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South African Journal of Clinical Nutrition

ISSN: 1607-0658 (Print) 2221-1268 (Online) Journal homepage: https://www.tandfonline.com/loi/ojcn20

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To cite this article: Stephanie V Wrottesley, Titilola M Pedro, Caroline H Fall & Shane A Norris (2019): A review of adolescent nutrition in South Africa: transforming adolescent lives through nutrition initiative, South African Journal of Clinical Nutrition

To link to this article: https://doi.org/10.1080/16070658.2019.1607481

Published online: 04 Jun 2019.

South African Journal of Clinical Nutrition 2019: 1–39
https://doi.org/10.1080/16070658.2019.1607481

SAJCN
ISSN 1607-0658 EISSN 2221-1268

REVIEW ARTICLE

A review of adolescent nutrition in South Africa: transforming adolescent lives through nutrition initiative

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Objective: In South Africa, urbanisation is associated with substantial burdens of adolescent overweight and obesity, making teenagers vulnerable to longer-term non-communicable diseases. In addition, as potential future parents, the nutritional status of adolescents is increasingly recognised as a key driver of health and well-being in the next generation. This review reported on the available literature examining nutritional status and dietary intakes and practices, as well as their determinants, in South African adolescents.
Study design and methods: Medline (Pubmed), Web of Science and EMBASE were searched for relevant articles published between 1994 and May 2018. Applicable search terms and phrases were identified in study titles and/or abstracts and full-text articles were reviewed according to inclusion/exclusion criteria. Data were extracted according to specific review objectives.
Results: A total of 67 relevant studies were identified. Only one study used a biochemical marker to describe adolescent nutritional status (vitamin D status; 25(OH)D). Overweight and obesity prevalence increased in South African adolescents over the reference period, with national increases of 6% in boys and 7% in girls between 2002 and 2008. Girls and urban-dwellers were particularly vulnerable to excess adiposity. Dietary intakes demonstrated a transition towards energy-dense, processed foods high in sugar and fat, but low in essential micronutrients. Food choices were driven by the adoption of obesogenic behaviours in the teenage years, including irregular breakfast consumption and fewer family meals, increased snacking and low levels of physical activity.
Conclusion: South African adolescents—particularly girls—are increasingly burdened by obesity as a result of urbanisation-associated shifts in dietary intake and eating behaviours. However, the implications for micronutrient status and long-term nutritional health are not known. Additionally, more data on the clustering of diet, activity and sedentary behaviours in adolescent boys and girls is needed, as well as on behaviour patterns to facilitate healthy growth and reduced adiposity.

Keywords Adolescence, diet, physical activity, South Africa

Introduction

Adolescence is a period of growth and development that is increasingly being recognised as a critical window for optimising the health and well-being of current and future generations.[1,2] While it is principally defined by the puberty-associated physiological changes that characterise a child's transition to adulthood, adolescence encompasses a range of developmental changes that form the foundation of one's ability to thrive physically, socially and emotionally as an adult.[1,3] In addition, the interplay between early life (prenatal, infant and childhood) growth and development and the physical and social environment experienced during adolescence may play a critical role in shaping the health trajectory of an individual, as well as of any future offspring.[2,3]

It is widely accepted that optimising growth and development during the first 1 000 days of life can result in substantial benefits, namely: reductions in childhood morbidity and mortality risk; improvements in cognitive and motor development, school performance and economic productivity in adulthood; and reductions in the risk of becoming obese or developing non-communicable diseases (NCDs) in later life.[4] While the importance of maternal nutrition and lifestyle in programming early growth and development is well established, research and intervention strategies have focused largely on nutritional status, diet and physical activity during pregnancy when the maternal risk profile is already established and the scope for affecting both maternal and infant outcomes is limited.[5–7] In addition, there has been a lack of focus on the role that paternal nutritional status, attitudes and behaviour may have on the offspring both physiologically and at the level of partner and/or parental influence.[2,8,9] As shown recently by Patton *et al.*, prioritising adolescent nutritional status in both females and males, as well as promoting healthy attitudes and behaviours around diet, physical activity, substance use and stress in this population, are critical to improving the intergenerational transmission of health and well-being.[2] In addition, it provides a window for intervention, during which investment is likely to yield substantial benefits for health, social development and economic growth and capacity.[2,10]

Adolescents and youth (10–24 years of age) constitute almost one-quarter of the world's population, with more than 80% of this group living in low- and middle-income countries (LMICs).[11] While improvements in childhood nutrition and health, education and rapid technological advancements, as well as access to effective contraception and delayed timing of parenthood, provide a platform upon which adolescents should thrive, their health and well-being face substantial threats during this time.[1,3] As individuals progress through adolescence their exposure to social health determinants undergoes a considerable shift. This means that the parental/family-

Table 1: National policy changes that may impact adolescent nutritional status in South Africa (1994–2017)

Policy area/programme	Year	Action(s)
School feeding programme	1994	School feeding schemes started in primary schools: one meal per day provided; tier 1–3 schools
Non-racial schooling		Non-racial education system established in new democracy
Child support grant		Child support grant can be claimed for children < 7 years
Integrated nutrition programme	1995	Introduction of a multi-sectoral programme aimed at addressing malnutrition by targeting the following key focus areas: (1) household food security; (2) disease-specific nutrition support; (3) food service management; (4) micronutrient malnutrition control; (5) growth monitoring and promotion; (6) nutritional promotion, education and advocacy; (7) breastfeeding; (8) nutrition programme monitoring and support
School fees	1996	Free Primary Health Care for pregnant women and children < 5 years
School feeding programme	1998	Increased funding
Prevention of mother-to-child transmission (PMTCT)		PMTCT programme started for the prevention of vertical transmission of HIV
School feeding programme	2000	High school children receive one free meal per day; tier 1–3 schools
Child support grant	2002	Child support grant extended to < 9 years
Child support grant	2003	Child support grant extended to < 11 years
Food fortification		Mandatory fortification of all maize meal and bread wheat flour with the following micronutrients: vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron, zinc
PMTCT		Pregnant HIV-positive women with CD4 counts ≤ 200 eligible for ART
Child support grant	2004	Child support grant extended to < 14 years
Child support grant	2005	Child support grant extended to < 15 years
School fees		Free basic education (Grade R–Grade 9) for children attending Tier 1–3 schools
Maternal and child health	2007	Pregnant girls no longer expelled from school and some care for pregnancy provided
Child support grant	2010	Child support grant extended to < 18 years
The Tiger Brands Foundation in-school breakfast feeding programme[a]	2011	Children in Tier 1 and Tier 2 schools (primary and combined) receive a daily breakfast at school (8 provinces)
HIV	2013	HIV-positive individuals with CD4 counts ≤ 350 eligible for ART
Salt reduction		Release of salt regulation policy to reduce content in processed food products
HIV	2014	HIV-positive individuals with CD4 counts ≤ 500 eligible for ART
Salt reduction	2016	Mandatory compliance with maximum limits for salt content by manufacturers of the following food products: bread, breakfast cereals, margarines and butter, savoury snacks, potato crisps, processed meats, sausages, soup and gravy powders, instant noodles, stocks
Sugar-sweetened beverage tax	2017	Taxation of all sugar-sweetened beverages (i.e. those with added caloric sweeteners) by 2.1 cents/g

[a]Partnership with the Department of Education to extend the national school feeding programme.

dominated determinants of lifestyle choices in childhood expand to include the influence of peers, the community, culture, education, the media and the economy.[10] Within this context, growing levels of independence make adolescents highly susceptible to the adoption of obesogenic behaviours that may persist into adulthood, thereby increasing the risk of obesity and NCDs in later life.[1,10,12,13] In LMICs rapid urbanisation exacerbates this by exposing young people to increasingly Westernised diets—high in saturated fat, added sugar, salt, processed/convenience foods and edible oils—in environments characterised by low levels of physical activity.[14–16] This is particularly relevant in sub-Saharan Africa where overweight and inactivity rates are comparatively higher than in other LMIC regions.[17]

In South Africa, where this nutrition transition has progressed considerably, approximately 27% of females and 9% of males are overweight or obese by 15–19 years of age, with those living in urban settings being particularly vulnerable.[18] Additionally, since the dawn of South Africa's democracy in 1994, policy changes around food production, composition and availability, as well as economic accessibility and education, have further reshaped the landscape of food consumption and activity patterns, predominantly in previously restricted black communities.[19–21] These policy changes are outlined in Table 1. Particularly since 1994 school feeding programmes have been implemented and expanded, and child support grants established, to improve food security at both individual and household levels. In 1995 a multi-sector policy aimed at addressing both clinical (leading to hospitalisation) and sub-clinical malnutrition was introduced and in 2003 a mandatory micronutrient fortification policy for maize and wheat was developed. More recently policies for salt reduction (2016) and sugar-sweetened beverage taxation (2017) were introduced in response to the country's rising obesity and NCD burdens. While these government policies highlight that nutrition-based issues are on the national agenda, their coverage and effectiveness are widely debated and their impact on adolescent nutrition is less clear.

Although individual studies have explored nutritional status, dietary intake and physical activity, as well as perceptions and attitudes around healthy eating and body image in rural and/or urban South Africa, relationships between these components and their determinants are not known. A comprehensive examination of nutritional health and well-being in the adolescent population is therefore critical to understanding the possible means of addressing the rapidly growing obesity epidemic in this—and future—generations.

In this review our aim was to report on the available literature examining nutritional status and dietary intake and practices, as well as their determinants, in South African adolescents. Data were therefore reviewed according to five specific objectives that summarised the following variables in rural and/or urban South African adolescents (10–20 years):

(1) nutritional status (anthropometric, biochemical and dietary indicators of macro- and micronutrient intakes);
(2) food consumption, dietary patterns and eating habits;
(3) diet, eating habits and demographic and lifestyle factors (age, setting, socioeconomic status (SES) etc.) and their associations with adolescent adiposity (e.g. body mass index [BMI]/fat mass);
(4) body image perceptions and eating attitudes;
(5) qualitative perceptions of, and attitudes towards, healthy eating and physical activity.

Methods

Search strategy

Comprehensive literature searches were performed in March 2018 by a team of researchers. Searches identified all available studies describing adolescent nutritional status, and its determinants, since the establishment of democracy in 1994. Searches were conducted using the following databases: Medline (Pubmed), Web of Science and EMBASE. Searches included the following search terms and phrases, as well as any applicable variations: adolescent and anthropometry/(specific anthropometric measure of interest, e.g. body mass index)/nutrition/(specific nutrient of interest, e.g. protein or iron)/(specific micronutrient deficiency of interest, e.g. anaemia)/(specific nutritional biomarker of interest, e.g. ferritin)/(specific dietary intake assessment method of interest, e.g. food frequency questionnaire) and Africa (full description of search terms is provided in Supplementary Appendix A). Search terms and phrases were used in various combinations for identification in study titles and/or abstracts. Full-text articles were obtained and reviewed to select those meeting the inclusion/exclusion criteria described below. Data were subsequently extracted from relevant publications into appropriate tables.

Selection criteria

Inclusion criteria

1. Studies conducted in South Africa.
2. Studies conducted in males and/or females aged 10–20 years.
3. Any study design.

For observational studies:

- studies that described adolescent nutritional status (assessed using anthropometry and/or objectively measured body composition [weight and/or height and/or BMI and/or waist circumference and/or body fat percentage] and/or biochemical indicators and/or reported dietary intakes) as an exposure and/or outcome; and
- studies that used quantitative methods to assess attitudes and/or perceptions and/or degree of satisfaction towards nutritional status (body size, composition, diet) or behaviours.

For intervention studies:

- nutritional intervention studies done in adolescents (with or without physical activity component(s) incorporated) with dietary values and/or where biochemical indicators from both the intervention and control group could be extracted.

For qualitative studies:

- studies that explored thoughts on dietary behaviours and practices (with or without physical activity) and their determinants;
- studies that explored perceptions and attitudes towards healthy dietary and lifestyle (e.g. physical activity) practices;
- studies using any of the following qualitative research methods: observations, face-to-face interviews, focus-group discussions; and
- studies using any qualitative analytical methods.

4. Studies published in peer-reviewed journals and/or as academic dissertations

Exclusion criteria

1. Studies conducted in animals.
2. Studies conducted in languages other than English.
3. Studies published prior to 1994.
4. Studies which do not describe nutritional status (anthropometry and/or biochemical indicators and/or reported dietary intakes) using aggregate data summarised as mean (SD) and/or median (IQR or 95% confidence interval).

Results

In total, 67 studies met the inclusion/exclusion criteria (Figure 1) and their characteristics are described in Table 2.[22–88]

The majority of studies were conducted within eight of South Africa's nine provinces (i.e. the country's principal administrative districts); specifically: Eastern Cape (*n* = 3),[72,75,76] Free State (*n* = 1),[71] Gauteng (*n* = 25),[22,26,31,32,35–37,40,46,48–52,56–58,61–63,69,77–80] KwaZulu -Natal (*n* = 3),[23,59,60] Limpopo (*n* = 4),[28,29,81,83] Mpumalanga (*n* = 8),[44,45,66–68,73,82,86] North West (*n* = 9)[25,27,30,42,47,64,65,74,88] and Western Cape (*n* = 8).[24,33,41,43,53–55,84] In addition, two studies compared adolescents across provinces (Mpumalanga vs. Limpopo[85]; Mpumalanga vs. Gauteng[87]) and four used national survey data.[34,38,39,70] Eleven pairs of studies were based on the same study sample and are therefore presented together.[28,29,38,39,44,45,49–54,57–60,66,67,75–78] The publication year ranged from 1997 to 2018. Sixteen studies used quantitative cross-sectional or longitudinal data (various ages between 10 and 19 years) from the Birth-to-Twenty (BTT) cohort, an urban longitudinal birth cohort in Soweto, Gauteng (*n* = 3273).[31,35–37,46,48–50,57,58,61,77–80,87] Of the remaining studies, 47 followed quantitative cross-sectional designs and four were qualitative studies.[51,52,68,83] Sample size ranged between 50 and 3 490 for quantitative studies and between 22 and 58 for qualitative studies. 19 studies were conducted in rural contexts[23,28,29,44,45,53,54,59,60,66–68,73,75,76,81,82,85,86] and 35 in urban and/or peri-urban contexts[22,24,26,31,33,35–37,40–42,46,48–52,55–58,61–65,69,71,72,77–80,84,88]; with two studies comparing rural and urban populations.[32,87] Ten studies included mixed populations[25,27,30,34,38,39,43,47,70,74] and one did not specify the context.[83] Twelve studies included specifically black adolescents[25,27,34,35,37,42,49,50,57,65,79,87] and one specifically white adolescents,[69] with the remaining studies using populations of mixed ethnicities.

The results of the included scientific papers are structured and presented below according to the specific review objectives.

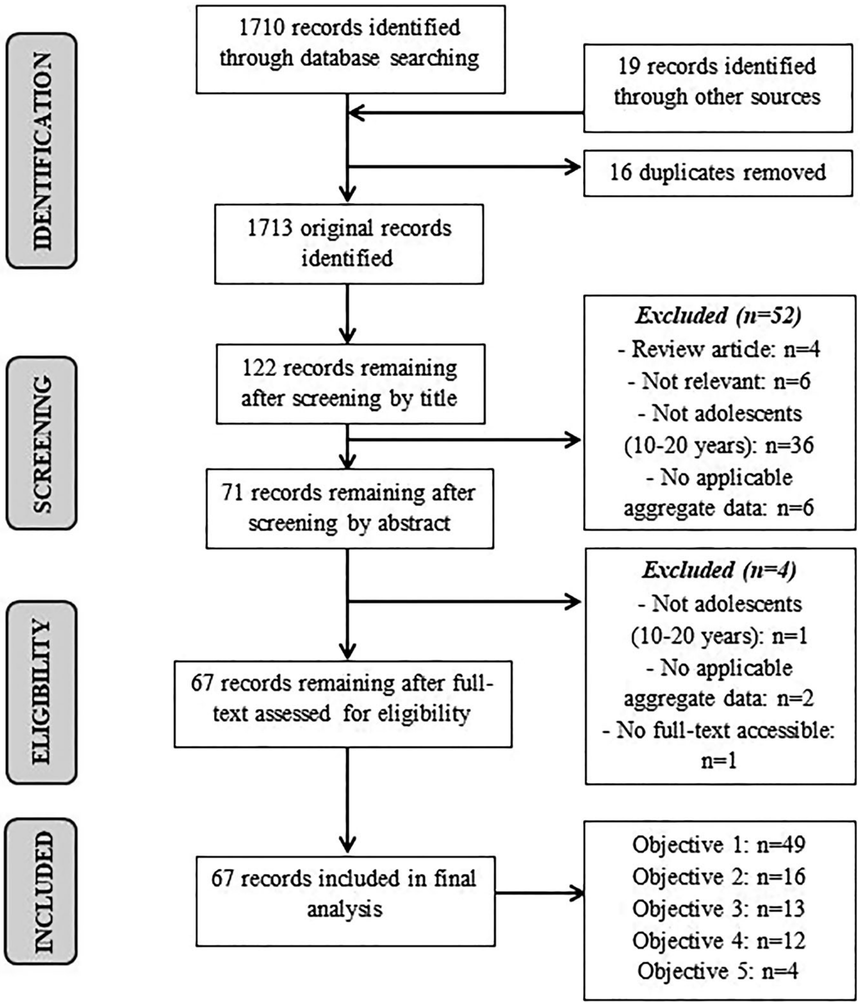

Figure 1. Flow diagram to illustrate the results of the literature review.

No weighting was applied across studies and therefore the data presented are actual findings per study.

