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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. 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. 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.

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. 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. In addition, there has been a lack of focus on the role that paternal nutrition status, attitudes and behaviour may have on the offspring both physiologically and at the level of partner and/or parental influence. 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. 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.

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). 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. 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 | 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 | 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 |

*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. 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. 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. This is particularly relevant in sub-Saharan Africa where overweight and inactivity rates are comparatively higher than in other LMIC regions.

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. 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. 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...
For intervention studies:

1. Studies conducted in South Africa.
2. Studies conducted in males and/or females aged 10–20 years.
3. Studies published in peer-reviewed journals and/or as academic dissertations.

For observational studies:

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 (anthropometrical or biochemical indicators and/or reported dietary intakes) using aggregate data summarised as mean (SD) and/or median (IQR or 95% confidence interval).

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 = 31),76 Free State (n = 1),71 Gauteng (n = 25),32,26,31,32,35–37,40,46,48–52,56–58,61–63,69,77–80 KwaZulu-Natal (n = 3),23,59,60 Limpopo (n = 4),28,29,81 Mpusmalanga (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 (Mpusmalanga vs. Limpopo85, Mpusmalanga vs. Gauteng87) and four used national survey data:44,38,39,70 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 2016. 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 contexts23,28,29,38,44,45,53,54,59,60,66–68,73,75,76,81,83,85,86 and 35 in urban and/or peri-urban contexts22,24,26,31,33,35–37,40–42,46,46–52,55–58,61–62,69,71,72,77–80,84,88 with two studies comparing rural and urban populations.32,87 Ten studies included mixed populations25,27,30,36,38,39,43,47,70,74 and one did not specify the context.83 Twelve studies included specifically black adolescents25,27,34,35,37,42,49,50,57,65,79,87 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.
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. 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. Where stunting prevalence was included, two studies used the WHO child growth standards and one used the Centers for Disease Control and Prevention (CDC)/National Center for Health Statistics (NCHS) growth charts to define stunting. Five studies additionally included objectively measured body fat percentage via dual-energy X-ray absorptiometry (DXA), air displacement plethysmography (ADP) or bioimpedance. One study used a nutritional biomarker (vitamin D status; 25(OH)D) and five used reported dietary intakes in addition to anthropometric assessments. The remaining four studies used reported dietary intakes alone.

**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. 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). In addition, for boys aged 11–12 years, height was substantially higher in those who had reached greater sexual maturity according to Tanner staging. 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)) (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).

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). 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/m² respectively at 18 years.
| First author | Main objective(s)                                                                                                                                                                                                                                                                                                                                 | Study design          | Sample size | Age (years) | Sex | Province* | Context (rural/ urban) | Relevant objective(s) |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------|-------------|-----|-----------|------------------------|-----------------------|
| Szabo22      | 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                     |
| Faber23      | To assess the adequacy of food intake of primary school children living in a low socioeconomic rural area                                                                                                                                                                                                                               | Cross-sectional       | 50          | 10–11       | M,   | KwaZulu-Natal | Rural                  | 1, 2                  |
| Caradas24    | 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               |
| Kruger25     | 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                     |
| Szabo26      | 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 Rooyen27 | 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,   | North West | Mixed                  | 1                     |
| Monyeki28,29 | (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,   | Limpopo    | Rural                  | 1                     |
| Kruger30     | 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,   | North West | Mixed                  | 1                     |
| Petersen31   | 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 [BTBH]) | Black (B): 148; white (W): 54 | 11    | F   | Gauteng    | Urban                  | 1, 3, 4               |
| Szabo32      | 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               |
| Temple33     | To investigate the food consumption patterns of adolescent students at schools                                                                                                                                                                                                                                                                                                                | Cross-sectional       | 476         | 14.5 ± 2.0 | M,   | Western Cape | Urban                  | 2                     |

