of nutrition on body composition and metabolic disease risk in school-aged children and adolescence in low-resource settings in South Africa. Information in this area could help develop future targeted nutrition intervention studies that will monitor and prevent the prevalence of obesity and its related health complications from childhood through to adulthood.

1.2 The context of the problem under study

1.2.1 Conceptual framework

Figure 1.1 presents the first conceptual framework used in this thesis and illustrates the influencing factors on the development of obesity risk. Three key research areas influenced this framework:

- Examining the etiology of obesity- The IDEA study [22]
- Complications of obesity in children and adolescents [23]
- The nutrition transition in developing countries [24] .

The framework depicts that fundamental factors including political, economic structure and globalization, which has been linked to nutrition transition [6]. In this research work, children's nutritional status and metabolic disease risk in a transitional society are described. In addition, distal factors such as environmental which is directly linked to psychological factors (body image, eating attitudes and perception of female body silhouettes) in adolescents are assessed. This study also include the more proximal factors that affect children's nutritional status, in particular, dietary patterns (food intake: macro and micronutrient intakes) of adolescents. Therefore this framework recognises the importance of fundamental, distal and proximal determinants that lead to the development of obesity and NCDs.

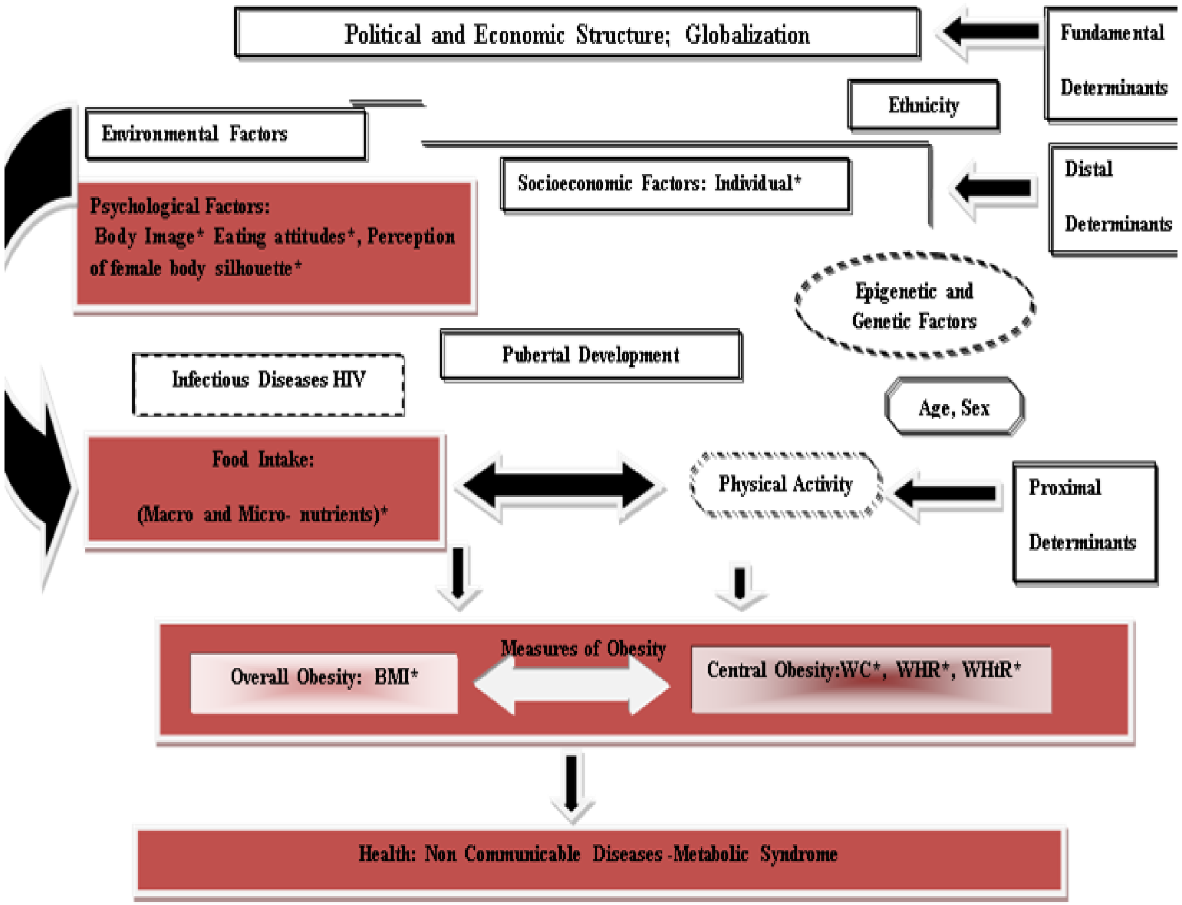


Fig. 1.1: Conceptual framework for this thesis
[22 - 24]

1.3 Nutrition transition

Some twenty-two years ago, Popkin [24–26], defined nutrition transition as changes in body composition patterns, diet and physical activity patterns and adoption of "Western" lifestyle, characterized by a diet high in saturated fat, sugar, and refined foods [20, 24–26]. Recently, other authors [27], defined nutrition transition as "the changes in dietary patterns and nutrient intakes when population adopt modern lifestyles during economic and social development, urbanization and acculturation; and it is associated with the documented increases in NCDs".

This has been associated with nutrition transition, which is characterised by:

- shifts from traditional plant-based diets to "Western" diets (high consumption of fatty foods and refined cooking oils, meat, sugar, and refined foods),
- reduced physical activity and with increasing sedentary behaviour,
- culture and socio-economic status [6, 15, 20, 28–31].

Multiple investigators have argued that low-and middle income (LMIC) countries experience periods of transitions differently and have documented three stages of transitions [25,26,32,33], which are: (1) demographic transition; (2) epidemiological transition; (3) nutrition transition. These transitions are characterised in Figure 1.2.

Popkin [24, 26], a known scholar in the area of nutrition transition, documented:

- The first stage of nutrition transition is when people move from receding famine and is characterised with consumption of energy dense carbohydrate foods, low in variety and labour intense work.
- The second stage of nutrition transition is described as degenerative stage. People consume more fat, sugar, and processed foods and there is a shift from labour intense work to technologically advanced work and increased leisure.
- The third stage of nutrition transition is the behavioural change. International researchers and DoHAD (Developmental Origins of Health and Disease) now highlighted that this behavioural stage is a critical and preventive stage as many LMICs are battling with double burden of disease [6, 7, 15, 25, 27, 34] (See Figure 1.3).

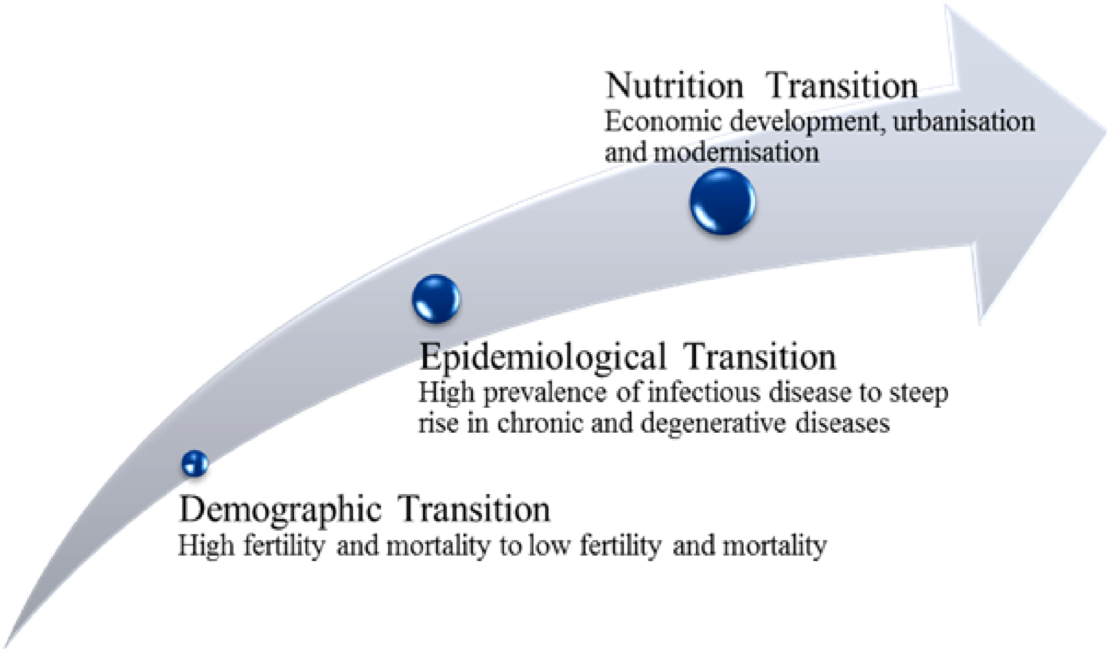


Fig. 1.2: Different transition periods leading to nutritional transition [25, 26, 32, 33]

- According to (DoHAD) concept, exploration of early human development in relation to chronic disease in later life and the development and application of public health strategies may help prevent chronic diseases [34].

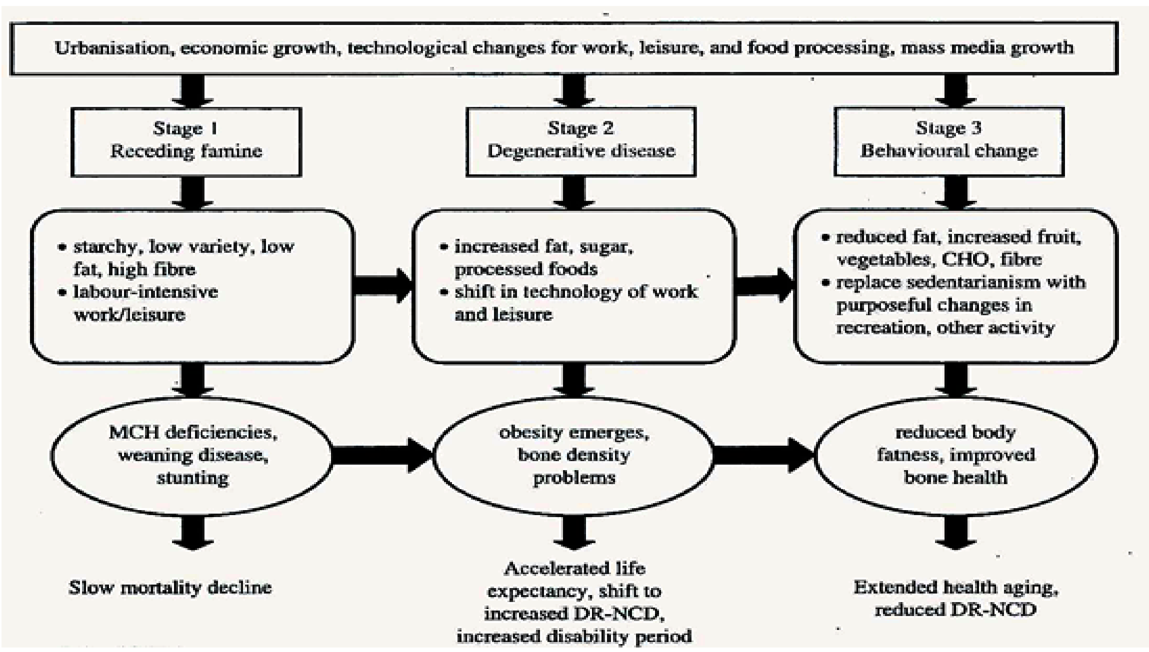


Fig. 1.3: Stages of nutrition transition adapted from Popkin [24]

1.3.1 The effects of nutrition transition

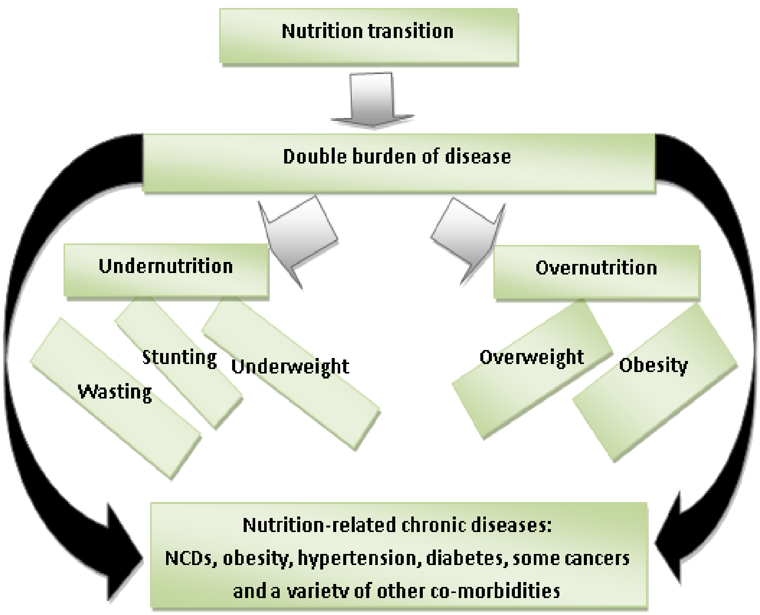


Fig. 1.4: The effects of nutrition transition and the nutrition-related chronic diseases

Figure 1.4 shows that nutrition transition leading to double burden of disease and later to nutrition-related chronic diseases. This was adapted and modified from Popkin and to other related works [20, 24]

1.3.2 Nutrition transition in LMICs and Africa

A wealth of information provides evidence of the rapid progression of nutrition transition in LMICs which are more advanced in socio-economic development such as Brazil, China, India, Mexico and Egypt, and South Africa is no exception [26, 35, 36]. This has been attributed to the global and improved food systems, socio-economic development, and globalisation of "Western" fast food, urbanisation and modernisation [6,8,20,24,27,37,38].

Today the consequences of nutrition transition in many LMIC so called the double burden of disease, which is characterized by co-existence of under and over-nutrition affecting all segments of populations from LMIC countries [8, 37, 39, 40]. Abrahams et al. showed in detail the stages of nutrition transition in many African countries with the prevalence of stunting in children and overweight and obesity in adult women [37]. Figure 1.5 depicts South Africa as having the highest (>50%) prevalence of obese and overweight women, with the prevalence of stunting above 20%.

In line with Abrahams et al. [37] report, the 2016 SADHS (South African Demographic Health Survey) found that growth stunting is a major concern at 27% and 68% of women in South African are overweight and obese, indicating South Africa is well advanced along the nutrition transition [8, 41].

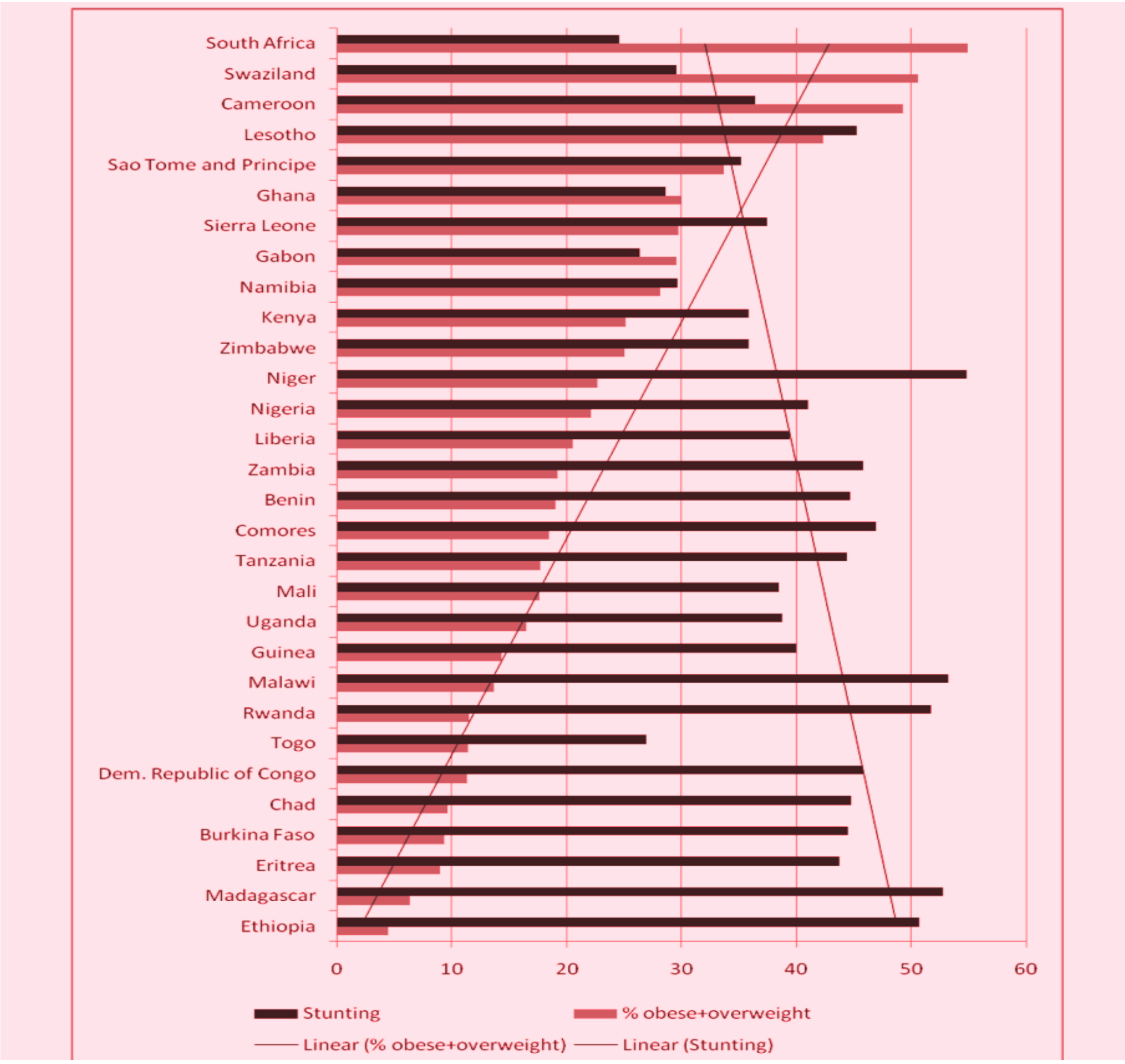


Fig. 1.5: Stages of nutrition transition in some African countries [37]

1.4 Definition of undernutrition

Undernutrition is defined as inadequate food intake (hunger) and exposure to repeated infectious diseases. Undernutrition includes underweight (low weight-for-age), stunting (low height-for-age) and wasting (low weight-for-height) and these have been described in sections 1.4.1 to 1.4.3 [18, 42, 43].

1.5 Trend of undernutrition in LMICs

As stated by Friedman "Food consumes our interest. To the hungry, it is the focal point of every thought and action [4], as evident in figure 1.6 [44]"

.

Fig. 1.6: Anonymous - Food aid for Africa
[44]

According to a 2014 UNICEF report, the number of deaths caused by undernutrition decreased globally from 12.7 million in 1990 to 6.3 million in 2013 [18]. Many regions and sub-regions have made huge progress in meeting the MDG1 target for reducing the number of chronically undernourished people by 2015. However, Africa is the only area not on track and the prevalence of childhood undernutrition continues to be slow (30% in 2010) [39] (See Fig. 1.7). In 2012, 25% of preschool children living in sub-Saharan Africa were underweight and in 2013, global estimates reported that 161 million children under five-year olds were stunted, 51 million were wasted and 17 million were severely wasted and of these, nearly one third came from Africa [39].

Evidence has shown that stunting in children is a result of poor diet and/or recurrent infections and is associated with greater risk of illness and death. In addition, multiple studies have shown that stunting:

1. is associated with an increased risk of adult overweight, given that birth weight has been used as proxy for intrauterine growth and positive associations with adult body mass index (BMI) [45, 46];

2. is a direct cause of short adult height and suboptimal function in adulthood [45];

3. often results in delayed mental development;

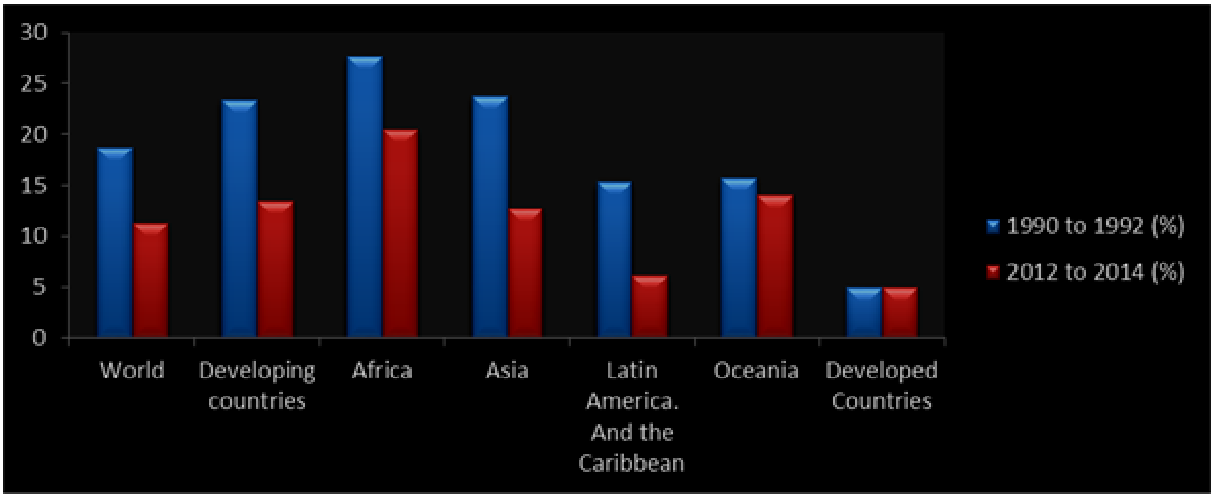


Fig. 1.7: The global and regional prevalence of undernutrition for the year periods: 1990 – 1992 and 2012 – 2014

[39]

4. usually results in poor school performance and reduced intellectual capacity;
5. causes retarded growth, which may lead to other adverse health outcomes, such increased morbidity, learning capacity and productivity; and
6. is an important factor for loss in Disability-Adjusted Life Years (DALYs) [20,39,45,47,48].

Given that stunting remains unchanged as the major clinical form of under-nutrition present in many children living in sub-Saharan Africa [13,39,45,49–51] (See Figure 1.8), many reports by international agencies - UNICEF, WHO and others - have called for urgent prevention strategies to reduce stunting which might lead to adulthood chronic diseases [16,39,48,52]. According to UNICEF - "The devastation caused by malnutrition afflicts millions of people, who are chronically susceptible to disease and endure all sorts of disabilities ... It places women and families in danger, thus threatening the viability of entire societies" [53].

1.5.1 Trend of undernutrition in South Africa

South Africa, multiracial, multi-ethnic and the wealthiest country in Southern Africa, is still battling with child malnutrition [54,55]. Seventeen years ago, the first South African National Food Consumption Survey (NFCS) indicated that approximately 25% of children aged 1 to 9 years (n = 2894) were stunted and Mpumalanga province had the highest

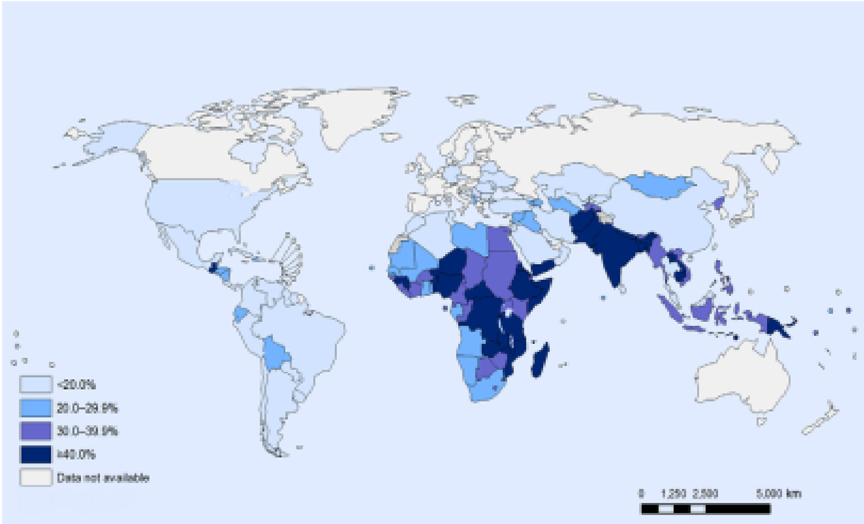


Fig. 1.8: The global prevalence of undernutrition
[39] [39]

percentage at 17%; in addition, 10% were underweight and 5% were wasted [56]. Interestingly, 2016 (SADHS) found that 27% of children (n = 2,024) under 5 are stunted (below -2 SD) and 10%are severely stunted (below -3 SD) [41]. According to the 1st Youth Risk Behaviour Survey (1st YRBS), 11% of youths (n = 9,224) examined were stunted, 9% were underweight and 4% were wasted [57]. Despite rapid economic growth in South Africa in the past two decades [27]. Fig. 1.9 [8] shows the trend of undernutrition found in 2013 (South African National Health and Nutrition Survey) SANHANES-1. In addition, findings from several local studies have found the persistence of undernutrition among South African children and adolescents [8, 13, 49, 50, 58].

For example, a study of black teenagers (n = 5322, aged 13.0 - 17.9 years), [49], found the prevalence of undernutrition was higher in males (18.4%) than females (2.6%) and in particular, 21.9% of the boys versus 9.4% of the girls were stunted respectively. Furthermore, it was noted that stunted girls were at higher risk of overweight than boys across all levels. Another cross-sectional study of children and adolescents aged 1 to 20 years from 21 rural villages in Mpumalanga, reported stunting was more prevalent in boys, 32% of 1-year olds, 3 to 5% of 5 year olds and 14 to 15 year olds boys were stunted [13]. Thus, confirming the findings of 2013 SANHANES-1 and 2016 SADHS that stunting is still prevalent in children and adolescents and rural informal areas are the most affected [8, 41].

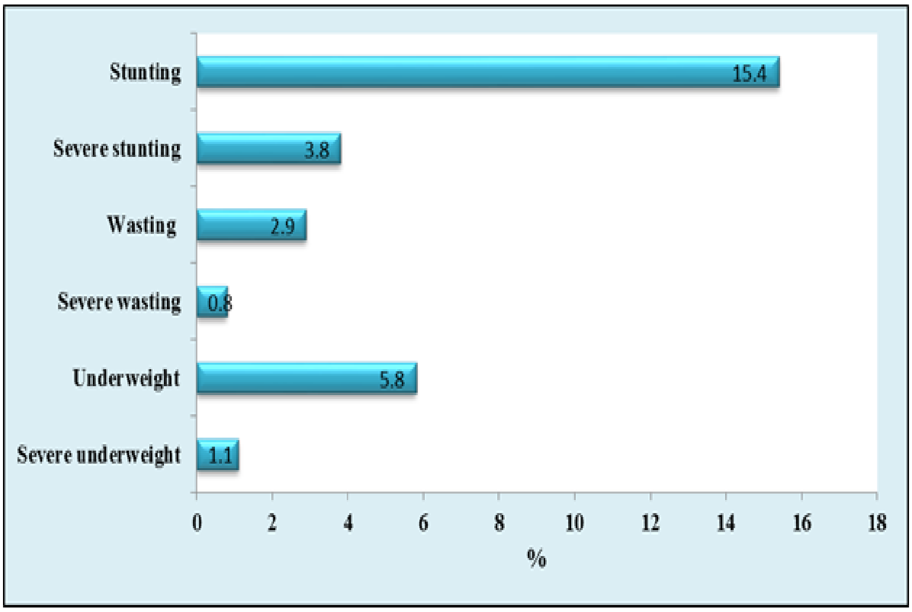


Fig. 1.9: The prevalence of undernutrition in South African children (0 - 14 years) [8]

1.6 Definition of overweight and obesity

WHO criteria define overweight an individual's body mass index (BMI) between 25.0 and 29.9 kg/m^2 and obesity an individual's BMI is above 30 kg/m^2 [43]. To compare, the prevalence of overweight and obesity between countries, the International Obesity Task Force (IOTF) developed age and gender-specific reference values for BMI in children and adolescents which is now widely used and this corresponds to the cut-off points used for adults [59].

1.6.1 Trend of overnutrition in adults population in LMICs

It is estimated that by 2030, 2.16 billion and 1.12 billion individuals will be overweight and obese respectively [12]. In 2014, 39% and 13% of adults, aged 18 and over were overweight and obese respectively, and of these, 300 million women compared to 200 million men are obese worldwide according to WHO reports [1,60]. Current data show that many LMICs are not immune from the increasing prevalence of overweight and obesity and more than 115 million were affected in 2008 [6,8,24,25,28,37]. Figure 1.10 displays the global aged standardized prevalence of obesity in women aged 18 years and over (BMI $<$ 30 kg/m^2) and current 2016 SADHS showed that 1 in 5 women in South Africa has BMI $>$35.0 kg/m^2 which is higher to developed and other developing nations in 2014 [1,41].

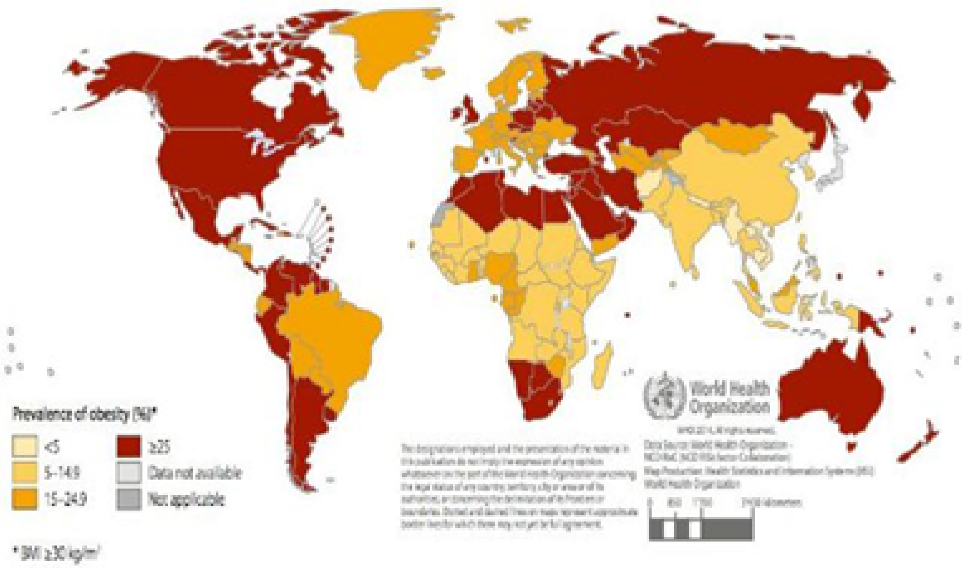


Fig. 1.10: Aged-standardized prevalence of obesity in women aged 18 years and over (BMI > 30 kg/m^2)

[1]

1.6.2 *Trend of overnutrition in younger population*

As stated by Walker: "... feeding children for maximum growth and physical development may not add to, and may indeed be harmful to their long-term health and longevity" [61]. According to de Onis [62], global childhood overweight and obesity increased from 4.2% in 1990 to 6.7% in 2010. In Africa, obesity among children was reported to be 8.5% and the prognosis is that this will likely reach 12.7% in 2020 [62]. In recent years, the steep rise in the prevalence of overweight and obesity in African children and adolescents has been documented [8, 14, 29, 57, 63, 64].

For example, a cross-sectional school study of 23496 adolescents (aged 11 to 17 years) in the Global School-based Student Health Survey (GSHS), which was conducted in seven African countries (Benin, Djibouti, Egypt, Ghana, Mauritania, Malawi, and Morocco), reported that: (1) 8.7% (Ghana) to 31.4% (Egypt) of the participants were overweight; (2) 0.6% (Benin) to 9.3% (Egypt) were obese and the prevalence of obesity was higher in female subjects in five countries [29]. Likewise, a study by Musa et al. [30], of 3240 children and adolescents (aged 9 to 16 years) attending primary and secondary schools from Benue State, Nigeria, found that rates of combined overweight and obesity were higher in the children (21.5%) than in adolescents (11.5%) and in comparison, boys from rural areas were more prone to being overweight than their urban counterparts.

Figure 1.11 shows the trends of obesity between 1990 and 2010 and it has been suggested that there will an increase in the prevalence of body mass index above 2 SD, which is equivalent to the 98th centile in preschool children in developed and developing countries [65].

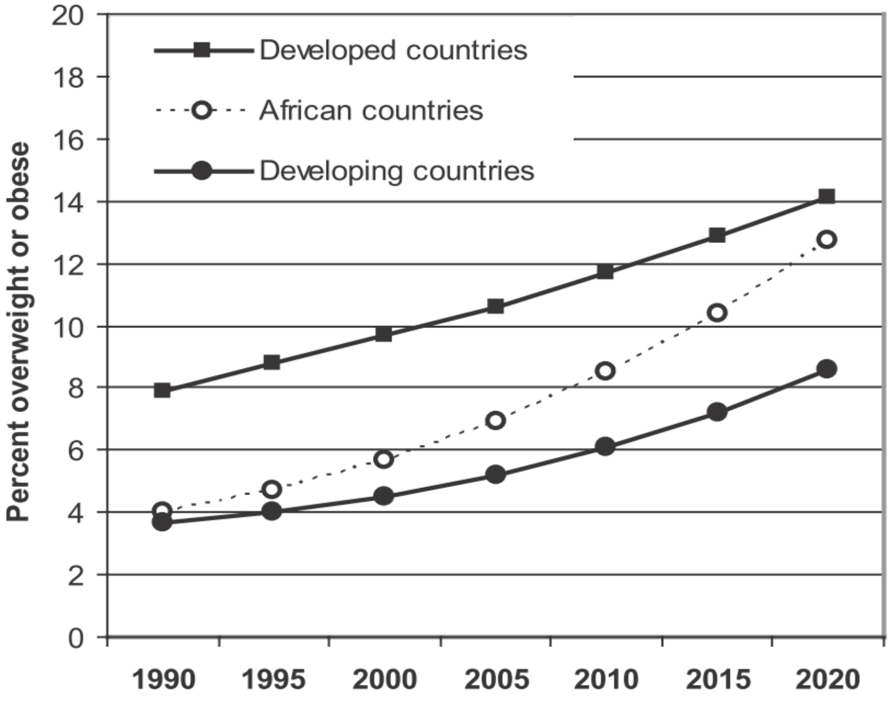


Fig. 1.11: The projection of obesity in developed, developing and African countries [65]

1.6.3 *Trend of overnutrition in adults in South Africa*

In line with global increases in overweight and obesity, South African researchers have documented this trend in the adult population as well [8, 15, 41]. In 1998, the first South African Demographic and Health Survey (SADHS) report of adults age 15 and above showed that women had significantly higher mean BMI (28.9 kg/m^2) compared to males (23.6 kg/m^2) [66]. Fifty-five percent of females and 29% of males were overweight and the prevalence of obesity was also higher in females compared to males 29% and 9% respectively. The 2013 SANHANES-1 showed that the prevalence of overweight and obesity was significantly higher in females compared to males (25% and 40% in comparison with 19.6% and 11% for females and males respectively [8]. In the 2016 SADHS, the prevalence of overweight and obesity was higher in females than males 68% and 31% respectively. In addition, the prevalence of obesity was highest amongst the Coloured women (26%) followed by Blacks (20%) [41]. South African representative surveys have highlighted that the increasing mean BMI values with age among women in South Africa is of concern [8] with national data showing:

1. Women had higher BMI than men;

2. BMI increased with age in both sexes;

3. The most recent 2016 SADHS report revealed that 1 in 5 women age 15 and above had BMI > 35 [41]. Therefore, researchers are now advocating for alternative and effective intervention studies to curb the upsurge of overweigh and obesity [34]

Figure 1.12 displays the BMI values by age and sex among South African males and females [67].

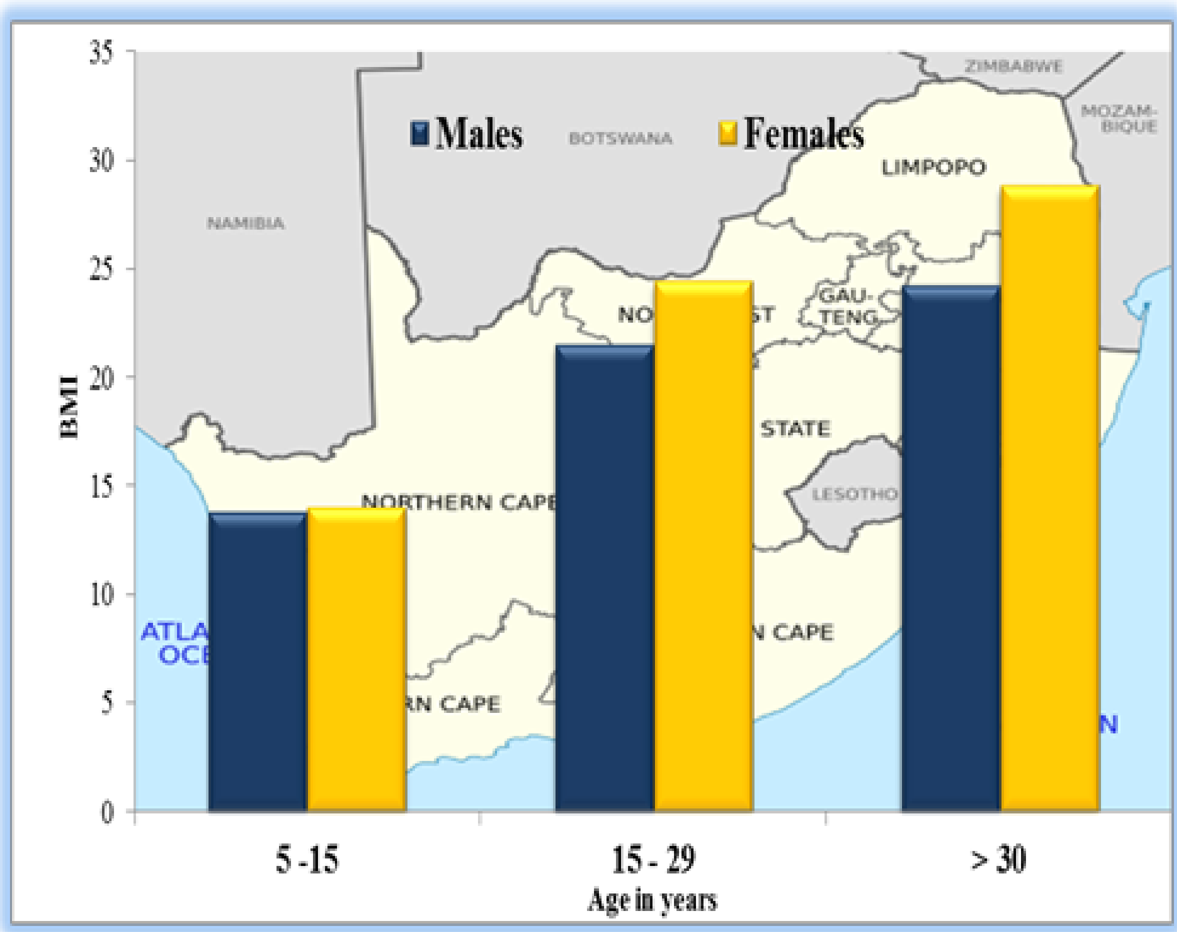


Fig. 1.12: The increasing BMI values by age and sex among South African males and females [71] [67]

1.6.4 Trend of overnutrition in children and adolescents in South Africa

The 2005 executive summary of the National Food Consumption Fortification Baseline (NFCS-FB-1), South Africa, showed that 10% and 4% of children (n = 2894) aged 1 to 9 years were overweight and obese respectively [68] and furthermore, the prevalence of overweight and obesity in rural children aged between 1 and 9 years was 11.6% and 3.7% respectively [56] (See Fig. 1.13). With regard to children and adolescents, the most recent 2013 SANHANES-1 study reported that the prevalence of overweight and obesity among 6 to 9 year-olds (n = 1220) was 8.4% and 3.4% respectively and further 12.1% and 4.2% of 10-14 years-old were overweight and obese [8].

In addition, the 2016 SADHS revealed that 24.4% and 15.5% of children aged 15 - 24 years (n = 1040) are overweight and obese respectively [41]. Ten percent of women aged between 15 and 24 years (n = 1772) were obese and the prevalence of overweight and obesity was found to be higher in black adult women (58.5%) from low socio-economical background compared to other population groups, mixed-race ancestry (52%), white (49.2%) and Indian women (48.9%), respectively [15].

