FOCUS

Childhood and adolescence are critical stages offering a window of opportunity for interventions to inculcate healthy eating habits to mitigate the occurrence of diet-related chronic diseases in later life associated with poor eating habits in earlier life.

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Dietary Intake of Schoolchildren and Adolescents in Developing Countries

by Sophie Ochola and Peninah Kinya Masibo

Key insights

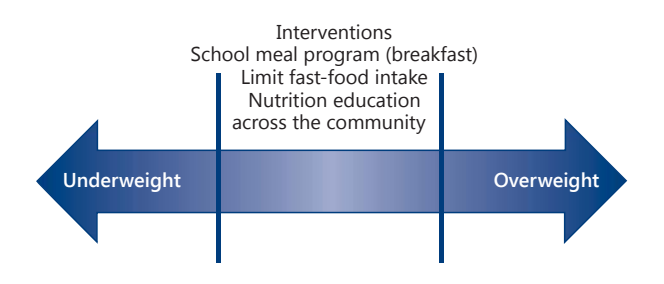
In developing countries, the diets of school-age children and adolescents are very limited in diversity. The pattern is characterized by minimal intake of animal foods, fruits and vegetables and high consumption of calorie-rich processed foods. The problem is further exacerbated by the replacement of traditional diets with Western diets in developing countries. Consequently, many children have an inadequate energy intake and are deficient in micronutrients.

Current knowledge

Data on dietary intake are critical for guiding health and nutritional interventions for children and adolescents. The school age and adolescent years comprise a dynamic period of growth and development that forms the basis for health and productivity in later life. This review of the dietary intake of schoolchildren and adolescents (aged 6–19 years) aimed to characterize the dietary patterns and assess the adequacy of nutrient intake in order to identify the effects on public health and nutrition. The analysis was based on 50 studies performed in 42 countries, published from 2000 to 2014.

Practical implications

Public health policies in developing countries must address the problems of over- and undernutrition within the same populations. In school-age children and adolescents, the pattern of energy consumption is not well distributed. These individuals (particularly those from low socioeconomic backgrounds) often skip breakfast with negative consequences for school performance and health outcomes. Dietary interventions should therefore consider the provision of school meals for improved health and performance. The consumption of processed food items is a major contributing factor to overweight and obesity. This highlights the need for nutrition education across the entire community, including school management, children and parents.



Interventions to address the problems of under- and overnutrition among school-age children and adolescents in developing countries.

Recommended reading

Rauber F, Hoffman DJ, Vitolo MR: Diet quality from pre-school to school age in Brazilian children: a 4-year follow-up in a randomised control study. Br J Nutr 2014;111:499–505.

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Dietary Intake of Schoolchildren and Adolescents in Developing Countries

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Key Messages

- Diets of schoolchildren and adolescents in developing countries are limited in diversity, with minimal consumption of animal foods and fruits and vegetables. Consequently, many children are deficient in micronutrients.
- There is insufficient energy intake, on the one hand, and consumption of high-calorie foods is increasingly becoming popular among schoolchildren and adolescents in urban areas, on the other hand.
- Schoolchildren and adolescents often skip breakfast with negative consequences for attainment of good health and educational objectives. Interventions for dietary improvements should consider providing school meals for improved health and performance of the children.
- The consumption of fast and high-energy food items is a major contributing factor to overweight and obesity creating the emerging public health concerns of the nutrition transition and the occurrence of non-communicable diseases. There is need for nutrition education for school management, children, adolescents, parents and the community at large to sensitise them on healthy eating habits.

Key Words

Dietary intake · Schoolchildren · Adolescents · Developing countries · Nutrition transition

Abstract

School age and adolescence is a dynamic period of growth and development forming a strong foundation for good health and productive adult life. Appropriate dietary intake is critical for forming good eating habits and provides the much needed nutrients for growth, long-term health, cognition and educational achievements. A large proportion of the population globally is in the school age or adolescence, with more than three quarters of these groups living in developing countries. An up-to-date review and discussion of the dietary intake of schoolchildren and adolescents in developing countries is suitable to provide recent data on patterns of dietary intake, adequacy of nutrient intake and their implications for public health and nutrition issues of concern. This review is based on literature published from 2000 to 2014 on dietary intake of schoolchildren and adolescents aged 6–19 years. A total of 50 studies from 42 countries reporting on dietary intake of schoolchildren and adolescents were included. The dietary intake of schoolchildren and adolescents in developing countries is limited in diversity, main-

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ly comprising plant-based food sources, but with limited intake of fruits and vegetables. There is a low energy intake and insufficient micronutrient intake. At the same time, the available data indicate an emerging trend of consumption of high-energy snacks and beverages, particularly in urban areas. The existence of a negative and positive energy balance in the same population points to the dual burden of malnutrition and highlights the emerging nutrition transition in developing countries. This observation is important for planning public health nutrition approaches that address the concerns of the two ends of the nutrition divide.

Introduction

School-age children make up a considerable portion of the world's population [1], and more than three quarters of these children live in developing counties. Similarly, 18% of the world's population are adolescents, with the vast majority (88%) living in developing countries [2]. School-age children and adolescents have an increased need for nutrients [3]. This dynamic period of growth and development forms a foundation for good adult health as children go through physical, emotional and social changes [4]. The health, physical growth, development and educational performance of schoolchildren depend largely on good nutrition. Undernourished children are prone to poor health because of the synergism between malnutrition and infections [5]. Nutritional status influences cognitive development and academic performance [6], and many studies have demonstrated the positive effects of adequate dietary intake on cognitive function and school performance of schoolchildren [7–14].

The health, physical growth, development and educational performance of schoolchildren depend largely on good nutrition.

Adolescence is a critical period in the life span, characterised by major physical, chemical and emotional changes. Optimal growth and development and the delay or prevention of non-communicable diseases can be achieved through nutritionally adequate diets and leading active lifestyles [15]. Adolescents are more autonomous in their food choices, which are largely influenced by peer pressure, and tend to disregard healthy eating messages [16, 17]. There is scant research available on dietary intake of adolescents in developing countries. Snacking, skipping meals and intake of junk foods are common features of the diet of adolescents in developed countries, where most of the studies have been conducted [18]. Some of these eating habits are increasingly being observed in developing countries [19–22].