(Continued)
| First author | Main objective(s) | Study design | Sample size | Age (years) | Sex | Province | Context (rural/urban) | Relevant objective(s) |
|--------------|-------------------|--------------|-------------|-------------|-----|----------|----------------------|----------------------|
| Jinabhai34   | 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 |
| MacKeown35   | 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 |
| Pedro36      | 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 |
| Feeley17     | To report on fast-food consumption in urban black adolescents | Cross-sectional (within BTT) | 320 (M); 335 (F) (black participants) | 17 | M, F | Gauteng | Urban | 2 |
| Reddy38,39   | (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 |
| Letlape40    | To assess 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 |
| Venter41     | To investigate the dietary fat knowledge and intake of 17-year-olds | Cross-sectional | 183 | 17–18 | M, F | Western Cape | Urban | 2 |
| Zeelie42     | 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 |
| Abrahams43   | 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-Murage44,45 | (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 |
| Feeley46     | 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 |
| Study | Overview | Design | Sample Size | Year | Sex | Area | Type |
|-------|----------|--------|-------------|------|-----|------|------|
| Monyeki47 | 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 |
| Poopedi48 | 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 |
| Kagura; Chirwa49,50 | (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 |
| English; Mao53,54 | (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 |
| Puoane55 | 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 |
| Goon56 | 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 |
| Feeley; Gitau57,58 | (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 |
| Voorend; Sedibe51,52 | (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 |
| First author | Main objective(s) | Study design | Sample size | Age (years) | Sex | Province | Context (rural/urban) | Relevant objective(s) |
|--------------|-------------------|--------------|-------------|-------------|-----|----------|-----------------------|-----------------------|
| Craig59,60   | 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 | 
| Feeley61     | 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 | 
| Gitau63      | 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 | 
| Gitau62      | 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 | 
| Mamabolo65   | 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 | 
| Mamabolo64   | 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 | 
| Mcklesfield; Pedro66,67 | (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 | 
| Sedibe68     | 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 | 
| Visser69     | 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 | 
| Mchiza70     | To examine body image in relation to body mass index and weight control in South Africa. | Cross-sectional (South African National Health and Nutrition Examination Survey) | 764 | 15–18 | M, F | National Mixed | 1, 4 |
| Author(s) | Objective(s)                                                                 | Study Design | Sample Size | Age Range | Gender(s) | Location | Type of Study |
|----------|------------------------------------------------------------------------------|--------------|-------------|-----------|-----------|----------|---------------|
| Meko     | 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 | 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     | 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      | 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  | 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 | (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 | (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   | 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  | 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)
| First author | Main objective(s) | Study design | Sample size | Age (years) | Sex | Province* | Context (rural/urban) | Relevant objective(s) |
|--------------|-------------------|--------------|-------------|-------------|-----|-----------|----------------------|----------------------|
| Monyeki     | 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       | 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    | To explore factors influencing weight control practices amongst adolescent girls | Qualitative | 30 | 13–19 | F | Limpopo | Not specified | 5 |
| Manyanga    | 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 | 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       | 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      | 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 |

*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; UW, urban white female; RMF, rural male and female; RBM, rural black male; RBF, rural black female; UMA, 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; 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; UW, urban white female; RMF, rural male and female; RBM, rural black male; RBF, rural black female; UMA, urban mixed-ancestry male; UMAF, urban mixed-ancestry female; M, male; F, female.
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) (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]). 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]). 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 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). *WHO child growth standards. **CDC/NCHS growth charts.

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.
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]).

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)]).

Adiposity (Figure 11 and Table 3)
Across age categories the majority of studies showed higher waist circumference in girls compared with boys (Table 3). White adolescents had higher waist circumference than their black counterparts at 12–16 years (65.5 cm [black], 70.4 cm [white]). Waist circumference tended to be lower in boys vs. girls across age (11 years: 12.3% (M), 20.3% (F); [14 years: 13.7% (M), 20.5% (F); [15 years: 9.0% (M), 24.7% (F)].

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

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). 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).

Reported dietary nutrient intakes (Table 4)
Of the nine studies reporting dietary nutrient intakes in South African adolescents, seven used 24-hour recall to describe intakes. Where 24-hour recalls were utilised, only two studies used a repeated recall method (one week and one weekend day) 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. 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. 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. It also incorporated validated instruments for portion size estimation. 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]). 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]). 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.