Adolescent nutritional status

In total, 49 studies met the inclusion criteria for objective one.[23–25,27–32,34,35,38,39,42–45,47–50,53,54,56–60,62–67,70–72,74–81,84–87] Of the included studies, all but four described adolescent nutritional status using one or more of the following anthropometric measurements: height and weight, BMI and waist circumference.[24,25,27–32,34,38,39,42–45,47–50,53,54,56–60,62–67,70–72,74,77–81,84–87] Where stunting prevalence was included, two studies used the WHO child growth standards[43,71,89] and one used the Centers for Disease Control and Prevention (CDC)/ National Center for Health Statistics (NCHS) growth charts[34,90] to define stunting. Five studies additionally included objectively measured body fat percentage via dual-energy X-ray absorptiometry (DXA),[48,77] air displacement plethysmography (ADP)[42,65] or bio-impedance.[59] One study used a nutritional biomarker (vitamin D status; 25(OH)D)[48] and five used reported dietary intakes[25,27,30,31,86] in addition to anthropometric assessments. The remaining four studies used reported dietary intakes alone.[23,35,75,76]

Weight, height and BMI (Figure 2)

Studies showed an anticipated increase in both height and weight of South African adolescents between 10 and 19 years of age (Figures 2–5). Across age categories, white adolescents were taller than both their black and mixed-ancestry counterparts and urban dwellers were taller than those from rural settings.[24,31,32,48,66,67,87] Similar results were shown for weight; however, the differences according to ethnicity and rural vs. urban settings were less consistent across studies. While height was similar in boys and girls between the ages of 10 and 13 years, boys were comparatively taller at older ages (15–18 years).[48–50,57,58,66,67,77–79,87] In addition, for boys aged 11–12 years, height was substantially higher in those who had reached greater sexual maturity according to Tanner staging.[53,54] Although females tended to be smaller in stature than their male counterparts as they aged, they were less likely to be stunted (height-for-age z-score (HAZ) < −2) throughout adolescence ([13 years, stunted: 14.9% (M), 10.5% (F)]; [17 years, stunted: 25.2% (M), 11.8% (F)])[34] (Figure 6). Stunting prevalence was relatively stable across age groups in girls; however, older boys demonstrated approximately 10% higher stunting prevalence than those of younger ages (17 vs. 13 years).[34]

National survey data demonstrated an increase in combined overweight and obesity prevalence in South African adolescents (13–19 years) between 2002 and 2008, with substantially higher prevalence in girls in both years ([2002: 7.9% (male, M), 29.3% (female, F)]; [2008: 14.3% (M), 36.5% (F)]) (Figure 10).[38,39] Overweight and obesity were defined using the International Obesity Task Force age- and gender-specific cutpoints for children and adolescents based on BMIs of 25 and 30 kg/m^2 respectively at 18 years.[91]

Table 2: Characteristics of studies meeting inclusion and exclusion criteria

First author	Main objective(s)	Study design	Sample size	Age (years)	Sex	Province[a]	Context (rural/ urban)	Relevant objective (s)
Szabo[22]	To document the existence of eating attitudes that may reflect current, pre- or subclinical eating disorders	Cross-sectional	213	14.8 ± 1.4	F	Gauteng	Urban	4
Faber[23]	To assess the adequacy of food intake of primary school children living in a low socioeconomic rural area	Cross-sectional	50	10–11	M, F	KwaZulu-Natal	Rural	1, 2
Caradas[24]	To investigate whether differences exist in eating attitudes and body shape concerns amongst adolescent schoolgirls representing South Africa's ethnically and culturally diverse population currently undergoing epidemiological transition	Cross-sectional	Black (B): 60; mixed ancestry (MA): 83; white (W): 85	15–18	F	Western Cape	Urban, peri-urban	1, 3, 4
Kruger[25]	To examine differences in body composition between stunted and non-stunted girls	Cross-sectional	Non-stunted (NS): 387; stunted (S): 91 (black participants)	10–15	F	North West	Mixed	1
Szabo[26]	To demonstrate that setting, and not race or ethnic group, has an important influence on eating attitudes	Cross-sectional	Black (B): 578; white (W): 506	Not specified (secondary school pupils)	F	Gauteng	Urban	4
van Rooyen[27]	To test the hypothesis that stunting may be related to changes in cardiovascular function in African children ages 10–15 years	Cross-sectional (Transition and Health during Urbanisation of South Africans; BANA, children [THUSA BANA])	Non-stunted (NS): 258 (M), 325 (F); stunted (S): 105 (M), 87 (F) (black participants)	10–15	M, F	North West	Mixed	1
Monyeki[28,29]	(1) To determine the relationships between body composition characteristics and nine physical fitness items in undernourished rural children in Ellisras, South Africa; (2) to determine the prevalence of overweight and hypertension in rural children	Cross-sectional (within Ellisras Longitudinal Study [ELS])	(1): 287 (M), 243 (F) (2): 654 (M), 636 (F)	10–14	M, F	Limpopo	Rural	1
Kruger[30]	To investigate the determinants of overweight and obesity among 10- to 15-year-old schoolchildren in the North West province	Cross-sectional (THUSA BANA)	608 (M); 649 (F)	10–15	M, F	North West	Mixed	1
Petersen[31]	To explore and describe eating attitudes in early pubertal 11-year-old black and white South African girls in an urban environment undergoing transition	Cross-sectional (within the Birth to Twenty Cohort–Bone Health sub-study [BTT-BH])	Black (B): 148; white (W): 54	11	F	Gauteng	Urban	1, 3, 4
Szabo[32]	To explore body figure preference in a cross-cultural South African sample	Cross-sectional	Urban black (UB): 578; urban white (UW): 775; rural black (RB): 361	13–18	F	Gauteng	Urban, rural	1, 3, 4
Temple[33]	To investigate the food consumption patterns of adolescent students at schools	Cross-sectional	476	14.5 ± 2.0	M, F	Western Cape	Urban	2

(*Continued*)

Table 2: Continued.

First author	Main objective(s)	Study design	Sample size	Age (years)	Sex	Province[a]	Context (rural/ urban)	Relevant objective(s)
Jinabhai[34]	To investigate the nutritional status of black South African teenagers by sex and compare this with nutritional profiles of teenagers from other countries	Cross-sectional [South African Youth Risk Behaviour Survey (YRBS); 2002]	13 years: 174 (M), 333 (F); 14 years: 400 (M), 604 (F); 15 years: 544 (M), 693 (F); 16 years: 669 (M), 716 (F); 17 years: 611 (M), 578 (F) (black participants)	13–17	M, F	National	Mixed	1
MacKeown[35]	To report on the energy, macro- and micronutrient intakes of a true longitudinal group of 143 urban black South African children	Prospective cohort (BTT)	143 (black participants)	10, 13	M, F	Gauteng	Urban	1
Pedro[36]	To report on the variety and total number of food items recorded by a true longitudinal group of urban black South African children from the BTT Study at five interceptions (ages: 5 [1995], 7 [1997], 9 [1999], 10 [2000], 13 [2003] years)	Prospective cohort (Birth to Twenty Cohort [BTT])	143	9, 10, 13	M, F	Gauteng	Urban	2
Feeley[37]	To assess of fast-food consumption in urban black adolescents	Cross-sectional (within BTT)	320 (M); 335 (F) (black participants)	17	M, F	Gauteng	Urban	2
Reddy[38,39]	(1) To report the prevalence of underweight, overweight and obesity by gender, ethnicity and grade, among participants in a 2002 national survey among South African school-going youth; (2) to study the prevalence and correlates of overweight and obesity among participants in the SA YRBS in 2002 and 2008	Cross-sectional (SA YRBS; 2002, 2009)	2002: 4184 (M), 5338 (F); 2008: 4565 (M), 4806 (F)	13–19	M, F	National	Mixed	1
Letlape[40]	To ascertain the knowledge of students on the composition of a healthy diet, daily nutritional requirements and the importance of regular exercise	Cross-sectional	209 (M), 276 (F)	15–18	M, F	Gauteng	Urban	2
Venter[41]	To investigate the dietary fat knowledge and intake of 17-year-olds	Cross-sectional	183	17–18	M, F	Western Cape	Urban	2
Zeelie[42]	To determine the relationship between body composition and selected markers of the metabolic syndrome in black adolescents	Cross-sectional (Physical Activity in the Young Study [PLAY])	Normal %fat (NF; ≤ 20%): 72 (M), 29 (F); high %fat (HF; > 20%): 27 (M), 104 (F) (black participants)	15–19	M, F	North West	Urban	1
Abrahams[43]	To identify and describe factors associated with tuck shop and lunchbox behaviours of primary-school learners in South Africa	Cross-sectional	717	10–12	M, F	Western Cape	Mixed	1, 2
Kimani-Murage[44,45]	(1) To investigate predictors of adolescent obesity in rural South Africa; (2) to understand the profiles of malnutrition among children and adolescents in a poor, high HIV-prevalent, transitional society in a middle-income country	Cross-sectional (Agincourt Health and Demographic Surveillance System [AHDSS])	903 (M); 945 (F)	10–20	M, F	Mpumalanga	Rural	1, 3
Feeley[46]	To assess changes in the dietary habits and eating practices of a longitudinal cohort of adolescents over a 5-year period living in Soweto and Johannesburg	Prospective cohort (BTT)	1451 (black/mixed-ancestry participants)	13, 15, 17	M, F	Gauteng	Urban	2

Monyeki[47]	To determine the prevalence of underweight, normal weight and overweight among adolescents aged 14 years in the North West Province, and to assess the association between physical fitness and body composition	Cross-sectional (within the Longitudinal Study on Physical Activity and Health [PAHLS])	100 (M); 156 (F)	14	M, F	North West	Mixed	1
Poopedi[48]	To assess vitamin D status in a cohort of healthy 10-year-old urban children	Cross-sectional (within BTT-BH)	Black (B): 155 (M); 140 (F); White (W): 43; 47 (F)	10	M, F	Gauteng	Urban	1
Kagura; Chirwa[49,50]	(1) To investigate the association between nutrition and growth during infancy, and body composition at 10 years of age; (2) to compare growth velocity of two African child cohorts and examine the relationship between growth velocity in infancy/early childhood and the risk of overweight/ stunting in early adolescence	Prospective cohort (BTT-BH)	(1): 140 (black participants) (2): 216 (black participants)	10	M, F	Gauteng	Urban	1, 3
English; Mao[53,54]	(1) To determine the association between pesticide exposure and reproductive health of boys; (2) to present descriptive data on anthropometric characteristics, secondary sexual characteristics, testicular volumes and reproductive hormones from boys residing in rural Western Cape	Cross-sectional	Tanner Stage 2 (TS2): 78, Tanner Stage 3 (TS3): 39, Tanner Stage 4 (TS4): 36, Tanner Stage 5 (TS5): 8	11.7 (10.4; 12.8) (TS2)—14.7 (12.9; 15.5) (TS5)	M	Western Cape	Rural	1
Puoane[55]	To determine body weight self-perceptions, preferences, and attitudes of 265 black South African adolescent females	Cross-sectional	265	10–19	F	Western Cape	Urban	4
Goon[56]	To explore gender and racial profiling of percentage body fat of 1136 urban South African children attending public schools in Pretoria Central	Cross-sectional	10 years: 113 (M), 138 (F); 11 years: 88 (M), 72 (F); 12 years: 135 (M), 146 (F); 13 years: 148 (M), 101 (F)	10–13	M, F	Gauteng	Urban	1
Feeley; Gitau[57,58]	(1) To assess the relationship between dietary habits, change in socioeconomic status and BMI z-score and fat mass in a cohort of black South African adolescents; (2) to examine the longitudinal changes in eating attitudes, body-esteem and weight control behaviours among adolescents between 13 and 17 years; and, to describe perceptions around body shape at age 17 years	Prospective cohort (BTT)	(1): 607 (M); 616 (F) (black participants) (2) 13 years, black (B): 666 (M), 742 (F); mixed-ancestry (MA): 81 (M), 91 (F); 17 years, B: 781 (M), 826 (F); MA: 100 (M), 113 (F)	13, 17	M, F	Gauteng	Urban	1, 2, 3, 4
Voorend; Sedibe[51,52]	(1) To explore if and how female adolescents engage in shared eating and joint food choices with best friends within the context of living in urban Soweto; (2) to investigate the narratives	Qualitative	58 (29 pairs)	18 ± 1.1	F	Gauteng	Urban	5

(*Continued*)

Table 2: Continued.

First author	Main objective(s)	Study design	Sample size	Age (years)	Sex	Province[a]	Context (rural/ urban)	Relevant objective(s)
	pertaining to dietary and physical activity practices							
Craig[59,60]	To assess agreement between widely used methods of assessing nutritional status in children and adolescents, and to examine the benefit of body composition estimates	Cross-sectional	11 years: 503; 15 years: 502	11, 15	M, F	KwaZulu-Natal	Rural	1
Feeley[61]	To determine the consumption of purchased foods and drinks among a cohort of urban adolescents, and to estimate the added sugar and dietary sodium intake from these foods and beverages	Cross-sectional (within BTT)	720 (M); 731 (F)	17	M, F	Gauteng	Urban	2
Gitau[63]	To examine differences between black and white female adolescents in eating attitudes, body image perceptions, and self-esteem, and the association of these with BMI	Cross-sectional	Black (B): 61 (13 years), 59 (15 years), 63 (17 years); white (W): 54 (13 years), 54 (15 years), 49 (17 years)	13, 15, 17	F	Gauteng	Urban	1, 3, 4
Gitau[62]	To examine eating attitudes, body image and self-esteem among male adolescents	Cross-sectional	Black (B): 60 (13 years), 60 (15 years), 59 (17y); white (W): 68 (13 years), 78 (15 years), 66 (17 years)	13, 15, 17	M	Gauteng	Urban	1, 3, 4
Mamabolo[65]	To determine if insulin-like growth factor-1 is a significant predictor of body fat percentage, lean body mass, and insulin resistance in black adolescents presenting with overnutrition and undernutrition	Cross-sectional	70 (M), 111 (F) (black participants)	13–20	M, F	North West	Urban	1
Mamabolo[64]	To determine the association between dyslipidaemia and anthropometric indices in black and white adolescents	Cross-sectional	Black (B): 129; White (W): 69	12–16	M, F	North West	Urban	1
Micklesfield; Pedro[66,67]	(1) To examine physical activity and sedentary behaviour patterns in South African adolescents; (2) to determine the prevalence of under- and overnutrition, as well as evidence of metabolic disease risk, in South African children and adolescents	Cross-sectional (AHDSS)	(1): 11–12 years: 98 (M), 97 (F); 14–15 years: 91 (M), 95 (F) (2): 11–12 years: 102 (M), 100 (F); 14–15 years: 92 (M), 97 (F)	11–12; 14–15	M, F	Mpumalanga	Rural	1
Sedibe[68]	To explore perceptions, attitudes, barriers, and facilitators related to healthy eating and physical activity among adolescent girls in rural South Africa	Qualitative	22 (11 pairs)	16–19	F	Mpumalanga	Rural	5
Visser[69]	To determine the prevalence of abnormal eating attitudes and weight-loss behaviour in female Jewish adolescents	Cross-sectional	220 (white participants)	15.7 ± 1.2	F	Gauteng	Urban	4
Mchiza[70]	To examine body image in relation to body mass index and weight control in South Africa	Cross-sectional (South African National Health and	764	15–18	M, F	National	Mixed	1, 4

		Nutrition Examination Survey [SANHANES-1]; 2012)						
Meko[71]	To determine the nutritional status of 13- to 15-year-old children in Bloemfontein and its association with socioeconomic factors	Cross-sectional	174 (M); 240 (F)	13–15	M, F	Free State	Urban	1, 3
Nkeh-Chungag[72]	To investigate the prevalence of pre-hypertension and hypertension in peri-urban school-attending adolescents and explore the relationship between blood pressure and selected anthropometric measurements	Cross-sectional	118 (M), 274 (F)	13–17	M, F	Eastern Cape	Peri-urban	1
Pisa[73]	To identify and describe the diversity of nutrient patterns and how they associate with sociodemographic and lifestyle factors including body mass index in rural black South African adolescents	Cross-sectional (Agincourt Health and Demographic Surveillance System [AHDSS])	388	11–15	M, F	Mpumalanga	Rural	2, 3
Tee[88]	To determine the proportion and quality of breakfast intake in adolescents, and to determine the effect of breakfast intake and quality on overall diet quality	Cross-sectional	113 (M), 131 (F)	17.5 ± 2.3	M, F	North West	Urban, peri-urban	2
Toriola[74]	To evaluate longitudinal development of health-related fitness, anthropometry and body composition status amongst adolescents in Tlokwe Municipality, Potchefstroom, South Africa	Prospective cohort (PAHLS)	111 (M), 172 (F)	14–15	M,F	North West	Mixed	1
Oldewage-Theron[75,76]	(1) To assess the nutrition knowledge, nutrient intakes, and association between nutrition knowledge and dietary intakes of 98 adolescents in rural Cofimvaba, South Africa; (2) to investigate the association between diet quality, intakes of anti-inflammatory nutrients and food groups, and subclinical inflammation	Cross-sectional	(1) 14–18 years: 98 (2): 9–13 years: 82; 14–18 years: 97	9–18	M, F	Eastern Cape	Rural	1, 2
Pradeilles; Prioreschi[77,78]	(1) To investigate the associations of household and neighbourhood socioeconomic position with indicators of both under- and overnutrition in adolescents and to explore sex differences; (2) to examine growth trajectories from birth, and associations with adult body composition	Prospective cohort (BTT)	(1): 974 (M), 1045 (F) (2): 514 (M), 500 (F)	17–19	M, F	Gauteng	Urban	1, 3
Kagura[79]	To investigate the association between SES change between infancy and adolescence, and blood pressure, in young adults, and the impact of early growth on this relationship	Prospective cohort (BTT)	838 (black participants)	18	M, F	Gauteng	Urban	1
Lundeen[80]	To describe gender differences in overweight and obesity from infancy to late adolescence in a South African cohort	Prospective cohort (BTT)	566 (M), 606 (F)	11–12, 13–15, 16–18	M, F	Gauteng	Urban	1

(*Continued*)

Table 2: Continued.