The assessment of dietary and nutrient intake is one of the most widely used indirect methods of establishing nutritional status. Estimating the true dietary and nutrient intake is extremely difficult. The main limitations of the common methods of assessing dietary intake centre on the accuracy of the data obtained by such methods in estimating an individual's usual dietary intake [23]. This article reviews studies on the challenges of dietary intake assessment including methods of assessment, availability of appropriate food composition tables and dietary reference standards that have been used to estimate adequacy of nutrient intake. A discussion of dietary diversity, meal patterns, adequacy of nutrient intake and their implications for health, growth and development of children and adolescents is included. Emphasis is placed on both the effects of under- and overconsumption of food to reflect the current nutrition transition being experienced in the developing countries with the resultant increasing levels of overweight and obesity in school-age children [8, 24–30] and adolescents [31–34]. Childhood and adolescence are critical stages offering a window of opportunity for interventions to inculcate healthy eating habits to mitigate the occurrence of diet-related chronic diseases in later life associated with poor eating habits in earlier life. A discussion of the dietary intake of schoolchildren and adolescents in developing countries is suitable to point out data that are available for the formulation of food-based dietary models and guidelines to establish healthy dietary habits in these critical population groups.

Methodology

A literature search was conducted in various online databases to identify articles and publications on dietary intake of school-age children and adolescents from Africa, East Asia, South Asia, Western Asia, Latin America and the Caribbean. This classification of developing countries is as provided by the United Nations [35]. The literature search was conducted using the following key terms: dietary intake assessment methods, diet, dietary pattern, diet variety, diet score, food intake, food choices, school-age children, schoolchildren, adolescents, nutrient adequacy, micronutrient intake (specific vitamins and minerals) and names of countries of interest. The search was carried out in several databases: PubMed, Access to Global Online Research in Agriculture (AGORA), Biomed Central, Cambridge Journals, Hinari, Oxford Journals, Wiley Online Library, ScienceDirect, Cochrane Database of Sys-

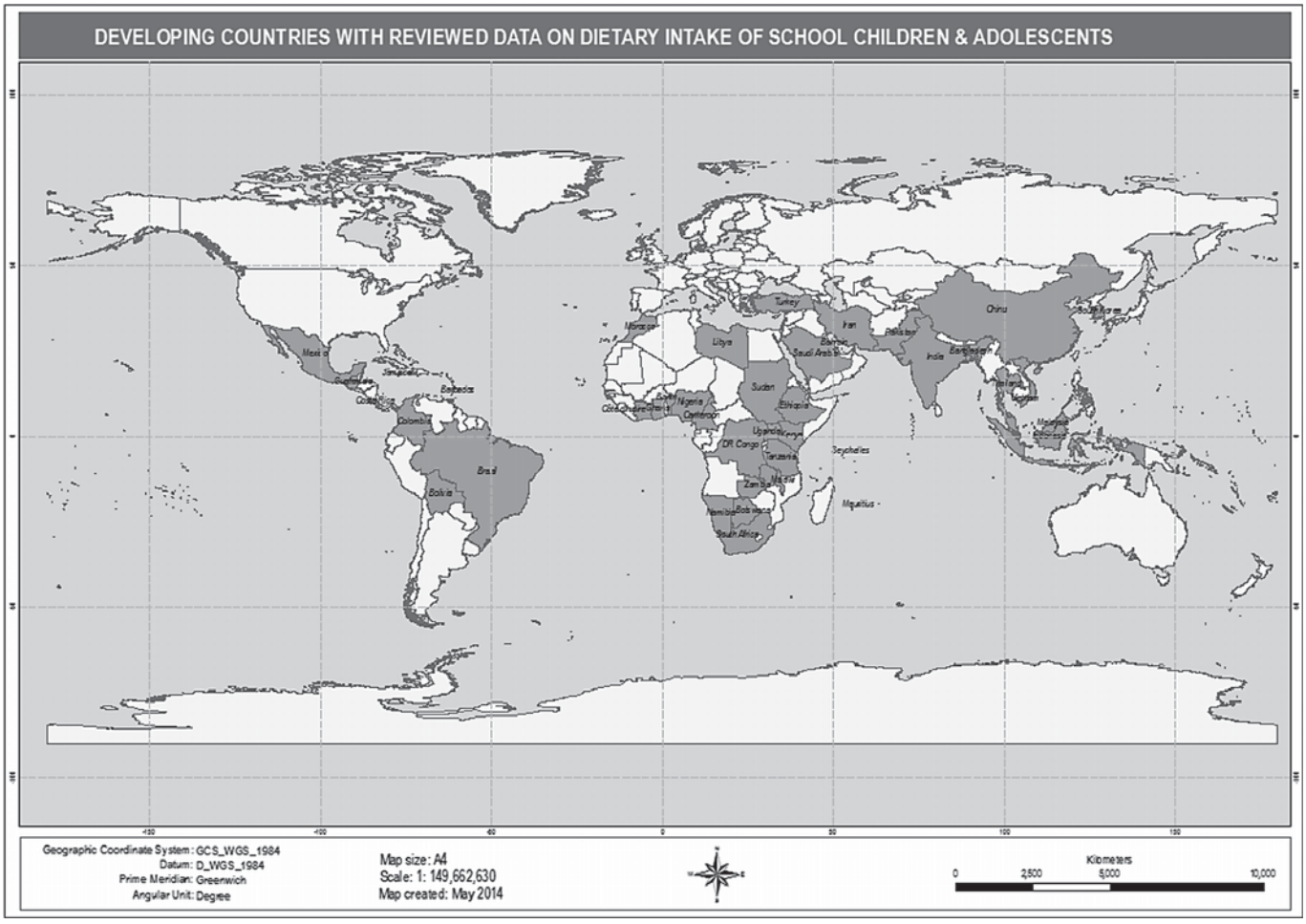

Fig. 1. Developing countries with reviewed data on dietary intake of schoolchildren and adolescents.

tematic Reviews (CDSR), Springer, Elsevier, Directory of Open Access Journals, World Bank (data.worldbank.org), Informa Healthcare, SciELO, Korean Medical Journal Information and Google Scholar. Information was also searched on specific international organisations' websites including the World Health Organization (WHO), UNICEF, World Food Programme and the World Bank. Studies and articles for review were limited to materials published from 2000 to 2014.

Literature was included in the review if it was written in English or a translated version into English was available, and if study subjects were 6–19 years of age. If the study was an intervention providing dietary and nutrient supplements to subjects, baseline findings were considered for inclusion if dietary intake was measured and reported at baseline. Studies for inclusion were evaluated on the basis of reported outcomes such as differences between dietary intake within age categories, sex or those that compared different settings and circumstances such as rural and urban setups and socioeconomic status.