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. 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. Energy, macro- and micronutrient intakes were similar in stunted compared with non-stunted 10–15-year-old black adolescents.
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 Rooyen77 | Non-stunted (NS): 258 (M), 325 (F); stunted (S): 105 (M), 87 (F) (black participants) | 10–15 | M, F | Mixed | %fat (skinfolds) | M, NS: 14.2 (5.8) |
| | | | | | | S: 12.5 (4.8) |
| | | | | | F, NS: 22.8 (6.9) |
| | | | | | S: 19.3 (7.0) |
| Monyeki28   | 287 (M); 243 (F) | 10–14 | M, F | Rural | %fat (skinfolds) | 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) |
| Zeelie42     | 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) |
| Poopedi48   | 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) |
| Monyeki47   | 100 (M); 156 (F) | 14 | M, F | Mixed | %fat (skinfolds) | M: 13.7 (7.0) |
| | | | | | F: 20.5 (5.6) |
| Craig59     | 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) |
| Goon56      | 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) | 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) |
| Mamabolo65  | 70 (M), 111 (F) (black participants) | 13–20 | M, F | Urban | %fat (ADP) | M: 18.2 (6.6) |
| | | | | | F: 28.8 (6.4) |
| Toriola74   | 111 (M), 172 (F) | 14–15 | M, F | Mixed | %fat (skinfolds) | 2011, M: 14.4 (9.1) |
| | | | | | F: 26.4 (8.6) |
| | | | | | 2012, M: 20.3 (9.4) |
| | | | | | F: 19.4 (9.7) |
| Pradeilles77| 839 (M), 889 (F) | 17–19 | M, F | Urban | %fat (DXA) | M: 12.1 (9.9; 15.3) |
| | | | | | F: 33.2 (7.1) |
| Moselakgomo85| Limpopo provinceb (L): 168 (10 years), 215 (11 years), 143 (12 years), 56 (13 years); Mpumalanga provinceb (M): 147 (10 years), 128 (11 years), 154 (12 years), 142 (13 years) | 10–13 | M, F | Rural | %fat (skinfolds) | 10 years, L: 21.5 (1.6) |
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]). 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) at 10 and 13 years respectively. 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). 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).

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

Sixteen studies met the inclusion criteria for Objective 2. Data collection was questionnaire based for all studies and included: dietary assessment via FFQ and/or 24-hour recall, as well as data on dietary habits and eating practices, nutrition knowledge, and fast-food intake/availability.

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). 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). 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). 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. 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. Many adolescents (47–61%) could not correctly identify less healthy food items (including sugar-sweetened beverages, samosas and pies). 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. 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. Between the ages of 13 and 17 years, regular breakfast consumption and lunchbox usage decreased, with adolescents purchasing more food at school. Smackling 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). 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. 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. 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). 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. 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. 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.

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). Significantly more rural girls (EA: 51.0%; MA: 48.5%) than boys (EA: 33.3%; MA: 28.5%) consumed their main meal with the family almost every day.