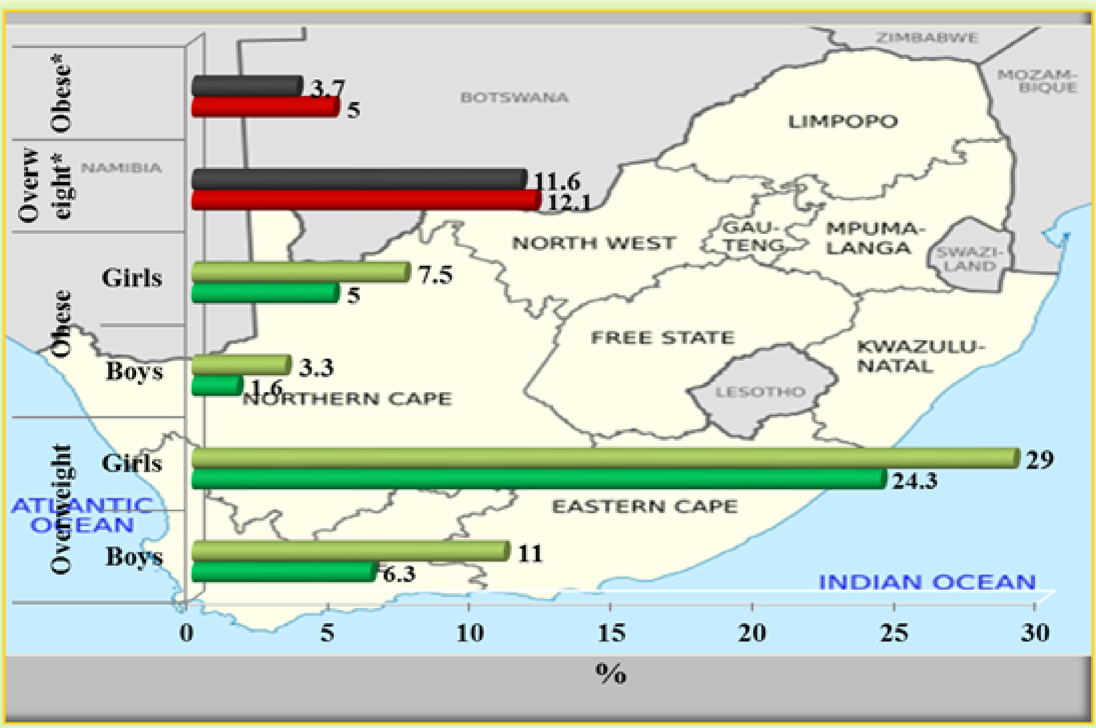


Fig. 1.13: Prevalence of overweight and obesity in South African children and youths [72-74]

Figure 1.13 further displays the two reports of YRBS (in grades 8 to 11 (n=9491 in 2002 and 9442 in 2008). The prevalence of overweight among adolescent boys and girls increased from 6.3% in 2002 to 11.0% in 2008 and from 24.3% to 29.0%, respectively. The prevalence of obesity more than doubled in adolescent boys from 1.6% in 2002 to 3.3% in 2008 (See Fig. 1.13) [57, 70]. In addition, a study by Armstrong et al. [69] of more than 10,000 primary school children, which was conducted between 2001 and 2004, found that 10.8% and 13.0%; 3.2% and 4.9% of the males and the females were overweight and obese respectively. From 1994 to 2004, the same study showed an increase in the prevalence of overweight from 1.2% to 13%, while obesity increased from 0.2% to 3.3% in the South African Primary Schools' Anthropometric Survey and The Health of the Nation Study [58].

In comparison to urban areas [57, 70], researchers have noted there are limited studies in rural South African children and adolescents [13, 64, 71]. The most recent studies in rural settings confirmed that the prevalence of overweight was higher in females than males. For example, Kimani-Murage et al. [13] study of 3489 children and adolescents (n = 3489, aged 1 - 20 years) in Agincourt sub-district, Mpumalanga Province, showed that overweight and obesity was higher in females than males and the prevalence increased in late adolescents between 20 to 25% in girls [13, 72]. Similarly, a 2012 study by Toriola [64], of school children (541 boys and 631 girls) aged 10-16 years, documented that the prevalence of overweight was higher in girls (11%) than boys (9.1%), however obesity was more prevalent in boys (5.5%) than girls (4.4%), indicating there are age, sex, ethnic and geographical areas differences in the prevalence of overweight and obesity in South Africa [8, 71].

1.7 Determinants of obesity

The increasing prevalence of overweight and obesity in children and adolescents from sub-Saharan Africa and in South Africa have been highlighted by various researchers because of the potential long-term health concerns [8, 29, 30]. Overweight and obesity have been associated with lifestyle changes especially dietary change and predispose adolescents to extreme shape and weight, which in turn may influence unhealthy eating behaviors and psychological problems such as body image concerns, disordered eating attitudes and body dissatisfaction [73].

This section of the literature review has been based on scholarly articles [22, 74, 75] (See Figure 1.14) and the focus will be on the asterisks from the four groups listed below as these link directly to this thesis:

- Immutable factors, (*demographic and family history).
- Contextual factors (individual/*psychosocial, socio-environment - family, peers, schools, community, physical environment - home, school, neighbourhood).
- Behavioural factors - (*diet-related - eating patterns, nutrient intake, other factors - sleep, substance abuse, weight loss, activity related - *activity/sedentary patterns, activity/sedentary amount).
- Biological factors - (*metabolism, pubertal status and blood chemistry).

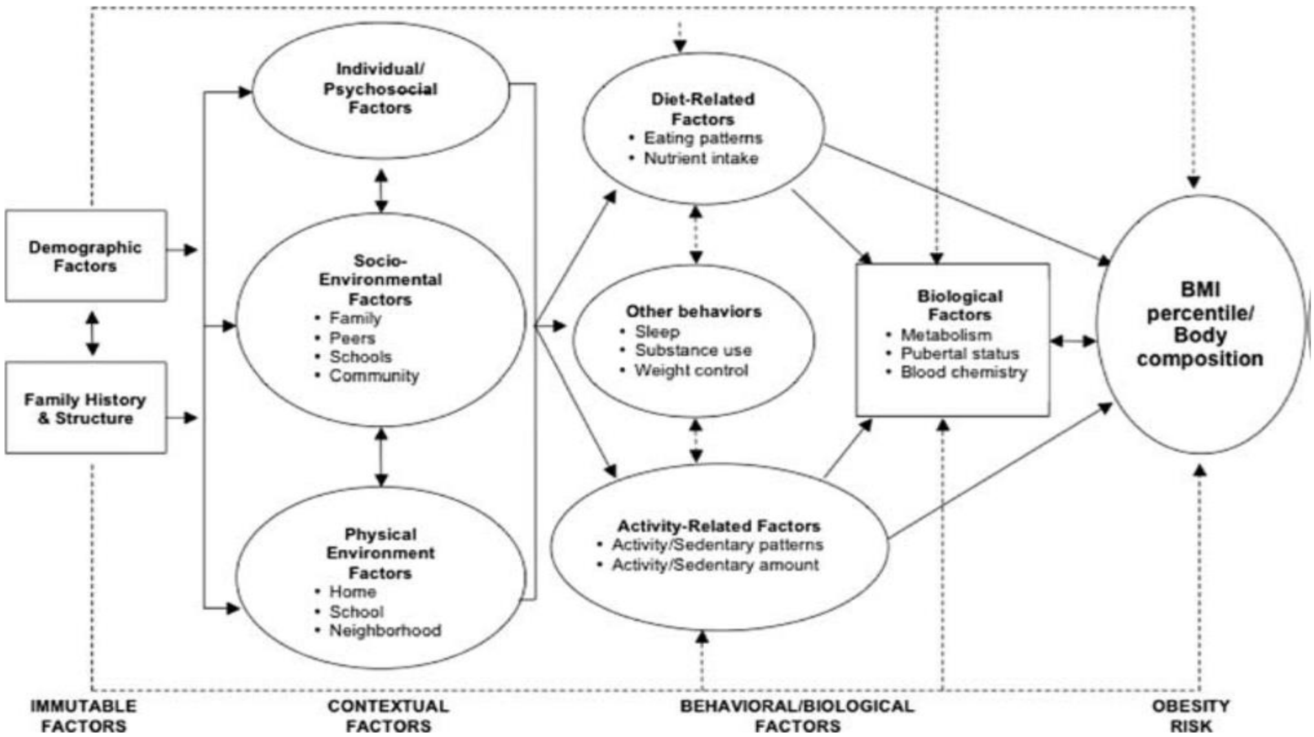


Fig. 1.14: Adapted from Examining the Aetiology of Childhood Obesity:The IDEA Study [22] [22]

1.7.1 Immutable factors - demography- urbanisation and globalization

As stated by Popkin: "Over the past several decades, a dramatic shift has occurred, in stages, regarding the way the entire global population eats, drinks, and moves, and these changes have clashed with human biology to create major changes in body composition" [6]. Evidence suggests that the pace of urbanisation and globalisation (the flow of information, goods, capital, and people across political and economic boundaries) has led to significant dietary and lifestyle changes in many developing countries [76] and

South Africa is not different from this trend [27,77]. Vorster et al.'s study in North West Province, South Africa, indicated there was improvement in micronutrient intakes and status among the participants through urbanisation [77]. However, this study and others argued that Black South Africans are increasingly exposed to foods (high total fat, sugar, and sweetened beverages) that are associated with overweight and obesity and subsequent risk factors for NCDs [6,24,27,77–79].

1.7.2 Contextual factors - Psychosocial factors

Body image has been defined as: "the picture of our body which we form in our mind, which includes our perceptions of our bodily boundaries, a sense of attractiveness and perception of bodily sensations" [80]. From the psychological point of view, obesity is associated with social, emotional, and psychological difficulties [81]. In recent years, there has been an alarming increase in the prevalence of overweight and obesity affecting children, adolescents and adults and has resulted in the gradual research in body image concerns in children and adolescents in Africa, especially in South Africa [82–85]. Analysis of literature tends to confirm that boys and girls now present with body dissatisfaction, and both have a low and high body mass index (BMI) influence weight control [86–88].

According to SANHANES report, which was undertaken in 2012 amongst 10 to 14 year olds, 76.5% perceived themselves to be fat, 21.9% agreed to having normal body image and only 1.6% perceived themselves to be very thin, with more females (13.8%) than males (8.8%) being unhappy with their current weight [8]. While there is some data concerning South African adolescents' eating attitudes and body image perceptions in relation to ethnic differences [82,83,89], limited information is available regarding rural adolescents [90]. Nevertheless, several cross-sectional studies have shown inconsistent results regarding body image concerns among adolescents and adults [85,89,91], suggesting that body image perceptions differ by culture, age, sex and ethnicity [86].

Studies in adult populations showed that an overweight body symbolises happiness, beauty, wealth and absence of illness (HIV/AIDs) [92]. In addition, a study by Mchiza et al. Intra-familial and ethnic effects on attitudinal and perceptual body image: a cohort of South African mother-daughter dyads, showed that black mothers and their daughters chose heavier silhouettes compared to their white and mixed ancestry [85], confirming cultural acceptance of bigger body size in African countries and elsewhere [82, 85, 86, 93, 94].

Furthermore, evidence shows that obesity is a potential risk factor for the development of eating disorders and vice versa [81]. Unfortunately, in South Africa, research on eating attitudes in rural poor settings is still sparse [95,96]. However, a summary of the literature indicated the presence of eating disorders amongst South African adolescents varies from 1% to 13.1% in females [73, 91, 95] and 5.2% to 40.2% in males [84], therefore, research intervention in these areas will add valuable insights to prevent the steep rise in obesity and assist the physical health of South Africans [8].

1.7.3 Behavioural factors: Dietary patterns

Nutritional requirement for healthy development of children and adolescents

"Good nutrition is the foundation for survival, health and development for current and succeeding generations" [18, 97].

This is true during adolescence, which is a period of rapid accretion of new tissue and other developmental changes and necessitates increased nutritional requirement compared to childhood years [43, 98]. For example, during adolescence:

- there is more than 20% of total growth in stature;
- 50% of adult bone mass are achieved;
- 50% increase in calcium intake are necessary for bone formation [43];
- iron requirements should be increased because of the expansion of red cell mass and myoglobin in newly gained muscle tissue, more so for adolescent girls who require additional up to 15% – iron supply in order to compensate for menstrual blood losses [43].

Given that the principles governing adequate nutrition are complex and are interlinked with many disciplines [18, 97], many scholars in South Africa were motivated to adopt the Food and Agriculture Organization of the United Nations/World Health Organization strategy to develop specific dietary guidelines to suit their populations owing to:

- global change in food processing, food production and in agricultural policies [25];
- disparities in food intake of populations [54];

- food availabilities [99];
- current massive global burden of diet-related diseases [6, 27, 38, 100];
- growing perception that nutrient-based dietary guidelines are not effective in promoting appropriate diets and healthy lifestyles [54];
- most importantly to reduce the emerging prevalence of NCDs in all groups of the populations associated with the increase in obesity [3, 6, 27, 38, 100].

Table 2.2 shows the revised and updated South African Food Based Dietary Guidelines (SAFDGs) [54] with eleven, clear and simple messages for South African adults and children aged 5 years and older.

Tab. 1.1: South African Food-Based Dietary Guidelines.

No.	**Guidelines**
1	Enjoy a variety of foods
2	Be active
3	Make starchy foods part of most meals
4	Eat plenty of vegetables and fruits everyday
5	Eat dry beans, split peas, lentils and soya regularly
6	Have milk, maas or yoghurt every day
7	Fish, chicken, lean meat or eggs can be eaten daily
8	Drink lots of clean, safe water
9	Use fats sparingly, choose vegetable oils, rather than hard fats
10	Use sugar and foods and drinks high in sugar sparingly
11	Use salt sparingly [54]

1.7.4 Dietary change

The nutritional status of South Africans varies according to race, ethnic-group, and geographical areas of the country. Despite the introduction of democracy in 1994, South Africa still has an unequal society and the black population, especially children living in rural areas, are the most affected [48, 56, 68]. According to a cross-sectional study of South African adults (n = 3287), the most commonly consumed food groups were cereals and roots, meat and fish, dairy and vegetables (other than vitamin A rich). The least consumed food items were eggs, legumes and vitamin A rich fruit and vegetables. Black South Africans had the lowest dietary diversity score < 4 (3.63) and consumed more sugar compared to other ethnic groups [8, 101].

Despite a growing body of evidence, studying children's dietary patterns are crucial in the development of overweight and obesity [11, 13] because "people choose foods and combinations of foods rather than isolated nutrients" [102]. However, limited literature exists regarding dietary patterns in rural South African children and adolescents, as past studies were mostly conducted on urban black participants living in disadvantaged areas and informal settlements [103].

From the few available studies that have examined the variety of foods, macro and micronutrient intakes of children and adolescents, added sugar, sweets, carbonated cold drinks, non-dairy creamer, tea, coffee, cheese curls and low intake of fruits and vegetables were among the commonly consumed food items [104,105]. In addition, high consumption of sugar and salt was found in urban adolescents [106] and the consumption of sugar-rich foods increases as children enter adolescence [105, 107]. There is supporting evidence that added sugar and consumption of sugar products are partly responsible for the rapid increase in global diabetes [8, 108] and low intake of fruits and vegetables has been associated with hypertension [9].

Dietary diversification has been suggested in the SAFDGs in order to meet optimal energy and nutrient goals that will address undernutrition and protect against over-nutrition related diseases of lifestyles in the South African population [54, 109, 110]. However, concerted efforts are needed to educate health professionals on how to disseminate information contained in SAFDGs to the public [111]. Additionally, international scholars are now advocating for dietary behaviour and lifestyle intervention trials with regard to testing the public health relevance of the use of dietary guidelines, which include analysis of overall diets (foods, food groups, and nutrients, their combinations and variety, frequency as well as quantity). This might help to change trajectories of future disease risk and reduction in NCDs later in adulthood [112–115].

1.7.5 Physical activity and sedentary behaviour

Physical activity is defined as: "bodily movement produced by the contraction of muscle and substantially increases energy expenditure above the basal level" [116]. Sedentary behaviour has been characterised as waking up time, when an individual requires little energy expenditure and thus spends time sitting and/or in reclined position [117]. Current evidence suggests that reduced physical activity and sedentary behaviours are associated with negative health outcomes such as obesity, poor cardio-metabolic health and poor psychosocial health [118, 119].

The WHO recommends 150 minutes of moderate to rigorous exercise per week [120]. Over the past few decades, studies have shown the multiple benefits of physical activity, such as lowering of serum triglycerides concentrations, improving lung and heart condition, muscular fitness, bone health, cardiovascular, metabolic health biomarkers, mental health, improved academic performance and to maintain healthy body weight, especially for children and adolescents [9, 121, 122]. However, global report documents that 78% of boys and 84% of girls aged between 11 and 17 did not meet these recommendations [9,123]. Alongside international studies [9, 121, 122], national data from the (1^{st} YRBS) of 2003 showed that:

- 37.5% of students (n = 10,699) in South Africa were engaged in insufficient physical activity;
- more coloured (45.6%) and blacks students (37.5%) compared to white (29.4%) were not physically active; and
- 25.9% of the students were not willing to participate in physical activities [124] and participation in physical activity among learners decreases with increasing school years [124, 125].

The increasing sedentary behaviours in South African children have been documented [31, 125], hence, the second guideline “Be active” has been included in SAFDGs for future research intervention and to protect against the increasing prevalence of overweight and obesity and other related diseases [9, 121, 122, 124].

1.7.6 Biological factors - Metabolism (under and subsequent overnutrition)

Human growth (size and body composition) is determined mainly by interaction between genetics and the environment. Twenty five percent of the body fat and total fat mass is attributed to genetics while 75% is determined by culture and lifestyle [42]. A body of evidence reaffirms that the period of intrauterine development is one of the most vulnerable in the human life cycle. It is a good indicator not only for the mother’s health and nutritional status but also of the chances of the new born for survival, growth, short/long term health and psychosocial development [52, 126, 127]; an adverse intra-uterine environment predisposes children to the development of obesity [116]. Studies have shown that up to 80% of overweight children become obese adults, and this will be a life-long burden to deal with because the economic and complications attached to obesity are huge [128,129]. Regarding the metabolic consequences of undernutrition and subsequent overweight and obesity, studies have reported the following:

- greater weight gain at any age was associated to elevated adult hypertension [126];
- lower birth weight was associated with greater insulin production and higher glucose concentrations at age seven [130];
- BMI at the age of seven was positively associated with insulin concentrations and insulin resistance [130];
- early life factors influenced body composition, weight at birth was a major component in shaping lean tissue of these children and high socio-economic was associated with fat tissue at the ages of 9 or 10 years [131];
- lower birth weight was associated with rapid weight gain within the first year and this was associated with 2.39 fold risk of becoming overweight at the age of three years [132];
- high subcutaneous fat and greater waist circumference in stunted girls may be involved in the development of obesity among black women in South Africa [133]; and
- obesity prevalence increases rapidly in girls after menarche [69].

Therefore, continuous research controlling for other confounding variables is essential with respect to metabolic consequences of undernutrition and subsequent overweight in children and adolescents [134].

1.7.7 Other factors

1. <u>School Environment:</u>

   School can be defined as: "a learning center where children spend between 6 to 8 hours per day" [135]. To date, global and regional research indicates that unhealthy, low nutrient density, high saturated fat snacks and meals, and sugar-sweetened drinks are sold at these premises [5,6,11,136,137]. Besides school tuck shops offering healthy (unsalted peanuts and fruits) and unhealthy foods in South Africa. Many school children are surrounded with street vendors selling cheap and unhealthy foods, such as chips/Niknaks, sweets/chocolates and biscuits, having high sugar or salt content [137]. Thus, scientists are now advocating that schools can play an important role in the prevention intervention programmes that will address the burgeoning obesity epidemic [5, 136–138].

2. Fast Food Environments and food industry:
   Fast foods can be defined as: "convenient foods purchased at food outlets" [139] and consumption of these foods has been associated with excessive weight gain owing to large portion sizes, palatability, high energy intake, saturated fat, salt, added sugar and sweetened beverages, all of which favour the development of metabolic disease risk factors [139–141]. At national level, a 2011 cross-sectional study (n = 3287, aged 16 and older) showed that consumption of street foods ranged between 1.8% to 20.6% for those participants who consumed these foods more than twice a week and purchase of soft drinks was higher amongst in blacks (16.4%) than whites (4.8%) [142]. The black South Africans were the most affected, 19% consumed these foods > 2 times/week compared with other ethnic groups 1.9% for Indians and 2.4% for the whites respectively [143].

   Likewise, small scale studies have reported the increasing consumption of fast foods [106, 141, 144]. Recently, Feeley and colleagues documented that urban black girls from the Bt-20 study consumed 5026 fast foods items within a week and the most frequently consumed item was a "quarter" (a quarter loaf of white bread, chips, a slice of cheese with meats and sausages) [141].

3. Media and Entertainment Environments- Television (TV):
   "Media, from television to the "new media" (including cell phones, iPads, and social media), are a dominant force in children's lives" [145]. Television has been identified as a major potent force and the duration of time children spent watching TV has been associated with the greatest increase in body fat over time [146, 147]. In most cases, the foods advertised on the TV are unhealthy, energy-dense foods and sweetened beverages, and researchers have argued that this is an important factor in the increasing prevalence of worldwide obesity in children and adolescents [11,

136, 137].

1.8 Consequences of obesity

Many comorbidities of obesity are reflected in metabolic syndrome, which is defined as insulin resistance with other features of obesity such as, large waist circumference, hypertension, abdominal concentrations of triglycerides, high-density lipoproteins cholesterol, fasting glucose and many others [5,7,148]. To date, several LMICs including South Africa are witnessing the rapid nutrition-related diseases such as hypertension, type-2 diabetes, NCDs, osteoporosis, some cancers, dislipidaema, sleep apnoea, gallstones psychological problems, and many others [9, 116, 149, 150]. However, no study could be traced in this regard.

Hypertension, defined as systolic and/or diastolic blood pressure >140/90 mmHg, prevalence was 22% among people 18 years old and over globally. In 2014, Africa had the highest prevalence of raised blood pressure (30%) in adult population and it was noted that hypertension is the leading risk factor for global mortality as it caused 9.4 million deaths and 7% of disease burden measured in DALYs [9]. High blood pressure is a key burden of disease (morbidity and mortality) in South Africa [149–151].

In 2003, Bradshaw and colleagues estimated that 37% of deaths in South Africa were associated with NCDs [151] and the increasing prevalence of NCDs in rural communities has also been highlighted [8, 149]. With regards to youths, nationally 5.3% of the 15 to 25 year olds had high systolic blood pressure and this increased with age to 63.7% in 65 year olds [8]. A study by Pedro et al., of 588 children and adolescents (aged 7 – 15 years) found that pre-hypertension prevalence in girls and boys was 15% and 10% respectively [14]. Consequently, the 11th SAFDGs suggested "Use salt sparingly" [54], which is in agreement with global trend, given that high consumption of salt is associated with increased risk of hypertension and cardiovascular disease [9].

Furthermore, obesity in the central abdominal region has been associated with type-2 diabetes [152]. Diabetes is defined as: "a fasting plasma glucose value > 7.0 mmol/L [126 mg/dl] or being on medication for raised blood glucose". High blood glucose has been associated with all the cause of diabetes and estimates show that diabetes accounted for

1.5 million deaths and 89 million DALYs. It was noted that the number of deaths were higher in women than in men [9,152]. Studies have predicted that much of the prevalence of diabetes will occur in LMICs due to increasing prevalence of overweight and obesity and reduced physical activity [9,116].

The emergence of type-2 diabetes has also been reported in South African studies and diabetes ranked seventh as the most common cause of death [8, 9, 153, 154]. A recent study of African females (n = 1251) participating in the Birth to Twenty cohort study in Soweto, Johannesburg, South Africa showed that 50.1% were obese, 14.3% and 42.1% had type-2 diabetes and metabolic syndrome, respectively [154]. Interestingly, the emergence of NCDs associated with childhood and adolescent overweight and obesity have been reported in recent studies from Agincourt sub-district, Mpumalanga [13].

For example, Kimani-Murage et al. [13] found that the risk of developing metabolic disease was higher in girls (16%) than in boys (1%) using waist circumference while Pedro et. al., documented that 5% of the participants examined had impaired fasting glucose and high-density lipoprotein cholesterol concentrations less than 1mmol/l was higher in the girls (12%) than in the boys (0.7%) respectively [14].
"The greatest health problems will be seen in the next generation of adults as the present childhood obesity epidemic passes through to adulthood" [5]. Figure 1.15 shows the wide range of serious health complications of obesity in children and adolescents [5,23,148,155–157].

1.9 Summary and gaps in the literature for sub-Saharan Africa and South Africa:

The following gaps have been identified in the literature review:

- Persistence of undernutrition in sub-Saharan Africa and South Africa have reported by previous authors [8,39,47].
- Global steep increase in the prevalence of overweight and obesity in children and adolescents, which are influenced by genetic and environmental factors [1,2].
- Emergence of NCDs in LMICs [8]

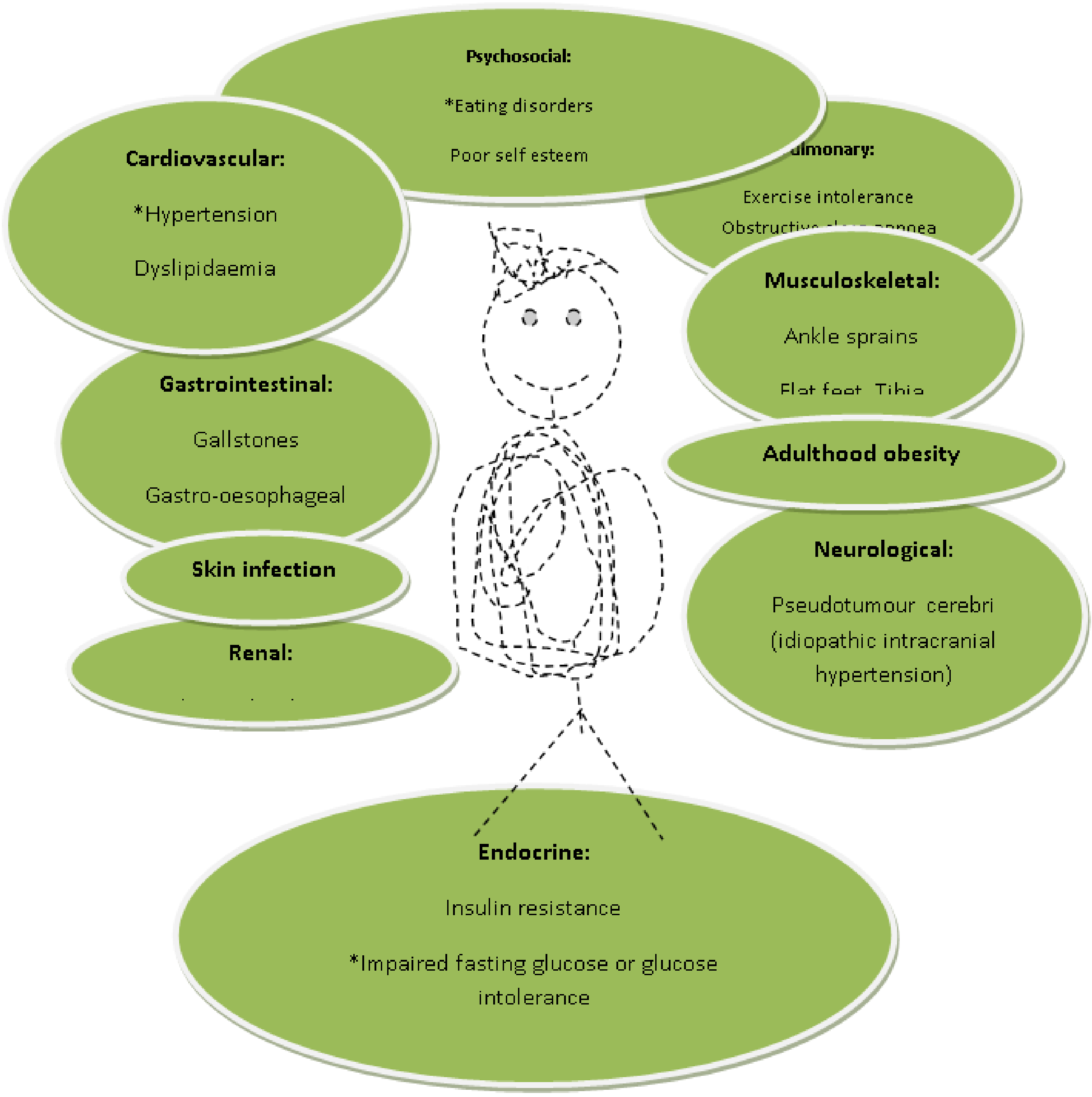


Fig. 1.15: Complications of obesity in children and adolescents [23] [148]

- The co-existence of under and overnutrition paralleled with emergence of NCDs and psychosocial factors associated with the development of obesity, globally [1, 2], in particular South Africa were highlighted [8, 41].

The rapid global increase in the prevalence of obesity has broadened the horizon of epidemiological research over the last several decades. Given that obesity is a complex phenomenon, there are still multiple evolving areas [6, 9, 158]. Although, co-existence of under and over-nutrition in LMICs has been identified in several studies [8, 64], unfortunately, limited information exists in the literature on: (1) the association of under and over-nutrition coupled with metabolic disease risk factors in the paediatric population in sub-Saharan Africa, most especially in rural areas in South Africa, which is still undergoing rapid lifestyle transition [13, 14, 72]. (2) Another gap identified in the existing literature was the little available data on eating attitudes and body image concentrated on urban children and adolescents in sub-Saharan Africa, including South Africa [73, 84]. (3) To date, no small scale study has been done in South Africa to explore frequently consumed food items, nutrient intakes and cardiovascular disease risk factors associated with BMI and diet in adolescents from rural settings in South Africa. Therefore, this study will add to the body of literature on the three listed gaps using a cross-sectional data.

1.10 Relevance and justification

The steep rise in the prevalence of childhood and adolescence obesity in LMICs is currently recognised as a public health concern. Current evidence shows that South Africans are not immune to this problem (See Figures 1.12 and 1.13). For these reasons, the need for continuous research into the many complex, dynamic and interactive factors in the development of metabolic disease in children has been advocated both regionally and internationally, with the aim of:

1. “predicting the progression of obesity epidemics,
2. “understanding its’ aetiology for effective targeted and future research intervention to slow its progress” [127],
3. “reducing and prevent the escalating increase in NCDs affecting all segments of the populations” [3, 8, 40, 71].

South Africa is a country that is well established along the nutrition transition and studies have shown that risk factors related to obesity and subsequent NCDs are on the rise [8, 149, 159]. However, limited information exists on the paediatric population regarding nutrition transition, biochemical analysis, psychosocial and metabolic disease risk factors [13,72,160]. A snapshot understanding of the association of nutrition on body composition and metabolic disease risk in under-studied geographical population, whose particular health needs have been under-served and poorly delineated in the past, would add to the existing body of literature. From the public health perspective, such information may pinpoint the direction of future research and interventions.

1.11 Aim and objectives of the study

Figure 1.16 shows the current tittle of this study which is to determine the association of nutrition on body composition and metabolic disease risk in rural South African children and adolescents.

The sub-tittle of this research are as follows:

- To determine the association of nutrition on body composition and metabolic disease risk in children and adolescents
- To examine the associations between body mass index (BMI), disordered eating attitude and body dissatisfaction in female adolescents, and descriptive attributes assigned to silhouettes of differing body habitus in male and female adolescents
- To investigate associations between diet and cardiovascular disease (CVD) risk factors in adolescents.

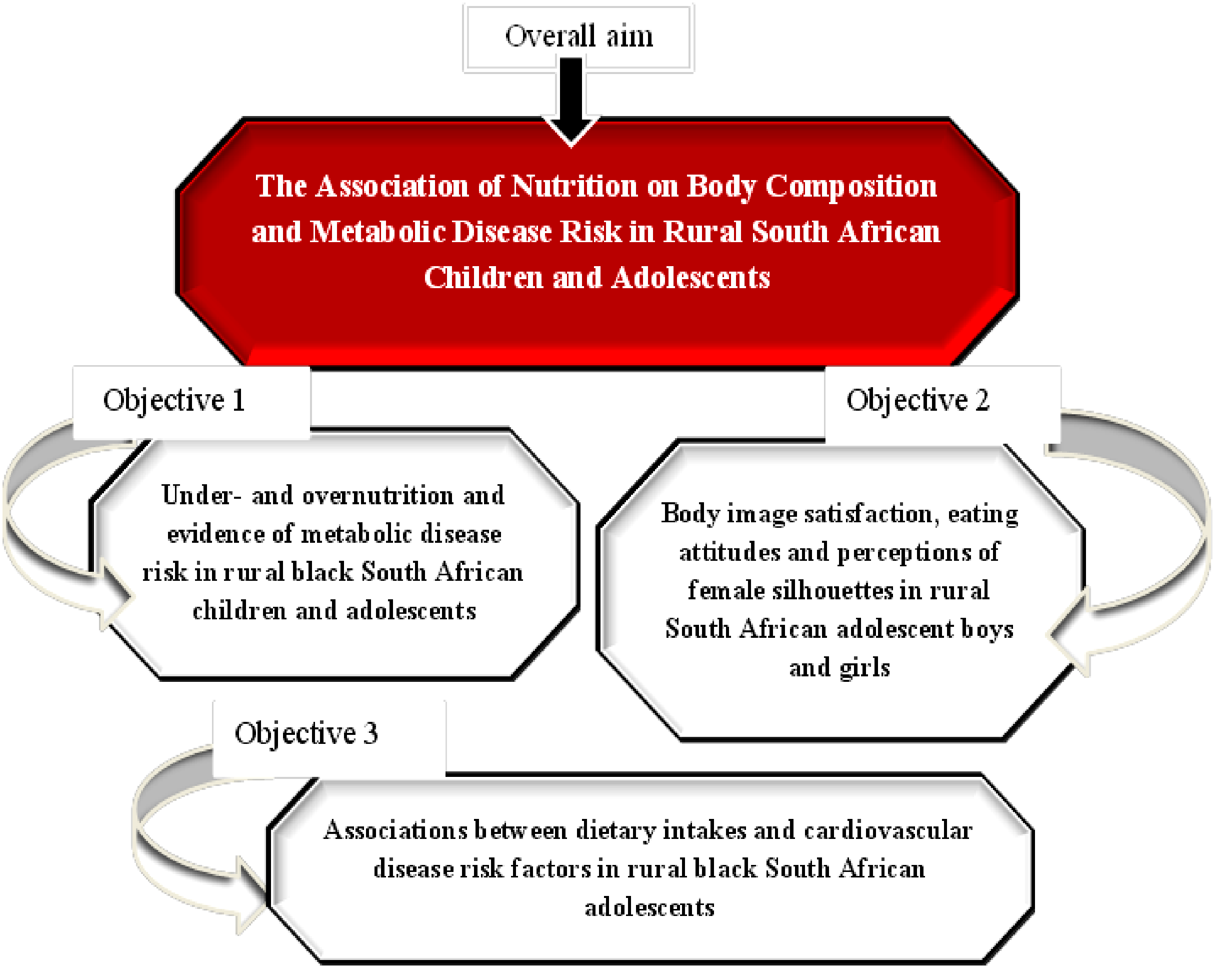
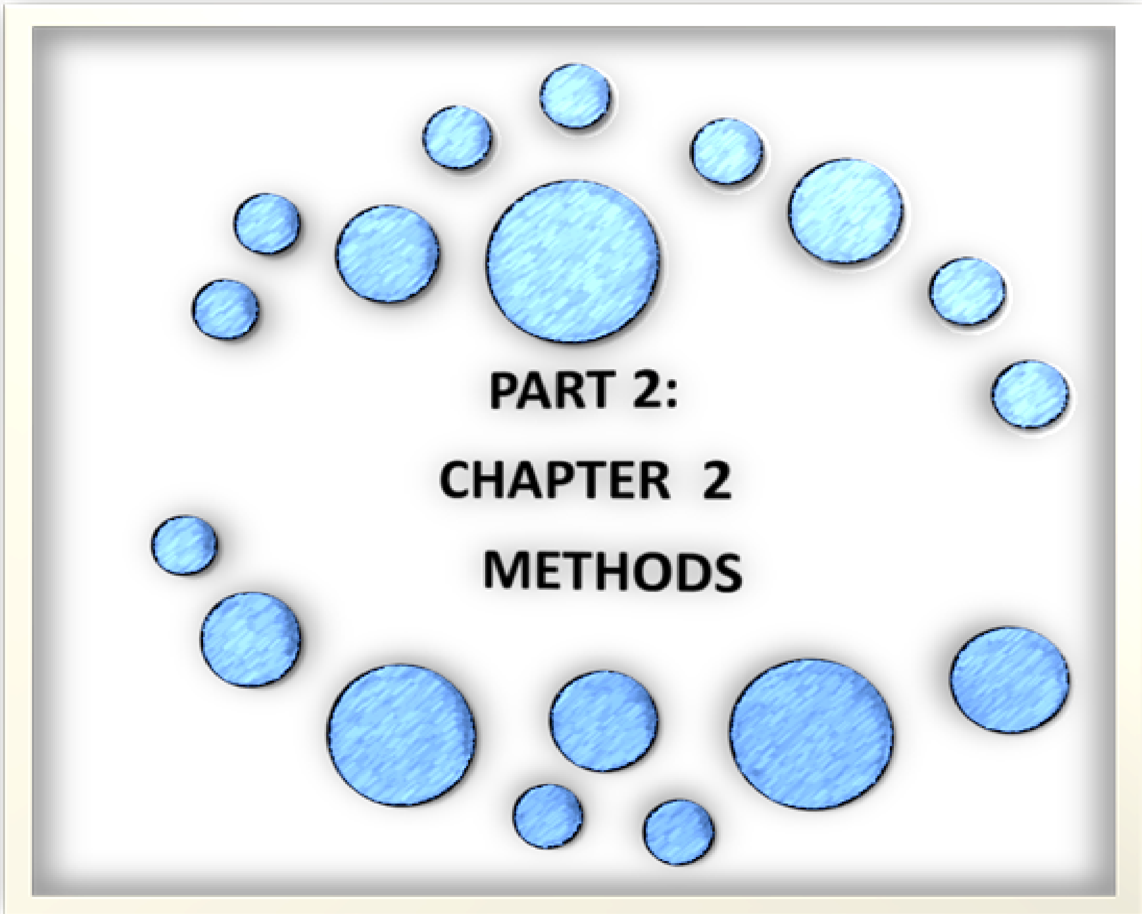


Fig. 1.16: Overall aim and objectives.

2. PART 2: CHAPTER 2 – METHODS



2.1 Methods

This chapter gives a historical short summary of apartheid, demography and this is followed by detailed information about the study settings.

2.2 Historical background

In South Africa, racial and colonial segregation was abolished in 1994 and the first democratic election was conducted. Prior to this, South African populations were divided into 4 racial groups (White, Black (African), Coloured (including people of mixed decent) and Asian/Indian) and the Group Areas Act of 1950 resulted in the allocation of separate areas for different racial groups. The Black South Africans were denied the right to citizenship. Thus, Back South African were moved to Black reserves known as "homelands" or "bantustans" [161, 162]. Today, South Africa is undergoing rapid social, economic and epidemiological transitions, particularly nutrition transition, attributed to increasing urbanisation (10% to 56% between 1990 to 2005) among Black South Africans [67]. Currently South Africa is battling with battling with a double burden of disease including the Human immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) and the emergence of non-communicable diseases (NCDs) [8, 41].

2.2.1 Demographics

According to the most recent census, there are 52 million South Africans, 19.3 million people live in rural areas and just over 41million are black Africans, making up 79.2% of the total population, followed by whites (8.9%), then Indians/Asians (2.5%) and others (0.5%) (Figure 2.1). Further, half of South African population consists of children and adolescents below the age of 19 years [163].

Likewise, the Agincourt area has a young population with 36% under 15 years [164]. The population of Agincourt consists mainly of South Africans and a third of the people are self-settled former Mozambican refugees, who migrated to South Africa in the early to mid-1980s during and after the civil war in Mozambique [160]. A baseline household census was conducted in 1992 and systematic annual recording of all vital events, specifically deaths, births, unions and in- and out-migrations, has been occurring from 1992

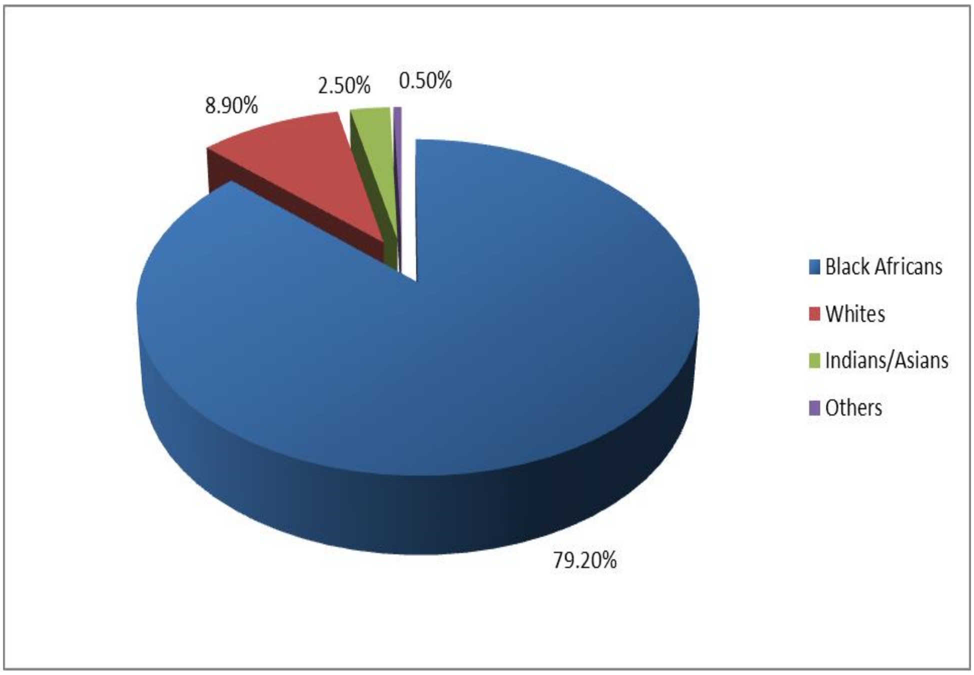


Fig. 2.1: South African population demographics
[171]

to-date. Additionally, the socio-economic data of this community is captured using an asset survey. Over two decades, the population under surveillance has increased from 66 840 to 90 000, living in 27 villages and approximately ± 20 000 households (Table 2.1) [165–167]. Figure 2.2 shows the location of Agincourt HDSS study area in South Africa [168].

Agincourt, a sub-district of Bushbuckridge region, is located in Mpumalanga Province, in the north-east of South Africa, and is about 500 km from Johannesburg [13, 165, 169]. The site extends between latitudes 2450' and 2456'S and longitudes 3108' and 3125'E, at an altitude of 400 to 600 m above sea level [166, 170]. Agincourt site is a typical disadvantaged rural South African community formerly called a homeland or Bantustan [171]. The Agincourt HDSS was established in 1992, just prior to the end of the apartheid era, by a team in the School of Public Health, University of the Witwatersrand [170].