Studies were excluded if the study sample included less than 50 subjects, if the research was conducted in acute humanitarian emergency circumstances or if the participants were selected based on specific health conditions. A total of 150 research articles were identified in the initial search, 91 were included for the review and 59 were excluded based on the exclusion criteria. Out of the included articles, 32 are summarised in table 1 with details of study designs, methods of assessing dietary intake, main target population and key findings. Data on schoolchildren and adolescents are presented and discussed together because many studies combine findings for the two age groups and do not have a clear definition of schoolchildren and adolescents. Reviewed studies were from all regions of the developing world (fig. 1).

Results

Methodology Issues in Assessing Dietary Intake in Schoolchildren and Adolescents

Dietary assessment of schoolchildren is challenged by the fact that cognitive abilities for self-reporting, good memory and long attention span required to answer the questionnaire, provide information about the food as well

Table 1. Summary of the selected literature with data on dietary intake of school children and adolescents in developing countries

No.	Author	Study title	Study design	Participants and study setting	Dietary intake assessment method	Main findings
1	Rauber et al. [56], 2014	Diet quality from pre-school to school age in Brazilian children: a 4-year follow-up in a randomised control study	Longitudinal study	Children aged 3–4 years (n = 345) and 7–8 years (n = 307)	Two 24-hour dietary recalls and a healthy eating index	93.5% of the children 3–4 years of age and 96% of the children 7–8 years of age had diets that were poor or needed improvement Percent of children meeting the recommended healthy eating index for various foods for children aged 7–8 years in the group that had received dietary counselling: vegetables 0%, fruits 2.3%, meat and legumes 11.5%, milk 42.7%, total fat 61.1%, cholesterol 96.2% and dietary fat 43.5%
2	Shroff et al. [21], 2013	Adherence to a snacking dietary pattern and soda intake are related to the development of adiposity: a prospective study in school-age children	Longitudinal study	Children aged 5–12 years, Colombia (n = 961)	Food frequency questionnaire	Snacking pattern was associated with higher BMI gain, mean change in subscapular:triceps skinfold thickness ratio Soda intake was positively and significantly associated with change in BMI and waist circumference
3	Turyashemererwa et al. [48], 2013	Dietary patterns, anthropometric status, prevalence and risk factors for anaemia among school children aged 5–11 years in Central Uganda	Cross-sectional study	Primary school-children aged 5–11 years, peri-urban area of Uganda (n = 122)	Food frequency questionnaire	Anaemia was associated with not eating fish and fewer meals (1–2 per day) One main dietary pattern was identified explaining approximately 20.4% of the variability of intake in the population
4	Mwaniki and Makokha [5], 2013	Nutrition status and associated factors among children in public primary schools in Dagoretti, Nairobi, Kenya	Descriptive cross-sectional design	Students aged 4–11 years, Kenya (n = 208)	24-Hour recall	Breakfast contributed 10% of the daily energy intake Few children consumed foods from more than 4 food groups Cereal-based grains contributed 18% of the total diet, vegetables contributed 12%, meat contributed 8.5% and fruits contributed only 3% Mean energy intake was 1,890 kcal per day: breakfast contributed 10% of the daily energy intake, 44.5% was from lunch and 45.3% from supper
5	Mehta et al. [54], 2013	Nutritional contribution of mid day meal to dietary intake of school children in Ludhiana District of Punjab	Cross-sectional survey	Schoolchildren aged 7–9 years, Punjab, India (n = 200)	Three consecutive days, 24-hour recall method	Kadhi chawal was the most liked meal (45%) followed by sabji roti and dhal chawal (35%), dhal roti (30%) and channa roti (29%) The least preferred meal was sweet rice (26%) Inadequate nutrient intake: the energy and protein was below the recommended norms of 450 kcal and 12 g protein The midday meal was found to be a substitute rather than a supplement for the home meal The percent contribution of energy, protein and fat by the midday meal to the actual nutrient intake of children was 28.2, 51.7 and 27.5%, respectively The percent contribution of other nutrients was 22.7% for β-carotene, 28.3% for thiamine, 25.3% for riboflavin, 28.7% for niacin, 23.6% for folacin, 15.2% for vitamin C, 25.7% for iron and 27.7% for calcium

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Table 1 (continued)

No.	Author	Study title	Study design	Participants and study setting	Dietary intake assessment method	Main findings
6	Doku et al. [64], 2013	Socio-economic differences in adolescents' breakfast eating, fruit and vegetable consumption and physical activity in Ghana	Cross-sectional survey	Adolescents aged 12–18 years, Ghana (n = 1,195)	Food habit questionnaire	31% of adolescents took breakfast at less than 4 days/week, over half (56%) and 48%, respectively, rarely ate fruits and vegetables Younger adolescents (12–15 years old) consumed fruits and vegetables frequently compared with older ones (16–18 years old) Boys were more likely to participate in physical activity than girls Eating breakfast was more likely for adolescents from more affluent backgrounds than for those from less affluent ones Reasons for not eating breakfast were: lack of food at home (50%), not enough time for breakfast (24%), cannot eat early in the morning (19%) Maternal educational attainment increased the probability of frequent fruit and vegetable intake High school performance was associated with frequent fruit intake, whereas high or medium school performance increased the likelihood of vegetable intake compared with low school performance
7	Barugahara et al. [42], 2013	Prevalence and risk factors of nutritional anaemia among female school children in Masindi district, western Uganda	Cross-sectional study	Adolescent girls aged 11–14 years, Uganda (n = 109)	24-Hour dietary recalls	There was a high intake of plant-based diets There was excess intake of fibre There was inadequate intake of iron, protein, folate, riboflavin, energy and vitamin A Percent of adolescent girls with macronutrient intake below WHO DRI: 50% protein, 73% energy and 17% dietary fibre Percent of school girls with intake of macronutrients above WHO DRI: 59% protein, 36% energy and 92% fibre Percent of adolescent girls with micronutrient intake below WHO DRI: iron 55%, folate 79%, riboflavin 55%, vitamin C 20% and vitamin A 48% Percent of adolescent girls with micronutrient intake above WHO DRI: iron 54%, folate 30%, riboflavin 54%, vitamin C 89% and vitamin A 61%
8	Akhter et al. [37], 2013	Calcium and vitamin D related knowledge in 16–18 years old adolescents: does living in urban or rural areas matter?	Cross-sectional survey	Children aged 6–18 years from urban and rural areas, Bangladesh (n = 2,992)	Food frequency questionnaire	Lack of knowledge and awareness of calcium and vitamin D Rural children were less familiar with vitamin D and osteoporosis, had higher diet milk consumption, engaged more in outdoor activities and had more exposure to sunlight
9	Elhisadi [61], 2013	Food and nutrients intake among Libyan school children	Cross-sectional survey	Schoolchildren aged 6–9 years, boys and girls, Ghana (n = 550)	24-Hour dietary recall, food frequency questionnaire	The average daily intake of total protein was 226% (±25.4 SD) There was a higher intake of protein among boys than girls Students overall consumed at least the RDA for all vitamins with the exception of vitamin B6 and carotene, which were nearly 1.5 times the recommendation Energy intake expressed as a percentage of RDA of all children was 76% of RDA (±5.8) The schoolchildren in this study, of both sexes, reported an average daily vitamin B6 and carotene intake of 149% (±9.6) and 129% (±52.2), respectively The average intake of total fat in percent of RDA was 91% (±9) The average daily fibre intake was 10.0 g (±7.9)