First author	Main objective(s)	Study design	Sample size	Age (years)	Sex	Province[a]	Context (rural/ urban)	Relevant objective(s)
Monyeki[81]	To determine whether arm span, mid-upper arm and waist circumferences and sum of four skinfolds can be used to predict height	Cross-sectional (within ELS)	310 (M); 298 (F)	15–18	M, F	Limpopo	Rural	1
Pedro[82]	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 11–15 years, in rural South Africa	Cross-sectional (AHDSS)	Early puberty (EP): 99 (M), 73 (F); mid- to post-puberty (MP): 91 (M); 122 (F)	11–15	M, F	Mpumalanga	Rural	3, 4
Tshililo[83]	To explore factors influencing weight control practices amongst adolescent girls	Qualitative	30	13–19	F	Limpopo	Not specified	5
Manyanga[84]	To examine relationships among dietary patterns and socioeconomic status of children from countries spanning a wide range of human development	Cross-sectional (International Study of Childhood Obesity, Lifestyle and the Environment [ISCOLE])	167 (M), 256 (F)	9–11	M, F	Western Cape	Urban	1, 2
Moselakgomo[85]	To estimate overweight and obesity in school children	Cross-sectional	Limpopo (L): 168 (10 years), 215 (11 years), 143 (12 years), 56 (13 years); Mpumalanga (M): 147 (10 years), 128 (11 years), 154 (12 years), 142 (13 years)	10–13	M, F	Limpopo, Mpumalanga	Rural	1
Pedro[86]	To assess the association between diet and cardiovascular disease risk factors in rural black South African adolescents	Cross-sectional (AHDSS)	193 (M), 195 (F)	11–15	M, F	Mpumalanga	Rural	1
Sedibe[87]	To investigate differences/ similarities in dietary habits and eating practices between younger and older, rural and urban South African adolescents	Cross-sectional (within BTT [urban site; U] and AHDSS [rural site; R])	Early adolescent (EA), rural (R): 105 (M), 98 (F); urban (U): 760 (M), 805 (F); mid-adolescent (MA), R: 89 (M), 100 (F); U: 747 (M), 786 (F) (black participants)	EA: 11–12 (R), 13 (U); MA: 14–15 (R), 15 (U)	M, F	Gauteng, Mpumalanga	Urban, rural	1, 2, 3

[a]Province refers to a principal administrative district in South Africa.

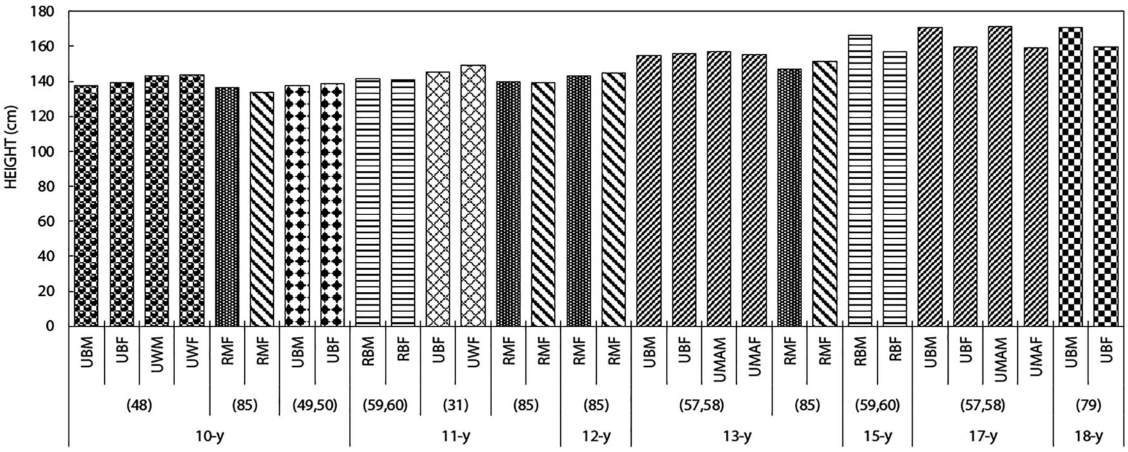

Figure 2: Results from studies describing height (mean/median) of South African adolescents according to age (years).
Abbreviations: UBM, urban black male; UBF, urban black female; UWM, urban white male; UWF, urban white female; RMF, rural male and female; RBM, rural black male; RBF, rural black female; UMAM, urban mixed-ancestry male; UMAF, urban mixed-ancestry female.

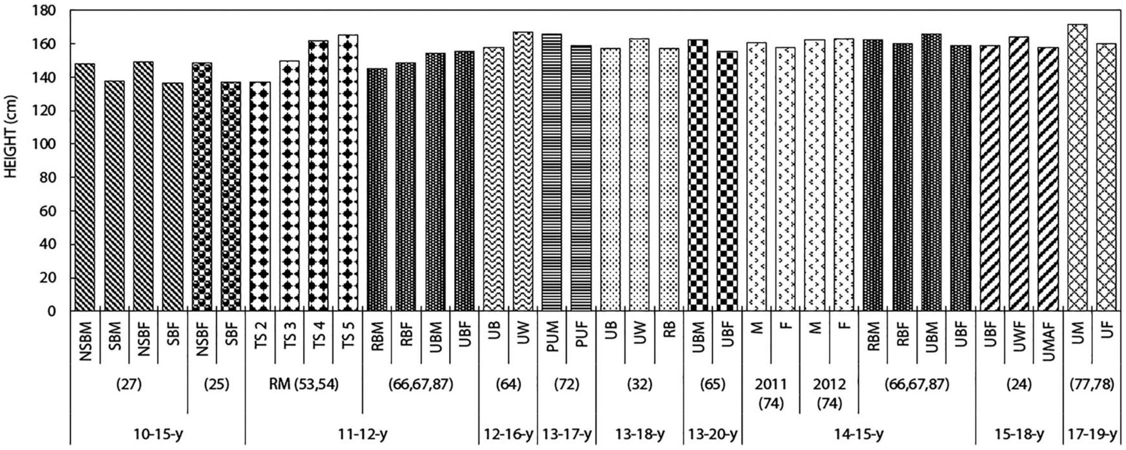

Figure 3: Results from studies describing height (mean/median) of South African adolescents according to age (years; range).
Abbreviations: NSBM, non-stunted black male; SBM, stunted black male; NSBF, non-stunted black female; SBF, stunted black female; TS2, Tanner stage 2; TS3, Tanner stage 3; TS4, Tanner stage 4; TS5, Tanner stage 5; RBM, rural black male; RBF, rural black female; UBM, urban black male; UBF, urban black female; UB, urban black; UW, urban white; PUM, peri-urban male; PUF, peri-urban female; RB, rural black; M, male; F, female; UMAF, urban mixed-ancestry female; UM, urban male; UF, urban female.

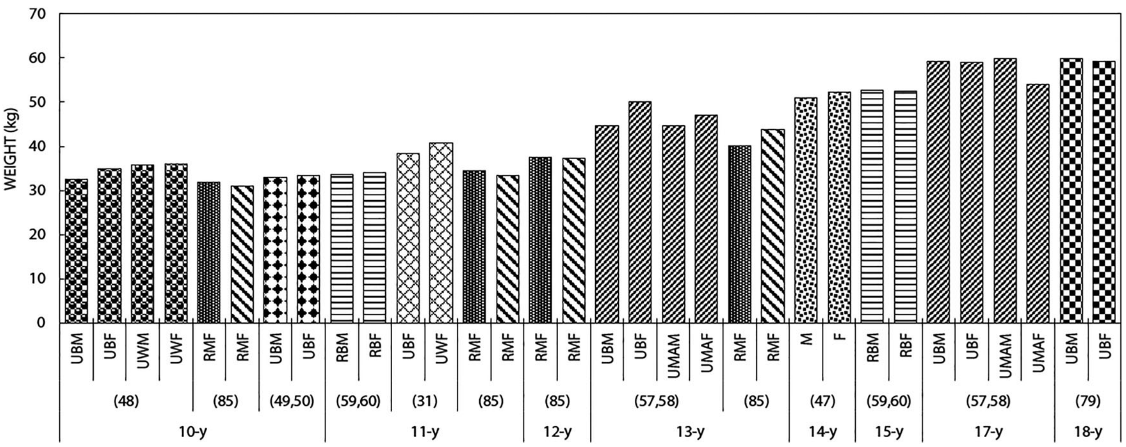

Figure 4: Results from studies describing weight (mean/median) of South African adolescents according to age (years).
Abbreviations: UBM, urban black male; UBF, urban black female; UWM, urban white male; UWF, urban white female; RMF, rural male and female; RBM, rural black male; RBF, rural black female; UMAM, urban mixed-ancestry male; UMAF, urban mixed-ancestry female; M, male; F, female.

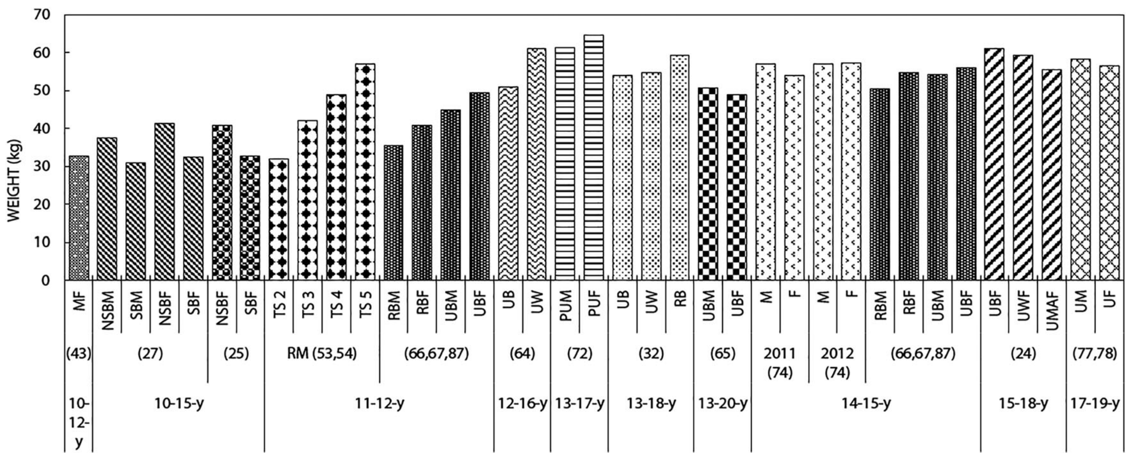

Figure 5: Results from studies describing weight (mean/median) of South African adolescents according to age (years; range).
Abbreviations: MF, male and female; NSBM, non-stunted black male; SBM, stunted black male; NSBF, non-stunted black female; SBF, stunted black female; TS2, Tanner stage 2; TS3, Tanner stage 3; TS4, Tanner stage 4; TS5, Tanner stage 5; RBM, rural black male; RBF, rural black female; UBM, urban black male; UBF, urban black female; UB, urban black; UW, urban white; PUM, peri-urban male; PUF, peri-urban female; RB, rural black; M, male; F, female; UMAF, urban mixed-ancestry female; UM, urban male; UF, urban female.

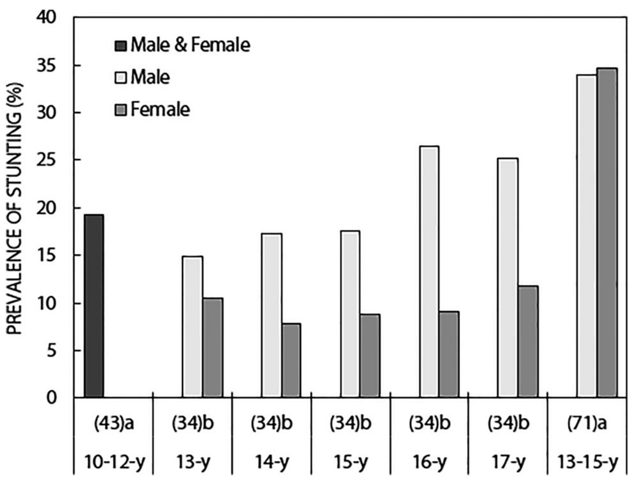

Figure 6: Results from studies describing the stunting prevalence in South African adolescents according to age (years). [a]WHO child growth standards.[89] [b]CDC/NCHS growth charts.[90]

Cross-sectional studies conducted in various rural and/or urban South African settings showed an overall increase in both BMI and prevalence of combined overweight and obesity as adolescents aged between 10 and 20 years (Figures 7–10). This increase was predominantly driven by increased adiposity in girls. Longitudinal data from the BTT cohort similarly showed higher overweight/obesity prevalence in girls at all ages, regardless of ethnicity (black, white and mixed-ancestry participants)[57,58,77,78,80] (Figures 9 and 10).

When comparing black and white adolescents in an urban setting, although the overweight/obesity prevalence was similar in black and white girls at 13 years of age (14.8% [black] vs. 15.7% [white]), there was a substantially higher prevalence of overweight/obesity in black girls at 17 years (16.1% [black] vs. 11.6% [white]).[63] The opposite was seen in boys (13, 15, 17 years), with higher combined overweight/obesity prevalence in white compared with black boys (28.8% [white] vs. 11.2% [black]).[62] Black girls demonstrated higher overweight/obesity prevalence than their mixed-ancestry counterparts at both 13 and 17 years of age (13 years: 20.2% [black], 13.2% [mixed ancestry]; 17 years: 27.5% [black], 15.9% [mixed ancestry]). While this was similar for boys at 13

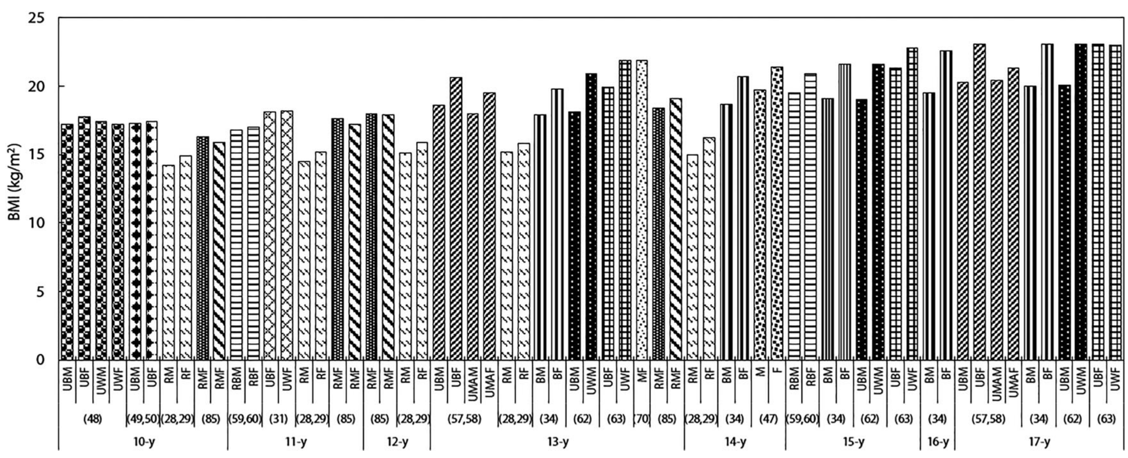

Figure 7: Results from studies describing body mass index (BMI; mean/median) of South African adolescents according to age (years).
Abbreviations: UBM, urban black male; UBF, urban black female; UWM, urban white male; UWF, urban white female; RMF, rural male and female; RBM, rural black male; RBF, rural black female; UMAM, urban mixed-ancestry male; UMAF, urban mixed-ancestry female; BM, black male; BF, black female; MF, male and female; M, male; F, female.

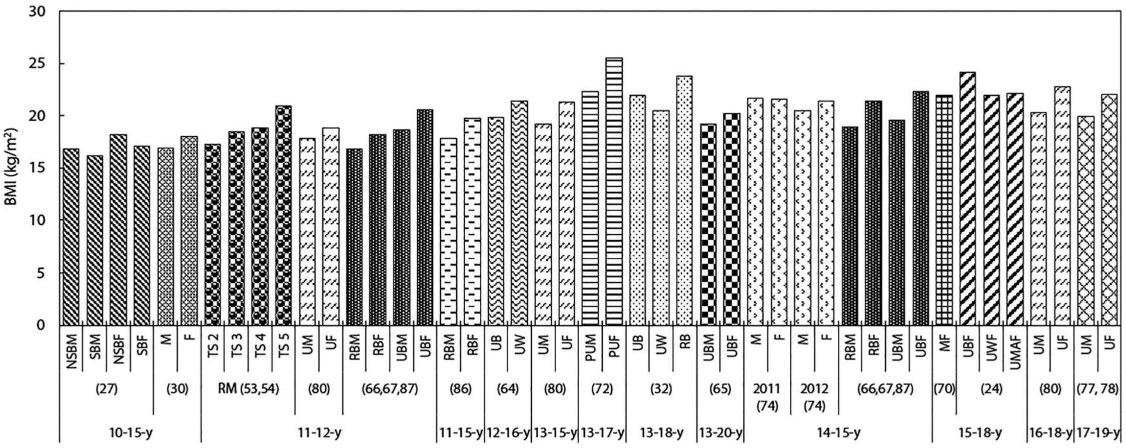

Figure 8: Results from studies describing body mass index (BMI; mean/median) of South African adolescents according to age (years; range). Abbreviations: NSBM, non-stunted black male; SBM, stunted black male; NSBF, non-stunted black female; SBF, stunted black female; M, male; F, female; TS2, Tanner stage 2; TS3, Tanner stage 3; TS4, Tanner stage 4; TS5, Tanner stage 5; UM, urban male; UF, urban female; RBM, rural black male; RBF, rural black female; UBM, urban black male; UBF, urban black female; UB, urban black; UW, urban white; PUM, peri-urban male; PUF, peri-urban female; RB, rural black; MF, male and female; UWF, urban white female; UMAF, urban mixed-ancestry female.