2.3 Site description - Physical geography of Agincourt HDSS

Table 2.1 shows the physical geography and population characteristics of Agincourt. Despite current government development initiatives, Acornhoek, Bushbuckridge, and Thulamahashe are the only business centres serving this municipality. In South Africa, there

Fig. 2.2: Location of Agincourt HDSS study area in South Africa

has been a striking improvement in household electricity access by 9.0% between 2002 and 2012 at a national level (78% to 85%). Likewise, by 39.2% in Agincourt between 2001 and 2013 (69% to 96%), however, periodic power cuts exists, disconnection owing to migration and many cannot avoid to pay for power connection [172].
With regards to wireless connectivity, most (> 90%) households now have at least 1 cell phone and digital reminders are now being used to support chronic disease management particularly for patients with hypertension [173]. Recent studies have found that adolescents from Agincourt opt for airtime over food during the school days. The study villages are located over an area of 420 km^2, vulnerable to drought with insufficient rainfall. Infrastructure in the area is still limited. Women and girls collect water from riverbeds, reservoirs and communal village taps, transported manually on their heads and/or in a wheelbarrow. Families live in traditional structures or brick houses with tin or tiled roofs [160, 169] (Figure 2.3).

Sanitation facilities are still poor and many households use pit latrines, which are situated outside in the yards. Many roads are currently levelled but not tarred and privately owned taxis are commonly used for transport [160, 168]. An overview of a structure for cooking or storing food in Agincourt field site is shown in Figure 2.4.

Tab. 2.1: The physical geography and population characteristics of Agincourt HDSS.

Area Name	**Bushbuckridge**
Areas Covered	420 km^2
Population	$\pm$ 90 000
Population Density	172 persons/km^2
Number of villages	27
Number of Households	$\pm$ 20 000
Average of Household members	5.58
Ethnic Group/Major language	Tsonga/Shangaan
Other Languages	Sotho, Pedi, Swazi
Major Religion	Christianity
District Hospital	(25 – 60 km from the study area)
Health centers	2
Number of Satellite Clinics	6
Number of Schools	Primary – 28, Secondary – 21
Rain fall	80% Summer (Nov. – March)
Other Religion	Traditional Believers
Drought Average	Every 3.5 years
Summer Temperature	20^o – 40^o C
Winter Temperature	5^o – 27^o C
Electrification	All study villages are electrified
Roads	Gravel roads within villages
Unemployment	80%
Migration	60% [13, 160, 164, 165, 169, 170]

Fig. 2.3: An overview of terrain in Agincourt field site
[164]

Fig. 2.4: A structure for cooking or storing food in Agincourt field site [163]

2.3.1 Socio-economic status

Today, unemployment and social unrest are major problems in South Africa [174, 175]. Nationally, 26% of South Africans are unemployed and the young black South Africans have the highest unemployment rate of 60% [176]. In Mpumalanga province, the level of unemployment ranges between 40 to 80% and income is generally low by South African standards. Besides household income from formal sectors and tourism, men work at the farms, in mining industries, in security companies and in construction firms located in nearby cities, whilst women are employed on farms and in game reserves as domestic workers. Social grants and remittances from migrant workers provide vital income for households in this rural community [150, 160, 177].

2.3.2 Migration

Historically, circular labour migration was established during the apartheid regime for economic and industrial growth and studies have shown that labour migration in Agincourt sub-district is very high. More than 60% of working men (aged between 30 to 54 years) with increasing young adult females (33% of 20- to 39-year-olds in 2010/2011) migrate in and out of the study area [167]. Temporary labour migration has been a survival strategy to improve their socio-economic status. However, some recent studies have shown that this has negative effects on health status [150, 167, 178, 179]. Figure 2.5 shows that the Agincourt HDSS has become a dynamic cohort which is updated on annual basis.

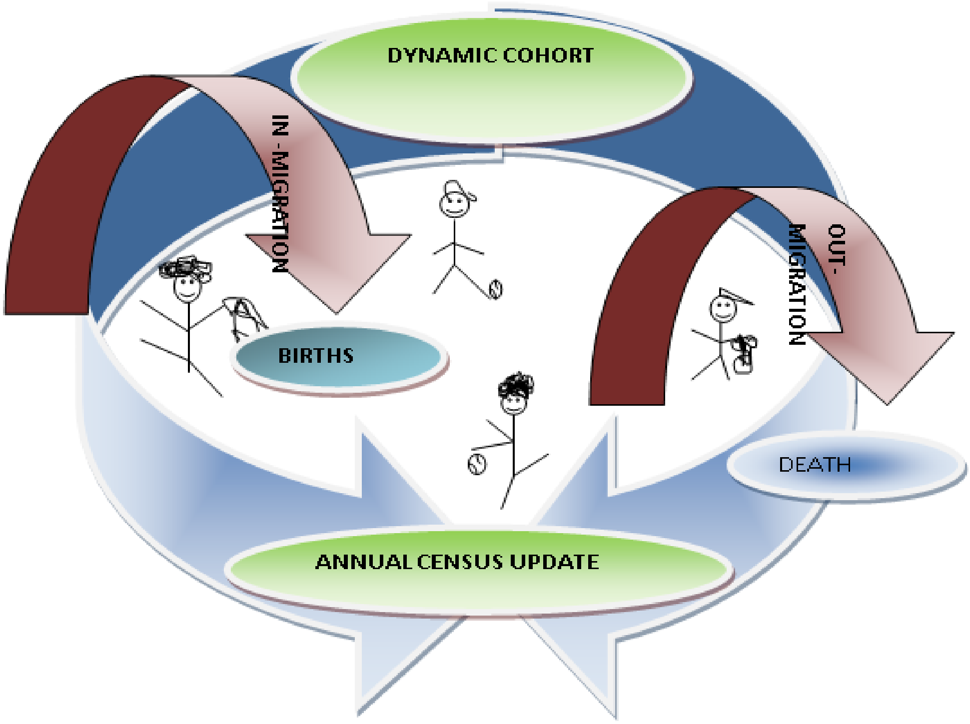


Fig. 2.5: Agincourt dynamic cohort showing births, deaths, in- and out-migration

2.3.3 Social grants

In addressing the past historical inequalities, the South African government provides a massive "pro-poor" investment and non-contributory child grants, government pension funds, disability grants, foster care grant, and care dependency grants. These grants play an important role of redistribution of income to poor households [180]. These have been associated with higher-grade school attainment, especially among girls and reduction of absenteeism in boys. Studies have also shown that pension funds are contributing substantially to the education of orphaned children [180, 181].

In addition, older women's pensions funds improve household food security and general well-being in men and women [182]. It is a source of cash income serving as a capital for small entrepreneurship - which stimulates local activity such as "pension markets" - an informal market springing up for petty trading, with local products being displayed as well. Produce found ranged from bulk purchase of foodstuffs, wood sales, hardware household goods, clothes and snacks [183]. Figure 2.6 shows a typical market day in Agincourt.

Fig. 2.6: A market day in Agincourt.

2.3.4 Education

"PEACE: P - please be polite, E - ensure that all work is done, A - accept others as they are, C - choose to be positive, E - eager to learn (Author- unknown)".Figure 2.7 displays a class rule posted on the wall in a school in the study area.

There different public schools in South Africa according to the quantile 1 to 5 system. In

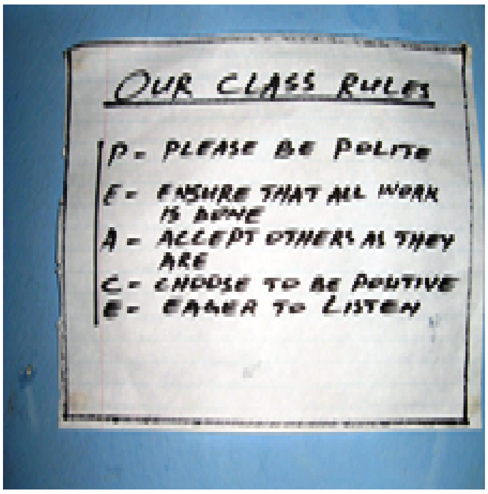


Fig. 2.7: A class rule in Agincourt site.

comparison to private schools, the quality of these public schools varies significantly owing to school fees. The rural schools are generally considered of poorer quality compared to urban private schools which are located in the nearby towns and are unaffordable for many low socio-economic households [160, 184]. In total, there are 28 primary schools and 21 secondary schools in this study area. The level of education in the Agincourt area has improved significantly. Over 95% of children aged between 6 to 19 years are enrolled at schools although progress is delayed: more than 30% of 21 year-olds are still attending school and some children are now enrolling in tertiary colleges. However,

Fig. 2.8: Students going to school.

illiteracy levels among adults (aged > 60 years) remain high. Figure 2.8 shows students going to school [160]. Figure 2.9 shows a school in Agincourt.

Fig. 2.9: A school in Agincourt.

2.3.5 Health status

South Africa had a poorly functioning health care system and, despite many notable achievements since 1994, this remains the case. Over 60% of poor households in rural areas do not have access to health care [185,186]. Traditional health care is used by many Agincourt residents, often in conjunction with Western services. The nurses working in the two health centres and the six clinics provide free primary health care services and they make referrals to the three district hospitals which are located 25 to 60 kilometres from the study area (Table 2.1). Literature documents that the Agincourt HDSS population is undergoing a rapid health transition with a triple burden of disease with infectious-related conditions including human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDs) and TB (tuberculosis), under- nutrition related illnesses, and parallel increasing NCDs. With regards to HIV, a study of 5037 aged 15 and above and the prevalence was high at 19.4% (10.6% for men and 23.9% for women) and 5.5% for females and 0.4% for males aged 15 to 19 respectively [187]. The prevalence of overweight and obesity and HIV/AIDs among young people is increasing in this study area and girls are at higher risk than boys. In addition, the increasing number of orphans has been a concern among previous authors because many households are headed by single parent and or only grandparent owing to AIDs [13, 188–190].

2.4 Agincourt research themes

The Agincourt HDSS [169] provides the research platform for the MRC/Wits Rural Public Health and Health Transitions Research Unit. This supports a range of cross-sectional and longitudinal observational studies targeting different stages along the life course, as well as trials and policy evaluations. This study is nested within a portfolio of research on child and adolescent health, development and wellbeing (See Figure 2.10).

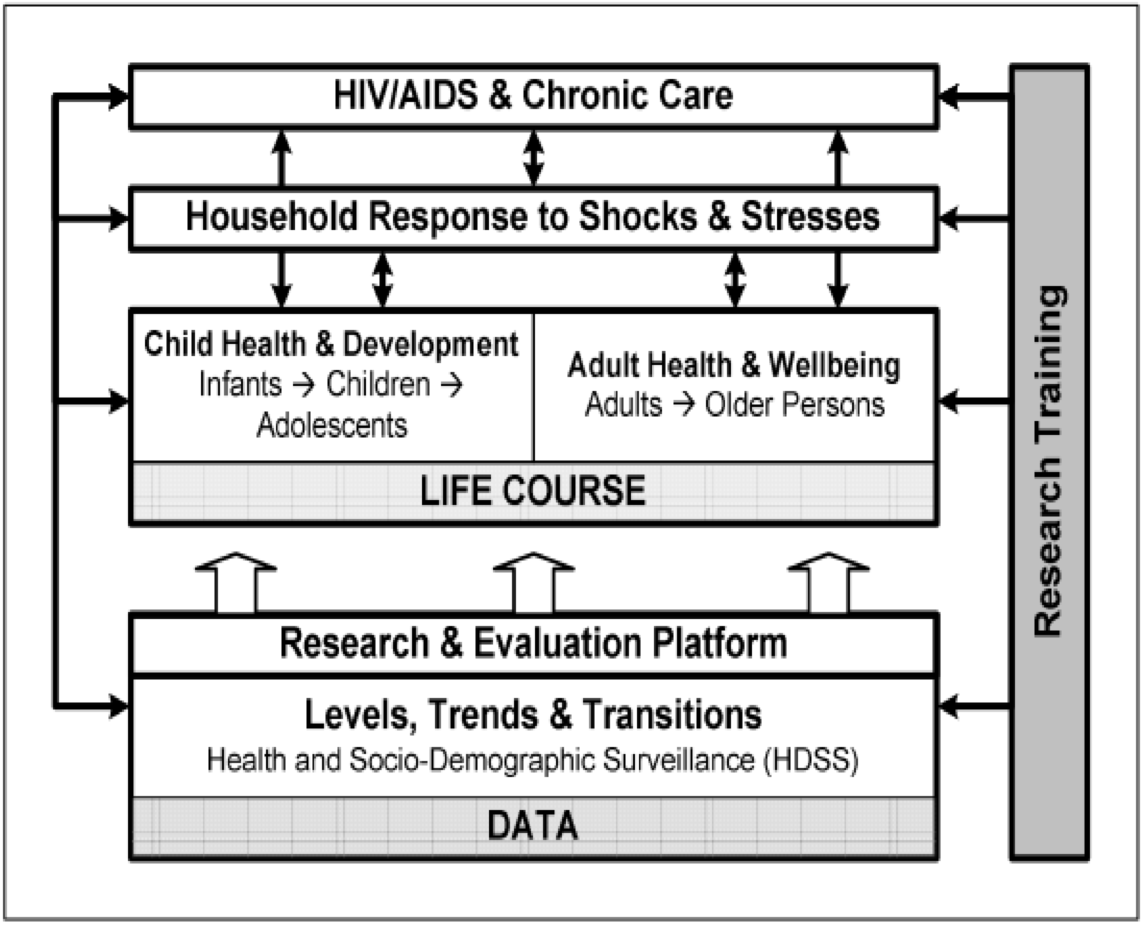


Fig. 2.10: Agincourt Research Themes

2.5 Assessment of under-and overnutrition in children and adolescents

Nutritional status is the current body status, of an individual or a group of population, related to their state of nourishment (the consumption and utilization of nutrient) The nutritional status is determined by two complex factors:

1. Internal or constitutional: age, sex, nutrition, behavior, physical activity and disease
2. External environmental: food safety, cultural, social and economic circumstances [43].

Assessment of nutritional status include: anthropometry, biochemical parameters and dietary history.

2.5.1 Body measure and body composition

Body composition can be defined as: "the percentage of fat, muscle and bone in the body". Two methods are used to determine the components of body composition assessment: (1) complex, (2) simple anthropometry methods. Complex methods, which include bioelectrical impedance, dual-energy X-ray absorptiometry, body density and total body estimates were beyond the scope of this research and will not be discussed [43, 191]. Anthropometry measurement is a measure of nutritional status of growth, body size and overall adiposity, which primarily depends on dietary intake, energy expenditure and general health of an individual and/or populations. Anthropometry is a term used to describe body mass, shape and levels of fatness in an individual and it is an inexpensive, non-invasive, basic method of assessing body composition and has been widely used in epidemiological studies [42, 192].

Therefore, current research is based on simple anthropometric measurements to assess weight-for-age, height-for-age, weight-for-height, weight, height, BMI and other measures that reflect abdominal adiposity, such as waist circumference, waist-hip ratio and waist-height ratio, and skin-fold measurements [5, 42, 43, 191–193].

2.5.2 Low weight-for-age

A term used for underweight. This is a consequence of growth retardation due to insufficient food intake and measures past and current undernutrition. However, it has been noted that it is difficult to interpret because it does not distinguish between stunting and wasting. The prevalence of underweight less than 10% is considered low in a population [18, 42, 43].

2.5.3 Low height-for-age

A term used for stunting. It is a measure of linear growth that reflects past nutritional and health status. It is a consequence of long-term nutritional deprivation and is associated with poverty, recurrent infections and inadequate feeding practices. The prevalence of stunting less than 20% is considered low in a population [18, 42, 43, 192].

2.5.4 Low weight-for-height

A term used for wasting. This is a symptom of acute undernutrition attributable to not gaining adequate weight relative to height due to marked deficit in tissue and fat mass. The prevalence of wasting less than 5% is considered low in a population [18, 42, 43].

2.5.5 Weight and Height

Weight and height alone have not been widely used in studies involving adults and more so, weight changes with age as children grow older. Therefore, BMI has been commonly used in epidemiological studies but it requires skilled and trained persons to conduct weight and height measurements which are also needed for the other indices [42, 43].

2.5.6 BMI

It has been widely used as an index of relative adiposity in children, adolescents and adults [5, 193]. The International Obesity Task Force (IOTF) age- and gender-specific reference values for BMI in children and adolescents, which corresponds to the cut-off points used for adult overweight and obesity, was used for this study [59]. Table 2.2 displays the international cut-off points for BMI for overweight and obesity by gender and age groups 7/8, 11/12 and 14/15. This has been defined to pass through BMI index 25kg/m^2 and 30 kg/m^2 at age 18, which was obtained by averaging data from Britain, Brazil, the Netherlands, Hong Kong, Singapore and the USA [59].

Tab. 2.2: The international cut-off points for BMI for overweight and obesity by gender and age groups

Age (years)	**BMI 25kg/m^2**		**BMI 30kg/m^2**	
	Boys	Girls	Boys	Girls
7	17.92	17.75	20.63	20.51
7.5	18.16	18.03	21.09	21.01
8	18.44	18.35	21.60	21.57
11	20.55	20.74	25.10	25.42
11.5	20.89	21.20	25.58	26.05
12	21.22	21.68	26.02	26.67
14	22.62	23.34	27.63	28.57
14.5	22.96	23.66	27.98	28.87
15	23.29	23.94	28.30	29.11

2.5.7 *Waist circumference*

Waist circumference is currently the preferred anthropometric measurement for assessment of abdominal fat distribution and to determine risk of metabolic disease in adults, children and adolescents. Adult cut-off points are being used for children and adolescents and these are: (1) > 0.94cm for males and (2) > 0.80cm for females [5, 42, 194].

Waist-to-hip ratio: Waist-to-hip ratio (waist circumference divided by hip circumference). This has been used to identify children, adolescents and adults with high central adiposity and to determine the prevalence of metabolic disease risk factors [5,42,193]. Adult cut-off points are being used for children and adolescents and these are: (1) >0.90 for males and (2) > 0.85 for females [195].

Waist-to-height ratio: Waist-to-height ratio (waist circumference divided by height). This has been used in predicting the risk of obesity related diseases and comes from regional abdominal adiposity. The recommended cut-off point for both children and adults is 0.5 for both sexes [43, 195].

2.5.8 Skin-fold measurements

Skin-fold measurements have been used to provide an estimate of subcutaneous fatness given that body fatness is composed of both subcutaneous fat and visceral fat and variations in distribution of subcutaneous fatness may occur depending on sex, race, ethnicity, and age [42, 192]. Caliper has been the commonly used instrument for skin-fold measurements. This is done by picking up a fold of skin and subcutaneous tissue between the thumb and forefinger and when the caliper is applied, it closes under the spring pressure and readings are taken on the micrometer dial immediately after compression [42]. Biceps, triceps, subscapular and suprailaic sites have been measured in this research.

1. Biceps:
   This is measured over the mid-point of the muscle belly with the subjects' arm resting on his/her thigh [42].

2. Triceps:
   This is measured over the mid-point of the muscle belly, mid-way between the olecranon and the tip of the acromion, with the subject's upper arm hanging vertically [42].

3. Subscapular:
   Participants were measured below the tip of the inferior angle of the scapula.

4. Suprailiac:
   This is measured just above the subjects' iliac crest in the mid-axillary line.

These (biceps, triceps, subscapular and supra-iliac) skin-fold measurements have been recommended as an additional anthropometric measurement to assess total body fat and regional fat distribution [5, 42, 43].

2.5.9 Z–scores

A Z–score, or standard deviation, can be defined as a measure of an individual's value in comparison to the distribution of the reference population and it is calculated as:

$$\text{Z} - \text{score} = \frac{\text{Individual raw score} - \text{Population mean}}{\text{Population standard deviation}} \tag{2.1}$$

Tab. 2.3: Measures/Malnutrition indicators/Cut-off points/Health outcomes

Measures	**Malnutrition indicators**	**Cut-off points**	**Health outcomes**
Anthropometry			
Height-for-age	Stunting	< -2SD*	Increased infection, Decreased physical and mental development
Weight-for- age	Underweight	< -2SD*	
Weight-for-height	Wasting	< -2SD*	
Height and weight BMI > 25kg/m^2	Overweight	> +1 SD*	Metabolic syndrome Type 2 diabetes
Height and weight BMI > 30 kg/m^2	Obese	> +1 SD*	

[42, 43, 192]

Tab. 2.4: Blood pressure/Biochemical parameters and the Cut-off points used in this study.

Measures	**Cut-off points**
Diastolic/systolic blood pressure DBP	> 90th but < 95th percentile for age, sex and height
High-density lipoprotein cholesterol (HDL-C)	< 1.03 mmol/l
Total cholesterol (TC)	> 5.17 mmol/l
Triglycerides (TG)	> 1.7 mmol/l
Impaired fasting glucose	> 5.6 mmol/l

[8, 196–198]

2.5.10 Summary of this research measures

Table 2.3 presents the summary of measures of nutritional status, indicators of nutritional status, cut-off points and health outcomes used in the present study. Further, blood pressure cut-off points and for biochemical parameters collected in this research are shown in Table 2.4, followed by a brief description of dietary assessment methods.

<u>Dietary assessment methods</u>

Dietary intake of both household and individuals can be assessed through different methods and these include 24-hour recall, dietary history and food frequency questionnaires and are determined retrospectively, however, prospective approach are used with regards to estimation of food records and weighed food records. The choice of dietary assessment method to be used in a study depend on the following:

- objectives of the research
- characteristics of the participants

- respondent burden
- availability of resources

There has been growing awareness that dietary intake techniques in individual is fraught with difficulties because random and systematic error that may occur. Therefore, no method is universally the best for assessing dietary intake because they all have their advantages and disadvantages [42]. Nutrition epidemiologists have highlighted that 24-h recall, repeated 24-h recall and food frequency questionnaire (FFQ) have various difficulties because they rely on interview approach and for participants to recollect daily intake accurately.

Therefore they are prone to recall bias and overestimation or underestimation of intakes can occur [42, 192, 199]. Besides these difficulties, 24-hour recall and quantitative FFQ have been used to collect dietary intake of a representative sample of South African children and FFQ, in particular, has been used for many years of dietary assessment among South African children [56]. Further, other small scale studies have used semi-quantitative FFQ to collect dietary intakes of urban populations in South African populations and this was used to assess dietary intake of adolescents in this research [200, 201]

Eating attitudes and body image dissatisfaction

Detailed information on validated questionnaires used to determine body image satisfaction, eating attitudes and perceptions of female body silhouettes in this research is given in part 3 (chapter 4).

2.6 Data collection procedures

2.6.1 Community participation

An established collaboration exists between the MRC/Wits-Agincourt research team, the community and the health services. The LINC (Learning, Information Dissemination and Networking with Community) office of the MRC/Wits-Agincourt Unit is responsible for community engagement that includes introduction of all studies to the study communities prior to study commencement.

2.6.2 Study design and study population

2007 Growth 1 Study

In 2007, 4000 children and adolescents aged 1 to 20 years were targeted (100 boys and 100 girls for each year). An oversampling of 10 to 15 years old children per age-sex group was conducted to counter possible non-participation. The inclusion criteria was that children who had lived in the study area at least 80% of the time since birth, or since 1992 when enrolment in the Agincourt HDSS began. A random sample of children was drawn from each age-sex-village stratum in proportion to the population size of the village. In 2007 baseline Growth 1 Study, 3489 children and adolescents participated and only anthropometric measurements for all 2007 study participants (aged 1-20 years) and pubertal assessment for adolescents aged 9-20 years. [72].

2009 Growth 2 Study

In 2009, a follow up of previous Growth 1 Study was designed (Growth 2 Study). Given the broad objectives of this study and for the level of statistical significance and envisage results, oversampling of 750 children and adolescents was conducted in order to have 80% response rate. These 750 children and adolescent were randomly selected from 3489 of children and adolescents (inclusion criteria) and those who did not participate in the 2007 Growth 1 Study were excluded. The stipulated number of children and adolescents for 2009 Growth 2 study was 600 and they were stratified by ages: 7/8 years (n = 200), 11/12 years (n = 200) and 14/15 years (n = 200). The motivation for the selection of 7/8 years, 11/12 and 14/15 years was base on the previous 2007 Growth 1 results and for comparison with global and regional trends. In total, 588 children and adolescents participated (98% response rate).

Further, contact sheets were generated for each 2009 participant with the following information:

- 2007's unique participant ID number
- First name, Surname
- Village code
- House Head name

- School name and Telephone number
- Bar codes were printed for each participant with the same 2007's unique participant ID number.

2.6.3 Data collection

Collection of the data for this study started from May to July in 2009 during the school holiday. Detailed information about the study was discussed with the village CDFs (Community Development Forums), school principals and clinics. The PhD candidate and one Agincourt HDSS supervisor visited the school principals a day before data collection. The schematic diagram of the procedures involved during the study data collection is shown in Figure 2.11.

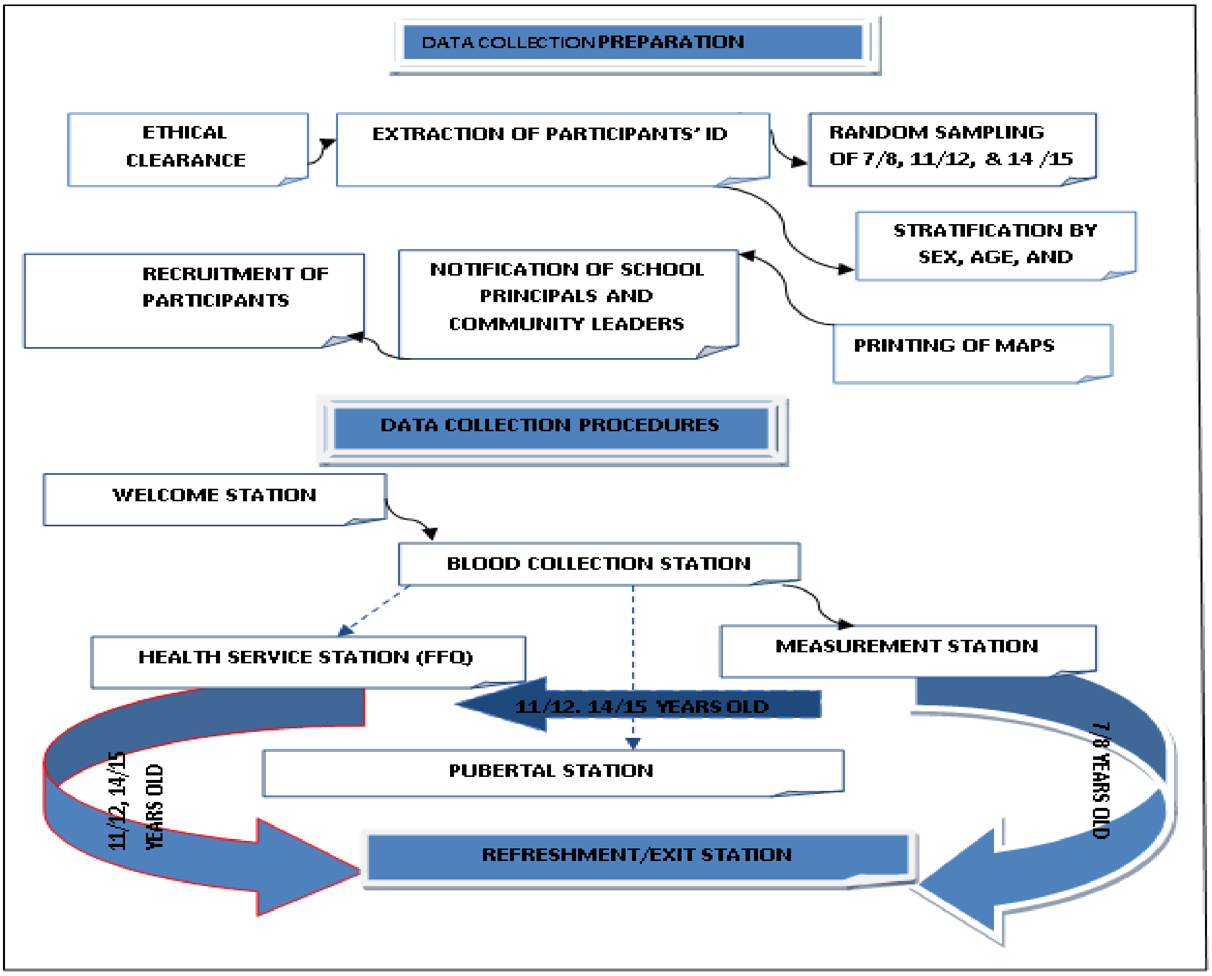


Fig. 2.11: Schematic diagram of the data collection procedures.

2.6.4 Data collection instruments, measurements and questionnaire

The questionnaires used in this study were interview administered and are listed in Table 2.5 (See appendices).

Tab. 2.5: The questionnaires used in this thesis.

Questionnaires	**Information provided**	**Variables collected**
Measurements	Anthropometry and Skinfold measurements	Height, weight, waist circumference, hip circumference, tricep, bicep, subscapular, supra-iliac, medial calf, blood pressure (systolic and diastolic), fasting blood glucose and pulse
Body image	Body image dissatisfaction	Body feel, Eating attitudes
Physical activity	Activities and exercise	Frequency of activities and exercises
Food Frequency questionnaires	Food consumptions and dietary intakes	Energy and nutrient intake Fast foods Eating habits and practices School lunch Food habits
Physical development	Pubertal assessment	Pubertal status

2.6.5 Piloting of the questionnaire

Translation and back translation of the questionnaires into the local Shangan language was conducted. Afterwards, there were training sessions with experienced MRC/Wits-Agincourt field workers [165,169]. If these training sessions did not meet levels of accuracy and specificity, then retraining and practice were repeated for quality and consistency. Participants, aged between 7 to 15 years (n = 30) were invited for pilot study and cross-checking probes were conducted and clarification of problems that might arise during data collection were addressed.

2.6.6 Interview

Data collection was conducted during the school holiday and participants were invited to a nearby school within each study village. The interview was conducted by experienced fieldworkers in local Shangan language. First and foremost, 16 field workers received intensive training on how to conduct the interview in Agincourt by experts from the Birth to Twenty Cohort Study (Bt20), located in Johannesburg South Africa. Training involved all measurements (anthropometric, pubertal assessment, body image satisfaction and on dietary intake) techniques and I supervised the field observations. Training and re-training were conducted for fieldworkers and each fieldworker was assigned anthropometric and other measurements where he/she performed best. Furthermore, a male and a female fieldworker were used in order to provide both the boys and girls with gender-specific assistance during measurement (for anthropometry and pubertal assessment). Coefficient of variation for the various anthropometric measurements was calculated for each fieldworker after the training. The anthropometric measurement variation remained below 2%.

In addition, blood pressure: Diastolic (DBP) and Systolic (SBP) were measured by trained fieldworkers and trained and qualified nursed collected fasting venous blood samples from all the participants (7/8, 11/12 and 14/15 years-olds). Data collection involved anthropometric and skin-fold measurements for all study participants aged 7/8, 11/12 and 14/15 years-olds and pubertal assessment, body image satisfaction and dietary intake for only 11/12 and 14/15 years-olds. Further, counselling was provided by qualified nurses to overweight and obese participants and parents/care givers and referrals were given to a nearby clinic. Only refreshments (Chess burn, orange juice and peanuts) were given after the interview.

2.6.7 Data analyses

The details of data analyses for each empirical paper will be discussed in Part 3 of this thesis. In order to be able to compare rural urban findings, there was close monitoring of field workers to ensure high quality and continuous standardisation according to the Bt-20 PLUS Research Programme. Anthropometric measurement variation remained below 2% and the laboratory coefficients of variation were below 5% (See Table 2.6).

Tab. 2.6: Inter and intra control variation.

Variables	**TC low**	**TC high**	**TG low**	**TG high**	**FG low**	**FG high**
Inter (%)	3.65	4.47	5.55	5.49	1.72	3.35
Intra (%)	2.95	4.21	4.98	3.95	1.45	2.51

Variables	**HDLC-C level 1**	**HDLC-C level 2**	**HDLC-C level 3**	**LDLC-C level 1**	**LDLC-C level 2**	**LDLC-C level 3**
Inter (%)	4.46	4.40	3.38	4.70	5.63	4.05
Intra (%)	3.96	3.50	2.5	3.41	4.25	3.76

TC - Total cholesterol, TG - Triglycerides, FG - Fasting glucose, HDL-C - High-density lipoprotein cholesterol, LDL-C - Low-density lipoprotein cholesterol.

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2.7 Ethical approval and consent

Ethical clearance for this study was granted by:

1. The Human Research Ethics Committee of the University of Witwatersrand (Medical) (M090212) (Appendix)

2. The Research and Ethics Committee of Mpumalanga Province (Appendix)

Therefore, this study has been conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. In addition, permission from the community leaders and school principals was obtained. Parental consent, as well as participant assent was secured after full explanation of the study objectives and testing procedures and prior to commencement into the study.

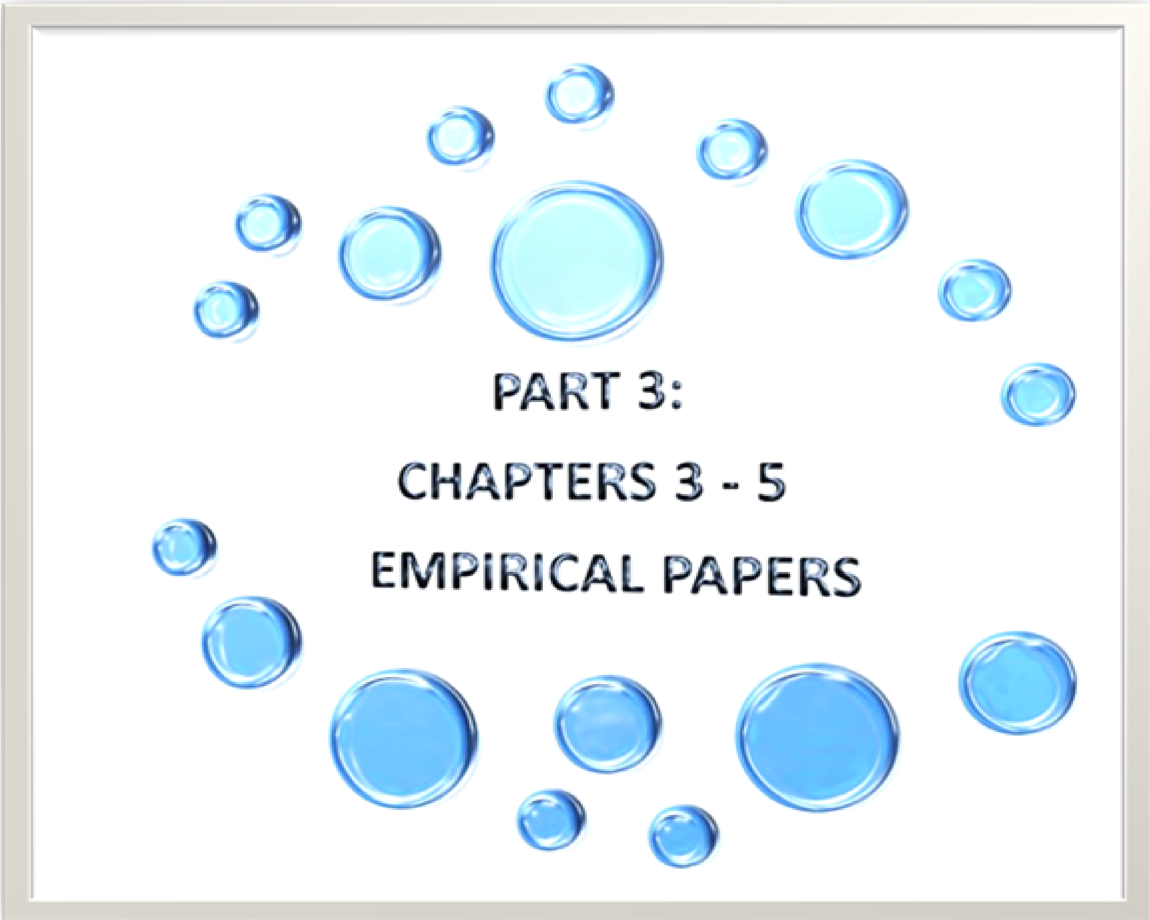
Fig. 2.12: Data collection photographs - 1

Welcome stations: clockwise from the top left: completion of forms, short exercise routine, participants resting outside in the sun to warm up after exercise, and showing their veins prior to venepuncture.

Fig. 2.13: Data collection photographs - 2

Stations: clockwise from the top left: a fieldworker weighing a participant, study nurse collecting blood samples from a participant, Food Frequency Questionnaire (FFQ) station, food models displayed on a table for FFQ, and a fieldworker observing as a participant sorted the food flash cards.

3. PART 3: CHAPTER 3– EMPIRICAL PAPER 1



Under- and overnutrition and evidence of metabolic disease risk in rural black South African children and adolescents

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3.1 Introduction

It is estimated that by 2020, noncommunicable diseases will account for three quarters of all deaths in developing countries, and will be associated with increasing prevalence in the young in low and middle-income countries [10]. Obesity is likely to increase in South Africa as a result of an ongoing lifestyle transition from a traditional rural to more urban "Westernised" lifestyle, characterised by a less healthy diet, reduced physical activity and increased sedentary behaviour [26, 134].

Fifteen years ago, 18.5% and 3% of rural children aged 7-9 years in South Africa were stunted and obese [56]. The recent National Health and Nutrition Examination Survey (SANHANES-1) showed that the prevalence of stunting in the 7- to 9-year-old age group was 10% and 8.7% for boys and girls, respectively. Also, the prevalence of overweight and obesity was significantly higher in girls than in boys aged 15-17 years (19.3% and 8%, compared to 7.3% and 1.5%, for females and males, respectively) [8]. A 2008 study, the 2nd Youth Risk Behaviour Survey, found that 11% of male and 29% of female adolescents in grades 8-11 (approximate age of between 13 and 19 years) were overweight [63]. Other recent studies have confirmed the coexistence of under- and overnutrition in both rural and urban South African children [13, 58, 64, 202].

Research on malnutrition and metabolic disease risk factors in children is vital [116]. given the limited data in rural South Africa, where lifestyle transitions are expected to be the most dramatic over the next decade. The aim of this study was to determine the prevalence of under-and overnutrition, as well as evidence of early metabolic disease risk in rural South African children and adolescents. The Agincourt Health and Socio-demographic Surveillance System site (HDSS) provided an opportunity for study participants to be randomly selected.

3.2 Method

3.2.1 Setting and study population

The study was nested in the Agincourt HDSS in rural Mpumalanga province. Detailed information on the study area and Agincourt HDSS has been published previously [13,160, 169]. The study area, bordering the Kruger National Park in north-east South Africa, is divided into plots that are generally too small to support reasonable subsistence farming, and the level of income is low by South African standards [13, 160, 169]. In 2007, 3 489 black South African children and adolescents aged 1-20 years were randomly chosen from the Agincourt HDSS villages in a growth survey [160].
In 2009, we randomly selected 600 participants, in the 7- to 8-year; 11- to 12-year and 14- to 15-year age groups from this study (200 participants in each group). Ethical approval was granted by the University of the Witwatersrand Human Subjects Research Committee Clearance No. M090212, and from the Mpumalanga Provincial Department of Health. Permission from community leaders and school principals was also obtained. Signed informed consent was provided by the parents and assent given by the children.

3.2.2 Anthropometric measurements

Anthropometric measurements were performed according to standard procedures [203]. Heights were measured using a stadiometer calibrated to the nearest 0.1 cm. The participants were weighed to the nearest 0.1 kg using a digital bathroom scale. The equipment was checked and calibrated daily before use. The girls and boys were measured in separate classrooms. Waist circumference (WC) was measured using an inelastic tape measure midway between the tenth rib and the iliac crest. In 2007 and 2009, hip circumference (HC) was measured at the level of maximum width of the buttocks, with the participants standing [203]. Skin fold (triceps, biceps, subscapular and suprailiac) measurements were made to the nearest 0.2 mm using a reliable calliper. The triceps and biceps skin folds were consistently measured in the non-dominant arm.

Three measurements of triceps, biceps, subscapular and suprailiac skin fold thickness were taken, and the average of the four sites' measurements was used in the analysis. Participants with complete four skin fold measurements were included in the study (86.7%). Anthropometric measurements were performed by two trained fieldworkers. Both intra- and interobserver variability were measured before the study commenced and during its course. The anthropometric measurement variation remained below 2%. A male and a female were used in order to provide both the boys and girls with gender-specific assistance during measurement.

3.2.3 Pubertal assessment

Participants self-reported their pubertal development using a validated questionnaire for black South Africans based on the Tanner staging criteria [204]. Pubic hair was assessed in both the boys and girls, as well as breast development in the girls and genitalia in the boys, for this study. The subjects were classified as prepubertal if they were at Tanner stage 1, early pubertal if they were at Tanner stage 2 and mid pubertal if they were at Tanner stage 3. Owing to the small number of participants, Tanner stages 4 and 5 were combined to represent late pubertal [204].

3.2.4 Blood pressure measurements

Three measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken from participants after 5-10 minutes of quiet rest using an OmronR M6 blood pressure monitor (Omron, Kyoto, Japan). The first reading was discarded and the subsequent two readings were averaged for analysis. The blood pressure data were classified according to age-, sex- and height specific cut-off points, based on the National High Blood Pressure Education Program Working Group [196].

3.2.5 Biochemical measurements

Two trained nurses collected a 12 hour fasting venous blood sample from the participants in the morning, i.e. between 08h00 and 10h00, to determine glucose, cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol and triglyceride (TG) concentrations. The blood samples for glucose analysis were collected in grey top tubes containing sodium fluoride, while lipids were collected in clot activator tubes. Both were centrifuged. The plasma and the serum were separated and stored in a freezer at -70C in the Agincourt laboratory. The samples were later transported to Johannesburg, packed in dry ice, and stored at -70C until analysed. Both glucose and lipid profiles were measured using the chemiluminescence RXR daytona analyser (Crumlin Co, Antrim Northern Ireland) [205].

3.2.6 Data analyses

Age and sex appropriate z-scores for weight and height were generated using the World Health Organization (WHO) 2007 growth references [206]. BMI and BMI z-scores were calculated for each participant. Levels of overweight and obesity were determined using Cole's international BMI cut-off points [59]. The risk of adiposity was assessed using waist-to-hip ratio (WHR) of > 0.85 for females, > 0.90 for males, [207] waist-to-height ratio (WHtR) of > 0.5 for both sexes, [208] and WC of > 80 cm for the females and > 94 cm for the males. As these are adult cut-offs points, a conservative approach was chosen to apply the cut-off points for WHR and WC only to those participants in Tanner stage 3 or greater, as they would be closer to attaining their final adult height. However, this was not applied to WHtR.