Table 1 (continued)

No.	Author	Study title	Study design	Participants and study setting	Dietary intake assessment method	Main findings
10	Masibo [40], 2013	Effects of Initial Nutritional Status on the Responses to a School Feeding Programme among School Children Aged 6–13 years in the Millennium Villages Project, Siaya, Kenya	Longitudinal study	Schoolchildren aged 6–13 years, Kenya (n = 220)	Food frequency questionnaire	Energy intake was below the estimated energy requirement for 66% of the children Low fat intake Inadequate intake of vitamin A, calcium, zinc and selenium based on EAR Protein and vitamin C intake was above the RDA and EAR, respectively
11	Acham et al. [91], 2012	Breakfast, midday meals and academic achievement in rural primary schools in Uganda: implications for education and school health policy	Cross-sectional survey	Schoolchildren in Kumi district, eastern Uganda (n = 645)	Meal patterns – quantitative questionnaire	School achievement was significantly associated with consumption of breakfast and a midday meal, particularly for boys
12	Kawade [52], 2012	Zinc status and its association with the health of adolescents: a review of studies in India	Intervention, provision of zinc-rich dietary supplements and ayurvedic jasad zinc tablet	Girls aged 10–16 years from two secondary schools, India (n = 630)	24-Hour recall method on 3 random days including Sunday	The prevalence of micronutrient deficiencies was high in these girls Poor cognitive performance was seen in half of the girls, and salt taste perception was affected in 45% Adolescent micronutrient quality index was correlated with nutrient intakes and blood micronutrient levels Results of the intervention trial indicated that supplementation of zinc-rich recipes vis-à-vis ayurvedic jasad zinc tablets had the potential to improve plasma zinc status, cognitive performance and taste acuity in adolescent girls
13	Hinnig and Bergamaschi [57], 2012	Food items in the food intake of children aged seven to ten years	Longitudinal study	Schoolchildren aged 7–10 years, Brazil (n = 115)	Three-day food diaries	Rice beans and lentils contributed significantly to the total intake of energy and carbohydrates Milk significantly contributed to the total intake of lipids, protein and energy Carbohydrates and energy intake from sugar-sweetened beverages (sodas and processed juices) were important contributors to the total diet intake of the children
14	Semproli et al. [79], 2011	Nutrient intake in 5–17-year-old African boys and girls in a rural district of Kenya	Cross-sectional study	Schoolchildren and adolescents aged 5–17 years, Kenya (n = 1,442)	24-Hour dietary recall	The diet was deficient in sodium, calcium and potassium Nutrient adequacy ratios were correlated to anthropometric values, particularly in males There were no correlations between anthropometric characteristics and sodium or vitamin C (in males and females) and vitamin A or potassium (in females)

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Table 1 (continued)

No.	Author	Study title	Study design	Participants and study setting	Dietary intake assessment method	Main findings
15	Gharib and Rasheed [49], 2011	Energy and macronutrient intake and dietary pattern among school children in Bahrain: a cross-sectional study	Cross-sectional descriptive study	Schoolboys and -girls aged 6–18 years, Bahrain (n = 2,594)	24-Hour dietary recall	Average energy intake was close to the estimated average requirements Protein intake substantially exceeded the reference nutrient intake values as did daily sugar consumption Dietary fibre intake was below the dietary reference values Energy percent limits for total fat, saturated fat and cholesterol in 36–50% of the students The polyunsaturated:saturated fat ratio remained at an unacceptable level of 0.6 for girls and boys 50% daily consumption of soda drinks High consumption of sweets, especially among girls (64.2 compared to 47.5% for boys) 50% consumed milk One fourth were taking fruits and vegetables
16	Abrahams et al. [7], 2011	What's in the lunchbox? Dietary behaviour of learners from disadvantaged schools in the Western Cape, South Africa	Cross-sectional survey	Grade-4 learners aged 10–12 years, South Africa (n = 717)	24-Hour dietary recall and dietary diversity score	69% of learners carried a lunchbox to school and 49% had consumed at least one item purchased from the school food shop/vendor Most lunchboxes contained white bread with processed meat, whereas the most frequent food shop/vendor purchase comprised chips/crisps Children who carried a lunchbox to school were significantly associated with a lower BMI, were younger, had a higher standard of living, higher dietary diversity scores, consumed more meals per day, had greater self-efficacy and came from predominantly urban schools Eating food from the vendors and shops was associated with a lower standard of living score and higher dietary diversity and meal scores
17	Onimawo et al. [63], 2010	Assessment of anaemia and iron status of school age children (aged 7–12 years) in rural communities of Abia State, Nigeria	Cross-sectional study	Schoolchildren, 120 males and 129 females, Nigeria (n = 249)	24-Hour dietary recall, food frequency questionnaire and weighed inventory technique	Prevalence of anaemia was 82.6%, while iron deficiency was 77.8% The average daily iron intake was 30% below the RDA The main foods consumed by these rural children were rice, beans and cassava processed into garri or foofoot; these foods contain non-heme iron as well as several iron inhibitors like tannins, polyphenols and phytates
18	Venter and Winterbach [22], 2010	Dietary fat knowledge and intake of mid-adolescents attending public schools in the Bellville/Durbanville area of the city of Cape Town	Cross-sectional descriptive survey	Adolescents aged 17 years attending public schools, South Africa (n = 168)	Qualitative screening questionnaire	The learners had relative knowledge of dietary fat Adolescents' diets were classified as typically Western, high in fat Dietary fat knowledge was positively associated with their fat intake
19	Nago et al. [55], 2010	Food, energy and macronutrient contribution of out-of-home foods in school-going adolescents in Cotonou, Benin	Cross-sectional study	Adolescents aged 13–19 years, Benin (n = 656)	24-Hour dietary recalls on 2 non-consecutive school days	Out-of-home prepared foods contributed more than 40% of the daily energy, fat, protein, carbohydrate and fibre intakes and of the daily weight of food in the adolescents Out-of-home foods popularly taken at breakfast and afternoon snacks providing more than three quarters of the daily energy intake Low consumers of out-of-home foods ate more fruit and vegetables and cereal grain products than high consumers High consumers of out-of-home foods took more sweets and ate energy-dense foods