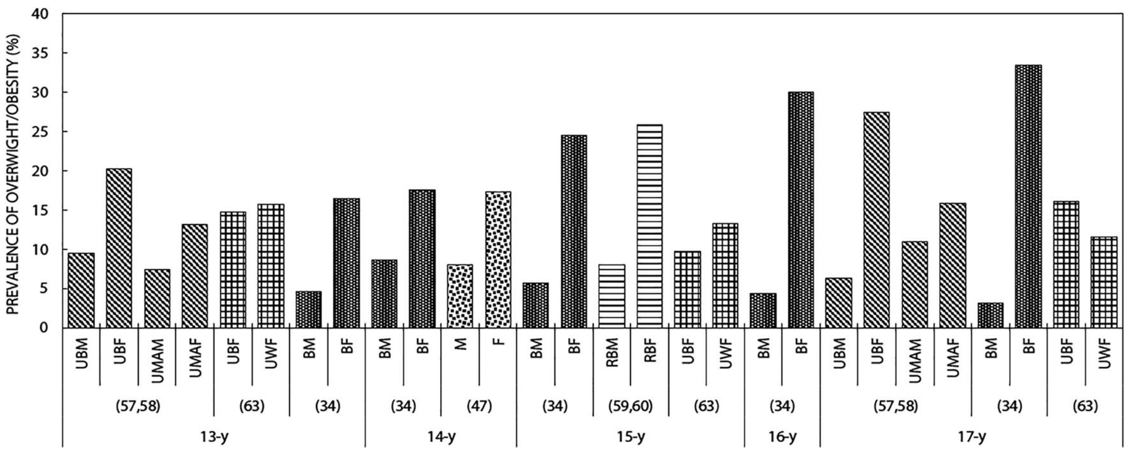

Figure 9: Results from studies describing the combined overweight and obesity prevalence in South African adolescents according to age (years) Abbreviations: UBM, urban black male; UBF, urban black female; UMAM, urban mixed-ancestry male; UMAF, urban mixed-ancestry female; UWF, urban white female; BM, black male; BF, black female; M, male; F, female; RBM, rural black male; RBF, rural black female.

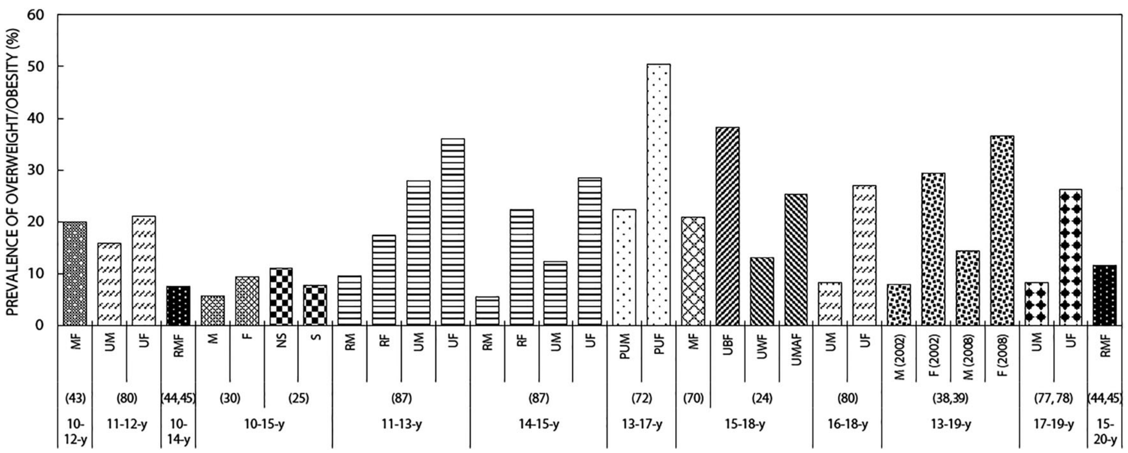

Figure 10: Results from studies describing the combined overweight and obesity prevalence in South African adolescents according to age (years; range). Abbreviations: MF, male and female; UM, urban male; UF, urban female; RMF, rural male and female; M, male; F, female; NS, non-stunted; S, stunted; RM, rural male; RF, rural female; PUM, peri-urban male; PUF, peri-urban female; UBF, urban black female; UWF, urban white female; UMAF, urban mixed-ancestry female.

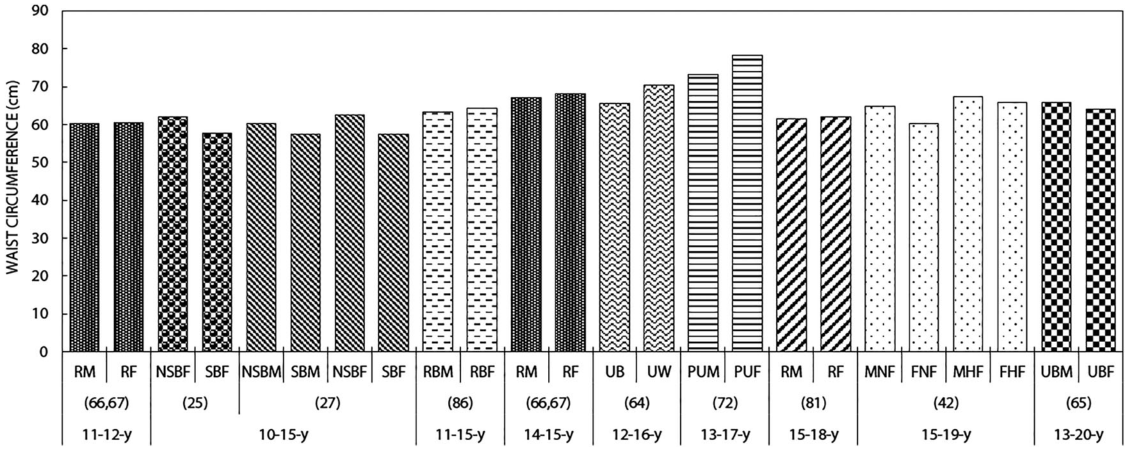

Figure 11: Results from studies describing central adiposity (waist circumference; mean/median) of South African adolescents according to age (years; range). Abbreviations: RM, rural male; RF, rural female; NSBM, non-stunted black male; SBM, stunted black male; NSBF, non-stunted black female; SBF, stunted black female; RBM, rural black male; RBF, rural black female; UB, urban black; UW, urban white; PUM, peri-urban male; PUF, peri-urban female; MNF, male normal body fat percentage (%fat); FNF, female normal %fat; MHF, male high %fat; FHF, female high %fat; UBM, urban black male; UBF, urban black female.

years of age, mixed-ancestry boys showed higher overweight/obesity prevalence rates than their black counterparts at 17 years (13 years: 9.5% [black], 7.4% [mixed ancestry]; 17 years: 6.3% [black], 11.0% [mixed ancestry]).[57,58]

In both early (11–13 years) and mid-adolescent (14–15 years) black boys and girls, the combined overweight and obesity prevalence was higher in those from urban ([early adolescent: 27.9% (M), 36.1% (F)]; [mid-adolescent: 12.3% (M), 28.5% (F)]) compared with rural settings ([early adolescent: 9.5% (M), 17.3% (F)]; [mid-adolescent: 5.5% (M), 22.3% (F)]).[87]

Adiposity (Figure 11 and Table 3)

Across age categories the majority of studies showed higher waist circumference in girls compared with boys[64,66,67,72,81,86] (Figure 11). White adolescents had higher waist circumference than their black counterparts at 12–16 years (65.5 cm [black], 70.4 cm [white])[64] and waist circumference tended to be higher in adolescents from urban vs. rural settings.[64,66,67,72,81,86] Body fat percentage (%fat) was similarly lower in boys vs. girls throughout adolescence ([11 years: 12.3% (M), 20.3% (F)]; [14 years: 13.7% (M), 20.5% (F)]; [15 years: 9.0% (M), 24.7% (F)])[47,59,60] (Table 3).

When stratified according to non-stunted (NS) vs. stunted (S) adolescents, 10–15-year-old stunted boys and girls had lower %fat ([M: 14.2% (NS) vs. 12.5% (S)]; [F: 22.8% (NS) vs. 19.3% (S)]) and waist circumferences ([M: 60.3 cm (NS) vs. 57.5 cm (S)]; [F: 62.4 cm (NS) vs. 57.5 cm (S)]) than their non-stunted counterparts.[27]

Biochemical markers (data not shown)

The single study describing any biochemical marker of micronutrient status in adolescent South Africans focused on Vitamin D status as assessed by serum 25-hydroxyvitamin D (25(OH)D).[48] 25(OH)D was higher in white compared with black adolescents (male: 129 ± 37.1 nmol/l [white], 100 ± 34.3 nmol/l [black]; female: 112 ± 34.8 nmol/l [white], 86 ± 31.1 nmol/l [black]). Some 22% and 12% of black and white adolescents respectively had insufficient vitamin D levels (50–74 nmol/l), while 8% and 1% of black and white adolescents respectively were vitamin D deficient (< 50 nmol/l).[48]

Reported dietary nutrient intakes (Table 4)

Of the nine studies reporting dietary nutrient intakes in South African adolescents, seven used 24-hour recall[23,25,27,30,31,75,76] and two used a quantitative food frequency questionnaire (QFFQ)[35,86] to describe intakes. Where 24-hour recalls were utilised, only two studies used a repeated recall method (one week and one weekend day),[75,76] with the remaining five using recall for a single day. However, three of these articles used data from the THUSA BANA study (Transition and Health during Urbanisation of South Africans; BANA, children) which validated its recall method via a repeated recall and a 3-day weighed record in a sub-sample.[25,27,30] While MacKeown *et al*. stated that QFFQs had been demonstrated as valid and reproducible instruments in other South African populations and that the same QFFQ was consistently used across time interceptions, the specific questionnaire was not validated.[35] In the case of Pisa *et al*., a QFFQ developed for the South African population was utilised and included nationally representative food items consumed by at least 3% of the population.[73] It also incorporated validated instruments for portion size estimation.[73] For studies that assessed reported micronutrient intakes, those of key micronutrients common across studies are presented in Table 4.

Median energy intakes were similar in rural adolescents at 9–13 and 14–18 years of age (7 172 kJ/d and 7 141 kJ/d respectively); with a slightly higher total fat intake at 14–18 years (48 g/d [9–13 years]; 50 g/d [14–18 years]).[75,76] Intakes of most of the micronutrients assessed (iron, magnesium, zinc and folate) were similar across age groups; however, vitamin C intake was higher in the 9–13 year group (23.8 mg/d [9–13 years]; 18.1 mg/d [14–18 years]).[75,76] Rural boys demonstrated higher energy intakes than girls at 11–15 years (9 900 kJ/d and 6 670 kJ/d respectively); however, girls had higher fat (32 g/d [M] vs. 37.8 g/d [F]), protein (39 g/d [M] vs. 42 g/d [F]) and cholesterol (25.2 g/d [M] vs. 43 g/d [F]) intakes.[86]

In the North West province, 10–15-year-old boys and girls had mean energy intakes of 8 014 kJ/d and 7 397 kJ/d respectively.[30] Mean fat intake was 56 g/d for boys and 53 g/d for girls, thereby contributing to 26.5% and 27.1% of daily energy intake in boys and girls respectively.[75] Energy, macro- and micronutrient intakes were similar in stunted compared with non-stunted 10–15-year-old black adolescents.[25,27]

Table 3: Results from studies describing adiposity in South African adolescents.

First author	Sample size	Age (y)	Sex (M/F)	Context (rural/urban)	Adiposity [mean (SD)/median (range)]	
					Measurement(s)	Value(s)
van Rooyen[27]	Non-stunted (NS): 258 (M), 325 (F); stunted (S): 105 (M), 87 (F) (black participants)	10–15	M, F	Mixed	%fat (skinfolds)[c]	M, NS: 14.2 (5.8)
						S: 12.5 (4.8)
						F, NS: 22.8 (6.9)
						S: 19.3 (7.0)
Monyeki[28]	287 (M); 243 (F)	10–14	M, F	Rural	%fat (skinfolds)[d]	10 years, M: 12.7 (3.6)
						F: 15.6 (5.2)
						11 years, M: 14.4 (4.3)
						F: 17.5 (8.7)
						12 years, M: 14.0 (4.2)
						F: 15.4 (4.9)
						13 years, M: 14.1 (6.6)
						F: 15.7 (5.2)
						14 years, M: 11.0 (2.6)
						F: 18.6 (8.2)
Zeelie[42]	Normal %fat (NF; ≤ 20%): 72 (M), 29 (F); high %fat (HF; > 20%): 27 (M), 104 (F) (black participants)	15–19	M, F	Urban	%fat (ADP)	M, NF: 14.3 (2.8)
						HF: 26.0 (5.0)
						F, NF: 20.3 (4.6)
						HF: 31.8 (4.8)
Poopedi[48]	Black (B): 155 (M); 140 (F); white (W): 43 (M); 47 (F)	10	M, F	Urban	%fat (DXA)	B, M: 22 (6.3)
						B, F: 28 (7.0)
						W, M: 22 (5.2)
						W, F: 27 (5.5)
Monyeki[47]	100 (M); 156 (F)	14	M, F	Mixed	%fat (skinfolds)[d]	M: 13.7 (7.0)
						F: 20.5 (5.6)
Craig[59]	11 years: 503; 15 years: 502	11, 15	M, F	Rural	%fat (bio-impedance)	11 years, M: 12.3 (10.1; 14.6)
						F: 20.3 (16.7; 24.2)
						15 years, M: 9.0 (6.5; 11.8)
						F: 24.7 (20.1; 29.5)
Goon[56]	10 years: 113 (M), 138 (F); 11 years: 88 (M), 72 (F); 12 years: 135 (M), 146 (F); 13 years: 148 (M), 101 (F)	10–13	M, F	Urban	%fat (skinfolds)[d]	10 years, M: 17.8 (6.9)
						F: 20.2 (5.2)
						11 years, M: 16.4 (6.2)
						F: 23.5 (6.0)
						12 years, M: 17.8 (8.3)
						F: 23.3 (5.5)
						13 years, M: 17.8 (7.8)
						F: 24.1 (4.1)
Mamabolo[65]	70 (M), 111 (F) (black participants)	13–20	M, F	Urban	%fat (ADP)	M: 18.2 (6.6)
						F: 28.8 (6.4)
Toriola[74]	111 (M), 172 (F)	14–15	M, F	Mixed	%fat (skinfolds)[d]	2011, M: 14.4 (9.1)
						F: 26.4 (8.6)
						2012, M: 20.3 (9.4)
						F: 19.4 (9.7)
Pradeilles[77]	839 (M), 889 (F)	17–19	M, F	Urban	%fat (DXA)	M: 12.1 (9.9; 15·3) F: 33.2 (7.1)
Moselakgomo[85]	Limpopo province[b] (L): 168 (10 years), 215 (11 years), 143 (12 years), 56 (13 years); Mpumalanga province[b] (M): 147 (10 years), 128 (11 years), 154 (12 years), 142 (13 years)	10–13	M, F	Rural	%fat (skinfolds)[d]	10 years, L: 21.5 (1.6)

(*Continued*)

Table 3: Continued.

First author	Sample size	Age (y)	Sex (M/F)	Context (rural/urban)	Adiposity [mean (SD)/median (range)]	
					Measurement(s)	Value(s)
						M: 26.3 (1.8)
						11 years, L: 16.4 (1.7)
						M: 18.4 (1.7)
						12 years, L: 13.3 (1.9)
						M: 14.6 (1.8)
						13 years, L: 11.9 (1.7)
						M: 12.5 (1.9)

Abbreviations: %fat: body fat percentage; ADP: air displacement plethysmography; DXA: dual-energy X-ray absorptiometry.
[a]Adolescent adiposity described using anthropometry (skinfolds) and/or objective measurements (ADP or DXA).
[b]Province refers to a principal administrative district in South Africa.
[c]Derived according to Boileau.[92]
[d]Derived according to Slaughter.[93]

Within the BTT cohort, energy and total fat intakes were similar between black and white girls at 11 years of age (energy: 5 422 kJ/d [black], 5 055 kJ/d [white]; fat: 38 g/d [black], 42 g/d [white]).[31] For BTT black boys and girls specifically, median energy intakes increased from 1 767 kcal/d to 2 127 kcal/d between the ages of 10 and 13 years; however, 73% and 59% of adolescents had intakes below the recommended dietary allowance (RDA; Food and Nutrition Board[94]) at 10 and 13 years respectively.[35] Daily intakes of all macro- and micronutrients similarly increased with age; however, increases in protein (56–59 g/d) and fibre (22–23 g/d) intake were small compared with those of carbohydrate (279–323 g/d), fat (51–70 g/d) and added sugar (68–102 g/d).[35] Intakes of calcium, iron, zinc, vitamin A, riboflavin and niacin were below the RDA at 10 and 13 years, while vitamin B6 and vitamin C intakes were below the RDA at 10 years only (data not shown).[35]

Food intakes, diet patterns and eating practices (Table 5)

Sixteen studies met the inclusion criteria for Objective 2.[23,33,36,37,40,41,43,46,57,61,73,75,76,84,87,88] Data collection was questionnaire based for all studies and included: dietary assessment via FFQ and/or 24-hour recall,[36,43,73,75,76,84] as well as data on dietary habits and eating practices,[23,33,46,57,61,87] nutrition knowledge,[40,41,43,75,76] and fast-food intake/availability.[37]

The odds of higher ‘Unhealthy Dietary Pattern (UDP)’ scores were 2.77 times higher in the lowest vs. highest SES group (SES defined according to a combined scale of annual household income and highest level of parental education).[84] In addition, adolescents attending high SES schools had better knowledge of healthy vs. unhealthy foods ($p < 0.01$) and were more likely to bring a lunchbox to school ($p < 0.001$).[33] Lunchbox usage was associated with younger age and urban school attendance ($p < 0.001$), as well as higher standards of living ($p < 0.001$), dietary diversity scores ($p = 0.012$) and number of meals per day ($p < 0.001$).[43] In addition, adolescents who brought food to school had lower BMI percentiles ($p = 0.002$) and BMI-for-age ($p = 0.034$) than those purchasing food at school.[43] Overall, ‘unhealthy’ food items were brought to school twice as often as ‘healthy’ foods and 70% of adolescents who purchased food at school reported purchasing no healthy items.[33] Many adolescents (47–61%) could not correctly identify less healthy food items (including sugar-sweetened beverages, samosas and pies).[33]