In addition, impaired fasting glucose of > 5.6 mmol/l was calculated according to International Diabetes Federation standards [209]. The following cut-offs were used for abnormal lipids: HDL cholesterol of < 1.03 mmol/l, near optimal LDL cholesterol of $>$ 2.59 mmol/l, TGs of > 1.7 mmol/l and total cholesterol (TC) of > 5.17 mmol/l [8,197,198]. Pre-hypertension was defined as the average of the last two readings of SBP or DBP, being $>$ 90th but $<$ 95th percentile for age, sex and height [196]. Normally distributed continuous variables were expressed as means with standard deviation. Student's t-test was used to test for differences between the means by sex with a significance level of p-value < 0.05. The median and interquartile range is given for the sum of the skinfold thicknesses owing to skewness. The chi square test was used to test for significant associations between the categorical variables, while Fisher's exact test was used when the cell frequencies were < 5. Linear regression was employed to test associations. The statistical analyses were performed using Stata@ version 11.

Tab. 3.1: Characteristics of study participants by sex and age.

Variables	**7–8 years (n = 197)**			**11–12 years (n = 202)**			**14–15 years (n = 189)**		
	Boys	**Girls**	**p-value**	**Boys**	**Girls**	**p-value**	**Boys**	**Girls**	**p-value**
Mean age (years) (SD), n = 588	7.5 (0.5)	7.6 (0.5)	0.178	11.5 (0.5)	11.5 (0.5)	0.780	14.5 (0.5)	14.5 (0.5)	0.430
Mean weight (kg) (SD), n = 588	25 (4)	26 (6)	0.240	43 (11.3)	48 (13.1)	0.000*	51 (11.1)	55.3 (10)	0.003*
Mean height (cm) (SD), n = 588	126.3 (6.1)	127.5 (6)	0.16	145 (7)	149 (8)	0.000*	163 (8.6)	160 (5.5)	0.002*
Mean BMI (SD), n = 588	15.6 (1.7)	16 (2.5)	0.613	17 (2)	18 (3.4)	0.004*	19 (2.4)	22 (4.1)	0.000*
Mean WC (cm) (SD), n = 588	55.4 (4.3)	52.7 (5.2)	0.000*	60.3 (5.2)	60.6 (7.2)	0.780	67 (6.3)	68 (9.4)	0.351
Mean HC (cm) (SD), n = 588	63.2 (0.5)	65 (0.7)	0.142	72 (0.7)	80 (1)	0.000*	80 (1.3)	90 (1.2)	0.000*
Mean BP (mmHG) (SD), n = 588	99 (12)	95.5 (12.4)	0.074	98.3 (12.4)	106 (14.5)	0.000*	111 (12.3)	112.3 (10.7)	0.423
Mean DBP (mmHG) (SD), n = 588	58 (12.1)	58 (11.1)	0.907	59(8)	61.2 (12)	0.076	64 (8)	65 (7.4)	0.433
Sum of skin folds (mm) (SD), n = 588	5.3 (4.6-5.9)	6 (5.1-7)	0.000*	5.5 (4.8-6.2)	5.3 (4.4-4.6)	0.130	5.8 (5.1-6.8)	9 (7.4-9.8)	0.000*
Mean HDL cholesterol (SD), n = 588	1.1 (0.4)	1.3 (0.3)	0.032*	1.2 (0.3)	1.2 (0.3)	0.700	1.2 (0.3)	1.2(0.3)	0.770
Mean LDL cholesterol (SD), n = 588	2 (0.6)	2 (0.6)	0.560	2 (0.7)	2 (0.6)	0.174	2 (0.5)	2 (0.6)	0.335
Mean TGs(mmol/l) (SD), n = 588	0.8 (0.3)	0.8 (0.3)	0.830	0.8 (0.3)	1 (0.5)	0.185	0.8 (0.3)	0.8 (0.3)	0.220
Mean TC (mmol/l) (SD), n = 588	4 (0.7)	4.1 (0.8)	0.242	4.1 (0.8)	4.2 (0.8)	0.111	3.8 (0.6)	4 (0.7)	0.145
Mean glucose (mmol/l) (SD), n = 588	4.6 (0.8)	4.7 (0.8)	0.520	5 (0.7)	4.6 (1.1)	0.200	5 (0.6)	4.8 (0.5)	0.070

*statistical significant

BMI: body mass index, DBP: diastolic blood pressure, HC: hip circumference, HDL: high-density lipoprotein, IQR: interquartile range, LDL: low-density lipoprotein, SBP: systolic blood pressure, SD: standard deviation, TGs: Triglycerides, TC: total cholesterol, WC: waist circumference

3.3 Results

3.3.1 Characteristics of participants

Twelve of the original 600 children were not in residence at the time of the study, thus 588 (98%) were seen. Fasting venous blood samples were only obtained from 387 (66%) participants because assent was not given for venipuncture (25.5%), or owing to an inability to obtain a blood sample (8.5%). Table 3.1 presents the general characteristics of the study sample by sex and age. The 11- to 12-year-old females were slightly heavier and taller than the males, while the 14- to 15-year-old girls were shorter and heavier than the boys. The girls' BMI was significantly greater at ages 11 and 12 years than that of the boys [girls: 18 ± 3.4, 95% confidence interval (CI): 17.33- 18.69; boys: 17 ± 2, 95% CI: 16.46-17.25; p-value 0.004] and at ages 14-15 years (girls: 22 ± 4.1, 95% CI: 20.82-22.47; boys: 19 ± 2.4, 95% CI: 18.39-19.38; p-value < 0.001). The younger girls, aged 7-8 years, had a smaller WC (p-value < 0.001), while the girls aged 11-12 years and 14-15 years had a larger HC than the boys (p-value < 0.001). The sum of the skin fold measurements for the girls in the 7- to 8-year-old, and 14- to15-year-old, groups, was significantly higher than that for the boys.

3.3.2 The prevalence of under- and overnutrition

Table 3.2 displays the prevalence of malnutrition and the metabolic risk characteristics of study participants by sex. Significantly, more boys (6.2%) than girls (2.7%) were stunted (p-value 0.04), and a similar sex prevalence of underweight was noted (4.1% of the boys and 4.4% of the girls). In the three age groups, stunting was significantly greater in boys (4.2%) than in girls (0.5%) aged 14-15 years (p-value 0.031), while 4.5% vs. 3.5% (11- to 12-year-old) and 0.5% vs. 0% (7- to 8-yearold) boys and girls were stunted, respectively. The prevalence of underweight was higher in the 11- to 12-year-old girls (4%) than it was in the boys (2.5%), and higher in the boys than in the girls aged 14-15 years (2.6% vs. 1.6%). The prevalence of underweight in the 7- to 8-year-old age group was 1% for both the boys and girls, respectively. The prevalence of wasting was 1.3% in the boys compared to (0.3%) in the girls aged 7-8 years. There were no significant differences by sex in underweight in the three age groups and wasting in the 7- to 8-year-old age group. The prevalence of combined overweight and obesity was significantly higher in the girls than in the boys (13.5% and 2.7%, respectively, p-value < 0.001).

Tab. 3.2: Prevalence of malnutrition and metabolic risk factors according to sex.

Variables	**Boys (n=292)**	**Girls (n=296)**	**p-value, χ^2**
Mean age in years (SD)	11.1 (3)	11.1 (3)	0.840
*HAZ < -2 SD: stunted n (%)	18 (6.2)	8 (2.7)	0.041, 4.168
*WAZ < -2 SD: underweight, n (%)	12 (4.1)	13 (4.4)	0.865, 0.030
*WHZ < -2 SD: wasted, n (%)	3 (1)	1 (0.3)	0.310, 1.035
*BMI 25-29.9 kg/m^2: overweight, n(%)	6 (2.1)	31 (10.5)	0.000, 17.700
*BMI $\geq$ 30 kg/m^2: obese, n(%)	2 (0.7)	9 (3)	0.035, 4.443
*BMI $\geq$ 25 kg/m^2: overweight and obese, n(%)	8 (2.7)	40 (13.5)	0.000, 22.800
WHtR > 0.5, n(%)	39 (13.4)	49 (16.6)	0.277, 1.181
TC (borderline high): 5.17-6.18 mmol/l, n = 388, n (%)	3 (1.5)	16 (8.5)	0.002, 10.077
TGs > 1.7 mmol/l, n=388, n(%)	3 (1.6)	8 (4.01%)	0.110, 2.560
Pre-hypertensive SBP and DBP, n=523, n(%)	26 (10)	40 (15)	0.051, 3.100
IFG (FG > 5.6 mmol/l), n=357, n(%)	9 (5)	9 (5.3%)	0.522, 0.034

*Derived from age-specific z-scores
χ^2: Chi square, BMI: body mass index, DBP: diastolic blood pressure, FG: fasting glucose, HAZ: height-for-age z-scores, IFG: impaired fasting glucose, SBP: systolic blood pressure, SD: standard deviation, TC: total cholesterol, TGs: triglycerides, WAZ: weight-for-age z-scores, WHtR: waist-to-height ratio, WHZ: weight-for-height z-scores.

3.3.3 Risk factors for metabolic disease

Indicators of adiposity in the participants at Tanner stage 3 or greater highlighted that 2.2% of the girls and none of the boys had a WC above the adult risk cut-off point. WHR was higher in the girls (17.2%) than in the boys (2%, p-value < 0.001). Across all of the participants, 13.4% of the boys and 16.6% of the girls had a WHtR above the cut-off point (Table 3.2). Just over 5% of the boys and girls had impaired FG. Using TC concentrations, more girls (8.5%) than boys (1.5%) had levels above the normal range in the borderline high category (p-value 0.002) (Table 3.2). 0.7% of the boys and 12% of the girls had concentrations of HDL cholesterol less than 1 mmol/l, which is indicative of cardiometabolic risk. Only 2.3% of the girls had borderline high LDL cholesterol concentrations, and 13.1% of the girls and 8.7% of the boys had near optimal LDL cholesterol concentrations. There were no mean differences by sex for LDL and HDL cholesterol and triglycerides.

Pre-hypertension, using either SBP or DBP, for sex, age and height was 15% and 10% in the girls and boys, respectively. The figures were similar across the age groups. After adjusting for sex and the pubertal stages of development, SBP was associated with indicators of obesity and adiposity [sum of the skin folds (p-value < 0.001), BMI (p-value 0.03) and WC (p-value 0.06] (Table 3.3).

Tab. 3.3: Factors associated with blood pressure adjusted for sex and pubertal stage (linear regression).

SBP (mmHg), n = 523	β	**95% CI**	**p-value**
BMI (kg/m^2)	0.80	0.08-1.50	0.030*
Sum of skin folds (mm)	3.56	2.38-4.74	0.000*
WC (cm)	0.28	− 0.18-0.58	0.066
HC (cm)	0.00	− 0.01-0.03	0.515
DBP (mmHg), n = 523	β	95% CI	**P-value**
BMI (kg/m^2)	0.12	− 0.20-0.62	0.636
Sum of skin folds (mm)	− 0.32	− 1.22-0.60	0.490
WC (cm)	0.20	− 0.11-0.31	0.372
HC (cm)	0.00	− 0.00-0.02	0.366

*statistically significant
BMI: body mass index, CI: confidence interval, DBP: diastolic blood pressure, HC: hip circumference, SBP: systolic blood pressure, WC: waist circumference

3.3.4 Characteristics of the study participants stratified by sex and Tanner stages of pubertal development

Table 3.4 summarises the anthropometry characteristics, and lipid profiles and blood pressure by Tanner stages of pubertal development (n = 574, 2% declined). Significant sex differences were observed with respect to height in the children at the pre- and late pubertal stages, while girls had a smaller WC in the pre-pubertal group. Girls' BMI and HC values were significantly higher than that of the boys at the early (p-value 0.031 and p-value < 0.001), mid (p-value 0.002 and p-value 0.004), and late (p-value < 0.001) pubertal stages. The female participants had a higher sum of skin fold measurements during the pre-, mid and late pubertal stages (p-value < 0.001, p-value 0.002 and p-value 0.001, respectively) (Table 3.4). There was no difference in the lipid profile with advancing puberty. However, there were significant differences between the sexes in certain pubertal stages. In particular, girls had higher LDL cholesterol than the boys at the mid-pubertal stage (girls: 2 $\pm$ 0.6, 95% CI: 1.82-2.17; boys: 1.7 $\pm$ 0.5, 95% CI: 1.54-1.91, p-value 0.030), and the girls had a higher TC mean at the early pubertal stage than the boys (girls: 4.2 $\pm$0.7, 95% CI: 3.95-4.5; boys: 3.8 $\pm$ 0.7, 95% CI: 3.59-4.10, p-value 0.050) and at the mid-pubertal stage (girls: 4.2 $\pm$ 0.7, 95% CI: 3.83-4.23; boys: 3.7 $\pm$ 0.7, 95% CI: 3.52-3.94, p-value 0.045) (Table 3.4). Female participants had a higher BMI, BMI-for-age z-score, and HC (p-value < 0.001) than males as they progressed through puberty, while boys had a higher WC than the girls (p-value < 0.001). A difference in blood pressure between the boys and the girls (p-value 0.021) was only found at mid-puberty.

Tab. 3.4: Characteristics (means (SD)) of the study participants stratified by sex and Tanner stages of development.

Tanner stages	**Pre-pubertal**			**Early pubertal**			**Mid-pubertal**			**Late pubertal**		
	Boys n=147	**Girls n=116**	**p-value**	**Boys n=46**	**Girls n=51**	**p-value**	**Boys n=54**	**Girls n=70**	**p-value**	**Boys n=38**	**Girls n=52**	**p-value**
Mean age (years) (SD), n = 574	9 (2.3)	8.2 (1.5)	0.001	12.2 (1.3)	12 (1)	0.071	13.53 (1.5)	13.3 (1.4)	0.344	14.4 (0.9)	14.4 (0.8)	0.850
Mean weight (kg) (SD), n = 574	28.6 (7.2)	26.6 (6)	0.012	37.3 (8)	42 (10)	0.013	46.1 (9.2)	48.2 (8)	0.170	54 (12)	60.1 (13)	0.022
Mean height (cm) (SD), n = 574	133 (11.3)	130 (8.1)	0.023	147 (8.4)	149.4 (8)	0.135	158.2 (10.3)	157 (7)	0.337	166 (8.2)	160 (6)	0.000
Mean BMI (kg/m^2) (SD), n = 574	16 (2)	16 (2.3)	0.172	17.1 (2.3)	18.4 (3.4)	0.031	18.2 (2.1)	20 (3)	0.002	20 (3)	23.5 (5)	0.000
Mean WC (cm) (SD), n = 574	57.1 (5.5)	53 (5)	0.000	61 (6)	61.3 (7.2)	0.783	65 (6)	64 (7.1)	0.476	68 (7)	71 (10)	0.158
Mean HC (cm) (SD), n = 574	65.8 (0.6)	65.3 (0.7)	0.526	73 (0.6)	80 (1)	0.000	78 (1.2)	84 (1.2)	0.004	81 (1.4)	93.4 (1.1)	0.000
Mean HDL cholesterol (mmo/l), (SD), n = 371	1.2 (0.3)	1.2 (0.4)	0.250	1.3 (0.3)	1.2 (0.3)	0.888	1.2 (0.3)	1.2 (0.3)	0.600	1.2 (0.2)	1.2 (0.3)	0.638
Mean LDL cholesterol (mmo/l), (SD), n = 367	1.9 (0.6)	1.9 (0.6)	0.905	1.8 (0.6)	2 (0.7)	0.244	1.7 (0.5)	2 (0.6)	0.030	1.8 (0.5)	1.8 (0.6)	0.763
Mean TC (mmo/l) (SD), n = 388	4 (0.7)	4.1 (0.8)	0.800	3.8 (0.7)	4.2 (0.7)	0.050	3.7 (0.7)	4 (0.7)	0.045	3.7 (0.5)	3.9 (0.7)	0.140
Mean TGs (mmo/l) (SD), n = 388	0.8 (0.3)	0.8 (0.3)	0.773	0.8 (0.2)	1 (0.6)	0.180	0.8 (0.3)	0.8 (0.3)	0.900	0.7 (0.2)	0.8 (0.3)	0.180
Mean glucose (mmo/l) (SD), n = 357	4.7 (0.7)	4.6 (1)	0.270	5 (0.5)	4.5 (1.3)	0.200	5 (0.8)	4.7 (0.6)	0.350	5 (0.8)	5 (0.5)	0.423
Mean SBP (mmHG) (SD), n = 523	96.6 (12.9)	99.3 (14)	0.141	101 (13.2)	125 (13.8)	0.240	106 (11)	111 (12.2)	0.021	113.3 (14.6)	112.2 (10.3)	0.700
Mean DBP (mmHG) (SD), n = 523	59(11)	59(12)	1.000	60(9.5)	61.2(12)	0.500	62.3(7.3)	62(8.1)	0.850	64.0(8.1)	67(7)	0.057
Sum of skin-fold (mm) Median (IQR), n = 503	5.3(4.6-6)	5.9(5-7)	0.000	5.8(5.3-6.3)	5.9(4.4-6.8)	0.942	5(4.6-6.8)	7(5.3-9)	0.002	5.6(5.1-6.9)	9.3 (7.4-10)	0.000

*statistically significant
BMI: body mass index, DBP: diastolic blood pressure, HC: hip circumference, HDL: high-density lipoprotein, IQR: interquartile range, LDL: low -density lipoprotein, SBP: systolic blood pressure, SD: standard deviation, TGs: Triglycerides, TC: total cholesterol, WC: waist circumference.

Table 3.5 presents changes in the various anthropometric parameters with regard to FG, TGs and HDL cholesterol from 2007-2009. A change in HC and WC was significantly associated with FG (β 0.01, p-value 0.020 and β 0.01, p-value 0.002, respectively). A change in WC and WHtR was significantly associated with TGs (β 2.4, p-value 0.050 and β 0.02, p-value 0.050, respectively). Also, a change in WC and HC was significantly associated with HDL cholesterol ($\beta -2.7$, p-value 0.050 and $\beta -4.1$, p-value 0.053, respectively). However, a change in the BMI and BMI-for-age z-score was not significantly associated with FG, TGs and HDL cholesterol. Examining the changes in anthropometric measures over two years revealed that indicators of central adiposity were positively associated with glucose concentrations and TGs in the participants.

Tab. 3.5: The correlation between fasting glucose, triglycerides and high-density lipoprotein cholesterol and a change in body mass index and BMI-for-age z-score, hip and waist circumference, and waist-to-height ratio from 2007-2009.

Variables	β	**95% CI**	**t**	**p-value**
FG (mmol/l) (n = 312)				
Change in BMI (kg/m^2)	0.13	-0.085 to 0.350	1.20	0.233
Change in BMI-for-age z-score	0.08	-0.050 to 0.204	1.20	0.233
Change in HC (cm)	0.01	0.001 to 0.013	2.37	0.020*
Change in WC (cm)	0.01	0.006 to 0.024	3.17	0.002*
Change in WHtR	0.01	-0.000 to 0.160	1.84	0.070
TGs (mmol/l) (n = 388)				
Change in BMI (kg/m^2)	-0.12	-0.60 to 0.040	-0.50	0.644
Change in BMI-for-age z-score	-0.10	-0.40 to 0.230	-0.50	0.644
Change in WC (cm)	2.4	0.053 to 4.800	2.01	0.050*
Change in HC (cm)	3.1	-0.056 to 6.83	1.67	0.096
Change in WHtR	0.02	0.000 to 0.033	2.01	0.050*
HDL cholesterol (mmol/l) (n = 367)				
Change in BMI (kg/m^2)	0.03	-0.055 to 0.610	0.10	0.920
Change in BMI-for-age z-score	0.02	-0.022 to 0.357	0.10	0.920
Change in WC (cm)	-2.7	-5.340 to -0.034	-2.01	0.050*
Change in HC (cm)	-4.1.	-8.200 to 0.560	-2.0	0.053*
Change in WHtR	-0.013	-0.032 to 0.005	-1.35	0.176

*statistically significant
BMI: body mass index, CI: confidence interval, FG: fasting glucose, HC: hip circumference, HDL: high-density lipoprotein, TGs: triglycerides, WC: waist circumference, WHtR: waist-to-height ratio

3.4 Discussion

To our knowledge, this is the first study that has examined both malnutrition and metabolic disease risk factors in South African children aged 7-8, 11-12 and 14-15 years.

National South African and cross-sectional studies have reported the coexistence of under and overnutrition in children and adolescents [8, 13, 56, 58, 63, 64, 116, 202]. However, limited information exists on the prevalence of metabolic disease risk factors in rural children [13, 134].

In this study, the prevalence of undernutrition in children aged 7-8 years was lower than the national prevalence in rural children [8, 56]. Our findings of a higher prevalence of stunting in 11- to 12- and 14- to 15-year-old boys than in girls is similar to an earlier study on adolescence [49]. However, this stunting prevalence was lower than that reported in the National Youth Risk Behaviour Survey in 2008 [70]. This higher prevalence of stunting in boys may be owing to a combination of nutrition and other factors. There was no evidence that there were significant household socio-economic differences between the sexes (unpublished data). Further investigation into dietary patterns and intake is warranted [31, 160, 169]. The difference in stunting prevalence between the boys and girls may, in part, be explained by the fact that there is some evidence that urban black, South African adolescent boys have a later onset of pubertal development and skeletal maturity (Birth to Twenty longitudinal data, unpublished) than their white peers. If this is the case, in this rural setting, a comparison of height with the WHO reference could result in a temporal overestimate of stunting as the rural boys may be in an earlier stage of maturity generally.

The prevalence of overnutrition in this study was also lower than that observed in the recent (SANHANES) study on 15- to 17-year old adolescents [8]. However, our study, which is consistent with other studies, found that overweight and obesity were greater in the girls than in the boys [13, 58, 58]. The differences in overnutrition by sex in this study may be owing to differences in physical activity levels [31]. Our data have demonstrated that moderate to vigorous physical activity was significantly higher in older male subjects than in female subjects, and that informal activity was lower in the boys than the girls, while sedentary time was higher in the older girls (aged 14-15 years) than in the younger girls (aged 11-12 years) [31]. Also, there has been increasing temporary rural-urban migration [178] and availability of fast food vendors in this area [144]. The increasing prevalence of childhood obesity may have potential long-term medical risks, such as type 1 and type 2 diabetes mellitus, cardiovascular disease, orthopaedic complications [156] and new-onset asthma [155].

Global trends indicate that pre-hypertension is on the rise in children and adolescents [210, 211]. Given that pre-hypertension is strongly predictive of future hypertension and the development of other noncommunicable diseases, [210, 212] the prevalence of 12.6% in this study on children is of concern. Furthermore, it was surprising to detect the levels of impaired FG and abnormal lipid profiles in this rural population at these younger ages. The factors that were associated with SBP in this study, e.g. glucose concentrations and lipid profile, are indicators of adiposity: both subcutaneous (sum of the skin folds) and abdominal (WC). Therefore, changes in adiposity during childhood, and with pubertal development, as seen in the girls, confer metabolic disease risk [213].

A study on children in the USA found that the percentage of fat, as measured by skin folds, related to metabolic risk factors, such as lipids, blood pressure and C-reactive protein [214]. In our study, we observed that the percentage of fat was associated with impaired fasting glucose, low HDL cholesterol and high LDL cholesterol, as well as TC.

This study could have a limitation in that 30% of the sample were of Mozambican origin, thus resembling major differences (maternal socio-economic status and other distal measures) from the core sample that mainly comprised South Africans. The strengths of our study were the longitudinal assessment of body composition and its relationship to metabolic disease risk in a rural setting in South Africa. In addition, the measurements were performed by experienced fieldworkers who followed standardisation procedures used in the Birth to Twenty longitudinal cohort. However, the results of this study cannot be overly extrapolated to other rural settings or population groups. Nevertheless, as this study community represents relatively poor rural villages with little subsistence farming, it is reasonable to assume that other rural villages that are further along the nutrition transition may have even higher metabolic risk factors than those observed in this study. Future research is warranted to investigate early signs of metabolic risk factors in South African children longitudinally, and to identify which environmental factors contribute to metabolic disease risk.

3.5 Conclusion

This study highlights a rural area in which late childhood undernutrition was present, but less than overnutrition, particularly in girls. The emergence of early pre-hypertension risk was concerning, as well as the higher-than-expected levels of impaired fasting glucose and abnormal lipid profiles, particularly in the girls. The implication is that rural South African communities are mirroring more urban environments in terms of metabolic risk profiles, which are indicative of a rapid nutritional and economic transition. Therefore, it is critical that health-promotion initiatives recognise that early childhood is a window of opportunity from which to ensure that children remain on a healthy journey to adulthood. Thus, risk-reduction policies need to be implemented in order to stem the advance of obesity and metabolic disease risk, as recommended by the WHO. This can be achieved through revitalised school health programmes, such as the early introduction of nutrition education, ensuring that children have access to healthy foods at schools and within the school vicinity, as well regulating "junk food" advertisements in the media that target children. In addition, children and adolescents should be encouraged to spend more time in physical activity, both at school and at home.

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4. PART 3:CHAPTER 4 – EMPIRICAL PAPER 2

Body Image Satisfaction, Eating Attitudes and Perceptions of Female Body Silhouettes in Rural South African Adolescents

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4.1 Introduction

Adolescence, a period of transition from childhood to adulthood, is characterised by psychological, physical and social changes [215]. Considerable research has been conducted on body image, eating disorders and other weight-related behaviours among adolescent girls and young women living in developed countries [216–218], with few research studies being done in low-to-middle income countries [73, 89, 90, 219]. The decreasing age at which body image dissatisfaction and disordered eating attitudes occur in adolescence is of public health concern globally [91, 94, 220], due to physiological and psychological health problems [221].

It is widely accepted that girls are at greater risk of body dissatisfaction and eating disorders [216], and that both a low and a high body mass index (BMI) have been shown to influence weight control behaviours [73, 86, 88]. Underweight boys who experience muscle dysmorphia may engage in weight control behaviours to gain weight and increase muscle mass [86] while overweight girls engage in other behaviours to lose weight, both leading to the development of eating disorders [221]. In addition, body dissatisfaction has been shown to be strongly related to societal norms, culture and ethnicity [86]. Increasing globalisation and exposure to a 'Western' ideal of thinness through the media [94, 216], which often differs from traditional beliefs, creates even greater conflict within the adolescent.

Traditionally, a larger figure has been considered desirable in African culture, as it represents wealth, beauty, and the absence of illness [82, 85, 93], however, recent studies have reported an increasing risk of eating disorders in urban Black South African children and adolescents [82–84]. Evidence from South Africa is conflicting as some studies have reported an increasing number of urban South African adolescents with a desire to be

thin [89, 91], while Puoane et al. [89] have shown that among 10 - 19 year old Black girls living in Cape Town, there is still a desire for a higher BMI.
Few studies [90, 95, 222] have been conducted on eating attitudes and body image in adolescents from South African rural communities who have recently been shown to be at high risk of overweight and obesity [13,64], the prevalence of which is expected to increase as these communities continue along the nutrition transition [8]. In this study, we aim to examine BMI, disordered eating attitudes, female body dissatisfaction and descriptive attributes assigned to silhouettes of varying sizes, amongst male and female adolescents in rural South Africa.

4.2 Methods

4.2.1 Sample and study setting

Data for this study were collected in rural villages in the Agincourt sub-district, located in the north-eastern part of South Africa, close to the border with Mozambique. The Agincourt Health and Socio-Demographic Surveillance System (HSDSS) was established in 1992 and collects prospective data on the community living in the Agincourt sub-district of Mpumalanga Province, South Africa. The land is subdivided into plots too small to support subsistence farming and includes 27 villages in total, with 90 000 people and 20 000 households [13,14,169]. Further, despite current government initiatives, infrastructure in the area is still limited and the level of income is generally low by South African standards (73% of households earn less than ZAR 9600 per annum) [13,169]. In 2009 [14], participants (n=600; age range 7 to 15 years (200 subjects in each group)), were randomly selected from 3489 Black South African children and adolescents (aged 1- to 20 years), who had participated in a 2007 growth survey [13]. Analysis for this study were limited to participants between 11- and 15 years of age (n=385, 190 boys and 195 girls). Data for the 7/8 year old age group were not included due to their poor comprehension and understanding of the questionnaires. Ethical approval was granted by the University of the Witwatersrand Committee for Research on Human Subjects (Medical, M090212) and from the Mpumalanga Provincial Government Department of Health. Permission from the community leaders and schools principals, and written parental consent were obtained and assent was given by all participants. Interviews were conducted in participant's local language by carefully trained staff at designated schools.

4.2.2 Measures

Height was measured using a stadiometer (Holtain, UK), calibrated in centimetres. Participants were measured without shoes, but with light socks, in a standing position with their hands parallel to their bodies and with the back of the head touching the vertical board of the stadiometer. The participants were weighed to the nearest 0.1kg, wearing light clothing and without shoes, using a mechanical bathroom scale (Hanson; Bathroom Trends Limited, Epson, UK). BMI was calculated as weight in kilograms (kg) divided by the height in meters squared (m^2) and underweight, normal weight and overweight and obesity were determined using International Obesity Task Force age and sex specific BMI cut-off points [59]. Pubertal assessment was measured using the Tanner 5-point pubertal self rating scale, which has been validated previously in Black South Africans [223]. Breast development in girls and genital development in boys were assessed and used to classify participants as early pubertal ($\leq$Tanner stage 2), and mid to post pubertal (Tanner stage > 2) [223].

Body image satisfaction was measured using Stunkard's silhouettes, which have previously been validated in South African adolescent females [93]. These silhouettes were presented randomly with each sheet of paper containing one image. From the eight body silhouettes presented to them, each female participant was required to select a body silhouette representing their current body shape (feel figure), and the body shape that they desire (ideal figure). The body silhouettes were coded 1 to 8 (from the thinnest to the fattest). Body image dissatisfaction was determined using the Feel-Ideal Discrepancy (FID) scores and which was calculated by subtracting the number of the ideal body silhouette from the feel body silhouette. Zero, positive and negative scores indicated contentment with body shape, desire to be thinner, and desire to be fatter, respectively [85, 93].

Further, the 8 silhouettes were randomly placed on a table and each of the participants (boys and girls) were asked to associate different body shapes from different silhouettes presented to them. Descriptions included the "best, worst, clumsy, has more respect, has less respect, the strongest, the weakest, the happiest and unhappy". The silhouettes were coded from 1 (thinnest) to 8 (biggest) and then grouped into 4 categories; silhouettes 1 and 2 (underweight), 3 and 4 (normal), 5 and 6 (overweight) and 7 and 8 (obese) [73].

The 26-item Eating Attitudes Test (EAT-26) was used to evaluate the adolescents' risk of a future eating disorder [224]. The EAT-26 has been widely used and has been shown to be valid in both rural and urban South African children [95, 96]. EAT-26 consists of 26-

items scored on a Likert scale (0 - never to 6 -always) and the items are summed to obtain an overall score (range=0-78). Adolescents with an overall score 20 are considered to be at risk of developing a future eating disorder. The three sub-scores of the EAT-26 were used to evaluate dieting, bulimia and food preoccupation, and oral control. The internal consistency (Cronbach Alpha) of the EAT-26 questionnaire and EAT-26 sub-components were low (0.50 - 0.60). Further examination revealed that some questionnaire items may have been poorly understood. In particular: (i) I am terrified about being overweight; (ii) I avoid eating when I am hungry; (iii) I am aware of the calorie content of foods that I eat; (iv) I engage in dieting behaviour.

4.2.3 Data analyses

All the statistical analysis were completed using STATA version 11 (StataCorp, Texas, USA). Using Student *t*-tests, differences between pubertal stage of development and sex were computed for normally distributed data (weight, height and BMI). The results were expressed as mean ± standard deviation (SD). The Wilcoxon-Mann-Whitney test was used to determine significant differences by sex and by pubertal stages for EAT-26 and EAT-26 sub-scores which were not normally distributed and the median and inter-quartile ranges (IQR) were reported. A one-way analysis of variance (ANOVA) test was used to evaluate if there were significant differences in BMI between body image dissatisfaction groups, with the post-hoc Bonferroni test to determine where significant differences exist. Pearson's chi-squared tests were used to determine significant differences between categorical variables (i.e. EAT-26 scores $<$ or $\geq$ 20, BMI and FID categories, and perceptual female silhouettes) between pubertal groups, and boys and girls and the percentages (%) were reported. The significance level was set at $P<0.05$.

4.3 Results

The descriptive characteristics of the participants by sex and pubertal stage of development are presented in 4.1. A total of 44.7% participants were classified as early pubertal (12.4±1.1 years of age) and 55.3% participants (14.5±1.3 years of age) were classified as mid to post pubertal. Within the early pubertal group, boys were significantly older than the girls in the same pubertal group, but there were no significant differences in weight, height or BMI between boys and girls in the early pubertal stage. Within the mid to post pubertal group, there was no significant difference in age, however, the girls were significantly heavier and shorter and had a higher BMI than the boys. Mid to post pubertal boys and girls were significantly older, heavier, taller, and had a higher BMI than their early pubertal counterparts (all $p<0.001$).

Tab. 4.1: Subjects characteristics by sex and pubertal stages of development.

Variables	**Early pubertal stage (Tanner stages 1 & 2)**		**Significant differences by sex**	**Mid to post pubertal stage (Tanner stages > 2)**		**Significant differences by sex**	**Significant differences by pubertal stages (A & B)**
	Boys (N=99)	**Girls (N=73)**		**Boys (N=91)**	**Girls (N=122)**		
Age (years)	12.6±1.2	12.2±1.0	**0.024**	14.5±1.4	14.4±1.3	0.547	
Weight (kg)	36.4±7.1	38.7±1.0	0.074	49.4±11.1	53.3±12.0	**0.016**	**0.001**^{A,B}
Height (cm)	146.0±8.1	147.5±8.0	0.203	161.4±10.1	158.1±6.4	**0.004**	**0.001**^{A,B}
BMI (kg/m^2)^a	17.0±2.0	17.5±3.3	0.198	19.0±2.6	21.2±4.0	**0.001**	**0.001**^{A,B}
*__EAT 26 scores__	10 (6 - 15)	12 (6 - 17)	0.180	12 (9 - 15)	10 (6 - 14)	0.067	0.833^A, 0.833^B
*__EAT 26 subcomponents scores__	**(N=95)**	**(N=66)**		**(N=89)**	**(N=112)**		
Dieting	4.8 (2 - 7)	4.9 (3 - 6)	0.871	5.5 (3 - 7)	5.1 (3 - 7)	0.174	0.516^A, 0.385^B
Bulimia and food preoccupation	2.4 (0 - 4)	2.0 (0 - 3)	0.424	2.4 (0 - 3)	1.8 (0 - 3)	0.064	0.618^A, 0.533^B
Oral control	3.4 (0 - 6)	4.7 (1 - 7)	**0.024**	3.9 (1 - 6)	3.4 (1 - 6)	0.015	0.921^A, 0.115^B
Underweight Normal weight Overweight and obesed combined	4(4.0%) 93(94.0%) 2(2.0%)	7(9.6%) 58(79.3%) 8(11.1%)	0.01 (χ^2=8.802)	6(6.6%) 82(90.1%) 3(3.3%)	4(3.3%) 94(77.1%) 24(19.7%)	0.001 (χ^2=13.332)	0.452^A, 0.179^B
*__EAT-26 Cut-offs__							
EAT-26 score < 20 EAT-26 score ≥ 20	85(89.5%) 10(10.5%)	59(89.4%) 7(10.6%)	0.978	82(92.1%) 7(7.1%)	103(92.0%) 9(8.0%)	0.965	0.701^A, 0.547^B

All values are presented as means ± standard deviation (SD) for normally distributed data (Student t test), median IQR reported for non normally distributed data and n(%) for categorical data. Comparison by sex and pubertal stages were completed using the Wilcoxon-Mann-Whitney test (median, IQR reported). χ^2-tests were used to determine significant differences for BMI and EAT-26 cut-offs categories. A - Significant differences between early and mid-post pubertal stage in boys. B - Significant differences between early and mid-post pubertal stage in girls. *Variation in sample size due to missing information. [a]IOTF age and gender specific BMI cut-offs for age 12.5 and 14.5 years adolescent boys and girls [59].

In Table 4.1, the percentage distribution of participants in the BMI categories of underweight, normal weight, and overweight/obese are shown for the boys and girls in the two pubertal groups. Although there were significant differences between the boys and girls categorised as underweight, normal weight and overweight/obese in both pubertal groups, there were no differences between the pubertal groups.

For the total sample of girls (n=188), the majority (58%) had a positive FID score, which is associated with a desire to be thinner, while 25.5% had a negative FID score, which is associated with a desire to be fatter, and 16.5% were satisfied with their bodies. The majority (83.5%) of the girls demonstrated body dissatisfaction. Within the early pubertal girls, 20% were satisfied with their current body size, while 18.6% had a negative FID score and 61.4% had a positive score. The majority 85.6% of mid to post pubertal girls were dissatisfied with their body size (55.9% had a positive FID score and 29.7% had negative FID score) and 14.4% were satisfied with their bodies. There was no difference between the pubertal groups for FID category (Fig.4.1).

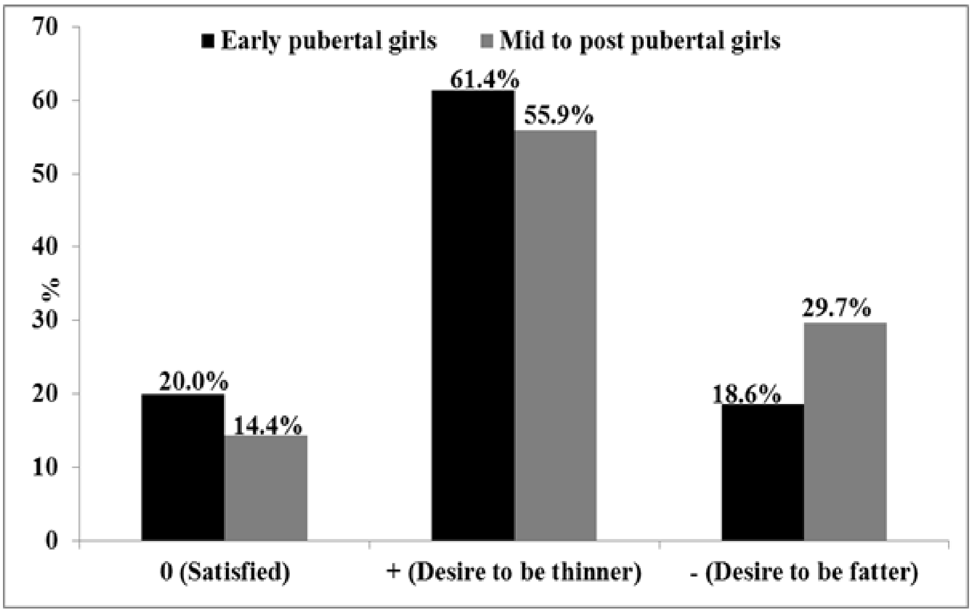

Fig. 4.1: Female adolescents' body image dissatisfaction.

Examination of the relationship between BMI and body dissatisfaction is presented in Table 4.2. There was a consistent trend, where girls in both pubertal groups who had negative FID score (desired to be fatter) had the highest body mass index and girls who desired to be thinner had the lowest body mass index in their respective pubertal groups. There was a significant difference in BMI between participants who desired to be fatter, and those who were satisfied with their current body sizes, and the girls who wished to be thinner (all p<0.001) (Table 4.2).

Tab. 4.2: Difference in BMI between the FID categories.

	Early-Pubertal Girls (n=70)	**Mid to Post-Pubertal Girls (n=118)**	**P-value**
	Mean±sd	**Mean±sd**	
Desire to be fatter	20.41±4.1 [n=13]	23.81±4.9 [n=35]	0.001^{C}
Satisfied	17.35±1.7 [n=14]	21.04±2.7 [n=17]	
Desire to be thinner	16.68±3.0 [n=43]	19.89±3.1 [n=66]	0.001^{D}

Values are presented as means ± standard deviation (SD) using ANOVA (one-way).
C - Significant differences in BMI between girls who desired to be fatter and those girls who are satisfied with their current body sizes.
D - Significant differences in BMI between girls who desired to be thinner and those girls who are satisfied with their current body sizes.

Tab. 4.3: Characteristics of Stunkard's silhouettes chosen by early and mid to post pubertal girls to represent different dimensions of body image.

Silhouettes	**Early vs. Mid to Post-Pubertal Girls (Mean±sd)**			**P-value**
Feel body image	3.0±1.6 vs. 3.5±1.4			0.331
Ideal body image	4.3±1.8 vs. 4.1±1.5			**0.045**
FID scores	1.3±1.9 vs. 0.5±1.8			0.244
	BMI Categories			
	Early vs. Mid to Post-Pubertal Girls (Mean±sd)			
Silhouettes	**Underweight**	**Normal weight**	**Overweight & obesed**	**P-value**
Feel body image	1.9±1.5 vs. 2.5±0.6	3.0±1.5 vs. 3.3±1.3	4.1±1.5 vs. 4.5±1.5	0.669
Ideal body image	4.8±1.9 vs. 3.5±0.6	4.3±1.9 vs. 4.1±1.4	3.8±1.0 vs. 4.0±1.5	0.637
FID scores	3.0±1.0 vs. 1.0±0.8	1.2±1.9 vs. 0.7±1.6	0.4±1.8 vs. -0.5±2.0	0.399

Values are presented as means ± standard deviation (SD) using ANOVA (one-way).

The difference in FID scores which represent the feel and ideal body image and the FID score chosen by early and mid to post pubertal girls are presented in (Table 4.3). The silhouettes chosen by the early pubertal girls to represent the ideal body image had a significantly higher score than that chosen by the mid to post pubertal girls (p=0.045). There was no difference in the chosen feel body image or the FID scores between the pubertal groups. The majority of early (78.6%) and mid to post pubertal (77.1%) girls chose silhouettes (3 - 4) which represented a normal BMI. When dividing the girls according to their BMI category, among overweight/obese participants, 11.4% of early pubertal chose silhouettes (3 - 5) and 19.5% of mid to post pubertal girls selected silhouettes (4 - 5), representing "normal and overweight" BMI category as their feel body image. Among underweight participants, 10% of early pubertal girls chose silhouettes (4 - 5) representing "normal and overweight" BMI category and 3.9% of mid to post pubertal girls chose normal silhouettes (3 - 4) as their ideal body image (Table 4.3).