Table 1 (continued)

No.	Author	Study title	Study design	Participants and study setting	Dietary intake assessment method	Main findings
20	Collison et al. [38], 2010	Sugar-sweetened carbonated beverage consumption correlates with BMI, waist circumference, and poor dietary choices in school children	Cross-sectional study	Adolescents aged 10–19 years, Saudi Arabia (n = 9,433)	Seven-day food frequency questionnaire	The overall prevalence of overweight and obesity was 12.2 and 27.0%, respectively, with boys having higher obesity rates than girls ($p \leq 0.001$) Waist circumference and BMI was positively correlated with sugar-sweetened carbonated beverage intake in boys only Sugar-sweetened carbonated beverage intake was positively associated with poor dietary choices in both males and females Fast-food meal intake, savory snacks, iced desserts and total sugar consumption correlated with sugar-sweetened carbonated beverage intake in both boys ($r = 0.39, 0.13, 0.10$ and 0.52, respectively, $p < 0.001$) and girls ($r = 0.45, 0.23, 0.16$ and 0.55, respectively, $p < 0.001$) Older children reported eating significantly less fruit and vegetables than younger children, and less eggs, fish and cereals
21	Bishwalata et al. [66], 2010	Overweight and obesity among schoolchildren in Manipur, India	Cross-sectional study	Schoolchildren, India (n = 3,356)	Qualitative dietary habits/patterns	Watching television for >2 h a day, higher family income, not eating other types of vegetables in the past week was associated with obesity
22	Hong et al. [44], 2010	Factors associated with overweight/obesity in Ho Chi Minh city	Cross-sectional study	Students aged 11–16 years, China (n = 678)	Food frequency questionnaire	Determinants of overweight and obesity were: sex (higher in males), age (higher in younger children), schools located in wealthy districts, higher family economic status, higher parental education, overweight or obese parents, more time spent watching TV, frequent consumption of soft drinks and more time studying after class The odds of overweight and obesity were lower with physical activity, availability of fruits at home, frequent consumption of fruit and vegetables
23	Flores et al. [43], 2009	Energy and nutrient intake among Mexican school-aged children, Mexican National Health and Nutrition Survey 2006	Cross-sectional National Health and Nutrition Survey	Children aged 5–11 years, Mexico (n = 8,716)	Food frequency questionnaires	Median energy intake was 1,501 kcal/day (percent adequacy: 88.0) Children with the lowest socioeconomic status, indigenous Mexicans and those from rural areas showed the highest inadequacies for vitamin A, folate, zinc and calcium Overweight children and those with the highest socioeconomic status had a higher risk of excessive intakes
24	Francis et al. [19], 2009	Fast-food and sweetened beverage consumption: association with overweight and high waist circumference in adolescents	Cross-sectional survey	Adolescents aged 15–19 years, Jamaica (n = 1,317)	Food frequency questionnaire	High waist circumference was associated with the absence of fruit consumption Overweight was associated with high sweetened beverage consumption
25	Mitchikpe et al. [59], 2009	Seasonal variation in food pattern but not in energy and nutrient intakes of rural Beninese school-aged children	Longitudinal study	Children aged 6–8 years, Benin (n = 80)	Observed weighed records	Food pattern showed seasonal variations Cereals, roots and tubers were the main staple foods Contributions of animal products to the diet were very small There were no differences in food patterns based on sex or/and if or not children were attending school Median daily energy intakes were not different between seasons Fat and vitamin C intake showed seasonal differences Energy and nutrient intakes were different for boys and girls

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Table 1 (continued)

No.	Author	Study title	Study design	Participants and study setting	Dietary intake assessment method	Main findings
26	Gewa et al. [51], 2014	Determining minimum food intake amounts for diet diversity scores to maximize associations with nutrient adequacy: an analysis of schoolchildren's diets in rural Kenya	Cross-sectional survey	Schoolchildren, mean age 7 years, Kenya (n = 529)	Three non-consecutive 24-hour recalls	Only DDS based on a 15-gram minimum and DDS based on nutrient content were significantly associated with mean probability of adequacy after adjusting for energy intake
27	Kim and Lee [50], 2008	Relationships between the nutrient intake status, dietary habits, academic stress and academic achievement in the elementary school children in Bucheon-si	Cross-sectional study	Fifth-graders in Bucheon-si, Gyeonggido, South Korea (n = 224)	24-Hour dietary recall	The overall nutrient intake and dietary habits were fairly good Calcium and folate intake was less than 75% DRIs Dietary habits of boys were inferior There was a relationship between higher energy, protein, phosphorus, potassium, zinc, polyunsaturated fatty acids and n-6 fatty acid intakes The overall academic performance was higher for those eating out less frequently Children with higher comprehensive dietary habit scores had a better academic performance
28	Li et al. [62], 2008	Factors associated with adolescents overweight and obesity at community, school and household levels in Xi'an City, China: results of hierarchical analysis	Cross-sectional nutritional study	Adolescents aged 11–17 years, China (n = 180)	24-Hour dietary recall, food frequency questionnaire	Factors associated with overweight and obesity: higher energy intake, living in urban areas, low physical activity, high household wealth, parental restrictions on purchasing snacks, parents being overweight and obese, having soft drinks more than four times per week, availability of home video games and not fussy about foods Eating sweets was negatively associated with overweight and obesity Boys had higher levels of overweight and obesity
29	Krittaphol et al. [60], 2006	Primary school children from northeast Thailand are not at risk of selenium deficiency	Cross-sectional study	Rural schoolchildren aged 6–13 years, Thailand (n = 515)	One-day weighed diet records	Low, median intakes of energy, calcium, iron, zinc, vitamin A, B2, B2, C, niacin and dietary fibre Adequate protein intake Low dietary quality and low median energy intake was higher among stunted children compared to non-stunted children No selenium deficiency
30	Mai et al. [13], 2003	Micronutrient status of primary school girls in rural and urban areas of south Vietnam	Cross-sectional study	Girls aged 7–9 years, Vietnam (n = 284)	24-Hour dietary recall	The dietary micronutrient pattern of the rural group showed deficiency of iron, calcium, phosphorus, potassium, magnesium, β-carotene, vitamin A and vitamin C In contrast, adequate consumption of these elements, except low β-carotene, was observed in the urban group
31	Ahmed et al. [41], 2006	Anaemia and vitamin A status among adolescent schoolboys in Dhaka City, Bangladesh	Cross-sectional study	Boys aged 11–16 years from 10 schools, Dhaka City (n = 381)	Food frequency questionnaire	Poor dietary habits Age, BMI, parents' occupation, serum vitamin A level and frequency of intakes of meat and fruit were significantly independently related to haemoglobin level