In urban adolescents, the most commonly consumed food items were: rice, stiff maize-meal porridge, chicken, added sugar, sweets, tea, eggs, full-cream milk, carbonated beverages and oil.[36] Consumption of grains, dairy products and fruits and vegetables decreased and consumption of meat and meat substitutes (e.g. chicken, cheese and polony) and oil increased with age.[36] Between the ages of 13 and 17 years, regular breakfast consumption and lunchbox usage decreased, with adolescents purchasing more food at school.[46,57] Snacking while watching television increased with age (3.6 ± 4.6–6.7 ± 5.9 snacks/week), with girls consuming significantly more snacks than boys ($p < 0.01$).[46] Over two-thirds of adolescents consumed fast foods and sweetened beverages three or more times/week, with median intakes reaching 11 fast-food items per week in both sexes and 8 and 10 sweetened beverages per week in males and females respectively at 17 years.[57,61] Confectionery consumption was high across the five-year follow-up (9–10 items/week) and reached 11 items per week in boys and 13 items per week in girls at 17 years.[46,61] Approximately three times the American Heart Association (AHA) recommended daily intake of added sugar was consumed via purchased food items (males: 561.6 g/week vs. females: 485.3 g/week; $p = 0.02$).[61,95] These items also contributed over half the AHA recommended daily intake of salt (males: 4 803 mg/week vs. females: 4 761 mg/week; $p > 0.05$) in adolescents.[96] The ‘kota’ (quarter-loaf of white bread filled with chips, a slice of cheese and delicatessen meats and sauces) was the least expensive and most regularly purchased fast food item at 17 years.[37] This item alone provided over half the estimated daily energy requirement (ER) containing, on average, 5 970 kJ of energy and 51 g of fat.[37,97]

Compared with urban adolescents, rural girls and boys demonstrated significantly lower snack consumption while watching TV during early adolescence (EA; 11–13 years) and significantly lower fast food consumption during mid-adolescence (MA; 14–15 years).[87] Significantly more rural girls (EA: 51.02%; MA: 48.51%) than boys (EA: 33.33%; MA: 28.57%) consumed their main meal with the family almost every day.[87]

Consumption of a dietary pattern driven by animal-derived nutrients was higher in rural girls vs. boys and in adolescents with higher SES (based on a Wealth Index) ($P < 0.05$).[73] Some 87.6% of girls and 89.8% of boys had low food variety scores (FVS; < 30 food items consumed per week) and 12.4% of girls and 10.2% of boys had medium FVS (30–60 food items per

Table 4: Results from studies describing reported dietary nutrient intakes of South African adolescents

First author	Sample size	Age (years)	Sex (M/ F)	Context (rural/ urban)	Dietary intake		
					Energy, kJ/day	Macronutrient(s)/ fibre, g/day	Micronutrient(s), mg/day
Faber[23]	50	10–11	M, F	Rural	7 624 (2 215)	Protein: 51.1 (20.5)	Ca: 282 (152)
						Animal protein: 13.8 (16.3)	Fe: 12.8 (4.7)
						Plant protein: 37.1 (14.3)	Mg: 229 (86)
						Fat: 57.9 (22.0)	Zn: 5.7 (3.4)
						SFA: 16.8 (7.6)	Vit A [RE]: 558 (364)
						MUFA: 18.2 (9.5)	Thiamin: 0.83 (0.31)
						PUFA: 18.4 (8.2)	Riboflavin: 1.53 (1.43)
						CHO: 273.0 (83.0)	Niacin: 8.15 (4.44)
						Fibre: 20.2 (9.7)	Vit B6: 1.12 (0.56)
						Added sugar: 35.1 (23.1)	Vit B12 [µg/d]: 1.46 (2.17)
							Folate [µg/d]: 206 (141)
							Vit C: 19.6 (17.9)
Kruger[25]	Non-stunted (NS): 387; stunted (S): 91 (black participants)	10–15	F	Mixed	NS: 7 258 (6 999; 7 518)	Protein, NS: 58.9 (56.5; 61.3)	
					S: 7 440 (6 879; 8 001)	S: 61.0 (55.5; 66.6)	
						Fat, NS: 52.1 (49.0; 55.1)	
						S: 53.4 (47.1; 59.6)	
						CHO, NS: 261.5 (251.6; 271.4)	
						S: 266.6 (246.7; 286.4)	
van Rooyen[27]	Non-stunted (NS): 258 (M), 325 (F); stunted (S): 105 (M), 87 (F) (black participants)	10–15	M, F	Mixed	NS: 7 595 (120) S: 7 534 (209)	Protein, NS: 61.8 (1.1) S: 60.4 (1.9)	Ca, NS: 418.9 (14.0) S: 405.4 (24.2)
						Animal protein, NS: 30.3 (0.8)	
						S: 30.5 (1.6)	
						Plant protein, NS: 31.2 (0.7)	Fe, NS: 8.4 (0.2)
						S: 29.7 (1.1)	S: 8.2 (0.4)
						SFA, NS: 18.0 (0.5)	Mg, NS: 230.4 (4.9)
						S: 17.7 (1.0)	S: 223.4 (7.4)
							K, NS: 1632.4 (37.0)
							S: 1569.7 (57.9)
							Na, NS: 1543.7 (46.4)
							S: 1552.6 (89.1)
							Zn, NS: 7.9 (0.2) S: 7.4 (0.3) Vit C, NS: 37.7 (3.1) S: 44.6 (6.2)

(*Continued*)

Table 4: Continued.

First author	Sample size	Age (years)	Sex (M/F)	Context (rural/ urban)	Dietary intake		
					Energy, kJ/day	Macronutrient(s)/ fibre, g/day	Micronutrient(s), mg/day
Kruger[30]	608 (M); 649 (F)	10–15	M, F	Mixed	M: 8 014 (3 022)	Fat, M: 55.9 (35.4)	
					F: 7 397 (2 763)	F: 52.7 (31.7)	
						Fat (%E), M: 26.5	
						F: 27.1	
Petersen[31]	Black (B): 148; white (W): 54	11	F	Urban	B: 5 422 (2 242) W: 5 055 (1 784)	Fat. B: 38 (22) W: 42 (20)	
MacKeown[35]	143 (black participants)	10, 13	M, F	Urban	10 years (kcal/d): 1 767 (1 697; 1 836)	Protein, 10y: 56 (53.76; 58.25)	Ca, 10y (g/d): 497 (462.5; 531.5)
					13 years: 2 127 (1 994; 2 260)	13 years: 59 (55.21; 62.79)	13 years: 642 (585.0; 699.0)
						Fat, 10 years: 51 (48.64; 53.36)	Vit B12, 10y (μg/d): 2.3 (2.12; 2.48)
						13 years: 70 (62.87; 76.73)	13 years: 2.8 (2.52; 3.08)
						CHO, 10 years: 279 (266.4; 290.6)	Fe, 10 years: 8.5 (8.12; 8.88)
						13 years: 323 (304.3; 341.7)	13 years: 10.2 (9.45; 10.95)
						Fibre, 10 years: 22 (20.8; 23.38)	Mg, 10 years: 290 (274.3; 305.7)
						13 years: 23 (20.70; 24.30)	13 years: 318 (294.6; 341.4)
						Added sugar, 11 years: 68 (62.46; 73.14)	
						13 years: 102 (95.04; 109.74)	
							K, 10 years: 1 695 (1621.3; 1768.7)
							13 years: 2 057 (1925.1; 2188.9)
							Zn, 10 years: 7.7 (7.36; 8.04)
							13 years: 8.2 (7.64; 8.76)
							Vit A, 10 years (RE): 332 (305.4; 358.0)
							13 years: 620 (545.7; 694.3)
							Thiamin, 10 years: 1.0 (0.95; 1.05)
							13 years: 1.2 (1.12; 1.28)
							Riboflavin, 10 years: 0.9 (0.83; 0.97)
							13 years: 1.2 (1.09; 1.32)
							Niacin, 10 years: 12.7 (12.08; 13.32)
							13 years: 14.7 (13.59; 15.82)
							Vit B6, 10 years: 1.1 (1.03; 1.17)
							13 years: 1.6 (1.49; 1.72)
							Folate, 10 years (μg/d): 197 (187.2; 206.9) 13 years: 242 (223.1; 260.9) Vit C, 10 years: 35 (29.29; 39.91) 13 years: 66 (58.28; 73.13)

Oldewage-Theron[75,76]	(1) 14–18 years: 98; (2): 9–13 years: 82; 14–18 years: 97	9–18	M, F	Rural	9–13 years: 7 172 (6 083; 8 599)	Fat, 9–13 years: 48 (31; 63)	Fe, 9–13 years: 6.4 (4.9; 8.0)
					14–18 years: 7 141 (5 700; 9 370)	14–18 years: 50 (15; 37)	14–18 years: 6.5 (4.9; 8.4)
						SFA, 9–13 years: 15 (11; 21)	Mg, 9–13 years: 207.0 (170.3; 245.7)
						14–18 years: 15 (9; 21)	14–18 years: 205.6 (167.8; 244.0)
						MUFA, 9–13 years: 16 (11; 22)	Zn, 9–13 years: 6.0 (5.0; 7.4)
						14–18 years: 16 (11; 22)	14–18 years: 6.4 (4.7; 7.6)
						PUFA, 9–13 years: 12 (7; 18)	Folate, 9–13 years (µg/d): 145.5 (104.9; 196.1)
						14–18 years: 12 (8; 21)	14–18 years: 143.3 (105·1; 212.7)
						TFA, 9–13 years: 1.7 (1.7; 2.6)	Vit C, 9–13 years: 23.8 (15.0; 34.0)
						14–18 years: 1.4 (0.6; 2.6)	14–18 years: 18.1 (13.1; 38.3)
						LLA, 9–13 years: 8.9 (5.2; 14.6)	
						14–18 years: 10.2 (5.5; 18.5)	
						LNA, 9–13y years: 0.3 (0.2; 0.5)	
						14–18 years: 0.2 (0.2; 0.4)	
Pedro[86]	193 (M), 195 (F)	11–15	M, F	Rural	M: 9 900 (5 065; 9 352)	Fat, M: 32 (28.4; 36.9)	Ca, M: 257.3 (253.4; 281.2)
					F: 6 670 (6 154; 7 229)	F: 37.8 (33.3; 42.8)	F: 283.0 (258.1; 310.38)
						Protein, M: 39 (35.2; 43.0)	
						F: 42 (38.2; 45.9)	
						Cholesterol, M: 25.2 (18.0; 35.1)	
						F: 43 (33.6; 54.9)	
						Fibre, M: 19 (17.1; 20.6)	
						F: 19 (17.6; 21.0)	

Abbreviations: %E: percentage of energy; Ca: calcium; CHO: carbohydrate; Fe: iron; K: potassium; LLA: linoleic acid; LNA: linolenic acid; Mg: magnesium; MUFA: monounsaturated fatty acids; Na: sodium; PUFA: polyunsaturated fatty acids; SFA: saturated fatty acids; TFA: trans fatty acids; Vit: vitamin; Zn: zinc.

Table 5: Results from quantitative studies describing food intakes, diet patterns and eating practices habits in South African adolescents

First author	Sample size	Age (years)	Sex (M/F)	Context (rural/ urban)	Data collection method	Main finding(s)
Faber[23]	50	10–11	M, F	Rural	Food production, preparation and preferences questionnaire	Adolescent diets comprised a limited number of food items; most commonly consumed items: stiff maize-meal porridge, bread and potatoes Fruit and vegetable consumption was low Crisps, sweets and chocolates were consumed regularly by > 70% of adolescents (often during school hours)
Temple[33]	476	14.5 ± 2.0	M, F	Urban	Eating habits questionnaire	77.8% of adolescents ate breakfast and 79.7% ate at school during the day Food was brought to school by 41–56% of adolescents; 69.3% bought food at the school shop ('tuck shop') 'Unhealthy' foods were brought to school twice as often as 'healthy' foods Of adolescents who purchased food at school, 70% purchased no 'healthy' items Only 47–61% of adolescents classified cola drinks, samosas (deep-fried pastry with spicy filling) and pies as less healthy options High socioeconomic status (SES) school students were twice as likely to bring food to school (64.7% vs. 31.0%, $p < 0.001$) and to score higher on the healthy vs. unhealthy food quiz ($p < 0.01$); however, they were no more likely to purchase healthier foods
Pedro[36]	143	9, 10, 13	M, F	Urban	Semi-quantitative food frequency questionnaire (FFQ)	10 most commonly consumed food items: rice, stiff maize-meal porridge, chicken, added sugar, sweets, tea, eggs, full-cream milk, carbonated beverages and oil Over the follow-up period, the number of recordings from the grain and cereal, the fruit and vegetable, and the milk and milk products groups decreased; recordings from the meat and meat substitutes (chicken, cheese and polony) and fats and oils groups increased No change in food item variety with age
Feeley[37]	320 (M); 335 (F) (black participants)	17	M, F	Urban	Fast-food intake and fast-food outlet visits questionnaire	Mean fast-food intake was 8.1 (4.6) items per week for males and 7.2 (4.7) items per week for females ($p = 0.01$) The most popular fast food item purchased was a 'kota' (quarter-loaf of white bread filled with chips, a slice of cheese and delicatessen meats and sauces) The 'kota' was the least expensive commercially available fast-food item; providing, on average, 51 g of fat (13 g saturated fat) and 5 970 kJ of energy (> half the estimated daily requirement at 17 years)
Letlape[40]	209 (M), 276 (F)	15–18	M, F	Urban	Diet, nutrition and physical exercise knowledge questionnaire	77% of students had inadequate knowledge on diet, nutrition and exercise (score < 50%); 23% showed satisfactory knowledge 18% of students prepared or cooked food for the family, with the majority (48%) having their food prepared by their mother; 26% of students reported participation in rigorous exercise and 16% in moderate exercise
Venter[41]	183	17–18	M, F	Urban	Dietary fat knowledge and intake questionnaire	46% of adolescents obtained average scores and 52% obtained below-average scores for dietary fat knowledge; 61% followed diets categorised as typically 'Western' with high fat content; main sources of fat were: margarine or butter, full-cream cheese or cheese spread and meat and

						meat products Interest in nutrition was positively associated with both dietary fat knowledge ($p < 0.05$) and intake ($p < 0.05$) Dietary fat knowledge was positively associated with fat intake ($p < 0.05$)
Abrahams[43]	717	10–12	M, F	Mixed	(a) Nutrition knowledge, attitude and behaviour (KAB) questionnaire; (b) unquantified 24-hour dietary recall	69% of learners carried a lunchbox to school 49% consumed at least one item purchased from the tuck shop/vendor Most lunchboxes contained: white bread, processed meat Most frequently purchased tuckshop/vendor item: chips/crisps Learners who carried lunchboxes: younger ($p < 0.001$), lower BMI percentiles ($p = 0.002$) and BMI-for-age ($p = 0.034$), higher standard of living ($p < 0.001$), dietary diversity scores ($p = 0.012$) and number of meals per day ($p < 0.001$) and attended predominantly urban schools ($p < 0.001$)
Feeley[46]	1451 (black/ mixed-ancestry participants)	13, 15, 17	M, F	Urban	Dietary habits and practices questionnaire (home, school, community environments)	Weekday breakfast consumption decreased from 76% to 65% over the 5-year follow-up ($p < 0.001$) Snacking while watching television increased with age (3.6 ± 4.6–6.7 ± 5.9 snacks/week) Female subjects consumed more snacks than males ($p < 0.01$) Confectionery consumption was consistent at 9 and 10 items/week for males and females respectively, but fast-food consumption increased by half a portion/week Use of a lunchbox decreased over the 5 years, while purchasing food from the tuck shop increased
Feeley[57]	645 (M); 653 (F) (black participants)	13, 15, 17	M, F	Urban	Dietary habits and practices questionnaire (home, school, community environments)	Irregular breakfast consumption increased from 13–17 years of age, with girls consistently skipping breakfast more often than boys ($p< 0.05$); 30–40% of adolescents consumed their main meal with their family infrequently across the 5 years Over two-thirds of adolescents consumed fast foods and sweetened beverages three or more times/week
Feeley[61]	720 (M); 731 (F)	17	M, F	Urban	Dietary habits and practices questionnaire (home, school, community environments)	Median fast-food intake was 11 (7; 16) items/week in boys and girls Females consumed more sweetened beverages (10 [6; 11] vs. 8 [5; 11]) and confectionery items (13 [9; 17] vs. 11 [8; 15]) per week than males Both sexes consumed seven (5; 10) salty snack items/week Purchased food items contributed to approximately three times the recommended daily intake of added sugar (males: 561.6 g/week vs. females: 485.3 g/week; $p = 0.02$) and more than half the recommended daily intake of salt (males: 4 803 mg/week vs. females: 4 761 mg/week; $p > 0.05$) in adolescents
Pisa[73]	388	11–15	M, F	Rural	Nutrient pattern analysis (FFQ; principle component analysis [PCA])	Four nutrient patterns were identified via PCA and explained 79% of the total variance in nutrient intakes: PC1 (26%) was characterised by animal derived nutrients; PC2 (21%) by vitamins, fibre and vegetable oil nutrients; PC3 (19%) by both animal- and plant-derived nutrients (mixed diet driven nutrients); and PC4 (13%) by starch and folate Female gender was positively and low SES negatively associated with the animal-derived nutrients pattern ($p \leq 0.05$) Mid-pubertal status was positively associated with the vitamins, fibre and vegetable oil nutrients pattern ($p \leq 0.05$) Physical activity and being in the lowest SES tertile were positively associated with the mixed diet driven pattern

(*Continued*)

Table 5: Continued.