Differences in EAT-26 total scores and EAT-26 sub-components (dieting, bulimia and food preoccupation and oral control) between the sexes and between pubertal groups were not significant, however the early pubertal girls had significantly higher mean value for oral control than boys of the same pubertal stage (4.7 vs. 3.4, p=0.024).

The silhouettes chosen to represent various attributes were consistent between the early and mid to post pubertal girls (Table 4.4). The majority of girls in both pubertal groups associated the overweight/obese silhouettes with being the worst, having more respect, having less respect, being the strongest, and the happiest. In contrast, underweight silhouettes were associated with only negative attributes - being clumsy, being weak and being unhappy. Most of the girls in both pubertal groups considered the normal silhouettes to be the "best". There was a significant difference between the pubertal groups with regard to the silhouettes which best represented the "weakest" (p=0.010) and "unhappiest" (p=0.030).

The silhouettes chosen to represent various attributes were also consistent between the early and mid to post pubertal boys (Table 4.5). The majority of boys in both pubertal groups associated the overweight and obese silhouettes with being the "worst", having "more respect", having "less respect", being the "strongest", and the "happiest". The majority of boys in both pubertal groups associated the negative attributes "weakest" and "unhappy" with the underweight silhouettes. There was a significant difference between the pubertal groups with regard to the silhouette that represented an "unhappy" attribute (p=0.020).

4.4 Discussion

To our knowledge, this is the first study reporting on the associations between BMI, disordered eating attitude, body dissatisfaction in female adolescents, and descriptive attributes assigned to silhouettes of varying sizes in male and female adolescents from rural South Africa. In this study, the prevalence of overweight and obesity was higher in girls than boys (16.4% vs 2.6%), and was greater in late puberty compared to early puberty. The prevalence of overweight and obesity that we report in this sample of rural adoles-

Tab. 4.4: Female body silhouettes with attributes as assessed by early and mid to post pubertal girls.

Silhouettes	**Early-Pubertal Girls**	**Mid to Post -Pubertal Girls**	**P-value**
Best			
Underweight	19.0%	14.5%	
Normal	50.0%	60.0%	0.471
Overweight and obesed combined	31.0%	25.5%	
Worst			
Underweight	31.0%	29.0%	
Normal	0.0%	1.0%	0.963
Overweight and obesed combined	69.0%	70.0%	
Clumsy			
Underweight	54.4%	52.1%	
Normal	4.4%	1.7%	0.466
Overweight and obesed combined	41.2%	46.2%	
More respect			
Underweight	20.5%	16.2%	
Normal	38.1%	34.2%	0.590
Overweight and obesed combined	41.4%	49.6%	
Less respect			
Underweight	26.5%	36.7%	
Normal	7.4%	14.5%	0.134
Overweight and obesed combined	66.1%	47.8%	
Strongest			
Underweight	4.4%	6.7%	
Normal	10.3%	6.0%	0.458
Overweight and obesed combined	85.3%	86.3%	
Weakest			
Underweight	79.4%	87.2%	
Normal	9.0%	0.0%	**0.010** χ^2 **=10.870**
Overweight and obesed combined	11.6%	12.8%	
Happiest			
Underweight	16.2%	14.5%	
Normal	36.6%	36.7%	0.849
Overweight and obesed combined	47.2%	48.8%	
Unhappiest			
Underweight	84.0%	85.5%	
Normal	0.0%	6.0%	0.030 χ^2 **=8.444**
Overweight and obesed combined	16.0%	8.5%	

Comparison by pubertal stage was computed using χ^2-tests and (%) are reported.

Tab. 4.5: Female body silhouettes with attributes as assessed by early and mid to post pubertal boys.

Silhouettes	**Early-Pubertal Boys**	**Mid to Post -Pubertal Boys**	**P-value**
Best			
Underweight	10.5%	3.3%	
Normal	43.2%	53.3%	0.087
Overweight and obesed combined	46.3%	43.4%	
Worst			
Underweight	48.4%	40.0%	
Normal	1.1%	0.0%	0.266
Overweight and obesed combined	50.5%	60.0%	
Clumsy			
Underweight	45.3%	53.3%	
Normal	8.3%	3.3%	0.436
Overweight and obesed combined	46.4%	43.4%	
More respect			
Underweight	6.3%	15.6%	
Normal	34.7%	25.6%	0.175
Overweight and obesed combined	59.0%	58.8%	
Less respect			
Underweight	35.8%	35.6%	
Normal	9.5%	7.7%	0.918
Overweight and obesed combined	54.7%	56.7%	
Strongest			
Underweight	6.3%	3.3%	
Normal	6.3%	6.6%	0.798
Overweight and obesed combined	87.4%	90.1%	
Weakest			
Underweight	83.2%	90.0%	
Normal	7.3%	2.2%	0.228
Overweight and obesed combined	9.5%	7.8%	
Happiest			
Underweight	9.5%	10.0%	
Normal	35.8%	36.7%	0.929
Overweight and obesed combined	54.7%	53.3%	
Unhappiest			
Underweight	91.5%	90.0%	
Normal	1.1%	0.0%	**0.020**
Overweight and obesed combined	7.4%	10.0%	$\boldsymbol{\chi^2}$ **=8.085**

Comparison by pubertal stage was computed using χ^2-tests and (%) are reported.

cents was lower than the 2008 National Youth Risk Behaviour Survey [63], but consistent with other studies [58, 202]. In contrast, a 2012 study, conducted on rural school children (aged between 10 and 16 years) reported that although the prevalence of overweight was higher in girls than boys, obesity was more prevalent in boys [64]. In that study, 11% of the girls and 9% of the boys were overweight, while 5.5% and 4.4% of boys and girls were obese, respectively. Therefore, the focus of interventions within the public health context should be improved through school-based nutrition and physical activity programmes among South African children and youth [225].

Our study also showed a consistent trend, where early and mid to post pubertal girls who desired to be fatter had the highest body mass index and those who desired to be thinner had the lowest body mass index in their respective pubertal groups. We found that the majority (83.5%) of the girls demonstrated body dissatisfaction, with 58% expressing a desire for a thinner body size. Interestingly, with regard to BMI categories which represented the silhouettes chosen by the girls to represent themselves, the overweight/obese girls chose silhouettes with a lower BMI than their actual BMI. Further, girls in the underweight and normal weight groups expressed a desire to be thinner (positive FID scores). Recent evidence from South Africa has shown that many urban children and adolescents are less satisfied with their body shape [73,84,85] Similarly, the majority of both our early and mid to post pubertal girls wanted to be thinner, with the proportion of those who preferred to be thinner being higher in early rather than mid to post pubertal girls (61.4% vs. 56%). We have shown that BMI was higher in participants who desired to be fatter, compared to the BMI of the girls who wished to be thinner. Similar to earlier South African studies [83, 89, 90], 48.9% of the the girls with a normal BMI wished to be thin in the present study. In a study by Gitau et al., (2014), the majority (59.6%) of urban Black and White girls, aged between 13 and 17 years wanted to be thin, whilst 38.8% of Black girls had higher body dissatisfaction compared to White girls (16.7%) [83].

In another study by Puoane et al., (2013), 63% of black schoolgirls aged between 10 and 19 years, living in poor suburbs of Cape Town, had a desire for a low BMI (<21.7) [89]. Our results also mirror findings from developed and other low and middle income countries [88, 219, 226, 227] countries, Ricciardelli and McCabe (2001), showed that the desire for thinner body size amongst girls from different countries ranges from 28% to 55% [88]. Of concern is that 5.8% of the underweight girls expressed a desire to be thinner. This may lead to food restriction and excessive exercise to change their bodies, which may place them at a greater health risk and lead to pathological eating disorders such as anorexia nervosa and bulimia nervosa [228].

Nearly 20% of the mid to post pubertal girls, who were classified as overweight/obese wanted to be fatter. Similarly, studies have also reported a trend towards a larger figure in Black populations and evidence suggests that being overweight is traditionally accepted in African culture as a sign of wealth, beauty and the absence of illness [82, 85, 93]. This is of concern given the health consequences of obesity and that almost 80% of overweight children become overweight and obese adults [129]. Therefore, primary prevention of obesity should start at an early age, particularly for girls [15].

Our study contributes to the body of literature on the risk for future eating disorder in South African adolescents. The prevalence rates of EAT-26 score ≥ 20 in this study (10.6% and 8% for early and mid to post pubertal girls, respectively) were higher than previously reported a decade ago (3%) for older (17.8 years) rural South African female adolescents [95]. In comparison, this was lower than 13% reported for young students (aged 20 years) from rural and urban origins, from the University of the North, Limpopo Province [222]. Beyond the rural settings, the percentages of abnormal eating attitudes found in the present study were within range of studies conducted in Johannesburg on urban Black adolescent girls aged 11 years (1%) and among adolescents between 13 and 17 years old (11%, and 13.1%) respectively [73, 91]. The only other study on South African male subjects showed that more urban Black than White males (40.2% vs. 5.2%) (aged 13, 15 and 17 years) had abnormal eating attitudes [84]. These prevalences are much higher than the 10.5% and 7.1% of our early and mid to post pubertal boys in the current study, indicating important transitional difference between the two settings.

These findings are the first to describe attributes assigned to silhouettes of varying sizes, amongst male and female adolescents in rural South Africa, but also shows conflicting perceptions as the majority of the adolescents still associated the overweight/obese silhouette with positive attributes including more respect, strongest, and happiest, and the underweight silhouette with only negative attributes (weak and unhappy), which might be associated with illness such as HIV/AIDS and tuberculosis [92].

The strength of this study is the inclusion of an under-studied geographical population whose particular health needs have been under-served and poorly delineated in the past. In addition, the questionnaires used in this study were validated internationally and within South Africa and the interview techniques were carried out by experienced fieldworkers who followed standardised procedures used in the Birth to Twenty longitudinal cohort.

This study had limitations, including the low internal consistency for EAT-26 and EAT-26 sub-components and therefore these results should be interpreted with caution. Examination revealed that some question items may have been poorly understood despite the questions being translated into the local language. It is possible that in a rural setting where food insecurity is still prevalent, some of the concepts around not eating, vomiting or dieting practices, are less well understood or engaged in. This suggests a need for critical research around both the methodological value of the EAT-26 and its applicability in rural South Africa and how food insecurity impacts understanding of certain eating practices. Second, the cross-sectional design of this study does not allow for cause-effect relationship. Third, the results can not be generalised to other rural settings or population groups because of the fact the sample included adolescents aged between 11 to 15 years. Another study limitation is the recall bias and the motivation of the participants in the interview setting [229]. Nevertheless, these findings from this rural setting, in conjunction with previous studies in South Africa, may be useful to guide future research interventions.

4.5 Conclusions

In summary, the findings of this study confirmed the higher prevalence of combined overweight and obesity in females than males. Our results highlighted that the majority of rural adolescent girls are dissatisfied with their body sizes, and this differs by BMI category, but indicates growing desire for Western ideals of thinness. This is most likely associated with the socio-economic transition that has taken place in South Africa within the last two decades and greater exposure to "Western" media. The study findings suggest that many adolescents are struggling with body image and desiring "unhealthy" body shapes, either too thin or too fat. This necessitates the critical need for policy intervention which would aim to educate and promote a healthy body size in adolescence and improve access to adolescent counselling support around eating disorder pathology and body image dissatisfaction.

4.5.1 S1 File

S1 File: [This is the raw data collected and analysed for this study.]

Analysis of: (a) BMI, (b) disordered eating attitudes, (c) female adolescents' body dissatisfaction, and (d) male and female silhouettes' descriptive attributes.

5. PART 3:CHAPTER 5 – EMPIRICAL PAPER 3

Associations between dietary intakes and cardiovascular disease risk factors in rural Black South African adolescents

(Submitted to Nutrition, Metabolism and Cardiovascular Diseases)

Introduction

Adolescence is a period of transition from childhood to adulthood and evidence shows that adolescents are increasingly vulnerable to social changes including exposure to inappropriate diets [21]. In recent years, adolescents from low and middle- income countries (LMICs) have demonstrated an increasing trend in overweight and obesity prevalence, which has become a global public health concern [8, 9, 230]. Exposure to inadequate diets in the adolescent stage has been suggested to increase risk for developing metabolic diseases later in adulthood, hence the nutrition and health at this unique stage being important [20, 21].This has been linked to subsequent maternal health status which is important for optimal development of the fetus [21].

South Africa, a country with a well-established and documented nutrition transition [8], is battling with a double burden of disease including the Human immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) and the emergence of non-communicable diseases (NCDs) [8]. Data from the 2013 South African National Health and Nutrition Survey (SANHANES-1) results indicate that 13.5% of school-aged (6 - 14 years) children were overweight and obese [8], which was higher than the reported 10% global prevalence in school children [11].An updated analysis of South African 2^{nd} Youth Risk Behaviour Survey (YRBS) of adolescents (aged between 13 and 19 years, n=9491 in 2002 and 9442 in 2008) showed that the prevalence of being overweight increased from 6.3% to 11% in the boys and from 24.3% to 29% in the girls within six years of the follow up [63].

What's concerning is that NCDs have become one of the cause of death in South Africa and it accounted for 30% cause of years of life lost (YLLs) in 2009 [159]. Evidence suggests that the underlying causes of obesity and subsequent development of NCDs are associated with increasing consumption of high energy, added sugar, high fat and less nutrient-dense foods and reduced physical activity [8, 9, 11]. Although, there are fragmentary studies on the prevalence of over-nutrition and metabolic disease risk in adolescents from South African rural communities, limited information exists on dietary intakes and CVD risk factors in adolescents [14, 72]. In this study, we reported on the dietary intakes and CVD risk factors (including anthropometric, lipid profiles, FG, SBP and DBP) and how they are associated within a rural South African adolescent population.

5.1 Methods

5.1.1 Study design and population

This cross-sectional study was conducted in the Agincourt Health and Socio-demographic Surveillance Systems (HSDSS) and detailed information on this study area is available elsewhere [14,169,231]. Briefly, in 2007, Black South African children and adolescents (n= 3489, aged 1 - 20 years), who had lived in the study area at least 80% of the time since birth, or since 1992 when enrolment into the Agincourt HSDSS begun were recruited in a growth survey [13]. In 2009, participants [n=600; age range 7 to 15 years (200 subjects in each group)], were randomly selected from children and adolescents (n = 3489), who had participated in the 2007 study [231]. Analysis for this paper was limited to adolescents on whom dietary data were collected (n=388, 193 boys and 195 girls, aged between11 and15 years).

5.1.2 Ethics

This study was conducted according to the guidelines in the Declaration of Helsinki and ethical approval was granted by the University of the Witwatersrand Human Subjects Research Committee (clearance number: M090212) and from the Mpumalanga Provincial Department of Health. Written informed consent was obtained from community leaders and school principals. Signed informed consent was provided by the parents and assent from the adolescents [231].

5.2 Measurements

Dietary assessment

Dietary intakes were assessed using semi-Quantitative Food Frequency Questionnaire (QFFQ). This QFFQ included 214 foods which were derived from 11 rural and urban dietary surveys. Furthermore, these food items are commonly eaten by at least 3% of the South African population [200]. Trained staff conducted the interviews in the participants' local language and each interview took between 35 to 45 minutes. In order to improve the quality of interview assessment, various food models were used to quantify food intakes and included food flash cards (high-quality photographs) to capture the previous week's (7 day) dietary intakes. The participants were asked to browse and sort these food ash cards into three piles: "rarely/never", "occasional" and "regularly" consumed or drank foods within the seven days. Information on the frequency and the amount of regularly food consumed items were recorded on the QFFQ after respondents were helped to determine the portion sizes using household measures, and a combination of two-dimensional life-size drawings of food and utensils and three-dimensional food models, as described by Steyn et al. [200, 201]. Occasional, rarely and never eaten food items by the participants were also recorded. Coding involved the conversion of the household measures (e.g. one cup/one serving spoon/one slice) to grams and average daily intakes were determined. The food data were converted to nutrient data using the South African food composition tables and computer programme "FoodFinder" of the South African Medical Research Council [232].

5.2.1 Anthropometry

Body weight was determined to the nearest 0.1kg using a digital scale from Hanson; Bathroom Trends Limited, Epson, UK. Using stadiometer from Holtain, UK, height was measured with light clothing but no shoes to the nearest 0.1cm. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared. Waist circumference (WC) was measured, using an inelastic tape measure, midway between the tenth rib and the iliac crest. Hip circumference (HC) was measured at the level of maximum width of the buttocks with the participant standing in an upright position. Waist to hip ratio (WHR) was calculated by dividing the WC by HC measurements. Waist to height ratio (WHtR) was calculated by dividing WC by height. Girls and boys were measured in separate classrooms by trained fieldworkers using a standardised protocol.

The anthropometric measurement variation remained below 2% [14].

5.2.2 Blood pressure and biochemical measurements

Using an Omron blood pressure monitor (Omron M6; Omron, Kyoto Japan), three measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken from seated participants, after 5 to 10 minutes of quiet rest. The first reading was discarded and the subsequent two readings were averaged for analysis [196]. Two qualified nurses collected 12 - hour fasting venous blood samples from participants between 08:00am and 11:00am. The lipids examined were total cholesterol (TC), high- density lipoprotein-cholesterol (HDL-C), low- density lipoprotein-cholesterol (LDL-C), and triglycerides (TG). The blood samples were stored at -70C in the Agincourt laboratory and later packed in dry ice and transported to Developmental Pathways for the Health Research Unit (DPHRU) laboratory, Baragwanath Hospital, Johannesburg, and stored at - 70C until analysed. The same laboratory was used to analyse both lipid profiles and plasma glucose, by enzymatic methods,- using the chemiluminescence Daytona RX analyser (Crumlin, Co. Northern Ireland) [14].

5.3 Data analyses

All analyses were performed using STATA version 11 (StataCorp, Texas, USA). Using student t-tests, daily energy intake, macronutrients and selected CVD risk factors were computed and compared by sex. Food items were ranked in descending order according to their percentage contributions to the total number of recordings. The prevalence of overweight and obesity was determined using Cole's international BMI cut-off points [59]. The risk of adiposity was assessed using WHR of >0.85 for females, >0.90 for males, [195] WHtR of >0.5 for both sexes, [208] and WC of >80 cm for the females and >94 cm for the males [195]. Furthermore, fasting glucose (FG) of >5.6 mmol/l was computed according to International Diabetes Federation standards [209]. The following cut-offs were used for abnormal lipids: HDL-C of <1.03 mmol/l, LDL-C of >2.59 mmol/l, TGs of >1.7 mmol/l and TC of >5.17 mmol/l [8, 198]. Pre-hypertension was defined as the average of the last two readings of SBP or DBP, being >90th but <95th percentile for age, sex and height [196]. Pearson's Chi-squared tests were used to compare the number and the percentages of adolescents below adiposity risk indicators cut-off points. Bivariate linear regressions were computed to explore associations between anthropometric indices and dietary intakes. Significant tests were set at the $p<0.05$ level.

5.4 Results

Table 5.1 shows the 24 food items recorded ranked in descending order according to the total number of food items recorded. Added sugar and sweets contributed 10%, and maize meal and bread contributed 7.2% to the total number of food items recoded. In addition, a limited number of fruit and vegetables, and meat and meat products were recorded.

Tab. 5.1: The top 24 food items ranked in descending order according to total number of times each food item was recorded and their percentage contribution to total recorded items.

Number	**Food**	**Percentage (%)**
1	Added Sugar (Brown or white)	6.3
2	Maize Meal, Cooked, Stiff Porridge	3.8
3	Sweets, Hard Boiled and Soft Jelly Type	3.5
4	Bread/rolls, Brown	3.4
5	Tea, Brewed	3
6	Orange, Raw (peeled)	2.7
7	Sunflower Oil	2.7
8	Creamer (coffee and Tea) Non Dairy Powder	2.5
9	Rice, White, Cooked	2.4
10	Banana, Raw (peeled)	2.2
11	Feet, Chicken, Raw	2.1
12	Avocado, Raw (peeled)	2.1
13	Sauce, Tomato	2.1
14	Sweetened Drinks	2.0
15	Apple, Average, Raw	1.9
16	Paw Paw, Raw (peeled)	1.8
17	Coffee, Brewed/Instant	1.8
18	Margarine,	1.6
19	Potato Chips/French Fries, Fried in Sunflower Oil	1.6
20	Chicken, Dark Meat, Frozen, Cooked - Moist	1.6
21	Bread/Rolls, White	1.5
22	Pilchards in Tomato Sauce	1.5
23	Stewed Tomato and Onion	1.5
24	Chicken Skin	1.5

Table 5.2 presents daily dietary intakes, body composition, metabolic and adiposity risk factors of participants by sex. Total energy intake was numerically higher in the boys while

Tab. 5.2: Daily energy and macronutrient intake and selected CVD risk factors by sex in rural Black South African adolescents.

Variables	**Boys (N = 193) Mean (95%CI)**	**Girls (N = 195) (95%CI)**	**P-value**	**P-value***
Dietary intake				
Total energy (TE) KJ	9900.26 (5064.90-19352.00)	6669.61 (6153.85-7228.60)	0.28	
Total protein (g) (% of TE)	38.87 (35.21-43.00) (10.5)	41.86 38.21-45.86) (10.7)	0.27	0.87
Animal protein (g) (% of TE)	10.30 (8.54-12.39) (2.8)	12.69 (10.63-15.10) (3.2)	0.11	0.18
Plant protein (g) (% of TE)	26.18 (24.10-28.44) (7.1)	27.00 (24.80-29.21) (6.9)	0.64	0.05
Total fat (g) (% of TE)	32.40 (28.40-36.94) (19.1)	37.75 (33.33-42.75) (21.0)	0.96	0.004
Saturated fat (g)	7.60 (6.60-8.80)	9.32 (8.12-10.70)	0.04	0.001
Monounsaturated fat (g)	10.60 (9.14-12.24)	12.20 (10.72-13.90)	0.15	0.03
Polyunsaturated fat (g)	9.88 (8.64-11.30)	11.64 (10.13-13.37)	0.09	0.03
P:S ratio	1.37 (1.25-1.50)	1.30 (1.20-1.43)	0.45	0.15
Cholesterol (g)	25.20 (18.03-35.05)	43.00 (33.63-54.92)	0.01	0.001
Total carbohydrates (g) (% of TE)	242.82 (230.75-255.52) (65.8)	231.62 (219.50-244.41) (59.0)	0.21	0.14
Dietary fibre (g)	18.75 (17.10-20.61)	19.20 (17.60-21.00)	0.72	0.05
Alcohol intake g/day (ethanol)	0.02 (-0.01-0.06)	0.01 (-0.01-0.04)	0.7	0.60
Age and Body composition				
(years)	13.63 (13.32-14.00)	13.71 (13.40-14.03)	0.74	
BMI (kg/m^2)	17.81 (17.40-18.24)	19.71 (19.00-20.50)	0.001	
Metabolic				
High-density lipoprotein (mmol/L)	1.21 (1.15-1.26)	1.18 (1.13-1.24)	0.54	
Low-density lipoprotein (mmol/L)	1.78 (1.70-1.90)	1.91 (1.80-2.06)	0.13	
Total cholesterol (mmol/L)	3.9 (3.80-4.03)	4.02 (3.90-4.20)	0.24	
Triglycerides (mmol/L)	0.76 (0.71-0.81)	0.82 (0.76-0.88)	0.18	
Fasting glucose (mmol/L)	4.80 (4.65-4.95)	4.50 (4.21-4.80)	0.07	
Systolic blood pressure (mmHg)	103.70 (101.23-106.21)	84.20 (78.50-90.33)	0.001	
Diastolic blood pressure (mmHg)	61.01 (59.40-62.70)	63.12 (61.24-65.07)	0.09	
Waist to hip ratio	0.84 (0.83-0.85)	0.77 0.02 (0.71-0.83)		
Waist to height ratio	0.41 (0.41-0.42)	0.42 (0.40-0.44)	0.77	

All values are presented as geometric means and 95% confidence intervals (CI) (Student t test). KJ - Kilojoule, % P:S ratio - Polyunsaturated: saturated fat ratio, % of TE - Percentage of total energy, kg/m^2 - Kilogram/meter square, g - gram, mmol/L - milli-mole/litre, mmHg - milli-meter mercury, P-value - unadjusted, P-value* - adjusted for Age, Total Energy.

protein intake was higher in the girls, however, no sex significant differences were found. Before adjusting for total energy and age, total animal protein, plant protein, monounsaturated fat, and polyunsaturated fat and dietary fibre were higher in girls than boys without sex differences. In addition, girls had higher and significant intake for saturated fat intake ($p<0.04$) and cholesterol ($p<0.01$). After adjustment, girls had significant and higher intakes than boys for total fat, saturated fat and cholesterol (all $p<0.001$), mono and poly unsaturated fat (all $p<0.03$), plant protein and dietary fibre (all ($p<0.01$) respectively. BMI was significantly higher in the girls than in the boys and SBP ($p<0.001$) and WHR ($p<0.02$) mean values were significantly higher in the boys than in the girls (Table 5.2).

Tab. 5.3: The number and proportions of percentages of adolescents above cut-off points for indicators of metabolic risk by sex.

Variables	**Cut-off points**	**Boys, N(%) above cut-off points**	**Girls, N(%) above cut-off points**	**P -value**
Adiposity WC (cm)	$\geq$ 80 for girls $\geq$ 90 for boys	0(0)	13 (6.7)	**0.000;** $\chi = 13.3127$
WHR	> 0.85 for girls, > 0.90 for boys	6 (3.11)	43 (22.0)	**0.000;** $\chi = 31.5429$
WHtR	> 0.5 for boys and girls	12 (6.2)	35 (18.0)	**0.000;** $\chi = 13.3127$
Body composition BMI	overweight and obese $\geq$ 25 (kg) (m^2)	6 (3.1)	27 (14.0)	**0.000;** $\chi = 14.3706$
Metabolic HDL-C (mmol/l)	< 1.03 (mmol/l)	38 (28.6)	32 (24.6)	0.468; $\chi = 0.5268$
LDL-C (mmol/l)	> 2.59 (mmol/l)	3 (2.3)	12 (9.3)	**0.02;** $\chi = 5.9517$
TC (mmol/L)	$\geq$ 5.17-6.18 mmol/l	5 (3.5)	17 (12.7)	**0.01;** $\chi = 7.899$
TG (mmol/L)	> 1.7 mmol/l	2 (1.4)	6 (4.4)	0.134; $\chi = 2.244$
FG (mmol/L)	$\geq$ 5.6 mmol/l	7 (5.6)	6 (5.2)	0.90; $\chi = 0.0135$
Pre-hypertensive (average SBP and DBP)	$\geq$90th but < 95th percentile for age, sex and height	15 (8.4)	28 (15.3)	**0.04;** $\chi = 4.1405$

% - Percentage, WC - Waist circumference, WHR - Waist to hip ratio, WHtR - Waist to height ratio, HDL-C - High density lipoprotein cholesterol, LDL-C - Low density lipoprotein cholesterol, TC - Total cholesterol, FG - Fasting glucose, SBP - Systolic blood pressure, DBP - Diastolic blood pressure [8, 197, 198].

The number and proportions of adolescents below and above cut-off points for CVD risk factors are presented in Table 5.3. Significantly, more girls than boys had higher number and percentages for measures of central and/or abdominal obesity: WC (13(6.7%) vs. 0(0%), WHR (43(22.0%) vs. 6(3.1%)), WHtR (35(18.0%) vs. 12(6.2%)) and the prevalence of overweight and obesity was greater in females than males (27(14.0%) vs. 12(6.2%)) (all p<0.001). Similar results were found for LDL-C (12(9.3%) vs. 5(3.5%), p=0.02)), TC (17(12.7%) vs. 5(3.5%), p<0.01), and SBP and DBP (28(15.3%) vs. 15(8.4%), p<0.04).

Table 5.4 presents bivariate associations between dietary intakes (total energy, total carbohydrate (CHO), total dietary fat and total saturated fat) and anthropometric parameters (BMI and WC). In females, total energy was associated with BMI (p=0.05) and total dietary fat and saturated fat were associated with BMI and WC (p=0.01, p=0.03) (p<0.001, p=0.02) respectively. However, no significant associations were observed between anthropometric indices and diet in males.

Tab. 5.4: The association between BMI and WC and total energy, total CHO, total fat and total saturated fat in rural Black South African female adolescents.

Variables	β	**95% CI**	**t**	**p-value**
Total energy				
BMI (kg/m^2)	0.000	1.89e-06 to 0.000	2.0	**0.047**
WC (cm)	0.000	-0.000 to 0.001	1.21	0.228
Total CHO				
BMI (kg/m^2)	0.002	-0.002 to 0.005	0.89	0.376
WC (cm)	0.001	-0.010 to 0.103	1.4	0.892
Total fat				
BMI (kg/m^2)	0.020	0.005 to 0.030	2.73	**0.007**
WC (cm)	0.040	0.004 to 0.748	2.21	**0.03**
Total saturated fat				
BMI (kg/m^2)	0.073	0.034 to 0.112	3.69	**0.001**
WC (cm)	0.171	-0.065 to 0.278	3.17	**0.002**

β - Beta, CI - Confidence interval, BMI - Body mass index, WC - Waist circumference, CHO – Carbohydrate.

5.5 Discussion

This paper reports on the dietary intakes and cardiovascular disease (CVD) risk factors (anthropometric indices, lipid profiles, FG, SBP and DBP) and how they associate in rural Black South African adolescents. Previous researchers have reported the steep rise in the prevalence of overweight and obesity in adolescence [8,14,63,64], however, little information exists on dietary intakes and CVD risk factors in adolescence from rural South

African communities [8, 14].

With regards to diets, our study found that added sugar (brown or white) and sweets (hard boiled and soft jelly type) contributed 10%, and maize meal and bread contributed 7.2% to the total number of food items recorded respectively (Table 5.1). This is consistent with national [56], longitudinal [104] and other studies conducted in Black South African communities [107, 233]. Our findings were similar to those found in urban children from Johannesburg (aged 5- to 13 years-old), in which, added sugar and sweets were the top food items recorded [104] and in the rural North West Province, "Cheese Curls" (cheese flavor maize snack) and sweets were reported among 10- to 15 year-old school adolescents [107]. It is of concern that sugar and sugar products were the top food items recorded in this study given that the global rise in the prevalence of obesity has been partly linked to added sugar and sugar products consumption [108].

Our findings on the limited consumption of fruit and vegetables are consistent with previous studies, which have reported low fruit and vegetable intake pattern among the South African populations [104, 234]. Furthermore, chicken feet, chicken dark meat and chicken skin were the main meat and meat products recorded in this study Table 5.1, this is in line with other investigators results from LMICs [235]. The potential important explanation for this, could be the high price of these food items (meat, fish, milk, fruits and vegetables) and other contributing factors could be due to poor access to markets/shops, lack of availability and most importantly, low socio-economic status [8, 236].

Examination of the number and proportions of adolescents above the cut-off points for metabolic risk factors in this study (Table 5.3) showed the prevalence of combined overweight and obesity (13.8% for the girls and 3.1% for the boys) are lower than the national report (2^{nd} YRBS) in adolescents of the same age [63]. However, our findings are in agreement with South African and other studies, in which, the prevalence overweight and obesity were greater in the girls than in the boys [13, 202, 230]. The sex differences in the prevalence of overweight and obesity in this study could be explained by either cultural acceptance of a bigger body, which symbolises wealth and lack of illness such as HIV/AIDs and/or sedentary behaviour and increased more screen time [8, 31].

Global trends indicate that weight gain in adolescence is a strong predictor of hypertension, which may have several adverse impacts on many CVD risk factors later in adulthood [210,212]. Our findings add to the small amount of literature regarding the increasing prevalence of hypertension and pre-hypertension and corroborate with other studies from developed and developing countries [210,212,237,238] and in the region [8,239]. We found that the prevalence of pre-hypertension was higher in females compared to males and this corresponds with our earlier work, in which, pre-hypertension prevalence was 15% and 10% in the girls and the boys (n = 588, aged 7 - 15) respectively [14]. Contrarily, a recent study of rural adolescents aged 13 to 17, living in Mthatha, South Africa, showed that hypertension and pre-hypertension was higher in the males (22% and 12.3%) than the females (20.9% and 16.5%) [239]. Therefore, early screening of blood pressure in children and adolescents may help reduce the increasing prevalence of CVDs in South African population [159, 239].

It is worrisome that a large proportion of adolescent girls have metabolic risk regarding anthropometric indicators, according to adult cut-off points (Table 5.3). This corroborates with some other studies, which have applied WC, WHR and WHtR to investigate central fat distribution and central obesity in children and adolescents and to relate these measurements to CVD risk factors [194,237,238]. We also found that more girls than boys have abnormal LDL-C and TC, which may be indicative of future CVDs [20, 21]. The important sex differences we observed in the present study could be attributed to genetic factors (hormonal changes during adolescence) other than overweight or obesity, because risk factors for the development of CVDs may change as adolescents grow older [21, 237].

Our study showed that, among adolescent girls, total dietary fat was associated with BMI, and the combination of total dietary fat and total saturated fat were closely correlated to BMI and WC. One possible explanation for the apparent associations with diet is that together with the poor-nutrient food items recorded in this study, our adolescent girls had lower carbohydrate intake and higher protein intake, total dietary fat, saturated fat, mono and polyunsaturated fat and cholesterol (Table 5.2). Previous investigators suggest that diets high in fat, in particular, saturated fat, low in CHO in parallel with sedentary behaviour are associated with the current obesity epidemics and subsequent increasing prevalence of CVDs in developing countries [20]. Therefore, future research, focusing on dietary and lifestyle changes and early detection of metabolic syndrome in children and adolescents may help reduce burgeoning chronic NCDs such as obesity, diabetes mellitus, hypertension and CVDs in the next generation of adults [9].

5.6 Strengths and limitations

The unique strength of this study was the inclusion of rural adolescents living in disadvantaged areas, whose dietary and nutritional statuses have been under-studied in the past. The examination of metabolic indicators (anthropometry, lipids, SBP and DBP) and their combination with dietary intakes in rural South African settings were added advantages. In addition, experienced fieldworkers were used and Birth to Twenty standardised procedures were applied for the data collection of this study.

This study was subject to a number of limitations which included the cross-sectional design as it does not allow for the determination of cause-effect relationship. Therefore, longitudinal study on diet and tracking the contributing risk factors of CVD associated with diet may shed more light on the health status of these rural adolescents. In addition, evidence has shown that dietary studies involving adolescents have inherent difficulties in reporting precisely what they ate and determining the portion sizes, however, the QFFQ used in the present study to determine the usual diet has been adopted by previous South African researchers [200, 201, 240]. The non-inclusion of dietary supplements was another limitation of this study, however, the use of supplements in this area is limited due to the cost [240].

5.7 Conclusion

Poor variety of food items was noticed and associations between adiposity and diet were found. Girls demonstrated greater CVD risk factors than boys. These cross-sectional results provide an urgent need for nutrition intervention programmes targeting rural adolescents.

5.8 Acknowledgement

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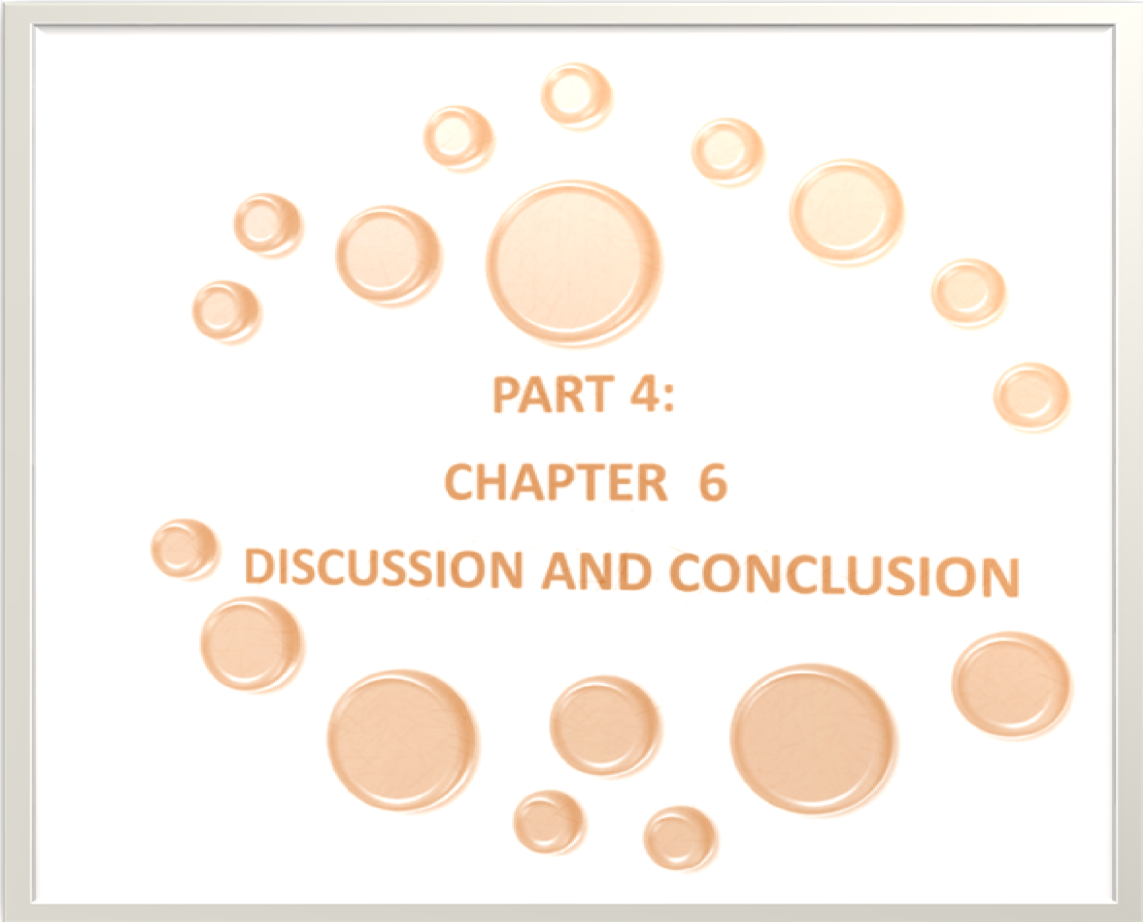
6. PART 4: CHAPTER 6– DISCUSSION AND CONCLUSION



6.1 Summary of the findings

The overall aim of this study was to determine the association between nutrition and body composition and metabolic disease risk in rural South African children and adolescents. In order to accomplish this aim, the three specific objectives and the main findings of the thesis and their implications are summarised in Table 6.1.

Tab. 6.1: Summary of thesis objectives, main findings and their implications.

Objectives	**Main findings**	**Implications**
To determine the prevalence of under- and overnutrition, and evidence of metabolic disease risk in rural South African children and adolescents	Boys had higher prevalence of stunting than girls. BMI and HC were significantly higher in girls than boys in the early, mid and late pubertal stages. Combined overweight and obesity was higher in girls than boys. Pre-hypertension prevalence in both boys and girls was high. disease preventive Impaired FG was detected in both sexes. HDL-cholesterol was higher in girls than boys, which is indicative of cardiometabolic risk.	The study highlights the critical need for targeted health promotion interventions to optimise child health as part of a noncommunicable strategy
To determine Body Image Satisfaction, Eating Attitudes and Perceptions of Female Body Silhouettes in Rural South African Adolescents	Overweight and obesity was higher in the early and mid to post pubertal girls than boys of the same pubertal stage. No differences were observed in EAT-26. The majority of the girls demonstrated body dissatisfaction. The girls who wanted to be fatter had a significantly higher BMI than the girls who wanted to be thinner. Underweight silhouettes were perceived with negative attributes by both sexes and girls perceived normal weight to be the best.	These findings suggest a need for intervention that will address a healthy body size among South African adolescents
Associations between dietary intakes and cardiovascular disease risk factors in rural black South African adolescents	Adolescent girls and boys are consuming high amounts of added sugar. Girls have a greater intake of total fat (in particular saturated fat) than boys, which may contribute to overall adiposity and higher LDL, TG, and elevated blood pressure. Girls are not only more overweight and obese than boys but are showing metabolic risk, with a large proportion having greater abdominal fat predisposition	These cross-sectional results provide an urgent need for nutrition intervention programmes targeting rural adolescents

In addition, our field observation revealed that: (1) 50kg miele meal, oil, and sugar were the commonly purchased food items by many households at the end of month; (2) Food ration given at schools were: (A) the first meal, (B) often the only meal of the day for many children and adolescents; (3) Many children and adolescents interviewed reported that the food items eaten at home were the same as those served at schools and (4) Our school observation showed that, out of 30 pupils, who purchased foods from the available school vendors, only 3 pupils bought fruits (apple, banana and an orange) and 27 pupils bought sweets, curls, and chewing gums (See Fig. 6.1).

Fig. 6.1: Food sold at entrance/exit of schools

6.2 Key consolidated findings

Figure 6.2 shows the consolidated findings of this cross-sectional study and 3 analyses from aforementioned Chapters 3 to 5 are: (1) under and overnutrition (2) body image dissatisfaction and (3) the emergence of metabolic disease risk. In reference to Figure 1.4 on the effects of nutrition transition and nutrition-related chronic diseases.