BMI = Body mass index; DRI = dietary reference intake; RDA = recommended dietary allowance; EAR = estimated average requirement; TV = television; DDS = dietary diversity score.

as the time concept required for a comprehensive dietary intake review may not be fully developed in the school-age child [36]. While parents provide reliable recalls of food intake for children under the age of 8 years in the home setting, they may not be fully informed about the food consumed away from home. Dietary recall in adolescents is affected by lack of motivation to respond to dietary intake questionnaires, and body image may affect the willingness to report [36]. Assessment of dietary intake of adolescents is influenced by underreporting and misreporting, which is common among overweight and obese adolescents given that dietary intake is a major concern for them [7, 37–40].

There is a lack of population-specific dietary assessment tools in many developing countries. The duration of recall time, collection techniques and quantification of food intake data were observed to differ to a large extent across different studies. Food frequency questionnaires are the most commonly used method of assessing dietary intake in schoolchildren and adolescents in developing countries [19–21, 37–48]. The use of single 24-hour recalls was also relatively common [5, 7, 13, 42, 49, 50], while some studies used repeated 24-hour recalls [51–56]. Less commonly applied methods were 3-day food diaries [57], 7-day food diaries [58], observed weighed records [59] and 1-day weighed diet [60], while yet others used a combination of one or two methods [61–63]. To a lesser extent, qualitative methodologies were applied especially for an adolescent population. This method of dietary assessment was more frequently applied in adolescents [22, 64, 65] than in schoolchildren [66].

A reliable food composition database that provides information on the nutrient composition of various foods and their bioavailability is necessary to assess dietary quality and estimate nutrient intake.

Methodological differences also occur with regard to the person interviewed to provide information on dietary intake for schoolchildren. In some studies, either the child [67–69] or the parents/caregivers were interviewed [13, 40, 45, 46, 70], while in others, both the parent and child were involved in answering the dietary intake questionnaires [13, 61, 69, 71]. There were differences in the administration of questionnaires; some parent-child pairs were interviewed at school [72], while in others, the questionnaire was self-administered [61].

It is noted that studies made efforts to increase the reliability of dietary recalls using food models, photographs or pictures [13, 42, 46, 68, 71, 73]. Determination of portion sizes is diverse in the studies reviewed. Household measures are mainly used to estimate portion sizes [46]. Methods of analysing diet quality also differed between the studies. For example, principle component analysis was used in Columbia [21] and in Kenya [51], while a healthy eating index was developed for diet quality analysis in Brazil [71, 73]. The comparability of dietary intake data is further affected by seasonality. Some studies are designed to measure seasonal variability in food intake, while the majority do not take this into consideration [45]. Although some researchers have used validated dietary intake assessment tools for schoolchildren [10, 19, 74–77], a number of others did not report the use of such tools.

Food Composition Databases

A reliable food composition database that provides information on the nutrient composition of various foods and their bioavailability is necessary to assess dietary quality and estimate nutrient intake. There are various types of food composition databases used for estimating the nutrient intake in developing countries depending on the availability of country-specific food composition databases. The variability of diets and composite meals across various regions, countries and in-country differences makes it difficult to find uniformity in the use of common food composition tables. This limits comparability of nutrient intake between countries and regions within one country. The general strategy observed in the reviewed literature was the adoption of global food composition databases with modifications to fit in specific foods not available in the global datasets. In a few of the countries, there are county-specific food composition databases, for example in India [54], Benin [59], South Africa [78] and Brazil [73]. Integrated use of local and international food composition databases was reported in Brazil [21, 53], Kenya [40, 46, 79], Thailand [10], Malawi [72], Libya [61], Bahrain [49] and Vietnam [13].

Estimating Nutrient Adequacy

The most commonly used methods of estimating nutrient adequacy in schoolchildren include the use of recommended daily allowances (RDAs) [13, 54, 58, 61, 71, 80] and various dietary reference intakes (DRIs) [45, 49–

51]. In adolescents, the reference standards used to define adequacy of nutrient intake include the DRIs [81], RDAs [82] and reference nutrition intakes [59, 65]. In addition to the use of different dietary reference standards, reporting of nutrient adequacy was different in the various studies. Some studies reported the percent of subjects with adequate or inadequate intake [83–86], while others reported the mean or median nutrient intake or average intake [87–90]. These differences in reporting adequacy of nutrient intake limit comparability across various studies.

Dietary Diversity

School-age children in developing countries are mainly consuming plant-based diets which are predominantly from cereals, roots and tubers with limited animal source foods [41, 42, 45–47, 51, 56, 59, 65, 83, 84]. This dietary pattern is especially common in rural communities. In some studies, the intake of milk and dairy products was observed in 50% of schoolchildren [49], while in others, milk was completely missing from the diet [41, 51]. Cereals and snacks were the most important sources of energy,

School-age children in developing countries are mainly consuming plant-based diets which are predominantly from cereals, roots and tubers with limited animal source foods.

contributing 27 and 18%, respectively, of the daily energy intake among schoolchildren of 6–12 years in Taiwan [84]. Over 7 days, 78% of adolescent boys did not consume liver, 33% did not consume milk, 38% did not consume small fish, 21% did not consume large fish and 23% did not consume dark green leafy vegetables in Bangladesh [41]. Animal products contributed only 7% of daily protein intake among Benin school-age children, while cereals provided 34 and 50% of the daily iron intake during post- and pre-harvest seasons, respectively [59]. The inadequate intake of dark green leafy vegetables [41, 51, 64, 83] and fruits [84] is important to note. In Taiwan, schoolchildren aged 6–9 and 10–12 years took 1.6 and 2.0 servings of dark green vegetables daily, respectively, and had a daily fruit intake below 1 serving [84]. Fruit and vegetables were eaten rarely by 56 and 48% of adolescents in Ghana, respectively [64]. In Brazil, 13% of the children met the diet quality index for meat and legumes, while none of the children aged 7–8 years met the diet quality index for vegetables [73]. On the other hand, some studies reported a high intake of fruits rich in vitamin C [51], with seasonal variability of vitamin C-rich food sources reported in another study [45].