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). 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) | 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: 61.0 (55.5; 66.6) |
|               |             |             |           |                       | S: 7 440 (6 879; 8 001) |                  | Fat, NS: 52.1 (49.0; 55.1) |
|               |             |             |           |                       | S: 33.4 (47.1; 59.6) |                  | SFA, NS: 261.5 (251.6; 271.4) |
|               |             |             |           |                       | S: 266.6 (246.7; 286.4) |                 | CHO, NS: 261.5 (251.6; 271.4) |
| 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) |
|               |             |             |           |                       | S: 7 595 (120) S: 7 534 (209) |                 | Animal protein, NS: 30.3 (0.8) |
|               |             |             |           |                       | S: 30.5 (1.6) |                  | 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) |                  | 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: 1552.6 (89.1) |                 | Vit C, NS: 37.7 (3.1)       |
|               |             |             |           |                       | S: 1552.6 (89.1) |                 | Vit B6, NS: 1.12 (0.56)     |
|               |             |             |           |                       | S: 1552.6 (89.1) |                 | Vit B12 [µg/d]: 1.46 (2.17) |
|               |             |             |           |                       | S: 1552.6 (89.1) |                 | Folate [µg/d]: 206 (141)    |
|               |             |             |           |                       | S: 1552.6 (89.1) |                 | Vit C: 19.6 (17.9)          |
| 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           | 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) | Fat, F: 52.7 (31.7) |
| Petersen         | Black (B): 148; white (W): 54 | 11         | F         | Urban                 | B: 5 422 (2 242) | Fat, B: 38 (22) |
|                  |             |             |           |                       | W: 5 055 (1 784) | Fat, W: 42 (20) |
| MacKeown         | 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) |
|                  |             |             |           |                       | 13 years: 2 127 (1 994; 2 260) | Ca, 10y (g/d): 497 (462.5; 531.5) |
|                  |             |             |           |                       | 13 years: 59 (55.21; 62.79) | K, 10 years: 1 695 (1 621.3; 1768.7) |
|                  |             |             |           |                       | 13 years: 642 (585.0; 699.0) | Zn, 10 years: 7.7 (7.36; 8.04) |
|                  |             |             |           |                       | 13 years: 2 057 (1925.1; 2188.9) | 13 years: 8.2 (7.64; 8.76) |
|                  |             |             |           |                       | 13 years: 77 (7.36; 8.04) | 13 years: 102 (95.04; 109.74) |
|                  |             |             |           |                       | 13 years: 102 (95.04; 109.74) | Vit A, 10 years (RE): 332 (305.4; 358.0) |
|                  |             |             |           |                       | 13 years: 2 057 (1925.1; 2188.9) | Thiamin, 10 years: 1.0 (0.95; 1.05) |
|                  |             |             |           |                       | 13 years: 1 695 (1 621.3; 1768.7) | Riboflavin, 10 years: 0.9 (0.83; 0.97) |
|                  |             |             |           |                       | 13 years: 8.2 (7.64; 8.76) | 13 years: 1.2 (1.09; 1.32) |
|                  |             |             |           |                       | 13 years: 1.2 (1.12; 1.28) | Niacin, 10 years: 12.7 (12.08; 13.32) |
|                  |             |             |           |                       | 13 years: 12.7 (12.08; 13.32) | 13 years: 14.7 (13.59; 15.82) |
|                  |             |             |           |                       | 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) | 13 years: 1.6 (1.49; 1.72) |
|                  |             |             |           |                       | 13 years: 1.6 (1.49; 1.72) | Folate, 10 years (μg/d): 197 (187.2; 206.9) |
|                  |             |             |           |                       | 13 years: 2 057 (1925.1; 2188.9) | Vit C, 10 years: 35 (29.29; 39.91) |
|                  |             |             |           |                       | 13 years: 35 (29.29; 39.91) | 13 years: 66 (58.28; 73.13) |
| Study | Sample Size | Sex | Rural | Energy | Fat | Cholesterol | Fibre | Protein | Carbohydrate | Calcium | Magnesium | Potassium | Zinc | Vitamin A | Vitamin C |
|-------|-------------|-----|-------|--------|------|-------------|-------|---------|-------------|---------|------------|-----------|------|-----------|-----------|
| Oldewage-Theron (14–18 years: 98; 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: 50 (15; 37) | 14–18 years: 6.5 (4.9; 8.4) |
| | | | Fe, 9–13 years: 207.0 (170.3; 245.7) | TFA, 9–13 years: 15 (11; 21) | Mg, 9–13 years: 20.5 (16.7; 24.4) | 14–18 years: 16 (11; 22) | 14–18 years: 6.4 (4.7; 7.6) |
| | | | SFA, 9–13 years: 12 (7; 18) | Folate, 9–13 years (μg/d): 145.5 (104.9; 196.1) | PUFA, 9–13 years: 12 (8; 21) | 14–18 years: 143.3 (105.1; 212.7) |
| | | | MUFA, 9–13 years: 16 (11; 22) | Vit C, 9–13 years: 23.8 (15.0; 34.0) | 14–18 years: 1.7 (1.7; 2.6) | 14–18 years: 1.4 (0.6; 2.6) |
| | | | 14–18 years: 10.2 (5.5; 18.5) | LLA, 9–13 years: 8.9 (5.2; 14.6) | 14–18 years: 0.3 (0.2; 0.5) | 14–18 years: 0.2 (0.2; 0.4) |
| | | | 14–18 years: 900 (5065; 9352) | M: 32 (28.4; 36.9) | Ca, M: 257.3 (253.4; 310.2) | F: 6 670 (6 154; 7 229) |
| Pedro (11–15 years: 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; 310.2) | F: 6 670 (6 154; 7 229) | F: 37.8 (33.3; 42.8) |
| | | | M: 39 (35.2; 43.0) | F: 283.0 (258.1; 310.38) | F: 42 (38.2; 45.9) |
| | | | F: 42 (38.2; 45.9) | Cholesterol, M: 25.2 (18.0; 35.1) | 14–18 years: 1.7 (1.7; 2.6) |
| | | | F: 43 (33.6; 54.9) | LLA, 9–13 years: 8.9 (5.2; 14.6) | 14–18 years: 0.3 (0.2; 0.5) |
| | | | 14–18 years: 900 (5065; 9352) | M: 32 (28.4; 36.9) | Ca, M: 257.3 (253.4; 310.2) | F: 6 670 (6 154; 7 229) |
| | | | M: 39 (35.2; 43.0) | F: 283.0 (258.1; 310.38) | F: 42 (38.2; 45.9) |