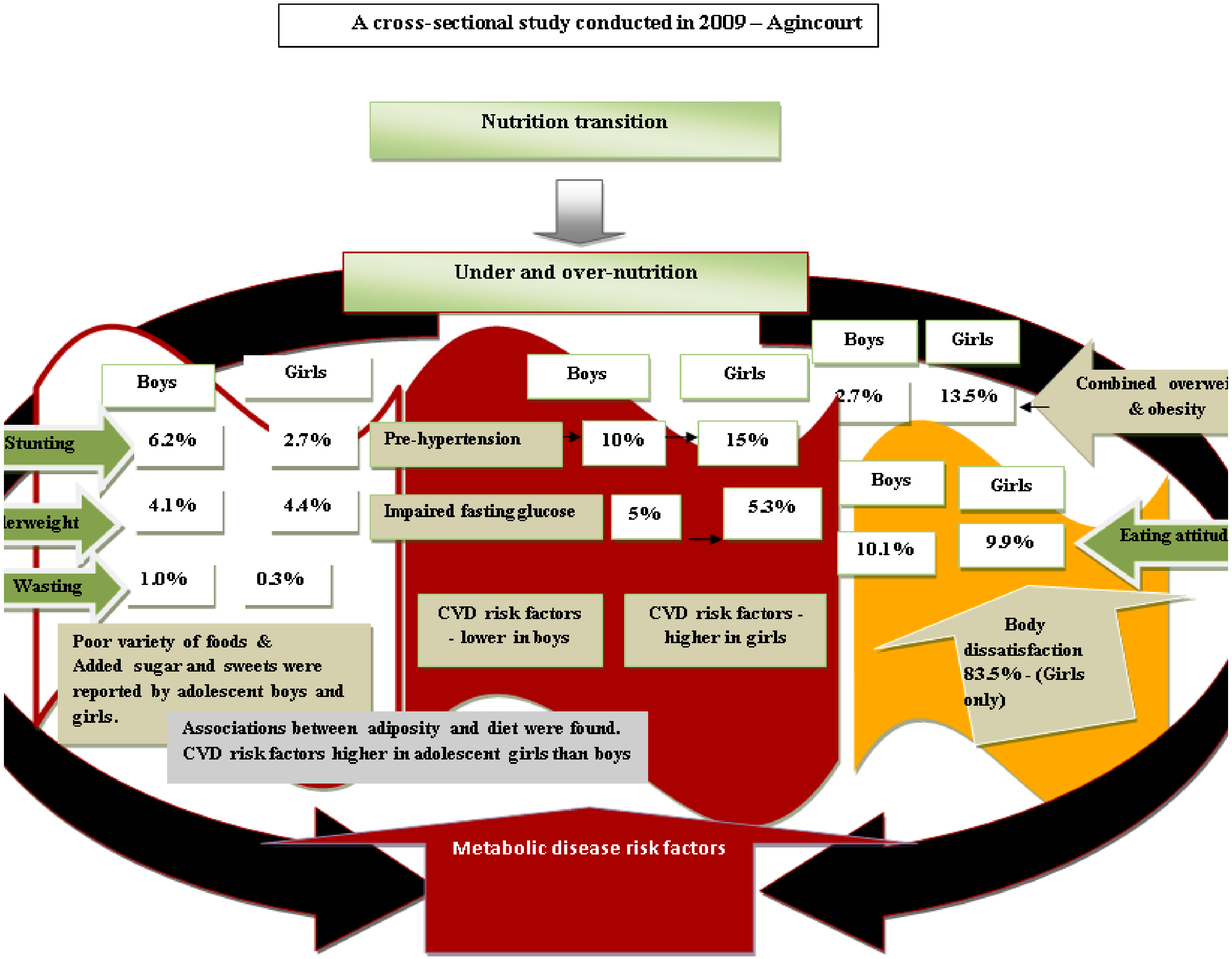


Fig. 6.2: Key findings

6.3 Contextual relevance

6.3.1 Local and national relevance

In line with South African studies, the stunting in boys and increasing prevalence of overweight and obesity in children and adolescents has been reported in other studies from other LMICs undergoing similar transitions. However, there is no sizable body of work regarding body image satisfaction, dietary intake and metabolic risk factors especially in rural children and adolescents living in transitioning settings [8]. These findings need to be included in interventions targeting the adolescent age group, and particularly girls. In recent years, evidence has shown that the prevalence of NCDs increases as countries undergo social and economic transitions [35]. It is noteworthy that our results provide confirmatory evidence of what is currently taking place in other LMICs and reflects the situation some decades ago in industrialised countries [11]. Therefore, international scholars are now advocating for preventive intervention trials, which will include stakeholders, politicians and academics targeting the young because of the serious health complications of obesity [112–114].

6.4 Limitations

The limitations of the empirical papers (Part 3, Chapters 3 to 5) has been discussed within their respective discussions, however, the overall limitations for the study will be discussed in this section.

<u>Cause-effect relationship</u>

The cross-sectional design of this study does not allow for cause-effect relationship. The need for longitudinal and effective research interventions in improving dietary behaviours and lifestyle changes might give a positive direction in decreasing and/or stemming the increasing prevalence of obesity and metabolic disease risk in these rural settings.

<u>Generalisability</u>

A cross-sectional study is defined as a prevalence study in which data were collected at a single point in time. The subjects for this study included rural Black children and adolescents who lived in Agincourt, a sub-district of Bushbuckridge region, Mpumalanga Province, South Africa, from1992 to-date. This study does not represent children or the adolescent population, in general, of South Africa. Our findings are similar to other rural settings regarding double burden of disease (under and over-nutrition) and the emergence of metabolic disease risk factors. Given it has been established that dietary behaviours and lifestyle changes are the major determinants of over-nutrition, which is associated increasing prevalence of NCDs in all countries, this study included a relatively large number of under-studied rural populations. Consequently, similar rural areas in the region and other transitioning countries can replicate the results of this study.

6.5 Future research areas

Although this study has provided unique information on the association between nutrition and body composition and metabolic disease risk profiles in a rural setting in South Africa, changes in anthropometric and biochemical parameters based on intervention control trials might provide additional insight into the metabolic risk factors associated with obesity. Emerging research based on the DoHAD concept, which shows potential for larger and long-lasting solutions to the prevention and control of rising obesity, may be explored and this includes:

- Analysis of food groups and nutrients, their combinations, frequency and quantity in rural adolescents - currently underway. This will provide useful input to recommendations on culturally acceptable Food Based Dietary Guidelines intervention programs and policies to prevent the steep rise in obesity.

- Given that poor variety of food items were consumed and associations between adiposity and diet were found and girls had greater CVD risk factors than boys, it would be necessary to understand barriers and opportunities for rural adolescents and their families in a food insecure environment to engage in healthier dietary practices. I plan to setup a series of focus groups with adolescents girls and boys and their families to share my research findings and to explore their responses and opportunities for healthier living. I hope to gain insights into possible intervention opportunities through my work and this qualitative study to inform future intervention development.

- Furthermore, I plan to setup a series of focus groups with adolescents girls and their families to share my research findings on body image dissatisfaction given that the majority of the girls were not satisfied with their body shapes. This might give a direction of behaviour change and lifestyle modification interventions. future research intervention that will lead to healthier body size among South African adolescents.

6.6 Overall conclusion

Firstly, this study highlights the presence of late childhood undernutrition in this rural area which is less than overnutrition, particularly in girls. The emergence of early pre-hypertension risk was concerning, as well as the higher-than-expected levels of impaired fasting glucose and abnormal lipid profiles, particularly in the girls suggesting that rural South African communities are mirroring more urban environments in terms of metabolic risk. Secondly, this study confirmed the higher prevalence of combined overweight and obesity in females than males and majority of rural adolescent girls are dissatisfied with their body sizes, and this differs by BMI category, but indicates growing desire for Western ideals of thinness. Lastly, adolescents recorded poor variety of food items and associations between adiposity and diet were found and girls demonstrated greater CVD risk factors than boys. In conclusion, this thesis highlights the health challenges of rural adolescents in South Africa. The time is now to act and seek opportunities for critical targeted health promotion intervention programmes, which might help to optimise adolescent health as part of a noncommunicable disease preventative strategy, especially, in remote areas in rapidly transitioning South Africa.

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7. APPENDICES

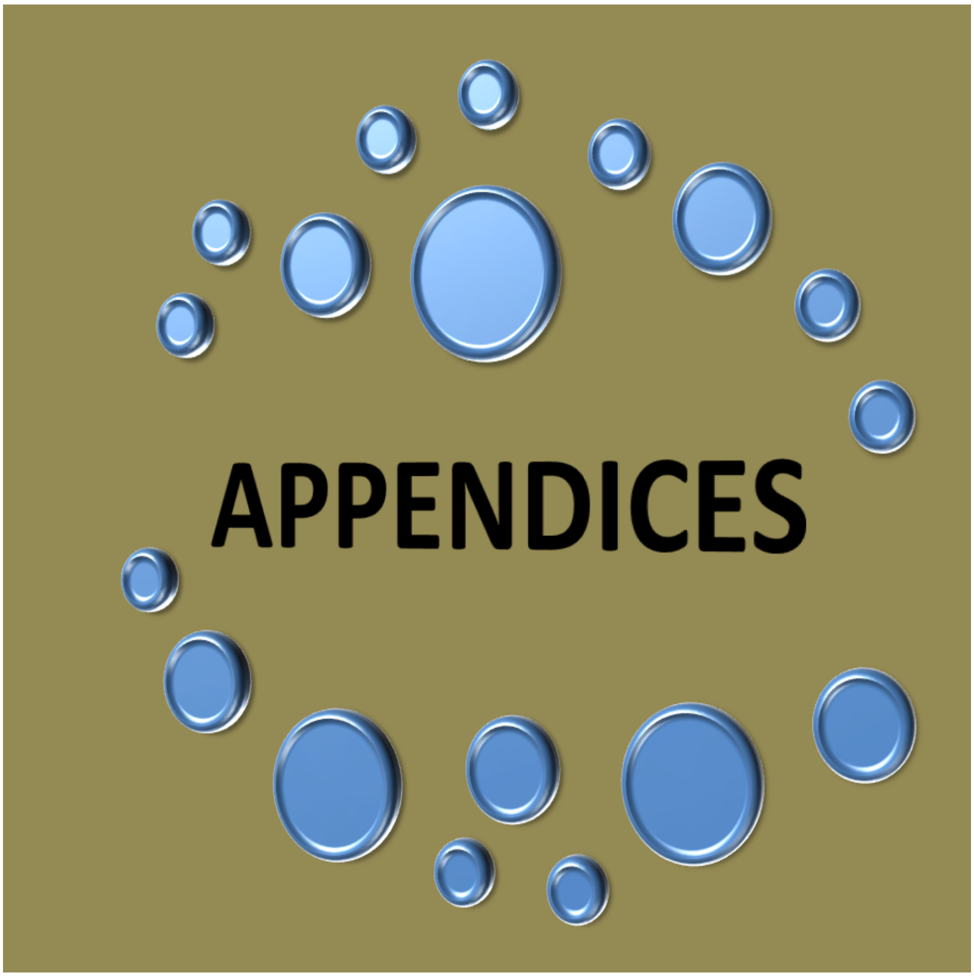

Fig. 7.1: Appendices

M0
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Mrs TM Pedro

CLEARANCE CERTIFICATE	**M090212**
PROJECT	The Association of Nutrition on Body Composition and Metabolic Disease Risk in Rural South African Children and Adolescents
INVESTIGATORS	Mrs TM Pedro.
DEPARTMENT	Department of Paediatrics/Birth to Twenty
DATE CONSIDERED	09.02.27
DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 09.05.15 **CHAIRPERSON** ....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Dr S Norris

DECLARATION OF INVESTIGATOR(S)

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

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

05/08/2009 10:14 0137663470 DEPT HEALTH SOCIAL S PAGE 01/02

MPUMALANGA PROVINCIAL GOVERNMENT

Building No 3
No. 7 Government Boulevard
Riverside Park Extension 2
Nelspruit
1200
South Africa

Private Bag X 11213
Nelspruit
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Tel: (013) 766 3129
Fax: 086 511 3208
E-mail: AlterM@social.mpu.gov.za

Department of Health

Litiko Letemphilo ne LaMisebenti ye Tenhlalo yeBantfu — UmNyango Wezamaphilo no Wezomphakhathi — Departement van Gesondheid en Maatskaplike Dienste

FACSIMILE TRANSMITTAL

TO : MRS PEDRO TITILOLA	**FAX:** 013 795 5074 **TEL:011 488 3604**
PAGES: 02 INCLUDING COVER	
FROM : MS KATE MATHE/MR MOLEFE MACHABA	
TEL. NO: (013) 766 3102/3009	**FAX NO:** 0865170729
DATE: 21July 2009	
SUBJECT: RESEARCH APPROVAL LETTER	

Kindly receive copies of the approval letter

KIND REGARDS

Ms KATE MATHE
EPIDEMIOLOGY & RESEARCH

University of the Witwatersrand

Rural Public Health And Health Transition Research Unit

AGINCOURT GROWTH STUDY

7-8 YEARS

DATE: **Day** **Month** **Year**

Consent Table

Components	**Yes**	**No**
Anthropometric measurements		
Oral Glucose Tolerance Test (OGTT)		

Contact details of a relative or a friend who will **always** know where you live (different to information on contact sheet):

Name: ____________________ Relationship: ____________________

Landline number: ____________________ Cell number: ____________________

Work number: ____________________ Other: ____________________

INFORMED CONSENT

I agree to participate in this study by Agincourt Health and Demographic

of the Witwatersrand.

I understand the reason for this research and the way it is going to be done. I understand that the study will involve collection of blood, that different measurements of my body will be taken, and that I will fill in questionnaires. The details and purpose of this study has been explained to me. I understand that I have the right to refuse my participation and / or that of my child and that nothing bad will result.

I agree to participate in the study on condition that:

1. I can choose to withdraw from the study at any time and that no bad things will happen as a result.
2. I have the right not to answer any or all questions asked in the interviews.
3. The Committee for Research on Human Subjects at the University of the Witwatersrand has approved the study itself and the way it is to be conducted.
4. All results will be treated with the strictest confidentiality.
5. Only group results, and not my individual results will be published.
6. The Agincourt Health and Demographic Surveillance System (AHDSS) of the MRC/Wits, Rural Public Health and Health Transitions Research Unit, School of

Public Health, and the Birth to Twenty Scientific Teams are committed to treating participants with respect and privacy throughout the procedure.

7. I will receive a referral note to a health service if any result is out of the normal range or a problem is detected in the course of the study.

PARTICIPANT ASCENT

Printed Name **Signature / Mark or Thumbprint** **Date and Time**

RESEARCH ASSISTANT:

Printed Name **Signature** **Date and Time**

WITNESS: (If applicable)

Printed Name **Signature** **Date and Time**

ANTHROPOMETRY

- STANDING HEIGHT: (mm)
- SITTING HEIGHT: (mm)
- WEIGHT: (kg)
- WAIST CIRCUMFERENCE: (mm)
- HIP CIRCUMFERENCE: (mm)

			•	

SKINFOLD MEASUREMENTS – LEFT SIDE (mm)

- TRICEP:
- BICEP:
- SUBSCAPULAR:
- SUPRA-ILIAC:
- MEDIAL CALF:

		•				•				•	
		•				•				•	
		•				•				•	
		•				•				•	
		•				•				•	

Research Assistant: **Date:**

BLOOD PRESSURE

- SYSTOLIC BP
- DIASTOLIC BP

		h						

- PULSE
- TIME OF BP

Research Assistant: **Date:**

ORAL GLUCOZE TOLERANCE TEST :

YES	NO

Research Assistant: **Date:**

ANTHROPOMETRIC MEASUREMENTS:

YES	NO

Research Assistant: **Date:**

Quality Check: | | **Date:** | |

Notes:

University of the Witwatersrand

Rural Public Health And Health Transition Research Unit

AGINCOURT GROWTH STUDY

ROUTINE QUESTIONNAIRE

DATE: **Day** ☐☐ **Month** ☐☐ **Year** ☐☐☐☐

☐☐☐☐☐☐☐

Consent Table

Components	Yes	No
Routine Questionnaire		
Food Frequency Questionnaire		
Self Completion Questionnaire		
Pubertal Assessment Questionnaire		
Anthropometric measurements		
Oral Glucose Tolerance Test (OGTT)		

Contact details of a relative or a friend who will **always** know where you live (different to information on contact sheet):

Name: ____________________ Relationship: ____________________

Landline number: ____________________ Cell number: ____________________

Work number: ____________________ Other: ____________________

INFORMED CONSENT

I agree to participate in this study by Agincourt Health and Demographic

of the Witwatersrand.

I understand the reason for this research and the way it is going to be done. I understand that the study will involve collection of blood, that different measurements of my body will be taken, and that I will fill in questionnaires. The details and purpose of this study has been explained to me. I understand that I have the right to refuse my participation and / or that of my child and that nothing bad will result.

I agree to participate in the study on condition that:

1. I can choose to withdraw from the study at any time and that no bad things will happen as a result.
2. I have the right not to answer any or all questions asked in the interviews.
3. The Committee for Research on Human Subjects at the University of the Witwatersrand has approved the study itself and the way it is to be conducted.

4. All results will be treated with the strictest confidentiality.
5. Only group results, and not my individual results will be published.
6. The Agincourt Health and Demographic Surveillance System (AHDSS) of the MRC/Wits, Rural Public Health and Health Transitions Research Unit, School of Public Health, and the Birth to Twenty Scientific Teams are committed to treating participants with respect and privacy throughout the procedure.
7. I will receive a referral note to a health service if any result is out of the normal range or a problem is detected in the course of the study.

PARTICIPANT ASCENT

Printed Name	**Signature / Mark or Thumbprint**	**Date and Time**

RESEARCH ASSISTANT:

Printed Name	**Signature**	**Date and Time**

WITNESS: (If applicable)

Printed Name	**Signature**	**Date and Time**

The FIRST section of the questionnaire we are going to chat about your thoughts around your APPEARANCE

Body image assessment

[USE BODY SILHOUTTE CARDS – PLEASE ENSURE THAT THEY ARE SHUFFLED BEFORE GIVEN TO THE ADOLESCENT]

1. Please look at the cards and choose the girl that you think…
   (Girls and Boys)

Looks the best	
Looks the worst	
Is clumsy	
Has more respect from others	
Has less respect from others	
Is the strongest	
Is the weakest	
Is the happiest	
Is the most unhappy	

2. Choose the girl that…
   (Girls only)

Looks like you	
You would want to look like	
Your family will want you to look like	

Your friends will want you to look like	

Y	N

3. Have you ever thought you were thin: *(Girls only)*

1	9

4. Between figure **1** or **9**, which girl would you rather look like? *(Girls only)*

5. Between figure **1** or **9**, which girl would you rather have as your girlfriend? *(Boys only)*

1	9

Yes	No

1. Have you tried to **lose weight** during the past year?

2. If YES, what was the **most important** reason (**mark only one**)

It is healthy	
I want to look better	
My clothes were too tight	
I am too fat compared to my friends	
I am unhappy with myself	
I dream of being a model or movie/TV star	
Any other reason, specify	

1. If you did try to **lose weight**, describe all the methods you have tried. Include any information on diet, exercise, pills or anything else that you have tried.

1. 2. 3. 4.

2. Did you try to **build more muscles** or grow bigger during the past year?

Yes	No

3. If YES, what was the most important reason (mark only one)?

It is healthy	
I want to look better	
Compared to my friends I have too little muscle	
I am unhappy with myself	
I dream of being a model or movie/TV star	
Any other reason, specify	

4. If you did **try to build more muscles**, describe all the methods you have tried. Include any information on diet, exercise, pills or anything else that you have tried.

1.
2.
3.
4.

Now I am going to ask you some questions about the way you feel about your body

	Never	Seldom	Sometimes	Often	Always
1. I like what I look like in pictures	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
2. Other people consider me good looking	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
3. I'm proud of my body 0	☐ 1	☐ 2	☐ 3	☐ 4	☐
4. I'm preoccupied with trying to change my body weight	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
5. I like what I see when I look in the mirror	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
6. There are lots of things I'd like to change about my looks if I could	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
	☐	☐	☐	☐	☐

7. I am satisfied with my weight	0	1	2	3	4
8. I wish I looked better	0	1	2	3	4
9. I really like what I weigh	0	1	2	3	4
10. I wish I looked like someone else	0	1	2	3	4
11. People my own age like my looks	0	1	2	3	4
12. My looks upset me	0	1	2	3	4
13. I'm as nice looking as most people	0	1	2	3	4
14. I'm pretty happy about the way I look	0	1	2	3	4
15. I feel I weigh the right amount for my height	0	1	2	3	4
16. I feel ashamed of how I look	0	1	2	3	4
17. Weighing myself depresses me	0	1	2	3	4
18. My weight makes me unhappy	0	1	2	3	4

19. I worry about the way I look	0	1	2	3	4	
20. I think I have a good body	0	1	2	3	4	
21. I'm looking as nice as I'd like to	0	1	2	3	4	

Now am going to ask you about EATING ATTITUDES TEST

	Always	Very often	Often	Sometimes	Seldom	Never
1. I am terrified *(very scared)* about being overweight						
2. I avoid eating *(try not to eat)* when I am hungry						
3. I find myself preoccupied with food *(think about food a lot)*						
4. I have gone on eating binges *(a lot of food in a short time)* where I feel that I may not be able to stop						
5. I cut my food into small pieces						
6. I am aware of the calorie/ *kilojoule (energy)* content of foods that I eat						
7. I particularly avoid foods with a high carbohydrate *(starch)* content *such* as bread, potatoes, rice *and pap*						
8. I feel that others would prefer *(like it)* if I ate more						
9. I vomit *(bring up food / throw up)* after I have eaten						
10. I feel extremely guilty (*I've done wrong)* after eating						
11. I am preoccupied with a desire to be thinner *(think about being thinner a lot)*						

12. I think about burning up calories/ kilojoules *(energy)* when I exercise						
13. Other people think I am too thin						
14. I am preoccupied with the thought of having fat on my body *(think about having fat on my body a lot)*						
15. I take longer than other people to eat my meals *(food)*						
16. I avoid *(try not to eat)* foods with sugar in them						
17. I eat "diet" foods *(special foods to lose weight)*						
18. I feel that food controls my life						
19. I display self control around food (*I can control my eating if there is a lot of food available)*						
20. I feel that others put pressure on me to eat						
21. I give too much time and thought to food						
22. I feel uncomfortable *(not good)* after eating sweets						
23. I engage in dieting behaviour *(try to lose weight)*						
24. I like my stomach to be empty *(I like the feeling)*						
25. I enjoy trying new rich (*creamy/ fatty*) foods						
26. I have the impulse *(need)* to vomit after meals						

If you are still at school, please complete the Physical Activity Section ONLY (SECTION B) on page 9

If you are not at school, please complete the Sub-Saharan Africa Activity Questionnaire ONLY (SECTION C) on page 14

SECTION B: PHYSICAL ACTIVITY AT SCHOOL

In this section we will talk about your activities and exercise at school

1. Do you attend physical education classes at school?
   (Exercise classes supervised by a teacher during school time)

Y	N

2. How often classes are held & how long are the classes?

Times / week	Hours / time

What are the three most frequent activities that you do during these classes?

Activities

3. Do your school teachers encourage you to participate in **physical activity**?

Y	N

4. Do your parents encourage you to participate in **physical activity**?

Y	N

5. Who (parent/caregiver or other) encourages you the most to participate in **physical activities? (This question MUST be answered)**

Informal activities

List 3 of the most frequent informal activities that you are involved in (eg: playing soccer with your friends for fun etc)

Activity	Frequency	Duration
1.		
2.		
3.		

Sedentary activities

Do you engage in any of the following activities before or after school, and if so, for how many hours?

Activity	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Watching TV & videos & movies							
Reading, drawing, homework							
Playing a musical instrument - please detail what musical instrument? ______________________							
Playing video/ TV/ computer games							
Internet surfing							
Listening to radio/ music							

What time do you go to bed on a school night?

What time do you go to bed on a non-school night (on a weekend or on holiday)?

What time do you wake up on a school morning?

What time do you wake up on a non-school morning (on a weekend or on holiday)?

Transport
How do you get to school and how long does it take to get there and back?

1. By car, bus, taxi, train etc.

Yes	No
There: __________ minutes	
Back: __________ minutes	

2. Walking

Yes	No
There: __________ minutes	

Back: __________ minutes

When you walk, at what pace (how fast) do you usually walk?

At a pace, that makes me breathe much harder than normal	1
At a pace that makes me breathe somewhat harder than normal	2
At a pace where there is no change in my breathing	3

3. Bicycle

Yes	No
There: __________ minutes	
Back: __________ minutes	

When you cycle, at what pace (how fast) do you usually cycle?

At a pace, that makes me breathe much harder than normal	1
At a pace that makes me breathe somewhat harder than normal	2
At a pace where there is no change in my breathing	3

~~Notes on Transport~~

EXTRA MURAL ACTIVITIES AT SCHOOL (*LAST 12 MONTHS*)

	How many months?	Prac/Wk	Hrs/Prac	Match/Comp/Wk
Athletics (running)				
Athletics (other)				
Cricket				
Swimming				
Tennis				
Hockey				
Netball				
Rugby				
Soccer				
Badminton				
Basketball				
Ballet				
Cycling				
Dancing				
Gymnastics				
Judo / karate				

Squash				
Volleyball				
Other				
Musical instrument				

PRIVATE EXTRA MURAL ACTIVITIES (*LAST 12 MONTHS*)

	How many months?	Prac/Wk	Hrs/Prac	Match/Comp/Wk
Athletics (running)				
Athletics (other)				
Cricket				
Swimming				
Tennis				
Hockey				
Netball				
Rugby				
Soccer				
Badminton				
Basketball				

Ballet				
Cycling				
Dancing				
Gymnastics				
Judo / karate				
Squash				
Volleyball				
Other				
Musical instrument				

END: Thank you, please sign on page 18 and make any notes on page 22

SECTION C: The Sub-Saharan Africa Activity Questionnaire

In this section we are going to talk about your physical activities and leisure time occupations.

SECTION C1 & C3: OCCUPATIONAL OR EDUCATIONAL (UNIVERSITY/COLLEGE) RELATED ACTIVITIES; WALKING/CYCLING TO WORK
(PAST YEAR)

Job name
Job schedule

Code
Cat
A,B,C

Date at start and finish (mm/yy)
start finish

Months held

Cycle to work
min/day

Walk to work (min/day)
slow (pace) brisk

mo./year d/week hr/day

Notes:

<u>SECTION C3</u>: <u>LEISURE-TIME ACTIVITIES</u>

In the table below, check all activities the participant did at least 6 times over the past year. Do not include activities related to his/her work

1. House-hold	14. Hunting	27. Gymnastics	40. Sexual intercourse
2. Needle-work	15. Fishing	28. Karate/wrestling	41. Playing music
3. Hair dressing	16. Teaching (at home)	29. Football	42. Singing
4. Home repairs	17. Reading/writing	30. Handball	43. Weight training (machine)
5. Gardening (around the house)	18. Type-writing/computer work	31. Basketball	44. Free weights

6. Light farming	19. Video game	32. Volleyball	45. Treadmill
7. Intense farming	20. Indoor games	33. Lawn tennis	46. Stationary bike

8. Wood splitting	21. Cinema/video/TV watching	34. Table tennis	47. Stair-climbing
9. Animal rearing	22. Discussions (meetings)	35. Cycling	48. Aerobics
10. Driving	23. Aerobic dancing	36. Horse riding	49. Spinning
11. Carpentry	24. Swimming	37. Classical dance	50. Kick-boxing
12. Painting	25. Leisure walking	38. Light traditional dance	51. (Other)
13. Construction work	26. Jogging	39. Vigorous traditional dance	52. (Other)

2.1 PAST YEAR **2.2 PAST MONTH**

Write down the number of sessions per week, the number of months Write down the number of sessions over the past month and the

per year and the mean duration of a session for each activity mean duration of a session for each activity performed during this performed over the past year. period of time.

PAST YEAR

PAST MONTH

Activity	Code	Month/year	Sessions/week	Min./session	Sessions/week	Min./session

SECTION C4: PERSONAL EVALUATION OF PHYSICAL ACTIVITY

- How would you describe your physical activity of the past year?

Intense ☐ Moderate ☐ Light ☐ Null ☐

- Would you like to do (more, less, the same)?

More ☐ Less ☐ The same ☐ Doesn't know ☐

Research Assistant: **Date:**

ANTHROPOMETRY

- STANDING HEIGHT: (mm)
- SITTING HEIGHT: (mm)
- WEIGHT: (kg)
- WAIST CIRCUMFERENCE: (mm)
- HIP CIRCUMFERENCE: (mm)

SKINFOLD MEASUREMENTS – LEFT SIDE (mm)

- TRICEP:
- BICEP:
- SUBSCAPULAR:
- SUPRA-ILIAC:
- MEDIAL CALF:

Research Assistant: **Date:**

BLOOD PRESSURE

- SYSTOLIC BP
- DIASTOLIC BP
- PULSE
- TIME OF BP

		h			

Research Assistant: **Date:**

SELF COMPLETION/PUBERTAL ASSESSMENT QUESTIONNAIRES:

YES	NO

Research Assistant: **Date:**

FOOD FREQUENCY QUESTIONNAIRE:

YES	NO	N/A

Research Assistant: **Date:**

YES	NO

ORAL GLUCOZE TOLERANCE TEST :

Research Assistant: **Date:**

YES	NO

ANTHROPOMETRIC MEASUREMENTS:

Research Assistant: **Date:**

Quality Check: **Date:**

Notes:

UNIVERSITY OF THE WITWATERSRAND

Rural Public Health and Health Transition Research Unit

Agincourt Growth Study

HEALTH SERVICES QUESTIONNAIRE

DATE : Day **Month** **Year**

AGS NUMBER :

The FIRST section of the questionnaire we are going to talk about…

EATING HABITS AND PRACTICES

SECTION A: Breakfast habits

Think about a **usual school week and weekend** and try to answer the following questions about your eating habits as truthfully as possible. There are no right or/ wrong answers so please feel free to give your answer.

1. On how many weekdays do you usually eat breakfast? **Mark one only**

Never	1
1-2 days	2
3-4 days	3
Every weekday (5)	4

2. How often do you usually eat breakfast on a weekend? **Mark one only**

Never	1
Saturdays only	2
Sundays only	3
Saturdays and Sundays	4

3.1 What best describes the way you usually eat during the week? **Mark one only**

3 or more meals a day	1
2 meals a day	2
1 meal a day	3

3.2 What best describes the way you usually eat over a weekend? **Mark one only**

3 or more meals a day	1
2 meals a day	2
1 meal a day	3

4. How many times do you eat snacks in a day? **Mark one only**

Just once a day	1
Twice a day	2
3 or more times a day	3
Never	4

SECTION B: Fast foods

1. How often during the **past week** (past 7 days) did you eat any of the following takeaways? **Tick each item**

	0 x last week	1x last week	2x last week	3x last week	4x last week	5+ last week
Hamburger						
Chicken Burger						
Chicken pieces						
Fried fish						
Fried chips						

Pizza						
Vetkoek						
Pies or sausage roll						
Samoosas						
Pita bread						
Hotdog						
Boerewors roll						
Doughnuts						
Sweets						
Cake						
Chocolates						
Chips e.g. nik naks						
Ice cream						
Soft drinks e.g. Coke						
Squash e.g. *Drink-o-pop/Oros*						
Diet drinks						
Other:						

2. How often do you usually eat at a friend's house? (In a week) Tick where applicable.

0 x per week	1x per week	2x per week	3x per week	4x per week	5+ x per week

SECTION C: School lunch box (if applicable)

Yes	No	Sometimes
1	2	3

How much money do you usually get to spend at school per week on food?

Mark one only

Transport	No money	1	**Lunch**	No money	1
	R10 or less	2		R10 or less	2
	R20 or less	3		R20 or less	3

More than R20	4	More than R20	4

Which of the following foods did you buy at school (tuck shop)? **Tick each item**

	Did not buy	**Bought 1 time**	**Bought 2 times**	**Bought 3 times**	**Bought 4 times**	**Bought 5 times or more**
White bread or rolls						
Brown bread or rolls						
Fresh fruit						
Chips (e.g. nik naks)						
Pap and Meat or chicken						
Chips (hot)						
Pie / sausage roll / samoosa						
Vetkoek						
Cold drink						
Diet cold drinks						
Fruit juice						
Milk or sour milk						
Yoghurt						
Cheese						
Sweets or chocolates						
Cakes/ donuts/ éclairs						
Hot dogs						
Hamburger (beef or chicken)						
Popcorn						
Peanuts/nuts						
Other:						

1. How often do you snack when you are watching TV? **Mark one only**

Every day	1
More than three days a week	2
Less than 3 days a week	3
Never	4

2. Which snacks did you eat while watching TV last week (past seven days)? And how often?

Tick each item

	Didn't eat	1 time	2 times	3 times	4 times	5 or more times
Fruit						
Popcorn						
Chocolates						
Bread (any type)						
Crisps e.g. nik-naks						
Biscuits						
Cakes/ donuts/ éclairs						
Drinks e.g. Coke						
Fries						
Other:						

4. Do TV adverts on foods influence you to buy those food items? **Mark one only**

Never	1
Hardly ever	2
Often	3
Very often	4

5. Which food and drinks that you see advertised on TV do you buy?

1.)

2.)

3.)

6. Where do you usually eat your main meal of the day? **Mark one only**

Kitchen at a table/counter (eating by yourself)	1
Dining room at a table (eating with other family members)	2
In front of the TV off your lap	3
Other	4

7. How many times do you eat dinner/supper with your family/parents/caregivers?

Never	1
Some Days	2
Most Days	3
Every Day	4

8. How much does your mother/caregiver/father control what you eat?

1.	Not at all	2.	Sometimes	3.	Mostly	4.	Completely

FOOD FREQUENCY QUESTIONNAIRE (FFQ)

Interviewer instructions (more detailed instructions in Food Photo Manual)

- **Step 1:** Ask the participant to think about the foods and drinks they eat and drink. Tell them you want them to recall the foods/drink they consumed and then the quantities/amounts.

- **Step 2:** Give the pack of Flash Food Cards to the participant with the following instructions: "Please look through the photographs and make 2 piles. One pile is for items which you hardly ever or never eat/drink. The other pile is for those items that you do eat/drink." Mark the 'never' eaten (column H) whilst the participant is sorting through the cards.

- **Step 3:** Now ask the participant to do the following: "Once again make 2 piles of cards. The one pile is for items which you ate/drank drink in the past 2 weeks. 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 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, tick the 'occasionally' eaten (column G). Do this until all the cards are accounted for. Herewith examples as shown on the example FFQ:

  "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."

- **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.** The FPM and any other available aids must be used to determine the portion size. 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 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. Do you add salt to your food before you eat it?

YES	1
NO	0

8. If yes, how much salt do you add to your food each day?

¼ teaspoon	1
½ teaspoon	2
¾ teaspoon	3
1 teaspoon	4
Other specify:	5

9. Do you add Aromat to your food before you eat it?

YES	1
NO	0

10. If yes, how much Aromat do you add to your food each day?

¼ teaspoon	1
½ teaspoon	2
¾ teaspoon	3
1 teaspoon	4
Other specify:	5

11. 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

12. In an average month how often do you eat food from the following places?

	Frequency of visits		
	Times/week	Times/month	Rarely/never
Nandos (or Galitos)			
Spur			
Macdonalds			
Steers			
KFC			
Chicken Licken			
Debonaire's Pizza			
Romans			
Anat			
Wimpy			
Something fishy			
Fontana			
Chinese takeaway			
Other restaurants/takeaways			
(Quarters from tuck shop)			

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

		Skim fat free							
	3. Buttermilk/maas	Buttermilk		2713					
		Maas		2787					
	4. Milk drinks, flavoured								
X	**5. Yoghurt**	Flavoured							
		Plain							
	1. Sugar (extra)								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	3. Breakfast cereals								
	2. Milk added to cereal								
	1. Sugar added to cereal								
	9. Ice cream	Full cream							
		Low sugar							
	9. Ice lollies								

	ASK ABOUT TYPE OF BREAD,THICKNESS OF SLICES AND THE SPREAD								
	1. Bread/rolls	White							
		Brown							
		Whole wheat							
		Traditional							
		Roti							
	Spread? Y / N	**Brand name**							
	1. Brick margarine								
	1. Tub margarine								
	1. Butter								
	Cheese spread								
	Fish paste								
	Honey/syrup								
	Jam								
	Marmite/Bovril								
	Sandwich spread								
	Peanut butter								
	Chocolate spread								
	Avocado								
Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionally	**H.** Never eaten

						Times/ day	Times/ week		
	Atchar								
	Eggs								
	Cold meats	Ham							
		Polony							
		Salami							
	6. Cottage cheese	Low fat							
		Full fat							
	7. Cheddar								
	7. Gouda								
	7. Other cheese								
	8. Cheese wedges								
	2. Fat cakes								
(Red)	**QUARTER**								
	4. Maize porridge stiff								
	4. Maize porridge soft								
	2. Milk on soft porridge								
	1. Sugar on soft porridge								
	1. Fat on soft porridge								

	4. Mabele/maltabella stiff								
	4. Mabele soft								
	2. Milk on Mabele								
	1. Sugar on Mabele								
	1. Fat on Mabele								
	4. Oats								
	2. Milk on Oats								
	1. Sugar on Oats								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionall y	**H.** Never eaten
						Times/ day	Times/ week		
	4. Maize & pumpkin porridge								
	5. Pasta/Pasta dishes								
	6. Spaghetti Bolognaise								
	6. Macaroni and cheese								
	6. Lasagne								
	7. Rice	White							
		Brown							

		With fat?							
	7. Samp/mealie rice	With fat?							
	7. Samp and beans	With fat?							
X	**7. Wheat rice**	With fat?							
	8. Pizza	Vegetable topping							
		Meat topping							
		Meat & vegetables							
	8. Savoury tart								
X	**EGGS-YELLOW**								
	Boiled								
	Fried								
	Omelette (filling and quantity)								
	Scrambled								
Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionall y	**H.** Never eaten
						Times/ day	Times/ week		
	FRUITS-ORANGE								
X	**1. Apples**								

X	**2. Bananas**	Fresh							
		Fried							
	3. Berries	Fresh							
		Canned							
		Candied							
X	**4. Figs/prickly pears &**	Fresh							
	Coconuts, dates	Candied							
	5. Fruit salad	Fresh							
		Canned juice							
		Canned syrup							
X	**6. Grapes**								
X	**7. Guavas**	Fresh							
		Canned juice							
		Canned syrup							
X	**8. Mango**	Fresh							
		Canned juice							
		Dried							
	8. Pawpaw	Fresh							
		Canned juice							
		Canned syrup							
	8. Kiwi fruit								
	8. Leechies								

X	**9. Watermelons**								
	9. Sweet melon								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionall y	**H.** Never eaten
						Times/ day	Times/ week		
X	**10. Naartjies**	Mineola fresh		4227					
		Naartjie fresh		3558					
		Naartjie canned syrup		3635					
X	**11. Oranges**	Fresh		3560					
	11. Grapefruit	Fresh		3546					
X	**12. Peaches**	Fresh							
		Canned juice							
		Canned syrup							
X	**12. Nectarines**	Fresh							
X	**13. Pears**	Fresh							
		Canned juice							
		Canned syrup							

	14. Pineapple	Fresh							
		Canned juice							
		Canned syrup							
X	**15. Plums**	Fresh							
	15. Apricots								
	16. Dried fruit								
	16. Dry stewed fruit								
	16. Raisins								
	17. Fruit juice	Fresh							
		Sweetened							
		Unsweetened							
Generic **Sketch** (look up)	**18. Canned fruit** **A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	SOUPS, LEGUMES, NUTS								
	1. Soups	Homemade							
		Commercial							

Generic **Sketch**	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g)	**E**. Eaten every day	**F**. Eaten every	**G**. Eaten Occasionall	**H.** Never eaten
		Vegetable							
		Meat							
		Meat & vegetable							
		With bones							
	2. Beans and lentils	Anything added							
	3. Nuts								
	3. Peanuts								
	FISH & SEAFOOD- BEIGE								
	1. Fried fish								
	1. Fish cakes								
	1. Fish fingers								
	1. Calamari								
	2. Grilled/smoked/dried fish								
	2. Haddock								
	3. Pilchards & sardines	Canned water							
		Canned tomato sauce							
		Mayonnaise							

(look up)					Generic/amount = g		week	y	
						Times/ day	Times/ week		
	3. Tuna	In brine water							
		In oil							
		Mayonnaise							
	3. Pickled fish								
	MEAT- RED								
	How do you eat meat 1= with fat 2= fat trimmed								
	1. Roast beef								
	1. Beef chops								
	1. Beef steak (bone)								
	1. Beef steak (no bone)								
	1. Beef stir-fry								
	1. Beef stew / carrots								
	1. Beef stew / cabbage								
	2. Beef patties								
	2. Mince	Regular							
		Lean							
		With fat							
		With vegetables							
X	**2. Meatballs**								

	2. Cottage pie								
	3. Burgers	Homemade							
		Fried							
		Takeaway							
		Crumbed							
	3. Hot dog								
	3. Pita with…								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	3. Chicken burger	Crumbed							
		Not crumbed							
		Takeaway							
		Home made							
		Shop bought							
	3. Chicken nuggets								
	4. Chicken stew								
	4. Fried chicken pieces	With skin							
		Without skin							

	4. Roast chicken	With skin							
		Without skin							
	4. Chicken stir-fry								
	4. Chicken schnitzel								
[1]									
	6. Fat cake & mince								
	7. Meat pies	Home made							
	King pie / pie city	Commercial							
	7. Samoosas	Meat							
		Vegetable							
	7. Sausage rolls								
	7. Spring rolls								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	8. Mutton stew no veg								
	8. Mutton stew with veg								

[1] See BLUE for 5 cold meats

	8. Mutton leg chop								
	8. Mutton loin chop								
	8. Roast mutton								
	9. Spare ribs								
	9. Pork chops								
	9. Bacon								
	9. Roast pork								
	10. Pork sausages								
	10. Viennas								
	10. Frankfurters								
	10. Boerewors								
	11. Traditional / organ meats								
	Chicken livers								
	Chicken organ meats								
	Chicken head & feet								
	Liver & fat								
	Sheep intestine / lungs								
	Pork shank								
	Mopani worms								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionall y	**H.** Never eaten
						Times/ day	Times/ week		
	12. Vegetarian products								
	13. Dry sausages								
	13. Biltong								
	VEGETABLES – GREEN								
	1. Asparagus	Fresh							
		Canned							
		Fat added							
		Sugar added							
	2. Avocado	Fresh							
	3. Baby marrows	Fat added							
		Sugar added							
		Sauce							
	4. Beetroot	Boiled							
		Grated							
	5. Butternut/pumpkin	Fat added							
		Sugar added							

	6. Broccoli	Fat added							
	6. Cauliflower	Fat added							
	7. Cabbage	Boiled							
		Fried							
	8. Carrots	Boiled							
		Fat added							
		Sugar added							

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	9. Gem squash	Boiled							
		Sugar added							
		Sauce							
	10. Green beans	Fat added							
		Sugar added							
		With onion							
		With potato							
		Sauce							
	11. Mealies	Fat added							

		Creamed							
	12. Mixed vegetables	Frozen							
		Fat added							
		Sugar added							
		Sauce							
	13. Mushrooms	Fat added							
		Sauce							
	14. Peas	Fat added							
		Sauce							
	15. Potatoes	Boiled							
		Roasted							
		Baked							
		Mash with fat							

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	15. Potato Salad								
	16. Potato chips	Homemade							

		Fried oil							
		Oven baked							
		Takeaway							
		Mayonnaise							
		Tomato sauce							
	17. Salad vegetables	Mayonnaise							
		Dressing							
	17. Cucumber								
	17. Peppers								
	18. Spinach/morogo	Peanuts							
		Fat added							
		Tomatoes							
		With onions							
		With potatoes							
	19. Sweet potatoes	Fat added							
		Sugar added							
	20. Tomatoes	Raw							
		Cooked							
		With onion							
		Fat added							

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B**. Description of food item	**Tick for yes**	**C**. Item code	**D**. Amount usually eaten(g) Generic/amount = g	**E**. Eaten every day	**F**. Eaten every week	**G**. Eaten Occasionall y	**H.** Never eaten
						Times/ day	Times/ week		
	FATS-TAN 'prompt'								
	1. Tub margarine	Where used							
		Number of spoons							
		Number in family							
	1, Butter								
	1. Brick Margarine								
	2. White margarine (type of fat)								
	3. Cream and substitutes (brand, real dairy/plant fats)								
	4. Oils	Where used							
		Number of spoons							
		Number in family							
	5. Salad dressings	Homemade							
		Shop bought							
	5. Mayonnaise	Where used							
		Number of spoons							

		Number in family							

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionally	**H.** Never eaten
						Times/ day	Times/ week		
	BISCUITS, CAKE & PUDDING - PURPLE								
	1. Biscuits/cookies	Homemade							
		Shop bought							
	2. Biscuits/savoury	Spread							
	3. Special buns	Spread							
	3. Muffins	Spread							
	3. Scones	Spread							
	4. Tart								
	4. Cake	Iced/Cream							
		Plain							
	5. Doughnuts	Plain							
	5. Doughnuts	Filled							
	5. éclairs								
	5. Koeksisters								

	6. Pancakes/crumpets	Spread							
		Syrup							
		Ice-cream							
	6. Waffles	Spread							
		Syrup							
		Ice-cream							
	7. Trifle								
	7. Baked Pudding								
	7. Instant pudding								
	7. Custard								
	8. Rusks								

Generic **Sketch** (look up)	**A.** Food items (with FPM numbers)	**B.** Description of food item	**Tick for yes for yes**	**C.** Item code	**D.** Amount usually eaten(g) Generic/amount = g	**E.** Eaten every day	**F.** Eaten every week	**G.** Eaten Occasionall y	**H.** Never eaten
						Times/ day	Times/ week		
	9. Special breads								
		Spread							
	SNACKS, SWEETS & COLD DRINKS-PINK								
	1. Carbonated cold drinks e.g. coke								

Generic **Sketch**	**A.** Food items (with FPM numbers)	**B.** Description of food	**Tick for yes for**	**C.** Item	**D.** Amount usually eaten(g)	**E.** Eaten	**F.** Eaten every	**G.** Eaten Occasionall	**H.** Never
	1. Diet cold drinks e.g. diet coke								
	2. Mageu								
	2. Cold drinks (powder)								
	2. Energy drinks								
	2. Squashes								
	3. Crisps								
	3. Popcorn								
	4. Sweets								
	Lollipops								
	4. Chocolates								
	SAUCES & CONDIMENTS-GREY								
	1. Cheese sauce	Full cream milk							
		Butter							
		Margarine							
	1. White sauce	Full cream milk							
		Butter							
		Margarine							

(look up)		item	**yes**	code	Generic/amount = g	every day	week	y	eaten
						Times/ day	Times/ week		
	2. Chakalaka								
	2. Atjar								
	2. Tomato sauce & other								
	2. Chutney								
	ALCOHOLIC DRINKS-GREY								
	1. Beer (regular/low alcohol)								
	1. Cider								
	Coolers								
	2. Wine								
	2. Champagne								
	3. Spirits (any carbonated drink e.g. coke added)								
	4. Liqueurs & Fortified wine								
	OTHER LOCAL FOODS								
	Locusts								
	Termites								

	Wild Fruits:								

University of the Witwatersrand

Rural Public Health And Health Transition Research Unit

AGS ID							

AGS Study: the assessment of physical development in adolescence – (2009)

Female

Section A

We would like to ask you a few questions about your physical development.