First author	Sample size	Age (years)	Sex (M/F)	Context (rural/urban)	Data collection method	Main finding(s)
						($p \leq 0.05$) Physical activity was negatively associated with the starch and folate pattern ($p \leq 0.05$)
Tee[88]	113 (M), 131 (F)	17.5 ± 2.3	M, F	Urban, peri-urban	24-hour recall	19% of adolescents skipped breakfast in the morning Mean breakfast quality score was 3.1 (1.27) (possible range: 1–5) and mean diet quality score was 58.3 (9.85) (possible range: 1–100) No difference in diet quality for those who ate vs. those who skipped breakfast Breakfast quality score was significantly higher in active vs. inactive adolescents ($p =$ 0.007)
Oldewage-Theron[75,76]	9–13 years: 82; 14–18 years: 97	9–18	M, F	Rural	(a) nutrition knowledge questionnaire (NKQ); (b) 24-hour recall; (c) FFQ (food variety score [FVS; count of food items], food group diversity score [FGDS; variety score within every food group])	In the 9–13 years group, dietary intakes were deficient in energy, folate and vitamin C, while the 14–18 years group was deficient in energy and all anti-inflammatory nutrients (iron, folate, zinc, magnesium and vitamin C). In the 14–18 years group only: The overall NKQ scores were 75.4% for correct food group and 41.3% for correct food portion size identification Median FVS was low overall (< 30 food items per week); 22.1 and 22.2 in girls and boys respectively; 87.6% of girls and 89.8% of boys had low FVS (< 30 food per week items); 12.4% of girls and 10.2% of boys had medium FVS (30–60 food items per week) Higher nutrition knowledge scores were significantly associated with higher FVS ($p = 0.003$) Lower carbohydrate, total fat and added sugar and higher protein intakes were associated with a higher quartile of nutrition knowledge score
Manyanga[84]	167 (M), 256 (F)	9–11	M, F	Urban	Dietary pattern analysis (FFQ; PCA)	Odds of higher Unhealthy Dietary Pattern (UDP) scores were 2.77 (95% CI: 1.22; 6.28) times higher in the lowest vs. highest SES group
Sedibe[87]	Early adolescence (EA), rural (R): 105 (M), 98 (F); EA, urban (U): 760 (M), 805 (F); mid-adolescence (MA), R: 89 (M), 100 (F); MA, U: 747 (M), 786 (F)	EA: 11–12 (R), 13 (U); MA: 14–15 (R), 15 (U)	M, F	Urban, rural	Dietary habits and practices questionnaire (home, school, community environments)	Home environment: during EA and MA, significantly more rural females than males ate their main meal with the family 'almost every day' (EA: 51.0% vs. 33.3%; MA: 48.5% vs. 28.6%) Irregular breakfast consumption on weekdays was significantly higher in girls (EA: 29.3%; MA: 44.9%) than in boys (EA: 21.2%; MA: 27.5%) in the urban site Snack consumption while watching TV was significantly higher in urban vs. rural adolescents during EA (49.5% vs. 18.7%) Community environment: during MA, urban girls consumed significantly more fast-food items than boys (18 ± 9.9 vs. 17 ± 8.9, $p \leq 0.00$) School environment: during EA, urban girls vs. boys purchased significantly more tuck shop items (13 ± 7.9 vs. 12 ± 8.0; $p \leq 0.00$) During MA, lunchbox usage was more irregular among boys vs. girls (92.3% vs. 81.9%) in the urban site

week).[76] FVSs were highest for those with high scores on the nutrition knowledge questionnaire (NKQ).[76] Additionally, NKQ scores were inversely associated with carbohydrate, total fat and added sugar intakes and positively associated with protein intake.[76]

Associations between diet and lifestyle factors and adolescent adiposity (Table 6)

Thirteen studies met the inclusion criteria.[24,31,32,44,49,57,62,63,71,73,77,82,87] Exposure variables were largely questionnaire based and included assessment of demographics, SES and household food security,[44,71,77] dietary intake (FFQ),[31,73] dietary habits and eating practices,[57,87] physical activity and sedentary behaviour,[31] as well as body-image perceptions, satisfaction and dissatisfaction and eating attitudes.[24,31,32,62,63,82] Only one study used anthropometry (birth to two years of age) as the exposure.[49] Anthropometry was used to assess adolescent adiposity in all studies and measurements included weight, height and BMI. Additionally, two studies included DXA assessed fat mass.[49,57]

Underweight and severe stunting prevalence rates were significantly higher in urban boys vs. girls across adolescence (13–19 years of age). Overweight/obesity prevalence was significantly higher in girls from both rural and urban settings (11–19 years).[71,77,82,87] A 1 SD increase in birthweight was associated with 0.22 higher BMI z-score and 1 051 g higher fat-free mass at 10 years of age ($p \leq 0.01$).[49] Additionally, underweight at one year was associated with lower fat-free mass, and stunting at one and two years was associated with lower fat-free and fat mass at 10 years of age ($p \leq 0.01$). A 1 SD increase in weight-for-age z-score (WAZ) between birth and two years of age was associated with adolescent adiposity (BMI and fat mass; $p \leq 0.01$).[49]

Urban black girls had higher BMIs than both their white and mixed ancestry counterparts (black: 24.1 ± 3.3, mixed ancestry: 22.1 ± 3.7, white 21.9 ± 3.0 kg/m^2; $p < 0.05$) between 15 and 18 years of age.[24] White girls were significantly taller ($p < 0.001$), had higher hip circumferences ($p < 0.05$) and participated in more formal, but less informal, physical activity ($p < 0.05$), than black girls.[31] In black girls only, sedentary time was positively associated with energy intake ($p < 0.01$) but not with body size.[31] Animal-driven nutrient pattern adherence was positively associated with adolescent BMI z-score in 11–15-year-olds (0.13 per + 1 SD; $p = 0.02$) and longitudinal sweetened beverage consumption was positively associated with BMI z-score and fat mass in boys at 17 years ($p < 0.05$).[57,73] For urban and rural adolescents, higher odds of overweight and obesity was associated with consumption of fewer family-based meals (i.e. eating the main meal with the family on some days or almost all days) and irregular breakfast consumption on weekdays.[87]

Stunting prevalence (13–15 years) was lowest in adolescents with a high household SES (high SES: 18.1%; medium SES: 30.4%; low SES: 31.4%; tertiles based on occupation and highest education level of the household's 'breadwinner').[71] Rural dwelling was associated with lower odds of overweight and obesity; however, this was seen only during early adolescence (11–13 years) (OR: 0.55 [0.32, 0.92]; $p \leq 0.02$).[87] Odds of a high body fat percentage (%fat; > 85th percentile) at 17–19 years was higher in females who lived in neighbourhoods with a low social support index (OR: 1.59; 95% CI: 1.03, 2.44), as well as in males with higher household wealth index (OR: 0.28; 95% CI: 0.10, 0.78).[77]

There was an inverse association between body image dissatisfaction and BMI in girls ($p = 0.0001$); however, overweight girls had a higher tendency towards a disordered body image than their normal-weight counterparts.[24,63] Across rural and urban settings, BMI was lowest in those who desired to be larger and highest in those desiring to be thinner (13–18 years).[32] A higher overall 26-item Eating Attitudes Test (EAT-26) score in girls (representing a greater tendency towards developing an eating disorder) was positively associated with BMI (white girls: $p = 0.0001$; black girls: $p = 0.038$)[63] and a higher dieting subscore was positively associated with weight, BMI and hip circumference in black girls specifically ($p < 0.01$).[31] Underweight girls had significantly lower EAT-26 scores than the other BMI groups.[24] For white boys, self-esteem was positively associated and dieting was inversely associated with BMI ($p = 0.01$ and $p = 0.004$ respectively), while in black boys lower bulimic and oral control scores were associated with higher BMIs.[62]

Body image perceptions and eating attitudes (Table 7)

Twelve studies met the inclusion criteria.[22,24,26,31,32,55,58,62,63,69,70,82] Data collection was questionnaire based and focused on the following: eating attitudes (26-item Eating Attitudes Test; EAT-26),[22,24,26,31,58,62,63,69,82] self-esteem (Rosenberg self-esteem questionnaire),[58,62,63] body figure perceptions, preferences and ideals,[24,32,55,70] body image satisfaction (Stunkard's silhouettes) and dissatisfaction (Feel-Ideal Discrepancy (FID) scores),[62,63] weight-control behaviours[58,69] and perceptions of female body silhouettes.[58,62,63,82]

National data showed that 84.5% of adolescents (15–18 years) had distorted body images (i.e. they either under- or overestimated their current body size) and 45.3% were dissatisfied with their body size.[70] Overweight and obese adolescents tended to underestimate their body size and desired to be thinner, while normal and underweight adolescents overestimated their body size and desired to be fatter.[55,70]

Some 16.7% and 38.8% of urban white and black girls respectively had high body image dissatisfaction, with significantly more black vs. white girls being dissatisfied with their body image at 13 ($p = 0.04$), 15 ($p = 0.001$) and 17 ($p = 0.0001$) years.[63] In addition, significantly more black girls were at risk of developing an eating disorder (EAT-26 scores ≥ 20) than their white counterparts, with higher reported scores on the bulimia and/or oral control subscales.[22,26,63] In contrast, white girls idealised a smaller body size than their mixed-race or black counterparts.[24] Low self-esteem and a desire to be thinner was more common in white compared with black girls.[32,63]

For rural girls, the desire to be thinner was higher in early puberty (Tanner stage ≤ 2) compared with mid- to post-puberty (Tanner stage > 2) (61.4% vs. 55.9%), while the desire to be fatter was lower in early vs. mid- to post-puberty (18.6% vs. 29.7%).[82] The majority of males and females in both pubertal groups perceived the underweight silhouettes to be 'unhappy' and 'weak'. In addition, the majority of females (early and mid–post-puberty) perceived the normal silhouette to be the 'best'. There were no differences in the risk of developing an eating disorder by sex or age; 10.5% and 10.6% of boys and girls respectively had an EAT-26 score ≥ 20 in early puberty, while in mid-puberty 7.1% of boys and 8.0% of girls scored ≥ 20.

For boys at 13, 15 and 17 years of age, body image dissatisfaction and risk of a disordered eating attitude were higher in

Table 6: Results from quantitative studies of the associations between diet and lifestyle factors and adolescent adiposity in South Africa

					Exposure		Outcome		
First author	Sample size	Age (years)	Sex (M/ F)	Context (rural/ urban)	Variable	Mean (SD)/ median (range)	Variable	Mean (SD)/ median (range)	Main findings(s)
Caradas[24]	Black (B): 60; mixed ancestry (MA): 83; white (W): 85	15–18	F	Urban, peri-urban	Eating attitudes (26-item Eating Attitudes Test; EAT-26) Body shape questionnaire (BSQ)		Height (m) Weight (kg) BMI (kg/m^2) Underweight (%) Overweight (%) Obese (%)	B: 1.59 (0.06) MA: 1.58 (0.06) W:1.64 (0.07) B: 61.0 (10.2) MA: 55.6 (10.1) W: 59.4 (9.8) B: 24.1 (3.3) MA: 22.1 (3.7) W: 21.9 (3.0) B: 0.0 MA: 6.0 W: 7.1 B: 30.9 MA: 20.5 W: 11.8 B: 7.3 MA: 4.8 W: 1.2	BMI was significantly higher in B compared with MA and W girls ($p < 0.05$) Proportion of adolescents at risk of developing an eating disorder (EAT-26 score ≥ 20) increased with BMI: 9% in underweight, 18% in normal weight, 24% in overweight, 33% in obese subjects Proportion of adolescents with a disordered body image (BSQ score ≥ 129) increased with BMI: 9% in underweight, 24% in normal weight, 39% in overweight, 56% in obese subjects EAT-26 scores were significantly lower in underweight girls compared with all other BMI groups ($p <$ 0.05), while overweight girls scored higher than normal weight girls on the BSQ
Petersen[31]	Black (B): 148; white (W): 54	11	F	Urban	Energy (kJ/d) Fat (g/d)	B: 5 422 (2 242) W: 5 055 (1 784) B: 38 (22) W: 42 (20)	Height (m) Weight (kg)	B: 1.45 (0.1) W: 1.49 (0.1) B: 38.4 (8.2) W: 40.8 (9.2)	W girls were taller ($p < 0.001$) and had higher waist-to-hip ratios ($p < 0.05$) than B girls W girls participated in more formal and less informal physical activity than their B counterparts (p< 0.05) In black girls: EAT-26 dieting sub-score was positively associated with weight, BMI, hip circumference and sedentary time (hours/ week) (< 0.01); sedentary behaviour was positively associated with energy intake ($p <$ 0.01)
					Formal physical activity (hours/ week)	B: 4 (5) W: 7 (5)	BMI (kg/m^2)	B: 18.1 (3.0) W: 18.2 (2.8)	
					Informal physical activity (hours/week) Sedentary behaviour (hours/week) Eating attitudes (EAT-26)	B: 14 (11) W: 5 (7) B: 24 (11) W: 22 (9)	Waist-to-hip ratio	B: 0.77 (0.53) W: 0.8 (0.56)	
Szabo[32]	Urban black (UB): 578, urban white (UW): 775; rural black (RB): 361	13–18	F	Urban, rural	Body figure preference test (BFPT)		Height (m)	UB: 1.57 (0.1)	BMI was highest in RB girls and lowest in UW girls In all groups, those desiring to be larger had the lowest BMIs (UB: 19.0 (3.1); UW: 17.8 (2.7); RB: 21.5 (2.8)) and those desiring to be

									thinner had the highest BMIs (UB: 23.6 (5.6); UW: 21.3 (3.5); RB: 26.2 (4.0))
								UW: 1.63 (0.08)	
								RB: 1.57 (0.06)	
							Weight (kg)	UB: 53.9 (10.3)	
								UW: 54.7 (9.6)	
								RB: 59.2 (11.4)	
							BMI (kg/m^2)	UB: 21.9 (5.2)	
								UW: 20.5 (3.9)	
								RB: 23.8 (4.0)	
Kimani-Murage[44]	903 (M); 945 (F)	10–20	M, F	Rural	Adolescent factors: age, sex, pubertal staging Maternal factors: age, nationality, education, marital status, co-residence with the child Household factors: head of household age, sex, education and relationship with the child, household food security and socioeconomic status (SES)		Overweight/ obese (%)	10–14 years: 7.5 15–20 years: 11.6	Odds of overweight and obesity was 4.24 (2.82; 6.38) times higher in girls vs. boys ($p < 0.001$) and 1.99 (1.28; 3.09) times higher in the highest vs. lowest SES tertile ($p = 0.002$) Odds of overweight and obesity was 40% lower in adolescents who lived in a household where the head had not completed secondary level education ($p < 0.05$)
Kagura[49]	140	10	M, F	Urban	Birthweight (g)	M: 3213 (528) F: 3012 (450)	BMI z-score (WHO, 2007)	M: −0.09 (0.81) F: 0.10 (1.20)	Birthweight was associated with a 0.22 higher BMI z-score and 1 051 g higher fat-free mass at 10 years of age (per + 1SD; $p \leq 0.01$) Stunting at one and two years was associated with lower fat mass and fat-free mass respectively at 10 years of age ($p \leq 0.01$) Underweight at one year was associated with lower fat-free mass ($p \leq 0.01$) 1 SD increase in WAZ between birth and two years was associated with fat mass and BMI at 10 years of age ($p \leq 0.01$)
					Height-for-age z-score (HAZ; age 1 years)	M: −0.5 (1.2) F: 0.6 (1.1)	DXA fat mass (g)	M: 6853 (3666) F: 9324 (5151)	
					HAZ (age 2 years)	M: 0.8 (1.1)	DXA fat-free mass (g)	M: 21 352 (3 113)	
						F: 0.9 (1.2)		F: 20 728 (4 075)	
					Weight-for-age z-score (WAZ; age 1 years)	M: −0.4 (1.4)			
						F: −0.1 (1.3)			
					WAZ (age 2 years)	M: −0.8 (1.4)			
						F: −0.4 (1.3)			
Feeley[57]	607 (M), 616 (F) (black participants)	13, 15, 17	M, F	Urban	Dietary habits and eating practices (home, school and community environments)		BMI (kg/m^2)	17y, M: 20.4 (3.2) F: 22.9 (4.4)	Longitudinal sweetened beverage consumption was positively associated with

(*Continued*)

Table 6: Continued.

					Exposure		Outcome		
First author	**Sample size**	**Age (years)**	**Sex (M/F)**	**Context (rural/ urban)**	**Variable**	**Mean (SD)/ median (range)**	**Variable**	**Mean (SD)/ median (range)**	**Main findings(s)**
									BMI z-score and fat mass in males at 17 years of age ($p < 0.05$)
							DXA fat mass (kg)	17y, M: 7 700 (4 800) F: 18 500 (7 600)	
Gitau[63]	Black (B): 61 (13 years), 59 (15 years), 63 (17 years); White (W): 54 (13 years), 54 (15 years), 49 (17 years)	13, 15, 17	F	Urban	Body image satisfaction (Stunkard's silhouettes) and dissatisfaction (FID) scores) Rosenberg self-esteem questionnaire Eating attitudes (EAT-26) Perceptions of female body silhouettes (Stunkard Body Silhouette)		BMI (kg/m^2)	B, 13 years: 19.9 (3.2)	Body image dissatisfaction was inversely associated with BMI (B and W girls: $p = 0.0001$). EAT-26 score was positively associated with BMI (B girls: $p = 0.038$; W girls: $p = 0.0001$)
								15 years: 21.3 (4.8)	
								17 years: 23.1 (3.7)	
								W, 13 years: 21.9 (5.3)	
								15 years: 22.8 (3.7)	
								17 years: 23 (3.7)	
							Overweight/ obese (%)	B, 13 years: 14.8	
								15 years: 9.7	
								17 years: 16.1	
								W, 13 years: 15.7	
								15 years: 13.3	
								17 years: 11.6	
Gitau[62]	Black (B): 60 (13 years), 60 (15 years), 59 (17 years); White (W): 68 (13 years), 78 (15 years), 66 (17 years)	13, 15, 17	M	Urban	Body image satisfaction (Stunkard's silhouettes) and dissatisfaction (FID) scores) Rosenberg self-esteem questionnaire Eating attitudes (EAT-26) Perceptions of female body silhouettes (Stunkard Body Silhouette)		BMI (kg/m^2)	B, 13 years: 18.1 (1.9)	In W boys: self-esteem was positively ($p = 0.01$) and dieting behaviour inversely ($p = 0.004$) associated with BMI In B boys: lower EAT-26 bulimic and oral control scores were associated with higher BMI
								15 years: 19.0 (1.9)	
								17 years: 20.1 (2.8)	
								W, 13 years: 20.9 (3.3)	
								15 years: 21.6 (2.8)	
								17 years: 23.4 (2.9)	
							Underweight (%)	B: 44.1	

							W: 9.9	
						Normal weight (%)	B: 44.7	
							W: 61.3	
						Overweight/ obese (%)	B: 11.2	
							W: 28.8	
Pisa[73]	388	11–15	M, F	Rural	Four nutrient patterns derived via principal component analysis: - Animal driven nutrients: high loadings for animal protein, saturated fat, cholesterol, riboflavin, vitamin B12, retinol, vitamin D, zinc - Vitamins, fibre and vegetable oil nutrients: high loadings for vitamin C, beta-carotene, vitamin E, dietary fibre, polyunsaturated fatty acids, sugars - Mixed diet driven nutrients: high loadings for animal and plant derived nutrients - Starch and folate driven pattern	BMI z-score (WHO, 2007)		1SD increase in the animal driven nutrient pattern score was associated with 0.13 (0.02; 0.24) higher BMI z-score ($p = 0.02$) 1 SD increase in the starch and folate driven pattern was associated with 0.10 (−0.01; 0.21) higher BMI z-score ($p = 0.05$) No associations between the vitamins, fibre and vegetable oil nutrients pattern or the mixed diet driven pattern and BMI in adolescents
Pradeilles[77]	974 (M), 1 045 (F)	17–19	M, F	Urban	Sex, household wealth index, caregiver education, neighbourhood socioeconomic position (SEP) tertile	Underweight (%)	M: 22.2	Overweight/obesity was significantly higher in females vs. males (26.2% vs. 8.2%; $p < 0.0001$) and underweight was significantly higher in males vs. females (22.2% vs. 10.6%; $p < 0.0001$) Odds of high %fat was 1.59 (95% CI: 1.03, 2.44) times higher for females living in neighbourhoods with a low social support index, while odds of overweight and high % fat were lower in men with a lower household wealth index (OR: 0.31 (95% CI: 0.12, 0.76); and OR: 0.28 (95% CI: 0.10, 0.78) respectively) A low household wealth index was associated with a lower odds of underweight in females (OR: 0.49 [0.25, 0.96])
							F: 10.6	
						Normal weight (%)	M: 69.6	
							F: 63.2	
						Overweight (%)	M: 6.1	
							F: 17.9	
						Obese (%)	M: 2.2	
							F: 8.3	
						Low %fat (DXA; ≤ 15th percentile)	M: 59.8 F: 14	

(*Continued*)

Table 6: Continued.