Meal Patterns and Food Choices

Varied meal patterns were reported among schoolchildren and adolescents. Breakfast was often skipped or rarely eaten by schoolchildren [5, 7, 64, 65, 70, 85] and adolescents [64], especially in rural areas. In Kuala Lumpur, 20% of schoolchildren and adolescents skipped at least one meal a day [85], especially skipping breakfast (12.6%), followed by lunch (6.7%) and dinner, which was not eaten by 4.4% of the students [85]. In Ghana, 32% of adolescents rarely ate breakfast [64]. Where breakfast was eaten, it was often reported to be a plain cup of tea, with milk and groundnuts, millet porridge or leftover food from the previous evening [65]. Breakfast contributed the lowest percentage (10%) of total daily energy in schoolchildren in Kenya [86].

There is an increasing trend towards the consumption of processed foods, especially in urban settings. Foods such as bread, cookies, sweets, soft drinks, ice cream, sweetened beverages, sausages, cheese, sweets and canned foods [49, 56, 87] which are high in sugar, saturated fat, sodium and salt were preferred particularly by the adolescents [39, 49, 53, 88]. School canteens that stock foods with a high energy density further increase the consumption of these foods [14]. This shift is intensified by the rapid replacement of traditional diets with 'western diets' [49, 89, 90]. Only one fourth of schoolchildren had a daily consumption of vegetables and fruits in Bahrain, while soda drinks were consumed daily by 50% of the schoolchildren [49]. These foods are eaten mainly away from home and make a large contribution to the overall diet [55]. The extent to which schoolchildren were consuming fast foods and high-energy foods was high, as is illustrated by the high percentage (60–70%) of Malay schoolchildren and adolescents who consumed these foods weekly [85].

Energy Intake

The intake of energy was inadequate for the majority of schoolchildren and adolescents [5, 21, 49, 54, 61, 69, 80, 86, 91–93]. The sources of energy, especially for those from poorer households, were limited to a monotonous intake of a few staples. In a peri-urban setting in Kenya, only 17.3% of the schoolchildren aged 4–11 years received adequate energy [5], whereas 50–64% of Bahraini students consumed barely adequate or less than adequate energy [49]. The findings of a study in Accra, Ghana, to compare the nutritional status of children in boarding

schools with non-boarders, revealed that only 11–27.3% of the children attained the RDA based on age and sex [92]. In Libya, 76% of the schoolchildren attained the RDA for energy [61], and in Brazzaville, Congo, the mean intake of energy for girls (1,998.9 ± 448 kcal) was close to the RDA [94]. In Mexico, 88.0% of the children had adequate amounts of energy [43].

For most of the children, the total energy consumed during the day was not well distributed among the meals. Breakfast contributed the least proportion of the day's energy because most of the children went to school without breakfast [5, 64, 86]. Among schoolchildren in a peri-urban setting in Kenya, breakfast contributed 10.2% of the total energy requirement instead of the recommended 30% [5]. Similarly, for children in an orphanage in the outskirts of Nairobi City, breakfast contributed only 11.2% of the total daily energy intake [5]. Lunch and the evening meal contributed the largest proportion of the day's total energy requirement [5, 79, 94]. In Kenyan primary schoolchildren, lunch contributed 44.5% and supper 45.3% of the total energy requirement for the day [5]. In Brazzaville, Congo, the evening meal provided 67.5% of the mean intake of kcal per day [94]. Many of the studies did not report the proportion of children not receiving adequate amounts of energy but reported the mean intake of energy compared to the RDA.

Macronutrients Intake

Protein Intake

On the whole, the findings show that the amount of protein consumed is adequate for the majority of the children and adolescents [43, 49, 59, 69]. Among the Bahraini students, the mean intake of protein exceeded the reference nutrition intake for all age groups and sex by between 1.5 and 2.5 times [49]. In Libya, the mean intake of protein among schoolchildren was 226% of the RDA [61]. In Ghana, schoolchildren, both boarders and non-boarders, attained 100% of the RDA for protein across age groups and sex [92]. The main source of proteins for the majority of children was from plant foods.

Fat Intake

Some studies revealed a higher intake of fats than recommended, especially for those children and adolescents from middle- and high-income settings, particularly from urban areas [21, 22], whereas some children and adolescents consumed less fat than the recommended amounts [59]. A study conducted in Accra, Ghana, among children showed that the mean intake of fats was 44.74 ± 20.22 g, which was higher than the RDA for this age group of children [92], and another study in Bahrain indicated that 36–50% of the children exceeded the energy limits for fats, both saturated fats and cholesterol [49]. The intake of fats depends on the foods most commonly consumed. For example, a study conducted in Cape Town reported that the consumption of fats was high or low depending on whether a child's intake of animal products was frequent or not [22].

Findings show that the amount of protein consumed is adequate for the majority of the children and adolescents.

Fibre

Data on fibre intake among school-age children and adolescents from developing countries do not present a specific pattern. Excessive intake of fibre was reported among schoolchildren in some studies [42, 59], while inadequate intake of dietary fibre was reported in others [43, 49, 61, 81]. Considering the recommended WHO DRI of 30 g of fibre per day, the average intake among schoolchildren was as low as 10 g/day in Libya [61] and 14 g/day in Mexico [43] and just adequate (31 g/day) in Cameroon adolescent girls [95]. In addition, daily dietary fibre intake was inadequate in 91% of adolescent girls in Tehran [81]. On the other hand, a median fibre intake of 53 g/day was reported in Beninese school-age children [59], while in Uganda, 84.5% of school girls had a fibre intake above the WHO DRI (30 g) [42].

Micronutrient Intake

Micronutrient intake among school-age children in developing countries is generally suboptimal. The most commonly reported vitamins with inadequate intake are vitamins A, B_1, B_2, B_3, B_{12}, folate and β-carotene [13, 42, 45, 46, 54, 79, 95]. At the same time, there is an indication of adequacy of intake of some vitamins, especially of vitamin B_6 [42, 81]. For example, in Ugandan schoolchildren, the average daily intake of vitamins A, C, B_1, B_2, E and folate was 61, 68, 54, 82, 56 and 17% of the RDA, respectively. In the same study, the intake of vitamin B_6 and carotene was above the RDA (145 and 129% of the RDA, respectively) [42]. Inadequacy of vitamin A intake in Ethiopian schoolchildren was as high as 85%, while only 33% of rural and 32% of urban children had sufficient intake of vitamin A in India [54]. In urban Cameroon, the percentage of adolescents with vitamin intake below the

estimated average requirement ranged from about 20% for vitamin A to 80% for folate, especially among girls [64]. In adolescents, an inadequate intake of vitamin B_{12}, folate and vitamin A was reported to be 83.9, 81 and 45.3%, respectively, while on the other hand, vitamin C, B_1, B_2 and B_6 intake was adequate in 95, 97, 83 and 100% of the adolescents, respectively [81].