PLEASE TICK ONLY ONE BOX IN EACH ROW

Question 1

Have you grown taller in the last 6 months?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, a lot ☐ now ☐

Question 2

Have you started puberty (i.e. do you have pubic hair or have your breasts enlarged)? (Please mark the appropriate block)

No ☐ Yes ☐

Question 3

Have your breasts started to develop (grow) yet?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, a lot ☐ now ☐

Question 4

Do you have any hair underneath your arms or in the pubic region?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, a lot ☐ now ☐

Question 5

Has your skin started to change (pimples)?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, a lot ☐ now ☐

Question 6

Have you begun to menstruate (have your period)?

(Please mark the appropriate block)

No ☐ Yes ☐

Question 7

If **Yes** to *Question 6*, at what age did you begin to menstruate? ☐

Question 8

If **Yes** to *Question 6*, do you have regular menstrual cycles (periods)?

(Please mark the appropriate block)

No ☐ Yes ☐

Question 9

If **Yes** to *Question 6*, have you been having periods for more than two years?

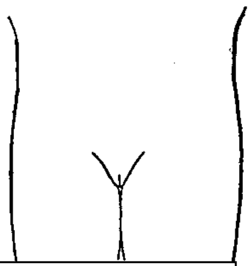
(Please mark the appropriate block)

No ☐ Yes ☐

Section B

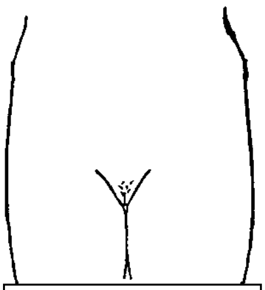
The drawings below show different amounts of pubic hair. A teenager passes through each of the five stages shown by these drawings. Please look at each drawing and read the sentences under the drawings. Then choose the drawing closest to your stage of hair development and mark it. (**Tick one box only**)

1. DRAWING A ______



There is no pubic hair

2. DRAWING B ______

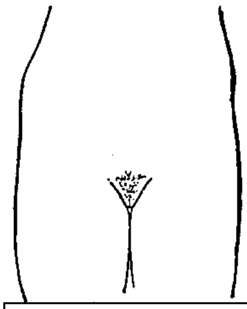


Texture of the hair is soft.

Density of the hair is little.

Distribution of the hair is along the mid-line. Pubic hair may be straight or curly

3. DRAWING C ______

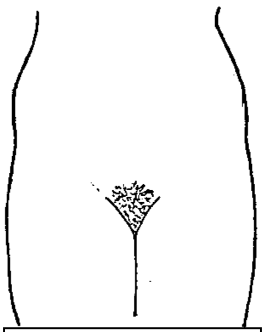


Texture of the hair is coarser.

Density of the hair is a little more.

Distribution of the hair has spread out thinly, up the mid-line, and covers a somewhat larger area.

4. DRAWING D ______

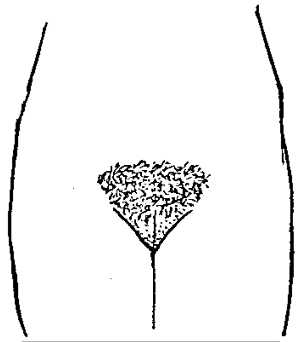


Texture of the hair is coarse.

Density of the hair is much more.

Distribution of the hair covers a large area in a triangular shape, but has not spread to the thighs. The hair is a darker colour.

5. DRAWING E ______



Texture of the hair is coarse.

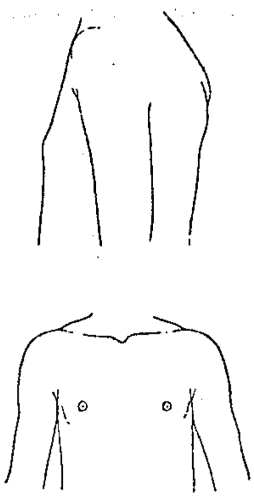
Density of the hair is that of an adult.

Distribution of the hair has spread to the thighs and moved up the mid-line.

Section C

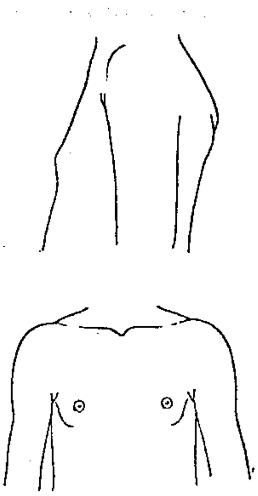
The drawings below show the different stages of development of breasts. A teenager passes through each of the five stages shown by these sets of drawings. Please look at each set of drawings and read the sentences under the drawing. Then choose the set of drawings closest to your stage of breast development and mark it. (**Tick one box only**)

1. DRAWING A



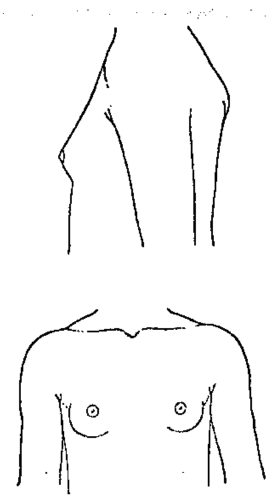
The breast is flat.

2. DRAWING B



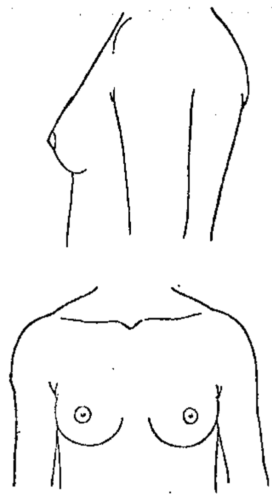
The breast is a small mound. The **areola** (circle around the nipple) is larger. The nipple is slightly raised.

3. DRAWING C



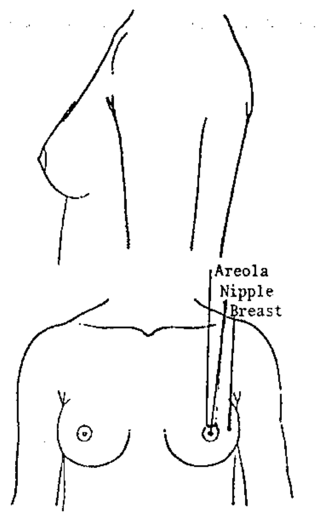
The **areola** circle has gotten bigger, and the **breast** has increased in size and more cone-shaped

4. DRAWING D



The **areola** and the **nipple** make up a mound that sticks up above the shape of the breast. Small bumps may be developing on the areola. The breast may have gotten bigger and rounder.

5. DRAWING E



The **breasts** are fully developed and extend to the arm pit, there are small bumps on the areola around the nipple, and only the **nipple** sticks out in this stage.

☐ ☐ ☐ ☐ ☐

University of the Witwatersrand

Rural Public Health And Health Transition Research Unit

AGS ID							

Today's Date: **Day** **Month** **Year**

AGS Study: the assessment of physical development in adolescence-(2009)

Male

PLEASE TICK ONLY ONE BOX IN EACH ROW

Section A

We would like to ask you a few questions about your physical development.

Question 1

Have you grown taller in the last 6 months?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, a lot D☐w ☐

Question 2

Do you have to shave your face because you have facial hair?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, everyday Don☐ ☐

Question 3

Have you started puberty (i.e. do you have pubic hair or have your genitalia enlarged)?

(Please mark the appropriate block)

No ☐ Yes ☐

Question 4

Has your skin started to change (pimples)?

(Please mark the appropriate block)

No ☐ Yes, a little ☐ Yes, some ☐ Yes, a lot ☐ now ☐

Question 5

Has your voice started breaking (do you speak in a deeper voice)?

(Please mark the appropriate block)

No ☐ Yes ☐

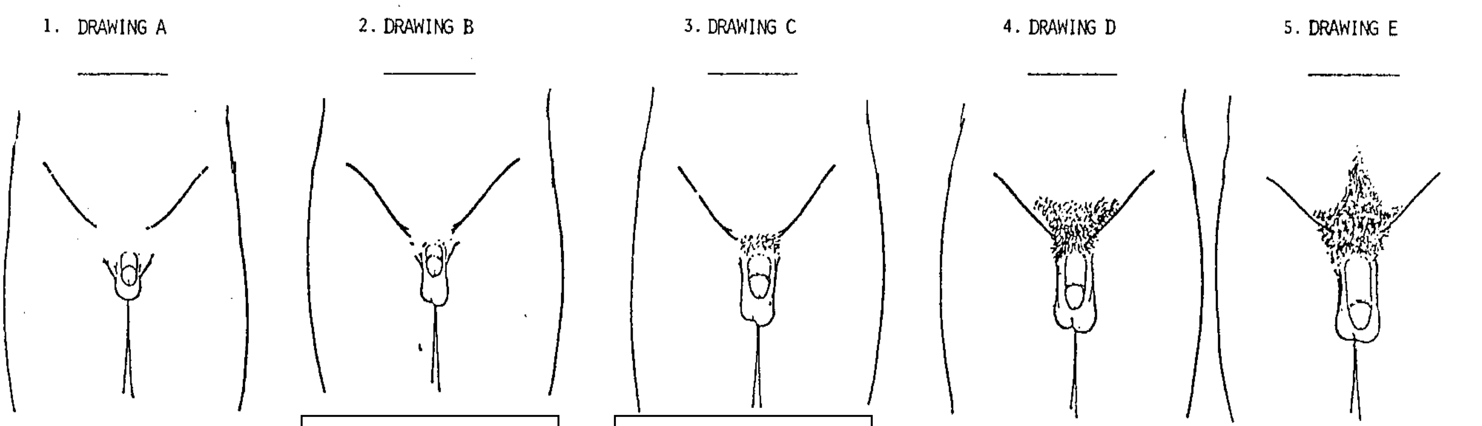
If YES, have you been speaking in a deeper voice for *more than* two years?

No ☐ Yes ☐

If YES, how old were you when your voice broke? ☐

Section B

The drawings below show different amounts of **pubic hair**. A teenager passes through each of the five stages shown by these drawings. Please look at each drawing and read the sentences under the drawings. Then choose the drawing closest to your stage of hair development and mark it.



There is no pubic hair

Texture of the hair is soft.

Density of the hair is little.

Distribution of the hair is at the base of the penis, especially on the sides. Pubic hair may be straight or curly

Texture of the hair is coarser.

Density of the hair is a little more.

Distribution of the hair has spread out thinly and covers a somewhat larger area around the base of the penis.

Texture of the hair is coarse.

Density of the hair is much more.

Distribution of the hair covers a large area but has not spread to the thighs. The hair is a darker colour.

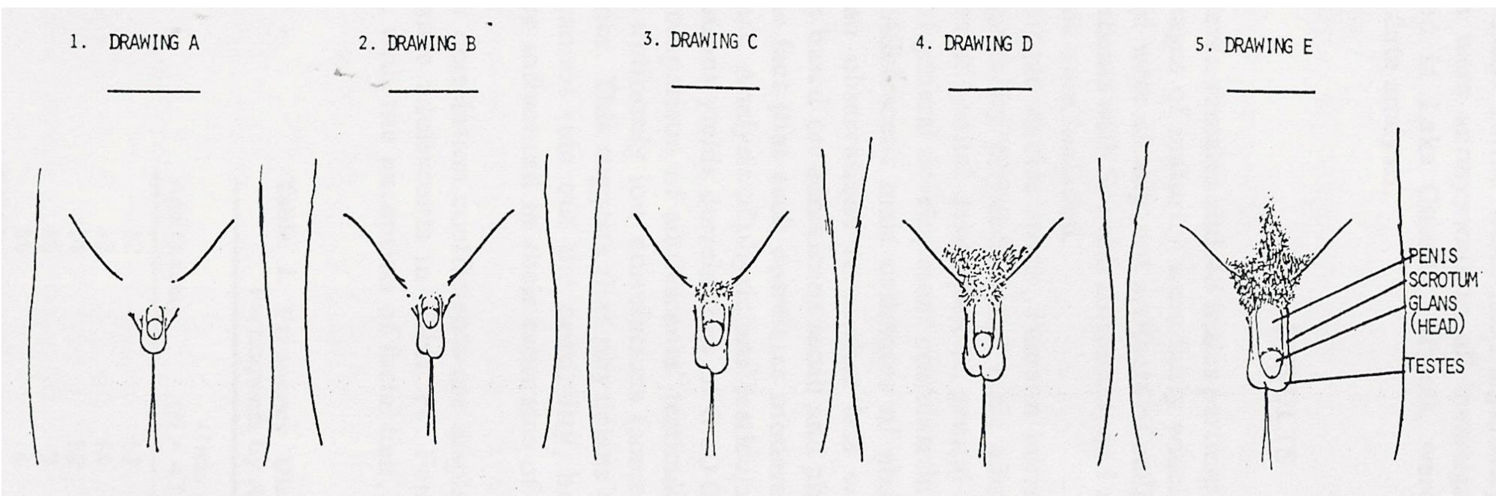
Texture of the hair is coarse.

Density of the hair is that of an adult.

Distribution of the hair has spread to the thighs and moved up the mid-line.

Section C

The drawings below show the different stages of development of genitals. A teenager passes through each of the five stages shown by these sets of drawings. Please look at each set of drawings and read the sentences under the drawing. Then choose the set of drawings closest to your stage of genital development and mark it.



There has been no change in the **testes** (balls), **scrotum** (sack holding the balls), and **penis**.	The **scrotum** has lowered a bit, and the skin of the scrotum has changed (smoother). The **testes**, **scrotum** and **penis** have gotten a little larger.	The **scrotum** has dropped lower than in stage 2. The **testes**, **scrotum** and **penis** have grown more.	The **scrotum** is bigger because the **testes** have gotten bigger. The **penis** has grown even larger and wider. The head of the **penis** is bigger	There have been no further size changes in the **penis, scrotum,** and **testes.**
☐	☐	☐	☐	☐

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

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SENATE PLAGIARISM POLICY: APPENDIX ONE

I Titilola M. PEDRO (Student number: 0310100X) am a student registered for the degree of PhD in the academic year 2017

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- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: TPedro

Date: 28/3/17.

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I, [Titilola M. PEDRO], student number [0310100X], declare that this Thesis/Dissertation/Research Report is my own work and that I contributed adequately towards research findings published in the article(s) stated below which are included in my Thesis/Dissertation/Research Report .

Signature of Student .... **Date** 30/03/2017

Name of Primary Supervisor ....**Prof. SA . Norris**

Signature of Primary Supervisor .... **Date** 28/03/2017

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Article 1: Title: Under- and overnutrition and evidence of metabolic disease risk in rural black South African children and adolescents. ***S Afr J Clin Nutr*** **2014;27(4):194-200.**

Authors	Name	Signature	Date
1st author	TM. Pedro		26/03/2017
2nd author	K. Kahn		23.03.2017
3rd author	JM. Pettifor		23/3/2017
4th author	SM. Tollman		23.03.2017
5th author	SA. Norris		
6th author			

Comments by primary supervisor:

....

Article 2: **Title: Body image satisfaction, eating attitudes and perceptions of female silhouettes in rural South African adolescent boys and girls.** ***Plos one*****, 2016; 11(5):e0154784).**

Authors	Name	Signature	Date
1st author	TM. Pedro		26/03/2017
2nd author	LK. Micklefield		23/3/2017
3rd author	K. Kahn		23.03.2017
4th author	JM. Pettifor		23/3/2017
5th author	SM. Tollman		23.03.2017

6th author	SA. Norris		

Comments by primary supervisor:

....

Article 3: Title: Associations between diet and cardiovascular disease risk factors in rural black South African adolescents (Submitted).

Authors	Name	Signature	Date
1st author	TM. Pedro		26/03/2017
2nd author	PT. Pisa		27/o3/2017
3rd author	K. Kahn		
4th author	JM. Pettifor		23/3/2017
5th author	SM. Tollman		
6th author	SA. Norris		

Comments by primary supervisor:

....

....

Under- and overnutrition and evidence of metabolic disease risk in rural black South African children and adolescents

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Keywords: stunting, underweight, overweight, obesity, metabolic disease risk, rural, South African children

Abstract

Objectives: The objective was to determine the prevalence of under- and overnutrition, as well as evidence of metabolic disease risk in rural black South African children and adolescents.

Design: A cross-sectional study was conducted.

Setting: The setting was the Agincourt Health and Socio-demographic Surveillance System site, Mpumalanga province.

Subjects: Six hundred children were randomly selected, of whom 588 were included in the analytical sample (mean age of 11.5 years, range of 7-15 years).

Outcome measures: Outcome measures were anthropometric and blood pressure assessments, Tanner pubertal staging, as well as the determination of fasting serum lipid and glucose concentrations.

Results: Using age and sex-specific World Health Organization 2007 growth references, the prevalence of stunting was determined to be 6.2% in the boys, and 2.7% in the girls, while 4.1% of the boys and 4.4% of the girls were underweight. Combined overweight and obesity prevalence was higher in the girls (13.5%) than in the boys (2.7%). Girls had significantly a higher body mass index and hip circumference than the boys in the early, mid and late pubertal stages. Pre-hypertension prevalence, using either systolic or diastolic blood pressure for sex, age and height, was 15% and 10% in the girls and boys, respectively. Furthermore, impaired fasting glucose (FG) (FG ≥ 5.6 mmol/l) was detected in 5% of the children. High-density lipoprotein cholesterol concentrations less than 1 mmol/l were observed in 0.7% of the boys and in 12% of the girls, which is indicative of cardiometabolic risk.

Conclusion: Stunting levels were higher in the boys than in the girls in mid to late childhood in a rural setting in South Africa, while the girls had a higher prevalence of overweight and obesity than the boys. Pre-hypertension prevalence in the boys and girls was high. Other metabolic risk factors, i.e. impaired FG and lipids, were also seen in this population and were associated with adiposity. The study highlights the critical need for targeted health promotion interventions to optimise child health as part of a noncommunicable disease preventative strategy.

Ⓟ Peer reviewed. (Submitted: 2013-09-10. Accepted: 2014-07-05) © SAJCN **S Afr J Clin Nutr 2014;27(4):194-200**

Introduction

It is estimated that by 2020, noncommunicable diseases will account for three quarters of all deaths in developing countries, and will be associated with increasing prevalence in the young in low- and middle-income countries.[1] Obesity is likely to increase in South Africa as a result of an ongoing lifestyle transition from a traditional rural to more urban "Westernised" lifestyle, characterised by a less healthy diet, reduced physical activity and increased sedentary behaviour.[2,3]

Fifteen years ago, 18.5% and 3% of rural children aged 7-9 years in South Africa were stunted and obese.[4] The recent National Health and Nutrition Examination Survey (SANHANES-1) showed that the prevalence of stunting in the 7- to 9-year-old age group was 10% and 8.7% for boys and girls, respectively. Also, the prevalence of overweight and obesity was significantly higher in girls than in boys aged 15-17 years (19.3% and 8%, compared to 7.3% and 1.5%, for females and males, respectively).[5] A 2008 study, the 2nd Youth Risk Behaviour Survey, found that 11% of male and 29% of female adolescents in grades 8-11 (approximate age of between 13 and 19 years) were overweight.[6] Other recent studies have confirmed the coexistence of under- and overnutrition in both rural and urban South African children.[7-10]

Research on malnutrition and metabolic disease risk factors in children is vital[11] given the limited data in rural South Africa, where lifestyle transitions are expected to be the most dramatic over the next decade.[3,7] The aim of this study was to determine the prevalence of under-and overnutrition, as well as evidence of early metabolic disease risk in rural South African children and adolescents. The Agincourt Health and Socio-demographic Surveillance System site (HDSS) provided an opportunity for study participants to be randomly selected.

Method

Setting and study population

The study was nested in the Agincourt HDSS in rural Mpumalanga province. Detailed information on the study area and Agincourt HDSS has been published previously.[7,12,13] The study area, bordering the Kruger National Park in north-east South Africa, is divided into plots that are generally too small to support reasonable subsistence farming, and the level of income is low by South African standards.[7,12,13] In 2007, 3 489 black South African children and adolescents aged 1-20 years were randomly chosen from the Agincourt HDSS villages in a growth survey.[13] In 2009, we randomly selected 600 participants, in the 7- to 8-year; 11- to 12-year and 14- to 15-year age groups from this study (200 participants in each group). Ethical approval was granted by the University of the Witwatersrand Human Subjects Research Committee Clearance No. M090212, and from the Mpumalanga Provincial Department of Health. Permission from community leaders and school principals was also obtained. Signed informed consent was provided by the parents and assent given by the children.

Anthropometric measurements

Anthropometric measurements were performed according to standard procedures.[14] Heights were measured using a stadiometer calibrated to the nearest 0.1 cm. The participants were weighed to the nearest 0.1 kg using a digital bathroom scale. The equipment was checked and calibrated daily before use. The girls and boys were measured in separate classrooms. Waist circumference (WC) was measured using an inelastic tape measure midway between the tenth rib and the iliac crest. In 2007 and 2009, hip circumference (HC) was measured at the level of maximum width of the buttocks, with the participants standing.[14] Skin fold (triceps, biceps, subscapular and suprailiac) measurements were made to the nearest 0.2 mm using a reliable calliper. The triceps and biceps skin folds were consistently measured in the non-dominant arm. Three measurements of triceps, biceps, subscapular and suprailiac skin fold thickness were taken, and the average of the four sites' measurements was used in the analysis. Participants with complete four skin fold measurements were included in the study (86.7%). Anthropometric measurements were performed by two trained fieldworkers. Both intra- and inter-observer variability were measured before the study commenced and during its course. The anthropometric measurement variation remained below 2%. A male and a female were used in order to provide both the boys and girls with gender-specific assistance during measurement.

Pubertal assessment

Participants self-reported their pubertal development using a validated questionnaire for black South Africans based on the Tanner staging criteria.[15] Pubic hair was assessed in both the boys and girls, as well as breast development in the girls and genitalia in the boys, for this study. The subjects were classified as prepubertal if they were at Tanner stage 1, early pubertal if they were at Tanner stage 2 and mid pubertal if they were at Tanner stage 3. Owing to the small number of participants, Tanner stages 4 and 5 were combined to represent late pubertal.[15]

Blood pressure measurements

Three measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were taken from participants after 5-10 minutes of quiet rest using an Omron® M6 blood pressure monitor (Omron, Kyoto, Japan). The first reading was discarded and the subsequent two readings were averaged for analysis. The blood pressure data were classified according to age-, sex- and height-specific cut-off points, based on the National High Blood Pressure Education Program Working Group.[16]

Biochemical measurements

Two trained nurses collected a 12 hour fasting venous blood sample from the participants in the morning, i.e. between 08h00 and 10h00, to determine glucose, cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol and triglyceride (TG) concentrations. The blood samples for glucose analysis were collected in grey top tubes containing sodium fluoride, while lipids were collected in clot activator tubes. Both were centrifuged. The plasma and the serum were separated and stored in a freezer at −70°C in the Agincourt laboratory. The samples were later transported to Johannesburg, packed in dry ice, and stored at −70°C until analysed. Both glucose and lipid profiles were measured using the chemiluminescence RX® daytona analyser (Crumlin Co, Antrim, Northern Ireland).[17]

Data analysis

Age and sex appropriate z-scores for weight and height were generated using the World Health Organization (WHO) 2007 growth references.[18] Body mass index (BMI) and BMI z-scores were calculated for each participant. Levels of overweight and obesity were determined using Cole's international BMI cut-off points.[19]

The risk of adiposity was assessed using waist-to-hip ratio (WHR) of > 0.85 for females, > 0.90 for males,[20] waist-to-height ratio (WHtR) of > 0.5 for both sexes,[21] and WC of ≥ 80 cm for the females and ≥ 94 cm for the males. As these are adult cut-offs points, a conservative approach was chosen to apply the cut-off points for WHR and WC only to those participants in Tanner stage 3 or greater, as they would be closer to attaining their final adult height. However, this was not applied to WHtR. In addition, impaired fasting glucose of ≥ 5.6 mmol/l was calculated according to International Diabetes Federation standards.[22] The following cut-offs were used for abnormal lipids: HDL cholesterol of > 1.03 mmol/l, LDL cholesterol

Table I: The characteristics of the study participants according to sex and age

Variables	7-8 years (n = 197)			11-12 years (n = 202)			14-15 years (n = 189)		
	Boys (n = 98)	Girls (n = 99)	p-value	Boys (n = 102)	Girls (n = 100)	p-value	Boys (n = 92)	Girls (n = 97)	p-value
Mean age (years) (SD), n = 588	7.5 (0.5)	7.6 (0.5)	0.178	11.5 (0.5)	11.5 (0.5)	0.780	14.5 (0.5)	14.5 (0.5)	0.430
Mean weight (kg) (SD), n = 588	25 (4)	26 (6)	0.240	43 (11.3)	48 (13.1)	0.000*	51 (11.1)	55.3 (10)	0.003*
Mean height (cm) (SD), n = 588	126.3 (6.1)	127.5 (6)	0.16	145 (7)	149 (8)	0.000*	163.1 (8.6)	160 (5.5)	0.002*
Mean BMI (kg/m^2) (SD), n = 588	15.6 (1.7)	16 (2.5)	0.613	17 (2)	18 (3.4)	0.004*	19 (2.4)	22 (4.1)	0.000*
Mean WC (cm) (SD), n = 588	55.4 (4.3)	52.7 (5.2)	0.000*	60.3 (5.2)	60.6 (7.2)	0.780	67 (6.3)	68 (9.4)	0.351
Mean HC (cm) (SD), n = 588	63.2 (0.5)	65 (0.7)	0.142	72 (0.7)	80 (1)	0.000*	80 (1.3)	90 (1.2)	0.000*
Mean SBP (mmHG) (SD), n = 523	99 (12)	95.5 (12.4)	0.074	98.3 (12.4)	106 (14.5)	0.000*	111 (12.3)	112.3 (10.7)	0.423
Mean DBP (mmHG) (SD), n = 523	58.5 (12.1)	58.3 (11)	0.907	59 (8)	61.2 (12)	0.076	64 (8)	65 (7.4)	0.433
Sum of skin folds (mm) (IQR, n = 509	5.3 (4.6-5.9)	6 (5.1-7)	0.000*	5.5 (4.8-6.2.)	5.3 (4.4-6)	0.130	5.8 (5.1-6.8)	9 (7.4-9.8)	0.000*
Mean HDL cholesterol (mmol/l), (SD), n = 371	1.1 (0.4)	1.3 (0.3)	0.032*	1.2 (0.3)	1.2 (0.3)	0.700	1.2 (0.3)	1.2 (0.3)	0.770
Mean LDL cholesterol (mmol/l), (SD), n = 367	2 (0.6)	2 (0.6)	0.560	2 (0.7)	2 (0.6)	0.174	2 (0.5)	2 (0.6)	0.335
Mean TGs (mmol/l) (SD), n = 388	0.8 (0.3)	0.8 (0.3)	0.830	0.8 (0.3)	1 (0.5)	0.185	0.8 (0.3)	0.8 (0.3)	0.220
Mean TC (mmol/l) (SD), n = 388	4 (0.7)	4.1 (0.8)	0.242	4.1 (0.8)	4.2 (0.8)	0.111	3.8 (0.6)	4 (0.7)	0.145
Mean glucose (mmol/l) (SD), n = 357	4.6 (0.8)	4.7 (0.8)	0.520	5 (0.7)	4.6 (1.1)	0.200	5 (0.6)	4.8 (0.5)	0.070

*statistically significant
BMI: body mass index, DBP: diastolic blood pressure, HC: hip circumference, HLD: high-density lipoprotein, IQR: interquartile range, LDL: low-density lipoprotein, SBP: systolic blood pressure, SD: standard deviation, TGs: triglycerides, TC: total cholesterol, WC: waist circumference

of > 2.59 mmol/l, TGs of ≥ 1.7 mmol/l and total cholesterol (TC) of > 5.17 mmol/l.[5,23,24] Pre-hypertension was defined as the average of the last two readings of SBP or DBP, being ≥ 90th but < 95th percentile for age, sex and height.[16]

Normally distributed continuous variables were expressed as means with standard deviation. Student's t-test was used to test for differences between the means by sex with a significance level of p-value < 0.05. The median and interquartile range is given for the sum of the skinfold thicknesses owing to skewness. The chi-square test was used to test for significant associations between the categorical variables, while Fisher's exact test was used when the cell frequencies were < 5. Linear regression was employed to test associations. The statistical analyses were performed using Stata® version 11.

Results

Characteristics of participants

Twelve of the original 600 children were not in residence at the time of the study, thus 588 (98%) were seen. Fasting venous blood samples were only obtained from 387 (66%) participants because assent was not given for venipuncture (25.5%), or owing to an inability to obtain a blood sample (8.5%). Table I presents the general characteristics of the study sample by sex and age. The 11- to 12-year-old females were slightly heavier and taller than the males, while the 14- to 15-year-old girls were shorter and heavier than the boys. The girls' BMI was significantly greater at ages 11 and 12 years than that of the boys [girls: 18 ± 3.4, 95% confidence interval (CI): 17.33-18.69; boys: 17 ± 2, 95% CI: 16.46-17.25; p-value 0.004] and at ages 14-15 years (girls: 22 ± 4.1, 95% CI: 20.82-22.47; boys: 19 ± 2.4, 95% CI: 18.39-19.38; p-value < 0.001). The younger girls, aged 7-8 years, had a smaller WC (p-value < 0.001), while the girls aged 11-12 years and 14-15 years had a larger HC than the boys (p-value < 0.001). The sum of the skin fold measurements for the girls in the 7- to 8-year-old, and 14- to15-year-old, groups, was significantly higher than that for the boys.

The prevalence of under- and overnutrition

Table II displays the prevalence of malnutrition and the metabolic risk characteristics of study participants by sex. Significantly, more

Table II: Prevalence of malnutrition and metabolic risk factors according to sex

Variables	Boys (n = 292)	Girls (n = 296)	p-value, χ^2
Mean age in years (SD)	11.1 (3)	11.1 (3)	0.840
*HAZ < −2 SD: stunted, n (%)	18 (6.2)	8 (2.7)	0.041, 4.168
*WAZ < −2 SD: underweight, n (%)	12 (4.1)	13 (4.4)	0.865, 0.030
*WHZ < −2 SD: wasted, n (%)	3 (1)	1 (0.3)	0.310, 1.035
*BMI 25-29.9 kg/m²: overweight, n (%)	6 (2.1)	31 (10.5)	0.000, 17.700
*BMI ≥ 30 kg/m²: obese, n (%)	2 (0.7)	9 (3)	0.035, 4.443
*BMI ≥ 25 kg/m²: overweight and obese, n (%)	8 (2.7)	40 (13.5)	0.000, 22.800
WHtR > 0.5, n (%)	39 (13.4)	49 (16.6)	0. 277, 1.181
TC (borderline high): 5.17-6.18 mmol/l, n = 388, n (%)	3 (1.5)	16 (8.5)	0.002, 10.077
TGs > 1.7mmol/l, n = 388, n (%)	3 (1.6)	8 (4.01%)	0.110, 2.560
Pre-hypertensive SBP and DBP, n = 523, n (%)	26 (10)	40 (15)	0.051, 3.100
IFG (FG ≥ 5.6 mmol/l), n = 357, n (%)	9 (5)	9 (5.3%)	0.522, 0.034

*Derived from age-specific z-scores
χ^2: chi-square, BMI: body mass index, DBP: diastolic blood pressure, FG: fasting glucose, HAZ: height-for-age z-scores, IFG: impaired fasting glucose, SBP: systolic blood pressure, SD: standard deviation, TC: total cholesterol, TGs: triglycerides, WAZ: weight-for-age z-scores, WHtR: waist-to-height ratio, WHZ: weight-for-height z-scores

Table III: Factors associated with blood pressure adjusted for sex and pubertal stage (linear regression)

SBP (mmHg), n = 523	β	95% CI	p-value
BMI (kg/m²)	0.80	0.08-1.50	0.030*
Sum of skin folds (mm)	3.56	2.38-4.74	0.000*
WC (cm)	0.28	−0.18-0.58	0.066
HC (cm)	0.00	−0.01-0.03	0.515
DBP (mmHg), n = 523	β	95% CI	p-value
BMI (kg/m²)	0.12	−0.20-0.62	0.636
Sum of skin folds (mm)	-0.32	−1.22-0.60	0.490
WC (cm)	0.20	−0.11-0.31	0.372
HC (cm)	0.00	−0.00-0.02	0.366

*statistically significant
BMI: body mass index, CI: confidence interval, DBP: diastolic blood pressure, HC: hip circumference, SBP: systolic blood pressure, WC: waist circumference

boys (6.2%) than girls (2.7%) were stunted (p-value 0.04), and a similar sex prevalence of underweight was noted (4.1% of the boys and 4.4% of the girls).

In the three age groups, stunting was significantly greater in boys (4.2%) than in girls (0.5%) aged 14-15 years (p-value 0.031), while 4.5% vs. 3.5% (11- to 12-year-old) and 0.5% vs. 0% (7- to 8-year-old) boys and girls were stunted, respectively. The prevalence of underweight was higher in the 11- to 12-year-old girls (4%) than it was in the boys (2.5%), and higher in the boys than in the girls aged 14-15 years (2.6% vs. 1.6%). The prevalence of underweight in the 7- to 8-year-old age group was 1% for both the boys and girls, respectively. The prevalence of wasting was 1.3% in the boys compared to (0.3%) in the girls aged 7-8 years. There were no significant differences by sex in underweight in the three age groups and wasting in the 7- to 8-year-old age group. The prevalence of combined overweight and obesity was significantly higher in the girls than in the boys (13.5% and 2.7%, respectively, p-value < 0.001).

Risk factors for metabolic disease

Indicators of adiposity in the participants at Tanner stage 3 or greater highlighted that 2.2% of the girls and none of the boys had a WC above the adult risk cut-off point. WHR was higher in the girls (17.2%) than in the boys (2%, p-value < 0.001). Across all of the participants, 13.4% of the boys and 16.6% of the girls had a WHtR above the cut-off point (Table II).

Just over 5% of the boys and girls had impaired FG. Using TC concentrations, more girls (8.5%) than boys (1.5%) had levels above the normal range in the borderline high category (p-value 0.002) (Table II). 10.7% of the boys and 12% of the girls had concentrations of HDL cholesterol less than 1 mmol/l, which is indicative of cardiometabolic risk. Only 2.3% of the girls had borderline high LDL cholesterol concentrations, and 13.1% of the girls and 8.7% of the boys had near optimal LDL cholesterol concentrations. There were no mean differences by sex for LDL and HDL cholesterol and triglycerides. Pre-hypertension, using either SBP or DBP, for sex, age and height was 15% and 10% in the girls and boys, respectively. The figures were similar across the age groups. After adjusting for sex and the pubertal stages of development, SBP was associated with indicators of obesity and adiposity [sum of the skin folds (p-value < 0.001), BMI (p-value 0.03) and WC (p-value 0.06] (Table III).