					Exposure		Outcome		
First author	Sample size	Age (years)	Sex (M/F)	Context (rural/ urban)	Variable	Mean (SD)/ median (range)	Variable	Mean (SD)/ median (range)	Main findings(s)
							High %fat (DXA; > 85th percentile)	M: 5.2 F: 24	
Meko[71]	174 (M); 240 (F)	13–15	M, F	Urban	Socio-demographic factors: sex and main household contributors' occupation and highest education level (classified as: low/ middle/high SES)		Underweight (%)	M: 27.6 F: 12.5	Boys vs. girls had significantly higher underweight (23.0% vs. 10.0%; $p = 0.0003$) and severe stunting (10.3% vs. 4.2%; $p = 0.01$) prevalence rates Girls had significantly higher overweight/obese prevalence vs. boys (7.5% vs. 4.0%; $p = 0.0002$) Stunting was significantly higher in low (31.4%) and medium (30.4%) SES groups than those with high SES (18.1%)
							Normal weight (%)	M: 59.2 F: 58.8	
							Overweight/ obese (%)	M: 13.2 F: 28.8	
							Severely stunted (%)	M: 10.3 F: 4.2	
							Stunted (%)	M: 33.9 F: 34.6	
Pedro[82]	Early puberty (EP): 99 (M), 73 (F); mid- to post-puberty (MP): 91 (M); 122 (F)	11–15	M, F	Rural	Body image satisfaction (Stunkard's silhouettes) and dissatisfaction (Feel-Ideal Discrepancy [FID] scores) (females) Eating attitudes (26-item Eating Attitudes Test; EAT-26) (females and males) Perceptions of female body silhouettes (Stunkard Body Silhouette) (females and males)		BMI (kg/m^2)	EP, M: 17.0 (2.0)	The prevalence of overweight and obesity was higher in girls than in boys ($p = 0.001$) BMI was significantly higher in girls who desired to be fatter than those who wanted to be thinner ($p < 0.001$)
								EP, F: 17.5 (3.3)	
								MP, M: 19.0 (2.6)	
								MP, F: 21.2 (4.0)	
							Overweight/ obese (%)	EP, M: 2.0	
								EP, F: 11.1	
								MP, M: 3.3	
								MP, F: 19.7	
Sedibe[87]	Early adolescence (EA), rural (R): 105 (M), 98 (F); EA, urban (U): 760 (M), 805 (F); mid-	EA: 11–12 (R), 13 (U); MA: 14–15 (R), 15 (U)	M, F	Urban, rural	Dietary habits and eating practices (home, school and community environments) in		Overweight (%)	EA (R), M: 3.8	In fully adjusted models (adjusted for: gender, site, dietary habits, and eating practices within the home, community and school environment) the following were

	adolescence (MA), R: 89 (M), 100 (F); MA, U: 747 (M), 786 (F)	male vs. female and urban vs. rural adolescents			associated with increased odds of overweight/obesity: (1) eating the main meal with family some days (OR: 1.78 (95% CI: 1.11, 2.84); $p \leq 0.02$); (2) eating the main meal with family almost every day (OR: 1.61 (95% CI: 1.11, 2.34); $p \leq 0.01$); (3) irregular frequency of consuming breakfast on weekdays (OR: 1.38 (95% CI: 1.01, 1.90); $p <$ 0.05) In MA irregular frequency of breakfast consumption on weekends (home environment) was associated with higher odds of overweight/obesity (OR: 1.53 (1.10, 2.13); $p \leq 0.01$) In EA and MA boys had lower odds of overweight/obesity vs. girls (EA, OR: 0.40 (0.30, 0.54); $p \leq 0.00$; MA, OR: 0.29 (0.22, 0.40); $p \leq 0.00$) Rural residence was associated with lower odds of overweight/obesity in EA (OR: 0.55 (0.32, 0.92); $p \leq 0.02$)
				F: 11.2	
				EA (U), M: 6.1	
				F: 15.0	
				MA (R), M: 1.1	
				F: 16.5	
				MA (U), M: 5.5	
				F: 17.0	
			Obese (%)	EA (R), M: 5.7	
				F: 6.1	
				EA (U), M: 21.8	
				F: 21.1	
				MA (R), M: 4.4	
				F: 5.8	
				MA (U), M: 7.3	
				F: 11.5	

Table 7: Results from quantitative studies describing body image perceptions and attitudes in South African adolescents

First author	Sample size	Age (years)	Sex (M/F)	Context (rural/ urban)	Data collection method	Main finding(s)
Szabo[22]	Black (B): 24; white (W): 179	14.8 ± 1.4	F	Urban	Eating attitudes (26-item Eating Attitudes Test; EAT-26)	Mean EAT-26 score was higher for B vs. W girls (16.16 vs. 11.50; $p = 0.05$) 37.5% of B and 20.7% of W girls were at risk of developing an eating disorder (i.e. EAT-26 scores ≥ 20)
Caradas[24]	Black (B): 60;	15–18	F	Urban, peri-urban	Eating attitudes (EAT-26)	No ethnic differences in EAT-26 score: 17.9% of B, 17.1% of MA and 21.2% of W girls had scores ≥ 20
	mixed ancestry (MA): 83; white (W): 85				Body shape questionnaire (BSQ)	Mean BSQ score was significantly higher in W compared with B and MA girls ($p < 0.01$); 19.6% of B, 25.9% of MA and 32.9% of W girls having scores that indicated abnormal body shape concerns (score ≥ 129)
					Body image perception (body silhouette chart)	Ideal body size was significantly smaller for W compared with MA and B girls Significantly more W girls were dissatisfied with their present body size ($p < 0.001$)
Szabo[26]	Black (B): 578; white (W): 506	Not specified (secondary school pupils)	F	Urban	Eating attitudes (EAT-26)	18.7% and 18.6% of B and W participants respectively had EAT-26 score ≥ 20 No significant difference in total EAT-26 score or the dieting subscale between groups B adolescent girls scored significantly higher on the bulimia subscale ($p = 0.03$) and the oral control subscale ($p = 0.001$)
Petersen[31]	Black (B): 148; white (W): 54	11	F	Urban	Eating attitudes (EAT-26)	No ethnic differences in total EAT-26 scores: 1% had scored ≥ 20 B girls had significantly lower oral control sub-scores and significantly higher dieting sub-scores than W girls ($p < 0.05$)
Szabo[32]	Urban black (UB): 578, urban white (UW): 775; rural black (RB): 361	13–18	F	Urban, rural	Body figure preference test (BFPT)	UB girls: 19.0% desired to be fatter; 61.6% desired to be thinner; UW girls: 8.7% desired to be fatter, 72.7% desired to be thinner; RB girls: 29.0% desired to be fatter; 40.0% desired to be thinner The drive to be thinner was highest in UW girls and lowest in RB girls ($p < 0.05$)
Puoane[55]	265	10–19	F	Urban	Body image perception and ideals questionnaire	Both being thin and being fat were preferences for bodyweight; 43% of the overweight sample perceived themselves as being smaller than they were (< 21.7 kg/m^2)
Gitau[63]	Black (B): 61 (13 years), 59 (15 years), 63 (17 years); white (W): 54 (13 years), 54 (15 years), 49 (17 years)	13, 15, 17	F	Urban	Body image satisfaction (Stunkard's silhouettes) and dissatisfaction (Feel-Ideal Discrepancy [FID] scores) Rosenberg	Overall, 16.7% of W and 38.8% of B girls had high body image dissatisfaction Significantly more B girls were dissatisfied with their body image than W girls at 13 ($p = 0.04$), 15 ($p = 0.001$) and 17 ($p = 0.0001$) years of age
					self-esteem questionnaire	Significantly more W vs. B girls had low self-esteem (48.7% vs 26.7%; $p = 0.001$)
					Eating attitudes (EAT-26)	Significantly more B vs. W girls demonstrated EAT-26 scores ≥ 20 (31.2% vs. 19.7%; $p < 0.05$) No change in risk of disordered eating attitudes with age For EAT-26 sub-components, oral control sub-score was significantly higher in B vs. W girls ($p = 0.009$)
					Perceptions of female body silhouettes (Stunkard's silhouettes)	Significantly more B vs. W girls chose a higher BMI silhouette to be the 'best' and to have 'more respect' ($o < 0.05$) More W vs. B girls viewed a higher BMI silhouette to be 'clumsier' ($p < 0.05$) For B girls: 38.8% desired to be thinner and 29.0% desired to be fatter For W girls: 65.4% desired to be thinner and 10% desired to be fatter

Gitau[62]	Black (B): 60 (13 years), 60 (15 years), 59 (17 years); white (W): 68 (13 years), 78 (15 years), 66 (17 years)	13, 15, 17	M	Urban	Body image satisfaction (Stunkard's silhouettes) and dissatisfaction (FID) scores	No difference in body satisfaction between racial groups (below average: 33.5% [W], 37.4% [B]; above average: 29.2% [W], 33.5% [B])
						37.5% and 38.4% of 13 and 15-year-old boys respectively had below average body satisfaction scores;
						37.7% of 17-year-old boys had above average body satisfaction scores
						Body dissatisfaction was higher in B vs. W boys (37.4% vs. 33.5%)
					Rosenberg	
					self-esteem questionnaire	Mean self-esteem score was significantly higher in W vs. B boys (33.2 vs. 30.5; $p < 0.001$). Prevalence of low self-esteem was higher in B compared with W boys (46.4% vs. 21.4%; $p < 0.001$)
						Proportion of low self-esteem scores was highest in the youngest age group (13 years: 43%; 15 years: 35%; 17 years: 23%)
					Eating attitudes (EAT-26)	Median Eat-26 score (total group) was 9 (IQR: 4; 18)
						Significantly more B vs. W boys had EAT-26 scores ≥ 20) (40.3% vs. 5.2%; $p < 0.001$)
						B boys also had significantly higher scores across all EAT-26 subcomponents compared with W boys: dieting ($p = 0.0001$); bulimia and food preoccupation ($p = 0.0001$); oral control ($p = 0.0001$)
						In W boys, EAT-26 scores were inversely associated with body image dissatisfaction ($p = 0.025$)
					Perceptions of female body silhouettes (Stunkard's silhouettes)	Significant racial differences in perceptions of female silhouettes:
						The overweight silhouette was perceived as the 'best' (67.1%) and the 'happiest' (44.7%) for B boys, while W boys chose the normal weight silhouette ('best': 86.2%; 'happiest': 74.5%)
						'Strength' was associated with the obese and overweight silhouettes in B and W boys respectively
						The obese silhouette was perceived as 'clumsy' in both groups
						In B boys: underweight silhouettes were perceived to demand 'less respect' from others
Gitau[58]	13 years, black (B): 666 (M), 742 (F); mixed ancestry (MA): 81 (M), 91 (F)	13, 17	M, F	Urban	Rosenberg self-esteem questionnaire	Prevalence of low body esteem increased in MA boys ($p = 0.002$) and girls ($p = 0.001$) between 13 and 17 years
	17 years, B: 781 (M), 826 (F); MA: 100 (M), 113 (F)				Eating attitudes (EAT-26)	11% and 13.1% of 13- and 17-year-olds respectively were at risk of developing an eating disorder; there were no differences by age or sex
					Weight-control behaviours questionnaire	37% of boys and 39.5% of girls engaged in unhealthy weight control behaviours at 13 years
						Prevalence of weight loss practices increased between 13 and 17 years in B girls ($p = 0.018$) and healthy weight-control behaviours increased in B boys ($p = 0.001$) In MA boys healthy weight-control behaviours decreased by 13% by 17 years of age ($p = 0.045$)

(*Continued*)

Table 7: Continued.

First author	Sample size	Age (years)	Sex (M/F)	Context (rural/urban)	Data collection method	Main finding(s)
					Perceptions of female body silhouettes (Stunkard's silhouettes)	At 17 years, the normal weight silhouette was perceived as the 'best', as 'getting respect' and as the 'happiest' for boys and girls
						The obese silhouette was associated with being the 'worst' and 'unhappiest'
						The underweight silhouette was perceived as the 'weakest'
Visser[69]	220 (white participants)	15.7 ± 1.2	F	Urban	Eating attitudes (EAT-26)	20% of girls had EAT-26 scores ≥ 20
					Weight loss behaviour questions	33% of girls considered themselves to be overweight;
					(extracted from the USA Youth Risk Behavior Survey)	64% of girls were trying to lose weight; 19% of girls had engaged in one or more extreme method(s) of weight loss in the previous 12 months
Mchiza[70]	764	15–18	M, F	Mixed	Body image perception and ideals and weight-related behaviours questionnaire	84.5% of adolescents had a distorted body image and 45.3% were dissatisfied with their body size Overweight and obese adolescents underestimated their body size and desired to be thinner; normal and underweight adolescents overestimated their body size and desired to be fatter; 12.1% attempted to lose and 10.1% attempted to gain weight, largely via adjusting their diet and physical activity behaviours
Pedro[82]	Early puberty (EP): 99 (M), 73 (F); mid- to post-puberty (MP): 91 (M); 122 (F)	11–15	M, F	Rural	Body image satisfaction (Stunkard's silhouettes) and dissatisfaction (FID) scores) (F only)	In EP: 61.4% desired to be thinner and 18.6% desired to be fatter In MP: 55.9% desired to be thinner and 29.7 % desired to be fatter
					Eating attitudes (EAT-26) (M, F)	There were no differences in EAT-26 scores by sex or pubertal stage; 10.5% vs. 10.6% of boys and girls were at risk of a future eating disorder (EAT-26 score ≥ 20) in EP; in MP 7.1% of boys and 8.0% of girls were at risk For EAT-26 sub-components, oral control was significantly higher in EP girls than boys (4.7 vs.3.4, $p = 0.024$)
					Perceptions of female body silhouettes (Stunkard's silhouettes) (M, F)	The majority of males and females in both pubertal groups perceived the underweight silhouettes to be 'unhappy'([M, EP: 91.5%, MP: 90.0%]; [F, EP: 84.0%, MP: 85.5%]) and 'weak'([M, EP: 83.2%, MP: 90.0%]; [F, EP: 79.4%, MP: 87.2%]) The majority of EP and MP females (50% vs. 60% respectively) perceived the normal silhouettes to be the 'best'

Table 8: Results from qualitative studies describing adolescents: perceptions of, and attitudes towards, dietary and lifestyle behaviours in South Africa

First author	Sample size	Age (years)	Sex	Context (rural/ urban)	Data collection method	Main finding(s)
Voorend; Sedibe[51,52]	58 (29 pairs)	18 ± 1.1	F	Urban	Semi-structured 'duo-interviews'	Breakfast consumption in the home was not prioritised: replaced by locally prepared convenience foods (deep-fried dough balls, i.e. 'fat cakes' from vendors)
						Lunchboxes not commonly used; girls preferred to purchase food from the school 'tuck shop'
						Most popular lunch choices: 'kotas', 'fat cakes', snacks due to affordability, convenience, peer influence, popularity
						Foods were commonly shared and money pooled together by friends to make joint purchases at school and at the shopping mall; some friends carefully planned expenditures together
						Preference shaped joint choices at the shopping mall
						Engagement in active recreational activities was minimal
						Barriers to activity: lack of facilities, safety concerns
Sedibe[68]	22 (11 pairs)	16–19	F	Rural	Semi-structured 'duo-interviews'	Majority of girls described locally grown, traditional foods—mainly fruits/vegetables—as healthy
						The importance of eating breakfast was noted
						Facilitators of healthy eating: female caregivers, school meal programmes
						Barriers to healthy eating: limited household food availability, accessibility to healthy foods; leading to consumption of 'convenient and less healthy foods'
						Physical activity was viewed as beneficial to health: various home, school and community activities engaged in including household chores, walking to school, traditional dancing and extramural activities (e.g. netball, soccer)
Tshililo[83]	30	13–19	F	Not specified	In-depth interviews	Majority of girls were dissatisfied with their body image; desired to be thinner
						Girls were influenced by a variety of factors to control their weight: individual (body image dissatisfaction), family (parental criticism), environmental (peer group endorsement of dieting) factors

black vs. white adolescents (dissatisfaction: 37.4% [black] vs. 33.5% [white]; EAT-26 scores ≥ 20: 40.3% [black] vs. 5.2% [white]; $p < 0.001$).[62] The prevalence of low self-esteem was higher in black boys (46.4% [black] vs. 21.4% [white]; $p < 0.001$), as well as at younger ages (13 years: 43%; 15 years: 35%; 17 years: 23%). The prevalence of low body esteem in mixed-ancestry adolescents increased from 0% at 13 years to 11% and 12.3% in boys and girls respectively by the age of 17.[58]

Significantly more urban black vs. white adolescents (13, 15 and 17 years) perceived higher BMIs to be the 'best', the 'happiest' and to have 'more respect'.[62,63] However, in the BTT cohort at 17 years of age, both black and mixed-ancestry adolescents assigned these attributes to a normal weight silhouette.[58] Black and mixed-ancestry adolescents perceived the obese silhouette to be the 'worst' and to be 'unhappy' at 17 years of age.[58] However in 13-, 15- and 17-year-old black and white boys, this silhouette also symbolised 'strength'.[62] The underweight silhouette was perceived as the 'weakest' by black boys and girls and as getting the 'least respect' by black boys only.[58,62]

Qualitative research: perceptions of, and attitudes towards, dietary and lifestyle behaviours (Table 8)

Four qualitative studies met the inclusion criteria, all of which were conducted in girls.[51,52,68,83] Data were collected using semi-structured 'duo-interviews' (friend pairs) in three studies[51,52,68] and individual in-depth interviews in one study.[83]

Breakfast consumption in the home was not prioritised and lunchboxes were not commonly used by urban girls.[52] Instead, girls preferred to purchase locally prepared convenience foods—commonly 'kotas', 'fat cakes' (deep-fried dough balls) and other snack foods—from vendors and the school tuck shop.[52] Food choices were driven by affordability, convenience and peer influence, as well as popularity of the food items.[51]

In rural girls the importance of eating breakfast was acknowledged and locally grown, traditional foods—mainly fruits and vegetables—were perceived to be healthy.[68] Female caregivers and school meal programmes were viewed as facilitators to eating healthy diets.[68] Limited household food availability and accessibility to healthy foods acted as barriers to regular breakfast consumption, as well as drivers of 'convenient and less healthy food' consumption.