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.
| First author | Sample size | Age (years) | Sex (M/F) | Context (rural/urban) | Data collection method | Main finding(s) |
|--------------|-------------|-------------|-----------|-----------------------|-----------------------|-----------------|
| Faber⁵³      | 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). |
| Temple⁵⁵     | 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. |
| Pedro⁶⁶      | 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. |
| Feeley⁶⁷     | 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). |
| Letlape⁶⁵⁰   | 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. |
| Venter⁶¹     | 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 ($p < 0.05$).

| Study | Sample Size | Age | Gender | Setting | Methodology | Findings |
|-------|-------------|-----|--------|---------|-------------|----------|
| 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 tuck shop/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$^{47}$ | 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$^{48}$ | 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; principal 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)
| First author       | Sample size | Age (years) | Sex (M/F) | Context (rural/urban) | Data collection method | Main finding(s)                                                                                                                                                                                                 |
|-------------------|-------------|-------------|-----------|-----------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tee               | 113 (M), 131 (F) | 17.5 ± 2.3  | M, F      | Urban, peri-urban     | 24-hour recall          | (p ≤ 0.05) Physical activity was negatively associated with the starch and folate pattern (p ≤ 0.05); 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    | 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 correcting food group and 41.3% for correcting 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          | 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            | 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 ≤ 0.00) School environment: during EA, urban girls vs. boys purchased significantly more tuck shop items (18 ± 7.9 vs. 12 ± 8.0, p ≤ 0.00) During MA, lunchbox usage was more irregular among boys vs. girls (92.3% vs. 81.9%) in the urban site |

*Note: Data collection methods include 24-hour recall, nutrition knowledge questionnaire (NKQ), food frequency questionnaire (FFQ), and dietary pattern analysis (FFQ; PCA).*
Associations between diet and lifestyle factors and adolescent adiposity (Table 6)

| Study | Criteria | Inclusion Criteria |
|-------|----------|--------------------|
| 13    |          |                    |

Exposure variables were largely questionnaire based and included assessment of demographics, SES and household food security, dietary intake (FFQ), dietary habits and eating practices, physical activity and sedentary behaviour, as well as body-image perceptions, satisfaction and dissatisfaction and eating attitudes. Only one study used anthropometry (birth to two years of age) as the exposure. 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.

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). 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 ≤ 0.01). 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 ≤ 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 ≤ 0.01).