Characteristics of the study participants stratified by sex and Tanner stages of pubertal development

Table IV summarises the anthropometry characteristics, and lipid profiles and blood pressure by Tanner stages of pubertal development (n = 574, 2% declined). Significant sex differences were observed with respect to height in the children at the pre- and late pubertal stages, while girls had a smaller WC in the pre-pubertal group. Girls' BMI and HC values were significantly higher than that of the boys at the early (p-value 0.031 and p-value < 0.001), mid (p-value 0.002 and p-value 0.004), and late (p-value < 0.001) pubertal stages. The female participants had a higher sum of skin fold measurements during the pre-, mid and late pubertal stages (p-value < 0.001, p-value 0.002 and p-value 0.001, respectively) (Table IV). There was no difference in the lipid profile with advancing puberty. However, there were significant differences between the sexes in certain pubertal stages. In particular, girls had higher LDL cholesterol than the boys at the mid-pubertal stage (girls: 2 ± 0.6, 95% CI: 1.82-2.17; boys: 1.7 ± 0.5, 95% CI: 1.54-1.91, p-value 0.030), and the girls had a higher TC mean at the early pubertal stage than the boys (girls: 4.2 ± 0.7, 95% CI: 3.95-4.5; boys: 3.8 ± 0.7, 95% CI: 3.59-4.10, p-value 0.050) and at the mid-pubertal stage (girls: 4 ± 0.7, 95% CI: 3.83-4.23; boys: 3.7 ± 0.7, 95% CI: 3.52-3.94, p-value 0.045) (Table IV). Female participants had a higher BMI, BMI-for-age z-score, and HC (p-value < 0.001) than males as they progressed through

Table IV: Characteristics [means (standard deviation)] of the study participants stratified by sex and Tanner stages of development

Tanner stages	Pre-pubertal			Early pubertal			Mid-pubertal			Late pubertal		
	Boys (n = 147)	Girls (n = 116)	p-value	Boys (n = 46)	Girls (n = 51)	p-value	Boys (n = 54)	Girls (n = 70)	p-value	Boys (n = 38)	Girls (n = 52)	p-value
Mean age (years) (SD), n= 574	9 (2.3)	8.2 (1.5)	0.001*	12.2 (1.3)	12 (1)	0.071	13.53 (1.5)	13.3 (1.4)	0.344	14.4 (0.9)	14.4 (0.8)	0.850
Mean weight (kg) (SD), n = 574	28.6 (7.2)	26.6 (6)	0.012*	37.3 (8)	42 (10)	0.013*	46.1 (9.2)	48.2 (8)	0.170	54 (12)	60.1 (13)	0.022*
Mean height (cm) (SD), n = 574	133 (11.3)	130 (8.1)	0.023*	147 (8.4)	149.4 (8)	0.135	158.2 (10.3)	157 (7)	0.337	166 (8.2)	160 (6)	0.000*
Mean BMI (kg/m^2) (SD), n = 574	16 (2)	16 (2.3)	0.172	17.1 (2.3)	18.4 (3.4)	0.031*	18.2 (2.1)	20 (3)	0.002*	20 (3)	23.5 (5)	0.000*
Mean WC (cm) (SD), n = 574	57.1 (5.5)	53 (5)	0.000*	61 (6)	61.3 (7.2)	0.783	65 (6)	64 (7.1)	0.476	68 (7)	71 (10)	0.158
Mean HC (cm) (SD), n = 574	65.8 (0.6)	65.3 (0.7)	0.526	73 (0.6)	80 (1)	0.000*	78 (1.2)	84 (1.2)	0.004*	81 (1.4)	93.4 (1.1)	0.000*
Mean HDL cholesterol (mmo/l), (SD), n = 371	1.2 (0.3)	1.2 (0.4)	0.250	1.3 (0.3)	1.2 (0.3)	0.888	1.2 (0.3)	1.2 (0.3)	0.600	1.2 (0.2)	1.2 (0.3)	0.638
Mean LDL cholesterol (mmo/l), (SD), n = 367	1.9 (0.6)	1.9 (0.6)	0.905	1.8 (0.6)	2 (0.7)	0.244	1.7 (0.5)	2 (0.6)	0.030*	1.8 (0.5)	1.8 (0.6)	0.763
Mean TC (mmo/l) (SD), n = 388	4 (0.7)	4.1 (0.8)	0.800	3.8 (0.7)	4.2 (0.7)	0.050*	3.7 (0.7)	4 (0.7)	0.045*	3.7 (0.5)	3.9 (0.7)	0.140
Mean TGs (mmo/l) (SD), n = 388	0.8 (0.3)	0.8 (0.3)	0.773	0.8 (0.2)	1 (0.6)	0.180	0.8 (0.3)	0.8 (0.3)	0.900	0.7 0.20	0.8 (0.3)	0.180
Mean glucose (mmo/l) (SD), n = 357	4.7 (0.7)	4.6 (1)	0.270	5 (0.5)	4.5 (1.3)	0.200	5 (0.8)	4.7 (0.6)	0.350	5 (0.8)	5 (0.5)	0.423
Mean SBP (mmHG) (SD), n = 523	96.6 (12.9)	99.3 (14)	0.141	101 (13.2)	125 (13.8)	0.240	106 (11)	111 (12.2)	0.021*	113.3 (14.6)	112.2 (10.3)	0.700
Mean DBP (mmHG) (SD), n = 523	59 (11)	59 (12)	1.000	60 (9.5)	61.2 (12)	0.500	62.3 (7.3)	62 (8.1)	0.850	64 (8.1)	67 (7)	0.057
Sum of skin folds (mm) (Median IQR), n = 503	5.3 (4.6-6)	5.9 (5-7)	0.000*	5.8 (5.3-6.3)	5.9 (4.4-6.8)	0.942	5 (4.6-6.8)	7 (5.3-9)	0.002*	5.6 (5.1-6.9)	9.3 (7.4-10)	0.000*

*statistically significant
BMI: body mass index, DBP: diastolic blood pressure, HC: hip circumference, HLD: high-density lipoprotein, IQR: interquartile range, LDL: low-density lipoprotein, SBP: systolic blood pressure, SD: standard deviation, TGs: triglycerides, TC: total cholesterol, WC: waist circumference

puberty, while boys had a higher WC than the girls (p-value < 0.001). A difference in blood pressure between the boys and the girls (p-value 0.021) was only found at mid-puberty.

Table V presents changes in the various anthropometric parameters with regard to FG, TGs and HDL cholesterol from 2007-2009. A change in HC and WC was significantly associated with FG (β 0.01, p-value 0.020 and β 0.01, p-value 0.002, respectively). A change in WC and WHtR was significantly associated with TGs (β 2.4, p-value 0.050 and β 0.02, p-value 0.050, respectively). Also, a change in WC and HC was significantly associated with HDL cholesterol (β –2.7, p-value 0.050 and β –4.1, p-value 0.053, respectively). However, a change in the BMI and BMI-for-age z-score was not significantly associated with FG, TGs and HDL cholesterol. Examining the changes in anthropometric measures over two years revealed that indicators of central adiposity were positively associated with glucose concentrations and TGs in the participants.

Discussion

To our knowledge, this is the first study that has examined both malnutrition and metabolic disease risk factors in South African children aged 7-8, 11-12 and 14-15 years. National South African and cross-sectional studies have reported the coexistence of under- and overnutrition in children and adolescents.[4-11] However, limited information exists on the prevalence of metabolic disease risk factors in rural children.[3,7]

In this study, the prevalence of undernutrition in children aged 7-8 years was lower than the national prevalence in rural children.[4,5] Our findings of a higher prevalence of stunting in 11- to 12- and 14- to 15-year-old boys than in girls is similar to an earlier study on adolescence.[25] However, this stunting prevalence was lower than that reported in the National Youth Risk Behaviour Survey in 2008.[26] This higher prevalence of stunting in boys may be owing to a combination of nutrition and other factors. There was no evidence

Table V: The correlation between fasting glucose, triglycerides and high-density lipoprotein cholesterol and a change in body mass index and BMI-for-age z-score, hip and waist circumference, and waist-to-height ratio from 2007-2009

Variable	β	95% CI	t	p-value
FG (mmol/l) (n = 312)				
Change in BMI (kg/m²)	0.13	–0.08 to 0.35	1.20	0.233
Change in BMI-for-age z-score	0.08	–0.05 to 0.20	1.20	0.233
Change in HC (cm)	0.01	0.00 to 0.01	2.37	0.020*
Change in WC (cm)	0.01	0.01 to 0.02	3.17	0.002*
Change in WHtR	0.01	–0.00 to 0.16	1.84	0.070
TGs (mmol/l) (n = 388)				
Change in BMI (kg/m²)	–0.12	–0.60 to 0.04	–0.50	0.644
Change in BMI-for-age z-score	–0.10	–0.40 to 0.23	–0.50	0.644
Change in WC (cm)	2.4	0.05 to 4.80	2.01	0.050*
Change in HC (cm)	3.1	–0.06 to 6.83	1.67	0.096
Change in WHtR	0.02	0.00 to 0.03	2.01	0.050*
HDL cholesterol (mmol/l) (n = 367)				
Change in BMI (kg/m²)	0.03	–0.06 to 0.61	0.10	0.920
Change in BMI-for-age z-score	0.02	–0.02 to 0.35	0.10	0.920
Change in WC (cm)	–2.7	–5.34 to –0.03	–2.01	0.050*
Change in HC (cm)	–4.1.	–8.20 to 0.56	–2.0	0.053*
Change in WHtR	–0.013	–0.03 to 0.01	–1.35	0.176

*statistically significant
BMI: body mass index, CI: confidence interval, FG: fasting glucose, HC: hip circumference, HDL: high-density lipoprotein, TGs: triglycerides, WC: waist circumference, WHtR: waist-to-height ratio

that there were significant household socio-economic differences between the sexes (unpublished data). Further investigation into dietary patterns and intake is warranted.[12,13,27] The difference in stunting prevalence between the boys and girls may, in part, be explained by the fact that there is some evidence that urban black, South African adolescent boys have a later onset of pubertal development and skeletal maturity (Birth to Twenty longitudinal data, unpublished) than their white peers. If this is the case, in this rural setting, a comparison of height with the WHO reference could result in a temporal overestimate of stunting as the rural boys may be in an earlier stage of maturity generally.

The prevalence of overnutrition in this study was also lower than that observed in the recent (SANHANES) study on 15- to 17-year-old adolescents.[5] However, our study, which is consistent with other studies, found that overweight and obesity were greater in the girls than in the boys.[7,9,10] The differences in overnutrition by sex in this study may be owing to differences in physical activity levels.[27] Our data have demonstrated that moderate to vigorous physical activity was significantly higher in older male subjects than in female subjects, and that informal activity was lower in the boys than the girls, while sedentary time was higher in the older girls (aged 14-15 years) than in the younger girls (aged 11-12 years).[27] Also, there has been increasing temporary rural-urban migration[28] and availability of fast food vendors in this area.[29] The increasing prevalence of childhood obesity may have potential long-term medical risks, such as type 1 and type 2 diabetes mellitus, cardiovascular disease, orthopaedic complications[30] and new-onset asthma.[31]

Global trends indicate that pre-hypertension is on the rise in children and adolescents.[32,33] Given that pre-hypertension is strongly predictive of future hypertension and the development of other noncommunicable diseases,[32,34] the prevalence of 12.6% in this study on children is of concern (Table II). Furthermore, it was surprising to detect the levels of impaired FG and abnormal lipid profiles in this rural population at these younger ages. The factors that were associated with SBP in this study, e.g. glucose concentrations and lipid profile, are indicators of adiposity: both subcutaneous (sum of the skin folds) and abdominal (WC). Therefore, changes in adiposity during childhood, and with pubertal development, as seen in the girls, confer metabolic disease risk.[35]

A study on children in the USA found that the percentage of fat, as measured by skin folds, related to metabolic risk factors, such as lipids, blood pressure and C-reactive protein.[36] In our study, we observed that the percentage of fat was associated with impaired fasting glucose, low HDL cholesterol and high LDL cholesterol, as well as TC.

This study could have a limitation in that 30% of the sample were of Mozambican origin, thus resembling major differences (maternal socio-economic status and other distal measures) from the core sample that mainly comprised South Africans. The strengths of our study were the longitudinal assessment of body composition and its relationship to metabolic disease risk in a rural setting in South Africa. In addition, the measurements were performed by experienced fieldworkers who followed standardisation procedures used in the Birth to Twenty longitudinal cohort. However, the results of this study cannot be overly extrapolated to other rural settings or population groups. Nevertheless, as this study community represents relatively poor rural villages with little subsistence farming, it is reasonable to assume that other rural villages that are further along the nutrition transition may have even higher metabolic risk factors than those observed in this study. Future research is warranted to investigate early signs of metabolic risk factors in South African children longitudinally, and to identify which environmental factors contribute to metabolic disease risk.

Conclusion

This study highlights a rural area in which late childhood undernutrition was present, but less than overnutrition, particularly in girls. The emergence of early pre-hypertension risk was concerning, as well as the higher-than-expected levels of impaired fasting glucose and abnormal lipid profiles, particularly in the girls. The implication is that rural South African communities are mirroring more urban environments in terms of metabolic risk profiles, which are indicative of a rapid nutritional and economic transition. Therefore, it is critical that health-promotion initiatives recognise that early childhood is a window of opportunity from which to ensure that children remain on a healthy journey to adulthood. Thus, risk-reduction policies need to be implemented in order to stem the advance of obesity and metabolic disease risk, as recommended by the WHO. This can be achieved through revitalised school health programmes, such as the early introduction of nutrition education, ensuring that children have access to healthy foods at schools and within the school vicinity, as well regulating "junk food" advertisements in the media that target children. In addition, children and adolescents should be encouraged to spend more time in physical activity, both at school and at home.

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RESEARCH ARTICLE

Body Image Satisfaction, Eating Attitudes and Perceptions of Female Body Silhouettes in Rural South African Adolescents

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Abstract

This study aims to examine the associations between BMI, disordered eating attitude, body dissatisfaction in female adolescents, and descriptive attributes assigned to silhouettes of varying sizes in male and female adolescents, aged 11 to 15, in rural South Africa. Height and weight were measured to determine BMI. Age and sex-specific cut-offs for underweight and overweight/obesity were determined using the International Obesity Task Force cut-offs. Body image satisfaction using Feel-Ideal Discrepancy (FID) scores, Eating Attitudes Test-26 (EAT-26), and perceptual female silhouettes were collected through self-administered questionnaires in 385 adolescents from the Agincourt Health and Socio-Demographic Surveillance System (HSDSS). Participants self-reported their Tanner pubertal stage and were classified as early pubertal (< = Tanner stage 2), and mid to post pubertal (Tanner stage > 2). Mid to post pubertal boys and girls were significantly heavier, taller, and had higher BMI values than their early pubertal counterparts (all p<0.001). The prevalence of overweight and obesity was higher in the girls than the boys in both pubertal stages. The majority (83.5%) of the girls demonstrated body dissatisfaction (a desire to be thinner or fatter). The girls who wanted to be fatter had a significantly higher BMI than the girls who wanted to be thinner (p<0.001). There were no differences in EAT-26 scores between pubertal groups, within the same sex, and between boys and girls within the two pubertal groups. The majority of the boys and the girls in both pubertal groups perceived the underweight silhouettes to be “unhappy” and “weak” and the majority of girls in both pubertal groups perceived the normal silhouettes to be the “best”. These findings suggest a need for policy intervention that will address a healthy body size among South African adolescents.

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Introduction

Adolescence, a period of transition from childhood to adulthood, is characterised by psychological, physical and social changes [1]. Considerable research has been conducted on body image, eating disorders and other weight-related behaviours among adolescent girls and young women living in developed countries [2–4], with few research studies being done in low-to-middle income countries [5–8]. The decreasing age at which body image dissatisfaction and disordered eating attitudes occur in adolescence is of public health concern globally [9–11], due to physiological and psychological health problems [12].

It is widely accepted that girls are at greater risk of body dissatisfaction and eating disorders [2], and that both a low and a high body mass index (BMI) have been shown to influence weight control behaviours [5, 13, 14]. Underweight boys who experience muscle dysmorphia may engage in weight control behaviours to gain weight and increase muscle mass [14] while overweight girls engage in other behaviours to lose weight, both leading to the development of eating disorders [12]. In addition, body dissatisfaction has been shown to be strongly related to societal norms, culture and ethnicity [14]. Increasing globalisation and exposure to a 'Western' ideal of thinness through the media [2, 10], which often differs from traditional beliefs, creates even greater conflict within the adolescent.

Traditionally, a larger figure has been considered desirable in African culture, as it represents wealth, beauty, and the absence of illness [15–17], however, recent studies have reported an increasing risk of eating disorders in urban Black South African children and adolescents [15, 18, 19]. Evidence from South Africa is conflicting as some studies have reported an increasing number of urban South African adolescents with a desire to be thin [7, 11], while Puoane et al. [7] have shown that among 10–19 year old Black girls living in Cape Town, there is still a desire for a higher BMI.

Few studies [8, 20, 21] have been conducted on eating attitudes and body image in adolescents from South African rural communities who have recently been shown to be at high risk of overweight and obesity [22, 23], the prevalence of which is expected to increase as these communities continue along the nutrition transition [24]. In this study, we aim to examine BMI, disordered eating attitudes, female body dissatisfaction and descriptive attributes assigned to silhouettes of varying sizes, amongst male and female adolescents in rural South Africa.

Methods

Sample and study setting

Data for this study were collected in rural villages in the Agincourt sub-district, located in the north-eastern part of South Africa, close to the border with Mozambique. The Agincourt Health and Socio-Demographic Surveillance System (HSDSS) was established in 1992 and collects prospective data on the community living in the Agincourt sub-district of Mpumalanga Province, South Africa. The land is subdivided into plots too small to support subsistence farming and includes 27 villages in total, with 90 000 people and 20 000 households [22, 25, 26]. Further, despite current government initiatives, infrastructure in the area is still limited and the level of income is generally low by South African standards (73% of households earn less than ZAR 9600 per annum) [22, 25].

In 2009 [26], participants (n = 600; age range 7 to 15 years (200 subjects in each group)), were randomly selected from 3489 Black South African children and adolescents (aged 1- to 20 years), who had participated in a 2007 growth survey [22]. Analysis for this study were limited to participants between 11- and 15 years of age (n = 385, 190 boys and 195 girls). Data for the

7/8 year old age group were not included due to their poor comprehension and understanding of the questionnaires. Ethical approval was granted by the University of the Witwatersrand Committee for Research on Human Subjects (Medical, M090212) and from the Mpumalanga Provincial Government Department of Health. Permission from the community leaders and schools principals, and written parental consent were obtained and assent was given by all participants. Interviews were conducted in participant's local language by carefully trained staff at designated schools.

Measures

Height was measured using a stadiometer (Holtain, UK), calibrated in centimetres. Participants were measured without shoes, but with light socks, in a standing position with their hands parallel to their bodies and with the back of the head touching the vertical board of the stadiometer. The participants were weighed to the nearest 0.1kg, wearing light clothing and without shoes, using a mechanical bathroom scale (Hanson; Bathroom Trends Limited, Epson, UK). BMI was calculated as weight in kilograms (kg) divided by the height in meters squared (m^2) and underweight, normal weight and overweight and obesity were determined using International Obesity Task Force age and sex specific BMI cut-off points [27]. Pubertal assessment was measured using the Tanner 5-point pubertal self rating scale, which has been validated previously in Black South Africans [28]. Breast development in girls and genital development in boys were assessed and used to classify participants as early pubertal ($\leq$Tanner stage 2), and mid to post pubertal (Tanner stage $>$ 2) [28].

Body image satisfaction was measured using Stunkard's silhouettes, which have previously been validated in South African adolescent females [16]. These silhouettes were presented randomly with each sheet of paper containing one image. From the eight body silhouettes presented to them, each female participant was required to select a body silhouette representing their current body shape (feel figure), and the body shape that they desire (ideal figure). The body silhouettes were coded 1 to 8 (from the thinnest to the fattest). Body image dissatisfaction was determined using the Feel-Ideal Discrepancy (FID) scores and which was calculated by subtracting the number of the ideal body silhouette from the feel body silhouette. Zero, positive and negative scores indicated contentment with body shape, desire to be thinner, and desire to be fatter, respectively [16, 17].

Further, the 8 silhouettes were randomly placed on a table and each of the participants (boys and girls) were asked to associate different body shapes from different silhouettes presented to them. Descriptions included the "best, worst, clumsy, has more respect, has less respect, the strongest, the weakest, the happiest and unhappy". The silhouettes were coded from 1 (thinnest) to 8 (biggest) and then grouped into 4 categories; silhouettes 1 and 2 (underweight), 3 and 4 (normal), 5 and 6 (overweight) and 7 and 8 (obese) [5].

The 26-item Eating Attitudes Test (EAT-26) was used to evaluate the adolescents' risk of a future eating disorder [29]. The EAT-26 has been widely used and has been shown to be valid in both rural and urban South African children [20, 30]. EAT-26 consists of 26-items scored on a Likert scale (0—never to 6 -always) and the items are summed to obtain an overall score (range = 0–78). Adolescents with an overall score 20 are considered to be at risk of developing a future eating disorder. The three sub-scores of the EAT-26 were used to evaluate dieting, bulimia and food preoccupation, and oral control. The internal consistency (Cronbach Alpha) of the EAT-26 questionnaire and EAT-26 sub-components were low (0.50–0.60). Further examination revealed that some questionnaire items may have been poorly understood. In particular: (i) I am terrified about being overweight; (ii) I avoid eating when I am hungry; (iii) I am aware of the calorie content of foods that I eat; (iv) I engage in dieting behaviour.

Data analysis

All the statistical analysis were completed using STATA version 11 (StataCorp, Texas, USA). Using Student *t*-tests, differences between pubertal stage of development and sex were computed for normally distributed data (weight, height and BMI). The results were expressed as mean ± standard deviation (SD). The Wilcoxon-Mann-Whitney test was used to determine significant differences by sex and by pubertal stages for EAT-26 and EAT-26 sub-scores which were not normally distributed and the median and inter-quartile ranges (IQR) were reported. A one-way analysis of variance (ANOVA) test was used to evaluate if there were significant differences in BMI between body image dissatisfaction groups, with the post-hoc Bonferroni test to determine where significant differences exist. Pearson's chi-squared tests were used to determine significant differences between categorical variables (i.e. EAT-26 scores $<$ or $\geq$ 20, BMI and FID categories, and perceptual female silhouettes) between pubertal groups, and boys and girls and the percentages (%) were reported. The significance level was set at $P<0.05$.

Results

The descriptive characteristics of the participants by sex and pubertal stage of development are presented in Table 1. A total of 44.7% participants were classified as early pubertal (12.4±1.1 years of age) and 55.3% participants (14.5±1.3 years of age) were classified as mid to post pubertal. Within the early pubertal group, boys were significantly older than the girls in the same pubertal group, but there were no significant differences in weight, height or BMI between boys and girls in the early pubertal stage. Within the mid to post pubertal group, there was no significant difference in age, however, the girls were significantly heavier and shorter and had a higher BMI than the boys. Mid to post pubertal boys and girls were significantly older, heavier, taller, and had a higher BMI than their early pubertal counterparts (all $p<0.001$).

In Table 1, the percentage distribution of participants in the BMI categories of underweight, normal weight, and overweight/obese are shown for the boys and girls in the two pubertal groups. Although there were significant differences between the boys and girls categorised as underweight, normal weight and overweight/obese in both pubertal groups, there were no differences between the pubertal groups.

For the total sample of girls (n = 188), the majority (58%) had a positive FID score, which is associated with a desire to be thinner, while 25.5% had a negative FID score, which is associated with a desire to be fatter, and 16.5% were satisfied with their bodies. The majority (83.5%) of the girls demonstrated body dissatisfaction. Within the early pubertal girls, 20% were satisfied with their current body size, while 18.6% had a negative FID score and 61.4% had a positive score. The majority 85.6% of mid to post pubertal girls were dissatisfied with their body size (55.9% had a positive FID score and 29.7% had negative FID score) and 14.4% were satisfied with their bodies. There was no difference between the pubertal groups for FID category (Fig 1).

Examination of the relationship between BMI and body dissatisfaction is presented in Table 2. There was a consistent trend, where girls in both pubertal groups who had negative FID score (desired to be fatter) had the highest body mass index and girls who desired to be thinner had the lowest body mass index in their respective pubertal groups. There was a significant difference in BMI between participants who desired to be fatter, and those who were satisfied with their current body sizes, and the girls who wished to be thinner (all $p<0.001$) (Table 2).

The difference in FID scores which represent the feel and ideal body image and the FID score chosen by early and mid to post pubertal girls are presented in (Table 3). The silhouettes

Table 1. Subjects characteristics by sex and pubertal stages of development.

Variables	Early pubertal stage (Tanner stages 1 & 2)		Significant differences by sex	Mid to post pubertal stage (Tanner stages > 2)		Significant differences by sex	Significant differences by pubertal stages (A & B)
	Boys (N = 99)	Girls (N = 73)		Boys (N = 91)	Girls (N = 122)		
Age (years)	12.6±1.2	12.2±1.0	**0.024**	14.5±1.4	14.4±1.3	0.547	
Weight (kg)	36.4±7.1	38.7±1.0	0.074	49.4±11.1	53.3±12.0	**0.016**	**0.001**[A,B]
Height (cm)	146.0±8.1	147.5±8.0	0.203	161.4 ±10.1	158.1±6.4	**0.004**	**0.001**[A,B]
BMI (kg/m^2)[a]	17.0±2.0	17.5±3.3	0.198	19.0±2.6	21.2±4.0	**0.001**	**0.001**[A,B]
***EAT 26 scores**	10 (6–15)	12 (6–17)	0.180	12 (9–15)	10 (6–14)	0.067	0.833[A], 0.833[B]
***EAT 26 subcomponents scores**	**(N = 95)**	**(N = 66)**		**(N = 89)**	**(N = 112)**		
Dieting	4.8 (2–7)	4.9 (3–6)	0.871	5.5 (3–7)	5.1 (3–7)	0.174	0.516[A], 0.385[B]
Bulimia and food preoccupation	2.4 (0–4)	2.0 (0–3)	0.424	2.4 (0–3)	1.8 (0–3)	0.064	0.618[A], 0.533[B]
Oral control	3.4 (0–6)	4.7 (1–7)	**0.024**	3.9 (1–6)	3.4 (1–6)	0.015	0.921[A], 0.115[B]
BMI category							
Underweight	4(4.0%)	7(9.6%)	0.01 (χ^2 = 8.802)	6(6.6%)	4(3.3%)	0.001 (χ^2 = 13.332)	0.452[A], 0.179[B]
Normal weight	93(94.0%)	58(79.3%)		82(90.1%)	94(77.1%)		
Overweight and obesed combined	2(2.0%)	8(11.1%)		3(3.3%)	24(19.7%)		
***EAT-26 Cut-offs**							
EAT-26 score < 20	85(89.5%)	59(89.4%)	0.978	82(92.1%)	103(92.0%)	0.965	0.701[A], 0.547[B]
EAT-26 score $\geq$ 20	10(10.5%)	7(10.6%)		7(7.1%)	9(8.0%)		

All values are presented as means ± standard deviation (SD) for normally distributed data (Student *t* test), median IQR reported for non normally distributed data and n(%) for categorical data. Comparison by sex and pubertal stages were completed using the Wilcoxon-Mann-Whitney test (median, IQR reported). χ^2-tests were used to determine significant differences for BMI and EAT-26 cut-offs categories.

[A]—Significant differences between early and mid-post pubertal stage in boys.

[B]—Significant differences between early and mid-post pubertal stage in girls.

*Variation in sample size due to missing information.

[a]IOTF age and gender specific BMI cut-offs for age 12.5 and 14.5 years adolescent boys and girls [27].

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chosen by the early pubertal girls to represent the ideal body image had a significantly higher score than that chosen by the mid to post pubertal girls (p = 0.045). There was no difference in the chosen feel body image or the FID scores between the pubertal groups. The majority of early (78.6%) and mid to post pubertal (77.1%) girls chose silhouettes (3–4) which represented a normal BMI. When dividing the girls according to their BMI category, among overweight/obese participants, 11.4% of early pubertal chose silhouettes (3–5) and 19.5% of mid to post pubertal girls selected silhouettes (4–5), representing "normal and overweight" BMI category as their feel body image. Among underweight participants, 10% of early pubertal girls chose silhouettes (4–5) representing "normal and overweight" BMI category and 3.9% of mid to post pubertal girls chose normal silhouettes (3–4) as their ideal body image (Table 3).

Differences in EAT-26 total scores and EAT-26 sub-components (dieting, bulimia and food preoccupation and oral control) between the sexes and between pubertal groups were not significant, however the early pubertal girls had significantly higher mean value for oral control than boys of the same pubertal stage (4.7 vs. 3.4, p = 0.024).

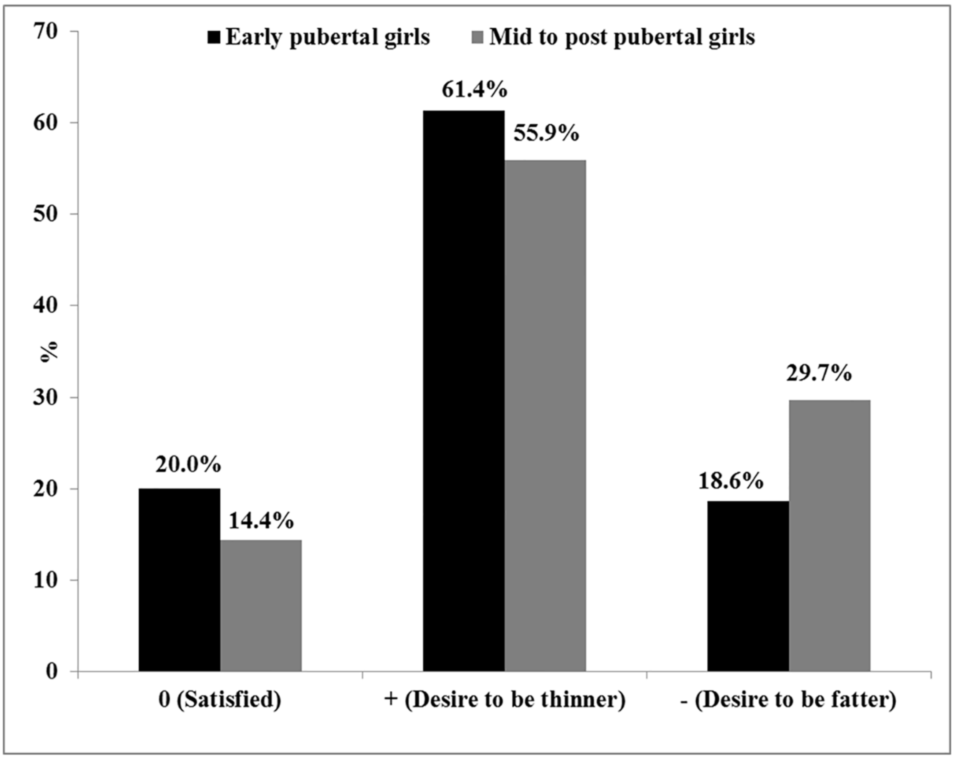

Fig 1. Female adolescents' body image dissatisfaction.

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The silhouettes chosen to represent various attributes were consistent between the early and mid to post pubertal girls (Table 4). The majority of girls in both pubertal groups associated the overweight/obese silhouettes with being the worst, having more respect, having less respect, being the strongest, and the happiest. In contrast, underweight silhouettes were associated with only negative attributes—being clumsy, being weak and being unhappy. Most of the girls in both pubertal groups considered the normal silhouettes to be the "best". There was a significant difference between the pubertal groups with regard to the silhouettes which best represented the "weakest" ($p = 0.010$) and "unhappiest" ($p = 0.030$).

Table 2. Difference in BMI between the FID categories.

	Early-Pubertal Girls (n = 70)	Mid to Post-Pubertal Girls (n = 118)	P-value
	Mean±sd	Mean±sd	
Desire to be fatter	20.41±4.1 [n = 13]	23.81±4.9 [n = 35]	0.001[C]
Satisfied	17.35±1.7 [n = 14]	21.04±2.7 [n = 17]	
Desire to be thinner	16.68±3.0 [n = 43]	19.89±3.1 [n = 66]	0.001[D]

Values are presented as means ± standard deviation (SD) using ANOVA (one-way).

[C]—Significant differences in BMI between girls who desired to be fatter and those girls who are satisfied with their current body sizes.

[D]—Significant differences in BMI between girls who desired to be thinner and those girls who are satisfied with their current body sizes.

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Table 3. Characteristics of Stunkard's silhouettes chosen by early and mid to post pubertal girls to represent different dimensions of body image.

Silhouettes	Early vs. Mid to Post-Pubertal Girls (Mean±sd)			P-value
Feel body image	3.0±1.6 vs. 3.5±1.4			0.331
Ideal body image	4.3±1.8 vs. 4.1±1.5			**0.045**
FID scores	1.3±1.9 vs. 0.5±1.8			0.244
	BMI Categories			
	Early vs. Mid to Post-Pubertal Girls (Mean±sd)			
Silhouettes	**Underweight**	**Normal weight**	**Overweight & obesed**	**P-value**
Feel body image	1.9±1.5 vs. 2.5±0.6	3.0±1.5 vs. 3.3±1.3	4.1±1.5 vs. 4.5±1.5	0.669
Ideal body image	4.8±1.9 vs. 3.5±0.6	4.3±1.9 vs. 4.1±1.4	3.8±1.0 vs. 4.0±1.5	0.637
FID scores	3.0±1.0 vs. 1.0±0.8	1.2±1.9 vs. 0.7±1.6	0.4±1.8 vs. −0.5±2.0	0.399

Values are presented as means ± standard deviation (SD) using ANOVA (one-way).

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The silhouettes chosen to represent various attributes were also consistent between the early and mid to post pubertal boys (Table 5). The majority of boys in both pubertal groups associated the overweight and obese silhouettes with being the "worst", having "more respect", having "less respect", being the "strongest", and the "happiest". The majority of boys in both pubertal groups associated the negative attributes "weakest" and "unhappy" with the underweight silhouettes. There was a significant difference between the pubertal groups with regard to the silhouette that represented an "unhappy" attribute (p = 0.020).

Discussion

To our knowledge, this is the first study reporting on the associations between BMI, disordered eating attitude, body dissatisfaction in female adolescents, and descriptive attributes assigned to silhouettes of varying sizes in male and female adolescents from rural South Africa. In this study, the prevalence of overweight and obesity was higher in girls than boys (16.4% vs 2.6%), and was greater in late puberty compared to early puberty. The prevalence of overweight and obesity that we report in this sample of rural adolescents was lower than the 2008 National Youth Risk Behaviour Survey [31], but consistent with other studies [32, 33]. In contrast, a 2012 study, conducted on rural school children (aged between 10 and 16 years) reported that although the prevalence of overweight was higher in girls than boys, obesity was more prevalent in boys [23]. In that study, 11% of the girls and 9% of the boys were overweight, while 5.5% and 4.4% of boys and girls were obese, respectively. Therefore, the focus of interventions within the public health context should be improved through school-based nutrition and physical activity programmes among South African children and youth [34].

Our study also showed a consistent trend, where early and mid to post pubertal girls who desired to be fatter had the highest body mass index and those who desired to be thinner had the lowest body mass index in their respective pubertal groups. We found that the majority (83.5%) of the girls demonstrated body dissatisfaction, with 58% expressing a desire for a thinner body size. Interestingly, with regard to BMI categories which represented the silhouettes chosen by the girls to represent themselves, the overweight/obese girls chose silhouettes with a lower BMI than their actual BMI. Further, girls in the underweight and normal weight groups expressed a desire to be thinner (positive FID scores).

Recent evidence from South Africa has shown that many urban children and adolescents are less satisfied with their body shape [5, 17, 18] Similarly, the majority of both our early and mid to post pubertal girls wanted to be thinner, with the proportion of those who preferred to

Table 4. Female body silhouettes with attributes as assessed by early and mid to post pubertal girls.

Silhouettes	Early-Pubertal Girls	Mid to Post-Pubertal Girls	P-value
Best			
Underweight	19.0%	14.5%	
Normal	50.0%	60.0%	0.471
Overweight and obesed combined	31.0%	25.5%	
Worst			
Underweight	31.0%	29.0%	
Normal	0.0%	1.0%	0.963
Overweight and obesed combined	69.0%	70.0%	
Clumsy			
Underweight	54.4%	52.1%	
Normal	4.4%	1.7%	0.466
Overweight and obesed combined	41.2%	46.2%	
More respect			
Underweight	20.5%	16.2%	
Normal	38.1%	34.2%	0.590
Overweight and obesed combined	41.4%	49.6%	
Less respect			
Underweight	26.5%	36.7%	
Normal	7.4%	14.5%	0.134
Overweight and obesed combined	66.1%	47.8%	
Strongest			
Underweight	4.4%	6.7%	
Normal	10.3%	6.0%	0.458
Overweight and obesed combined	85.3%	86.3%	
Weakest			
Underweight	79.4%	87.2%	
Normal	9.0%	0.0%	**0.010 χ^2 = 10.870**
Overweight and obesed combined	11.6%	12.8%	
Happiest			
Underweight	16.2%	14.5%	
Normal	36.6%	36.7%	0.849
Overweight and obesed combined	47.2%	48.8%	
Unhappiest			
Underweight	84.0%	85.5%	
Normal	0.0%	6.0%	0.030 χ^2 = **8.444**
Overweight and obesed combined	16.0%	8.5%	

Comparison by pubertal stage was computed using χ^2-tests and (%) are reported.

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be thinner being higher in early rather than mid to post pubertal girls (61.4% vs. 56%). We have shown that BMI was higher in participants who desired to be fatter, compared to the BMI of the girls who wished to be thinner. Similar to earlier South African studies [7, 8, 19], 48.9% of the the girls with a normal BMI wished to be thin in the present study. In a study by Gitau et al., (2014), the majority (59.6%) of urban Black and White girls, aged between 13 and 17 years wanted to be thin, whilst 38.8% of Black girls had higher body dissatisfaction compared to White girls (16.7%) [19].

Table 5. Female body silhouettes with attributes as assessed by early and mid to post pubertal boys.

Silhouettes	Early-Pubertal Boys	Mid to Post-Pubertal Boys	P-value
Best			
Underweight	10.5%	3.3%	
Normal	43.2%	53.3%	0.087
Overweight and obesed combined	46.3%	43.4%	
Worst			
Underweight	48.4%	40.0%	
Normal	1.1%	0.0%	0.266
Overweight and obesed combined	50.5%	60.0%	
Clumsy			
Underweight	45.3%	53.3%	
Normal	8.3%	3.3%	0.436
Overweight and obesed combined	46.4%	43.4%	
More respect			
Underweight	6.3%	15.6%	
Normal	34.7%	25.6%	0.175
Overweight and obesed combined	59.0%	58.8%	
Less respect			
Underweight	35.8%	35.6%	
Normal	9.5%	7.7%	0.918
Overweight and obesed combined	54.7%	56.7%	
Strongest			
Underweight	6.3%	3.3%	
Normal	6.3%	6.6%	0.798
Overweight and obesed combined	87.4%	90.1%	
Weakest			
Underweight	83.2%	90.0%	
Normal	7.3%	2.2%	0.228
Overweight and obesed combined	9.5%	7.8%	
Happiest			
Underweight	9.5%	10.0%	
Normal	35.8%	36.7%	0.929
Overweight and obesed combined	54.7%	53.3%	
Unhappiest			
Underweight	91.5%	90.0%	
Normal	1.1%	0.0%	**0.020 χ^2 = 8.085**
Overweight and obesed combined	7.4%	10.0%	

Comparison by pubertal stage was computed using χ^2-tests and (%) are reported.

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In another study by Puoane et al., (2013), 63% of Black schoolgirls aged between 10 and 19 years, living in poor suburbs of Cape Town, had a desire for a low BMI (<21.7) [7]. Our results also mirror findings from developed and other low and middle income countries [6, 13, 35, 36] countries, Ricciardelli and McCabe (2001), showed that the desire for thinner body size amongst girls from different countries ranges from 28% to 55% [13]. Of concern is that 5.8% of the underweight girls expressed a desire to be thinner. This may lead to food restriction and excessive exercise to change their bodies, which may place them at a greater health risk and lead to pathological eating disorders such as anorexia nervosa and bulimia nervosa [37].

Nearly 20% of the mid to post pubertal girls, who were classified as overweight/obese wanted to be fatter. Similarly, studies have also reported a trend towards a larger figure in Black populations and evidence suggests that being overweight is traditionally accepted in African culture as a sign of wealth, beauty and the absence of illness [15–17]. This is of concern given the health consequences of obesity and that almost 80% of overweight children become overweight and obese adults [38]. Therefore, primary prevention of obesity should start at an early age, particularly for girls [39].

Our study contributes to the body of literature on the risk for future eating disorder in South African adolescents. The prevalence rates of EAT-26 score $\geq$ 20 in this study (10.6% and 8% for early and mid to post pubertal girls, respectively) were higher than previously reported a decade ago (3%) for older (17.8 years) rural South African female adolescents [20]. In comparison, this was lower than 13% reported for young students (aged 20 years) from rural and urban origins, from the University of the North, Limpopo Province [21]. Beyond the rural settings, the percentages of abnormal eating attitudes found in the present study were within range of studies conducted in Johannesburg on urban Black adolescent girls aged 11 years (1%) and among adolescents between 13 and 17 years old (11%, and 13.1%) respectively [5, 11]. The only other study on South African male subjects showed that more urban Black than White males (40.2% vs. 5.2%) (aged 13, 15 and 17 years) had abnormal eating attitudes [18]. These prevalences are much higher than the 10.5% and 7.1% of our early and mid to post pubertal boys in the current study, indicating important transitional difference between the two settings.

These findings are the first to describe attributes assigned to silhouettes of varying sizes, amongst male and female adolescents in rural South Africa, but also shows conflicting perceptions as the majority of the adolescents still associated the overweight/obese silhouette with positive attributes including more respect, strongest, and happiest, and the underweight silhouette with only negative attributes (weak and unhappy), which might be associated with illness such as HIV/AIDS and tuberculosis [40].

The strength of this study is the inclusion of an under-studied geographical population whose particular health needs have been under-served and poorly delineated in the past. In addition, the questionnaires used in this study were validated internationally and within South Africa and the interview techniques were carried out by experienced fieldworkers who followed standardised procedures used in the Birth to Twenty longitudinal cohort.

This study had limitations, including the low internal consistency for EAT-26 and EAT-26 sub-components and therefore these results should be interpreted with caution. Examination revealed that some question items may have been poorly understood despite the questions being translated into the local language. It is possible that in a rural setting where food insecurity is still prevalent, some of the concepts around not eating, vomiting or dieting practices, are less well understood or engaged in. This suggests a need for critical research around both the methodological value of the EAT-26 and its applicability in rural South Africa and how food insecurity impacts understanding of certain eating practices. Second, the cross-sectional design of this study does not allow for cause-effect relationship. Third, the results can not be generalised to other rural settings or population groups because of the fact the sample included adolescents aged between 11 to 15 years. Another study limitation is the recall bias and the motivation of the participants in the interview setting [41]. Nevertheless, these findings from this rural setting, in conjunction with previous studies in South Africa, may be useful to guide future research interventions.

Conclusions

In summary, the findings of this study confirmed the higher prevalence of combined overweight and obesity in females than males. Our results highlighted that the majority of rural adolescent girls are dissatisfied with their body sizes, and this differs by BMI category, but indicates growing desire for Western ideals of thinness. This is most likely associated with the socio-economic transition that has taken place in South Africa within the last two decades and greater exposure to "Western" media. The study findings suggest that many adolescents are struggling with body image and desiring "unhealthy" body shapes, either too thin or too fat. This necessitates the critical need for policy intervention which would aim to educate and promote a healthy body size in adolescence and improve access to adolescent counselling support around eating disorder pathology and body image dissatisfaction.

Supporting Information

S1 File. This is the raw data collected and analysed for this study. Analysis of: (a) BMI, (b) disordered eating attitudes, (c) female adolescents' body dissatisfaction, and (d) male and female silhouettes' descriptive attributes.
(DTA)

Author Contributions

Conceived and designed the experiments: TM LK KK SMT JMP SAN. Performed the experiments: TM. Analyzed the data: TM. Contributed reagents/materials/analysis tools: TM LK KK SMT JMP SAN. Wrote the paper: TM.

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