Active recreational activity was minimal in urban girls, largely due to a lack of facilities and safety concerns.[52] Physical activity was more common in rural girls, with various activities—including household chores, walking to school, traditional dancing and extramural activities (e.g. netball, soccer)—reported.[68] Many rural girls believed that engaging in these activities was beneficial to their health.

For girls in Limpopo, body dissatisfaction was common, with many desiring to be thinner than they were.[83] A variety of factors influenced girls to control their weight, including individual-level body-image dissatisfaction, parental criticism of body size and endorsement of dieting behaviour by peer groups.

Discussion

Using a systematic approach, this review aimed to report on the available data on nutritional status and dietary intake and practices, as well as their determinants, in South African adolescents (10–20 years).

Adolescent nutritional status

Anthropometry and body composition

Using BMI, national data showed an overall increase in overweight and obesity prevalence in South African adolescents over time (2002–2008), with approximately 14% of boys and 36.5% of girls between 13 and 18 years of age being overweight or obese in 2008.[38,39] However, this is coupled with persistently high stunting prevalence, affecting as many as a third of 13–15-year-old boys and girls in the urban Free State.[71] Dual burdens of under- and overnutrition are widely documented in LMICs and have been linked to rapid urbanisation and a transition towards diets high in saturated fat, sugar, salt and processed foods and low in essential micronutrients, as well as decreased levels of physical activity.[4,15,16] In South Africa the coexistence of unyielding chronic undernutrition and increasingly prevalent obesity is well established and documented across the life course even at individual household levels, making tackling malnutrition in this context highly complex.[45,98]

Sex differences in under- and overnutrition were evident across studies, with the majority showing higher overweight and obesity prevalence—as well as central adiposity (waist circumference), sum of skinfolds and %fat—in girls and higher stunting prevalence in boys. While the differences between girls and boys were shown across age categories, they became more pronounced as adolescents aged, with girls experiencing substantial increases in adiposity from mid- to late adolescence. The disproportionate burden of obesity in adult females is well documented in South Africa—as well as across most LMICs.[18,99] These data suggest that adolescence may be a critical period of divergence in risk profiles between sexes, triggering high levels of fat deposition in girls from around the onset of puberty.

Across South Africa, urban adolescents tended to exhibit higher overweight and obesity prevalence than those from rural settings. Such urban–rural differences have been identified across LMICs and are supported by diet and activity changes, which result as food environments and access, infrastructure, occupation and transport become increasingly urbanised.[99] However, as the degree of urbanisation becomes more extensive and rural communities are increasingly exposed to obesogenic environments and behaviours, this gap in nutritional profiles is rapidly reduced, with one study documenting higher mean BMI in rural compared with urban black girls from Gauteng province.[32] Studies from other LMICs have suggested that, in such cases, the rate of increase in overweight and obesity may be even higher in some rural compared with urban communities.[99]

Biochemical markers

Only one article was retrieved that described nutritional status using any biochemical marker, highlighting the scarcity of data on adolescent micronutrient status in South Africa. Although this study showed low levels of vitamin D deficiency in both white and black urban adolescents—and adequate vitamin D status has been linked to a range of positive adolescent health outcomes—the levels required for optimal health are widely debated.[48,100] In addition, status of any single micronutrient in isolation is not reflective of highly interactive multi-nutrient profiles or dietary micronutrient adequacy, particularly for vitamin D, since diet is not typically the primary source.[73,100] This phenomenon is common across African populations, with available data being largely limited to single micronutrients or deficiencies and their associations with particular outcomes of interest in isolated target groups.[101] While such studies are useful, they do not take into account the complex nature of micronutrient deficiencies, which tend to occur in combination, particularly in populations of low socioeconomic status with low dietary diversity. More evidence is needed to understand the profiles of multi-micronutrient status and deficiencies in adolescents, as well as the diet and lifestyle determinants and health consequences of these in both the short and longer term.

Reported dietary intake and eating habits

Overall, in both rural and urban settings, energy intakes between 10 and 15 years either met or fell below the ER.[97] In rural adolescents, there was no change in energy intake between younger (9–13 years) and older (14–18 years) age groups.[75] This was surprising given the increase in adiposity during the later adolescent period, particularly in girls. However, these data were collected in a single rural population where food insecurity is common and almost 90% of adolescents consume diets of low food variety (i.e. < 30 food items per week).[76] This suggests that the monotonous diets of low dietary diversity, typically associated with poverty, persist in more isolated rural South African settings and intakes may not be comparable to those of the increasingly urbanised communities.[102] This is supported by the dietary habits demonstrated in rural adolescents who maintained more traditional eating behaviours than their urban counterparts, being more likely to partake in family meals and to consume fewer fast-food and snack-food items.[87] In addition, during qualitative interviews, rural girls reported household food availability to be a key driver of healthy eating behaviours such as regular breakfast consumption.[68]

In urban adolescents, energy intake increased with age, predominantly driven by increased intakes of carbohydrate, fat and sugar.[35] This was reflected in the types of food consumed, with lower fruit, vegetable and dairy intakes and higher processed meat, oil, fast-food and sugar-sweetened beverage intakes reported at older ages. In addition to changes in patterns of food consumption, older adolescents were less likely to eat breakfast and carry a lunchbox to school and were more likely to purchase food at school and to snack while watching TV. Such dietary behaviours were associated with lower dietary diversity and meal frequency and higher adiposity, as well as increased consumption of convenience food products.[43] These purchased items contributed substantially to the total added sugar and salt intakes of adolescents.[61] This is supported by studies in both high-income and LMIC settings, which demonstrates the adoption of obesogenic behaviours as adolescents age and gain independence.[10,12,103]

Poor dietary habits were reflected in the micronutrient intakes of adolescents, which were low across studies in both rural and urban settings. Whether using RDAs or dietary reference intakes (DRI; Institute of Medicine and National Research Council[104,105]), the majority of adolescents did not meet the recommendations for most micronutrients, including iron, zinc, calcium, vitamin A and folate,[23,35,75,76] with one study showing an increase in the proportion not meeting recommendations as adolescents aged.[35] It must be noted that the studies by Faber *et al*. and MacKeown *et al*. were conducted prior to the introduction of micronutrient fortification in 2003 and therefore whether improvements in intakes have occurred is not clear.[23,35] However, the persistently low micronutrient intakes documented in later studies suggest that potential benefits of food fortification may be insufficient to allow for substantial changes in the proportion of adolescents meeting recommendations.[75,76] In addition, poor micronutrient intakes are documented across South African populations and have been, in part, linked to food insecurity and low accessibility to more expensive high- protein and micronutrient-rich foods.[106] This is supported by Manyanga *et al*., who showed higher odds of an unhealthy dietary pattern in adolescents from the lowest SES group.[84] In addition, those with low SES demonstrated lower knowledge around healthy foods, with higher knowledge being associated with increased food variety, as well as lower carbohydrate, fat and added sugar and higher protein intakes. However, South African adolescents demonstrated poor knowledge of unhealthy foods overall, being unable to classify high fat and sugar products such as pies, samosas and sugar-sweetened beverages as unhealthy items. Sugar-sweetened beverage consumption has been identified as one of the key drivers of obesity and was positively associated with adiposity in urban South Africa boys at 17 years. This suggests that interventions aimed at improving education around diet and health may be beneficial in shaping healthier food choices and improving dietary diversity in adolescents. However, this would require multi-sector involvement in prioritising nutrition and health within the education system—potentially at school level—as well as ensuring adequate access to healthy food at home, school and community levels. In addition, encouraging healthy-eating behaviours—such as eating breakfast, carrying lunch to school and eating meals as a family—may be beneficial in improving dietary intake and nutritional status in adolescents and their families.

Although the findings of this review support urbanisation-associated changes in the diets of South African adolescents, which become more pronounced with age, data fail to explain the substantial increases in adolescent adiposity, particularly in girls. While some differences in eating behaviour were identified between boys and girls—with girls consuming more snack and confectionery items than boys—energy, macro- and micronutrient intakes were largely similar. Understanding the interplay between diet and physical activity in adolescents as they age may therefore be an important component in explaining these differences. While studies exploring activity and sedentary behaviour patterns in South African adolescents are limited, available data suggest low activity levels in girls, particularly in urban settings and at older ages.[107,108] This is supported by data from high-income countries (HICs), which show that older, female adolescents demonstrate clusters of behaviour defined by low levels of physical activity.[12] In addition, data suggest differences in the types of sedentary behaviour adopted by girls and boys, as well as high clustering of unhealthy activity and dietary behaviours.[12] These may be important factors in targeting future interventions. Future studies should therefore investigate the clustering of diet, physical activity and sedentary behaviour in South African boys and girls, as well as what may be driving distinct clusters of both healthy and unhealthy behaviour between sexes.

Body-image perceptions and eating attitudes

This review found that, in general, white girls desire to be thinner more commonly than their black or mixed-ancestry counterparts and tend to prefer a smaller body size, with rural black girls having the lowest desire to be thinner. This is supported by the fact that black adolescents believed higher BMIs to be the 'best', the 'happiest' and to receive the 'most respect', while underweight silhouettes were perceived as the 'weakest'. Similar findings have been documented between black and white girls in HICs, with black girls desiring to be thinner at comparatively higher BMIs.[109,110] Ethnic differences around desirable body size are maintained in adulthood and have been associated with cultural ideals, as well as stigmatisation of thinness in African settings.[111,112]

However, despite a preference towards a higher body size, black South African adolescents had more disordered eating attitudes than their white counterparts, with higher scores for oral control documented across studies. A previous study comparing urban and rural black South Africa women suggested that the EAT-26 may have poor applicability to rural settings, due to misinterpretation of the questionnaire in a food-insecure context.[113] This may similarly explain the differences exhibited between black and white adolescents in our review, with disordered eating attitudes reflecting restrictive eating behaviours due to limited food resources, rather than as methods of weight control.

Although cultural perceptions around ideal body size persist in South Africa, there is evidence of a shift in these social norms, with the majority of adolescents perceiving a normal-weight female silhouette to be the 'best'. In addition, older urban adolescents perceived an obese silhouette as the 'worst' and as 'unhappy'.[58] Such changes in desirability have been largely linked to urbanisation and increased exposure to, and adoption of, Western ideals.[114] This suggests a possible avenue for intervention in South African adolescents who already exhibit desire towards normal bodyweights—alongside potential declines in the influence of traditional barriers to change.[113] However, caution must be taken in promoting a healthy bodyweight while preventing development of more disordered attitudes to eating and weight loss during the vulnerable adolescent period. Research suggests that promotion of physical activity may be a critical component in such interventions, with exercise being associated with improved body-image perceptions, alongside the beneficial effects on adiposity.[113,115]

Taking into account the perceptions towards activity, as well as the facilitators and barriers, is important,; particularly between rural and urban contexts. Qualitative studies identified in this review showed that, while adolescent girls were aware of the health benefits associated with being active, physical activity was more common in those from rural settings. In urban settings, limited availability of facilities and concerns around safety were reported as key barriers to active recreation. Multisectoral approaches that address individual, household, school and community level factors and both encourage, and allow, adolescents to safely partake in physical activity are therefore needed.

Community engagement for intervention development

As previously mentioned, research that explores current diet and activity patterns in South African adolescents, as well as the drivers of these, is critical in developing interventions to promote healthy growth in boys and girls. However, development of targeted and effective interventions will only be successful if adolescents themselves are involved in this process. Studies show that involving teenagers in intervention design has a significant impact on its outcomes, facilitating ownership of, and accountability to, the intervention itself.[116] In addition, community engagement facilitates mutual benefit to both the researchers and the community members themselves, helping to identify those interventions for which the priorities of various community members—i.e. adolescents, parents and teachers—overlap.[116,117]

Limitations

This review provides a comprehensive overview of available literature describing adolescent nutritional status in South Africa, with the inclusion of both quantitative and qualitative data adding a multifaceted understanding to potential determinants. While review findings have, to an extent, been supported by literature from other settings, the strength of and comparability between included studies is limited. Across review objectives substantial differences in study design were identified, with the majority of studies using cross-sectional designs and various exposure and outcome variables measured by multiple techniques at a range of adolescent ages. For example, where SES was described, this was defined by a number of methods, including wealth indices, household income and highest level of education achieved. However, while comparison may be restricted between studies, all have been extensively utilised as proxies for SES at household level and provide useful information on associations between SES and adolescent nutritional status across studies in a South African context. In addition, sample sizes differed substantially between studies and were relatively low in prospective cohort designs. This not only made drawing conclusions across studies difficult but limited the ability to make within-study comparisons—for example in cases where sex- and age-stratified results were not provided, potentially leading to bias in the presented study estimates. Similarly, the lack of comparative data—and longitudinal data in particular—makes it difficult to examine trends in South Africa across the study period. In addition, studies used various international standards and guidelines to both define and assess adequacy of nutritional status, with the standards or guidelines used often dependent on the timing of the study within the review period (for example pre- or post-introduction of the WHO growth standards in 2007 or the DRIs in 2001). Whether these international standards are applicable to African populations is debated and may explain why an unexpected decrease in overweight/obesity prevalence was observed in boys between early and mid-adolescence. Data have shown a delay in the onset of puberty, and therefore skeletal maturity, in black South African boys, which may lead to a degree of misclassification in both stunting and overweight/obesity prevalence in younger boys when compared with international standards.[118] However, while use of different guidelines may make direct comparison between studies challenging, these studies still provide useful data describing nutrient adequacy over time. In addition, studies have shown a high degree of comparability between standards of weight classification (i.e. CDC/NCHS, IOTF and WHO growth standards) in adolescents, as well as in their associations with health outcomes, suggesting that the degree of misclassification between studies would be small overall.[119] For those studies reporting dietary intakes, all used either 24-hour recall or FFQ methodologies. While these are the most commonly utilised methods in African settings, innate limitations of using reported intakes exist, with strengths and weaknesses between specific methods being commonly acknowledged.[120] Recall bias, assumptions around regularity of eating habits, seasonality and inaccuracy in portion size estimation are all limitations of these methodologies and must be considered when interpreting the review findings.[121,122]

Conclusion

In South Africa, rapid urbanisation over the last two decades has resulted in a substantial rise in adolescent overweight and obesity, with urban females being most affected as they age. Rising adiposity in adolescents is driven by a transition towards increasingly Westernised diets characterised by high intakes of energy-dense, processed and convenience food products high in sugar and fat, but low in essential micronutrients. In addition, the changes in dietary intake demonstrated across South African populations are exacerbated in adolescents as they age and adopt more obesogenic behaviours, including irregular breakfast consumption and fewer family meals, increased snacking and consumption of purchased/fast-food products and reduced levels of physical activity. However, this review highlights a scarcity of data for the implications of these shifting dietary-intake and behaviour patterns on the micronutrient status of adolescents, which may have severe implications for their ability to grow into healthy and productive adults. In addition, little is known about the way in which diet, activity and sedentary behaviours cluster in adolescent boys and girls, as well as the patterns of behaviour that may facilitate healthy growth and reduced adiposity between the sexes.

Authorship

SVW: conceptualisation and methodology, literature search, data extraction and presentation, interpretation of results, writing—original draft, writing—review and editing; TMP: literature search, data extraction and presentation, writing—review and editing; CHF: conceptualisation and methodology, writing—review and editing; SAN: conceptualisation and methodology, interpretation of results, writing—review and editing. All authors gave final approval for the manuscript to be submitted.

Disclosure statement – No potential conflict of interest was reported by the authors.

Funding – This review was supported by a grant from the Sackler Institute for Nutrition Science and the UK Medical Research Council, which funded Transforming Adolescent Lives through Nutrition (TALENT). TALENT is a collaborative network for adolescent nutrition and health in sub-Saharan Africa and India supported by an MRC Confidence in Global Nutrition and Health Research grant.

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Received: 18-07-2018 Accepted: 7-04-2019