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/m²; p < 0.05) between 15 and 18 years of age. 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. In black girls only, sedentary time was positively associated with energy intake (p < 0.01) but not with body size.

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). 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.

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’). 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 ≤ 0.02). 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).

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. 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). 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) and a higher dieting subscore was positively associated with weight, BMI and hip circumference in black girls specifically (p < 0.01). Underweight girls had significantly lower EAT-26 scores than the other BMI groups. 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.22

Body image perceptions and eating attitudes (Table 7)

Twelve studies met the inclusion criteria. Data collection was questionnaire based and focused on the following: eating attitudes (26-item Eating Attitudes Test; EAT-26); Rosenberg self-esteem questionnaire (FFQ), dietary habits and eating practices, physical activity and sedentary behaviour, figure perceptions, preferences and ideals, body image satisfaction (Stunkard’s silhouettes) and dissatisfaction (Feel-Ideal Discrepancy (FID) scores), weight-control behaviours and perceptions of female body silhouettes. 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. 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.

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. 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. In contrast, white girls idealised a smaller body size than their mixed-race or black counterparts. Low self-esteem and a desire to be thinner was more common in white compared with black girls.

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%). 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.
| First author | Sample size | Age (years) | Sex (M/F) | Context (rural/urban) | Exposure | Outcome | Main findings(s) |
|--------------|-------------|-------------|-----------|----------------------|----------|---------|-----------------|
| Caradas²⁴    | 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) | | | 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 |
| Petersen³¹  | Black (B): 148; white (W): 54 | 11 | F | Urban | Energy (kJ/d) Fat (g/d) | | | 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) |
| Szabo²²     | Urban black (UB): 578; urban white (UW): 775; rural black (RB): 361 | 13–18 | F | Urban, rural | Body figure preference test (BFPT) | | | 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 smaller had the highest BMIs (UB: 23.8 (3.3); UW: 21.1 (2.8); RB: 26.0 (3.1)) |
| Study | Sex | Age | Location | Variables |
|-------|-----|-----|----------|-----------|
| Kimani-Murage | M, F | 10–20 | 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) |
| Kagura | M, F | 10 | Urban | Birthweight (g) | BMI (kg/m²) | Overweight/obese (%) | 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 ($p < 0.05$) |
| Feeley | M, F | 13, 15, 17 | Urban | Dietary habits and eating practices (home, school and community environments) | BMI (kg/m²) | Longitudinal sweetened beverage consumption was positively associated with... |

**Weight (kg)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | | | | UB: 53.9 (10.3) |
| | | | | UW: 54.7 (9.6) |
| | | | | RB: 59.2 (11.4) |

**BMI (kg/m²)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | | | | UB: 21.9 (5.2) |
| | | | | UW: 20.5 (3.9) |
| | | | | RB: 23.8 (4.0) |

**BMI z-score (WHO, 2007)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | 10–14 years | Rural | −0.09 (0.81) |
| | F | 15–20 years | Rural | 0.10 (1.20) |

**Birthweight (g)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | | Rural | 3213 (528) |
| | F | | Rural | 3012 (450) |

**DXA fat mass (g)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | | Rural | 6853 (3666) |
| | F | | Rural | 9324 (5151) |

**DXA fat-free mass (g)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | | Rural | 21352 (3113) |
| | F | | Rural | 20728 (4075) |

**Height-for-age z-score (HAZ; age 1 years)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | | Rural | −0.5 (1.2) |
| | F | | Rural | 0.6 (1.1) |

**Weight-for-age z-score (WAZ; age 1 years)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | | Rural | −0.4 (1.4) |
| | F | | Rural | −0.1 (1.3) |

**BMI z-score (WHO, 2007)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M | | Rural | −0.8 (1.4) |
| | F | | Rural | −0.4 (1.3) |

**Dietary habits and eating practices (home, school and community environments)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Feeley | M | | Urban | 20.4 (3.2) |
| | F | | Urban | 22.9 (4.4) |

**Birthweight**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 3213 (528) |
| | F | | Urban | 3012 (450) |

**BMI**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 20.4 (3.2) |
| | F | | Urban | 22.9 (4.4) |

**Odds of overweight and obesity**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | | | Rural | 4.24 (2.82; 6.38) |
| | | | Rural | 1.99 (1.28; 3.09) |

**Overweight/obese (%)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M, F | 10–14 years | Rural | 7.5 |
| | | 15–20 years | Rural | 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 ($p < 0.05$) |

**Birthweight**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 3213 (528) |
| | F | | Urban | 3012 (450) |

**BMI**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 20.4 (3.2) |
| | F | | Urban | 22.9 (4.4) |

**BMI**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 20.4 (3.2) |
| | F | | Urban | 22.9 (4.4) |

**Odds of overweight and obesity**

| Study | Sex | Age | Location | Value |
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| Kimani-Murage | | | Rural | 4.24 (2.82; 6.38) |
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**Birthweight**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 3213 (528) |
| | F | | Urban | 3012 (450) |

**BMI**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 20.4 (3.2) |
| | F | | Urban | 22.9 (4.4) |

**BMI**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kagura | M | | Urban | 20.4 (3.2) |
| | F | | Urban | 22.9 (4.4) |

**Odds of overweight and obesity**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | | | Rural | 4.24 (2.82; 6.38) |
| | | | Rural | 1.99 (1.28; 3.09) |

**Overweight/obese (%)**

| Study | Sex | Age | Location | Value |
|-------|-----|-----|----------|-------|
| Kimani-Murage | M, F | 10–14 years | Rural | 7.5 |
| | | 15–20 years | Rural | 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 ($p < 0.05$) |
**Table 6: Continued.**

| First author | Sample size | Age (years) | Sex (M/F) | Context (rural/urban) | Exposure Variable | Outcome Variable | Main findings(s) |
|--------------|-------------|-------------|-----------|-----------------------|-------------------|------------------|-----------------|
| Gitau        | 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) | DXA fat mass (kg) | BMI (kg/m²) | 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: \( p = 0.0001 \)) |
|              |             | 17y, M: 7 700 (4 800); F: 18 500 (7 600) |           | BMI (kg/m²) | B, 13 years: 19.9 (3.2) | Overweight/obese (%) | B, 13 years: 14.8 |
|              |             | 15 years: 21.3 (4.8) |         |           | 17 years: 23.1 (3.7) | W, 13 years: 21.9 (5.3) |
| Gitau        | 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/m²) | BMI (kg/m²) | 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) |
|              |             | 17 years: 21.6 (2.8) |         |           | 17 years: 23.4 (2.9) |  |
|              |             | Underweight (%) |         |           | B: 44.1 |  |
| Study | Sample Size | Age | Gender | Setting | Nutrient Patterns | BMI Z-score (WHO, 2007) | Additional Findings |
|-------|-------------|-----|--------|---------|------------------|----------------------|------------------|
| Pisa | 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, polysaturated fatty acids, sugars - Mixed diet driven nutrients: high loadings for animal and plant derived nutrients - Starch and folate driven pattern | 1 SD 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 | 974 (M), 1,045 (F) | 17–19 | M, F | Urban | Sex, household wealth index, caregiver education, neighbourhood socioeconomic position (SEP) tertile | 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)) |

(Continued)
Table 6: Continued.

| First author | Sample size | Age (years) | Sex (M/F) | Context (rural/urban) | Exposure | Outcome |
|--------------|-------------|-------------|-----------|------------------------|----------|---------|
| Meko⁷¹       | 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) | High %fat (DXA; > 85th percentile) | M: 5.2 F: 24 |
|              |             |             |           |                        |          | Boys vs. girls had significantly higher overweight (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%) |
| Pedro⁷²      | 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/m²) | 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) |
| Sedibe⁷⁷     | 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 |
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); \( p \leq 0.001 \); MA, OR: 0.29 (0.22, 0.39); \( p \leq 0.001 \)). Rural residence was associated with lower odds of overweight/obesity in EA (OR: 0.55 (0.32, 0.92); \( p \leq 0.02 \)).

| Gender | EA (R) | EA (U) | MA (R) | MA (U) |
|--------|--------|--------|--------|--------|
| F      | 11.2%  | 15.0%  | 5.7%   | 7.3%   |
| M      | 6.1%   | 11.1%  | 4.4%   | 5.5%   |

Note: OR = Odds Ratio; CI = Confidence Interval.
| First author | Sample size | Age (years) | Sex (M/F) | Context (rural/urban) | Data collection method | Main finding(s) |
|--------------|-------------|-------------|-----------|-----------------------|-----------------------|----------------|
| Szabo22      | 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) 37.5% of B and 20.7% of W girls were at risk of developing an eating disorder (i.e. EAT-26 scores ≥ 20) |
| Caradas24     | Black (B): 60; mixed ancestry (MA): 83; white (W): 85 | 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 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 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) |
| Szabo32      | Black (B): 578; white (W): 506 | Not specified (secondary school pupils) | F | Urban | Eating attitudes (EAT-26) | 18.7% and 16.8% 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) |
| Petersen33    | 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 subs-scores and significantly higher dieting sub-scores than W girls (p < 0.05) |
| Szabo32      | 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) |
| Puoane55     | 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/m²) |
| Gitau63      | 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’ (p < 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 |
| Study | Race | Age (Years) | Gender | Setting | Outcome Measures | Findings |
|-------|------|-------------|--------|---------|------------------|----------|
| Gitau 92 | 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 |
| | | | | | 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) |
|--------------|-------------|-------------|-----------|-----------------------|-----------------------|-----------------|
| Visser⁶⁹     | 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 |
| Mchiza⁷⁰    | 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 |
| Pedro⁸²      | 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 |
|              |             |             |           |                       | Perceptions of female body silhouettes (Stunkard’s silhouettes) (M, F) | For EAT-26 sub-components, oral control was significantly higher in EP girls than boys (4.7 vs.3.4, p = 0.024) |
|              |             |             |           |                       |                       | 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’ |
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). 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 studies51,52,68 and individual in-depth interviews in one study.83

| First author | Sample size | Age (years) | Sex | Context (rural/urban) | Data collection method | Main finding(s) |
|--------------|-------------|-------------|-----|-----------------------|-----------------------|-----------------|
| Voorend; Sedibe51,52 | 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 |
| Sedibe68     | 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) |
| Tshililo83    | 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 |

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

In rural girls the importance of eating breakfast was acknowledged and locally grown, traditional foods—mainly fruits and vegetables—were perceived to be healthy.58 Female caregivers and school meal programmes were viewed as facilitators to eating healthy diets.58 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.58 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. 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. 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. 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.

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. 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. 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. 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.

**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. 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. 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. 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. In rural adolescents, there was no change in energy intake between younger (9–13 years) and older (14–18 years) age groups. 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). 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. 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. 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.

In urban adolescents, energy intake increased with age, predominantly driven by increased intakes of carbohydrate, fat and sugar. 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. These purchased items contributed substantially to the total added sugar and salt intakes of adolescents. This is supported by studies in both high-income and LMIC settings, which demonstrate the adoption of obesogenic behaviours as adolescents age and gain independence.

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 intake references (DRI; Institute of Medicine and National Research Council), the majority of adolescents did not meet the recommendations for most micronutrients, including iron, zinc, calcium, vitamin A and folate, with one study showing an increase in the proportion not meeting recommendations.
as adolescents aged.\textsuperscript{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.\textsuperscript{25,35} 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.\textsuperscript{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.\textsuperscript{106} This is supported by Manyanga et al., who showed higher odds of an unhealthy dietary pattern in adolescents from the lowest SES group.\textsuperscript{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 African 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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’.\textsuperscript{58} Such changes in desirability have been largely linked to urbanisation and increased exposure to, and adoption of, Western ideals.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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. Multi-sectoral 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. 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.

**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. 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, IOFT 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. 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. 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.

**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.

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