The intake of minerals among schoolchildren and adolescents in developing countries is also generally suboptimal. Studies showed inadequate intake of iron, calcium and zinc [42, 45, 46, 54, 61, 79, 81, 95, 96] in schoolchildren and adolescents as well as inadequate intake of phosphorus, potassium and magnesium [13] in schoolchildren. For example, in Uganda, the average intake of calcium and zinc was 56 and 70% of the RDA, respectively, while the intake of magnesium, phosphorus and iron was above 100% of the RDA in schoolchildren [42]. In Libyan schoolchildren, calcium and iron intake was 56 and 70% of the RDA, respectively [61]. Adolescents had inadequate intake of calcium (71%) and zinc (95%) in Iran [81]. Inadequate intake of selenium was less commonly reported [96]. Although intake of iron was adequate in some cases, it was mostly derived from plant sources [82] with limited bioavailability.

Discussion

Dietary intake data for children and adolescents are critical to guide appropriate interventions to improve their health and growth. Various methods for collecting data on food consumption are available, but no single best method exists and, therefore, validation of methods needs to be conducted for various countries and contexts. Validation of dietary intake methods was not conducted in most of the studies reviewed, which may have implications for the accuracy and reliability of the findings. Food records, both estimated and weighed, provide accurate quantitative information on food consumed and are considered the gold standard with which other dietary assessment methods are compared [50]. Very few studies used these methods of data collection, probably because of the expense involved. The 24-hour recall was common because it is quick and inexpensive to administer and has high respondent compliance. Whereas the 24-hour recall is appropriate for estimating intake of groups of people, it does not represent the usual consumption. This limitation can be minimised by conducting multiple 24-hour recalls. Few studies conducted more than one 24-hour recall. The popularity of the food frequency questionnaire is due to the fact that it estimates the usual food consumption and may thus be more representative of an individual's usual intake than a 24-hour recall. The food frequency questionnaire is also relatively inexpensive to conduct and fast to administer, and it is easy to process the data [97].

Children less than 8 years of age have limited cognitive ability to self-report food intake [36]. In most of the reviewed studies, the questionnaires on dietary intake were completed at school by the children with little involvement of the parents and with few of the studies discussing the age of the children as a limitation to data collection. Schoolchildren are known to underreport dietary intake, thus limiting reliability of information [98–100]. Overestimation of dietary intake has also been observed in self-reported validation studies among school-age children [101, 102]. These limitations of dietary assessment methods need to be kept in mind when interpreting dietary intake data in schoolchildren and adolescents. There is need to validate in-county dietary assessment methods in many of the developing countries.

Dietary intake data for children and adolescents are critical to guide appropriate interventions to improve their health and growth.

Energy consumption is not well distributed over the meals of the day. Many children from low socioeconomic backgrounds go to school with a hungry stomach because they do not take breakfast. Breakfast contributes the least and the evening meal the most energy for such children. This may interfere with their level of attention in class and may have negative implications for the achievement of educational objectives and interfere with school enrolment, attendance and performance. This effect has been demonstrated in Ghana [64] and Uganda [91] where taking breakfast was associated with better school performance. This is especially true in situations where no meal is provided at school, which is the case in many developing countries where school lunches are limited to areas of high food insecurity and where world food programmes provide school meals to increase enrolment and attendance [103]. An association between school lunches containing animal source foods that increased the intake of micronutrients and had a positive effect on cognitive development, body composition and growth was demonstrated in Kenya by Neumann and collaborators [9, 104–106] and was pointed out in a systematic review by Kristjansson et al. [12].

Emerging evidence demonstrates that overweight and obesity are increasing in the developing world. Three quarters of the obese population worldwide are projected to be in non-industrialised countries by the year 2025 [107]. The state of being overweight coexists with undernutrition in developing countries [108]. In some parts of Africa, increased weight and fatness affect more children than malnutrition, signifying the double burden of malnutrition [109]. Childhood obesity is increasingly becoming a public health problem in the developing world because it is associated with serious health problems and the risk of premature illness and death later in life. Consequently, the prevalence of non-communicable diseases such as hypertension, cardiovascular diseases, type 2 diabetes and osteoarthritis is becoming a public health concern.

Eating patterns and diet quality have emerged as important determinants of obesity in children [21]. Obesity is thought to be associated with children's increased exposure to calorie-dense foods and sedentary lifestyle choices [110]. Although some genetic predispositions contribute to childhood obesity, its rapid increase in genetically stable populations indicates the importance of social and environmental factors in causing obesity. Strong associations between childhood obesity and daily lifestyle factors are reported, suggesting that many of the causes are environmental [111].

In some parts of Africa, increased weight and fatness affect more children than malnutrition, signifying the double burden of malnutrition

Some of the studies reviewed showed that children and adolescents, particularly those from higher socioeconomic status and urban areas, tend to consume more than adequate amounts of energy, confirming the nutrition transition taking place in the developing countries. A large proportion of the energy consumed is obtained mainly from the increased intake of high-calorie foods [19, 21, 57], which is associated with the development of adiposity and increases the risk of being overweight or obese as an adult in the future [18]. Typical urban lifestyles, technological advances and better economic status are accompanied by increased access to and consumption of energy-dense foods and sedentary activities [112, 113]. Consequently, children and adolescents have a positive energy balance and increased adiposity [114, 115].

The findings of this literature review confirm the changing trends in dietary patterns of children and adolescents [14, 116]. The consumption of soda and other sweetened beverages and fast foods [19, 21] is a risk factor for overweight and obesity [62]. Many children's and adolescents' diets are inadequate with respect to vegetable and fruit intake and, thus, are most likely to be low in fibre and consequently associated with a high waist circumference and, therefore, overweight and obesity [19, 66]. Low-intensity physical activity is associated with obesity in adolescents [96].

Conclusions

The dietary intake in the developing countries is interpreted based on global references and food tables because a majority of the countries do not have country-specific reference tables. Therefore, there is a need for countries to develop appropriate and relevant country-specific reference and food bases.

On the whole, the diets consumed by children and adolescents in the developing countries are inadequate in terms of energy and fats and a majority of the micronutrients. The diets are also limited in diversity and meal patterns are inappropriate, consequently interfering with the distribution of nutrients over the day. On the other hand, there are some children who consume more than adequate amounts of calories and high-energy-dense foods, which contributes to the increasing occurrence of overweight and obesity in schoolchildren and adolescents in developing countries. Interventions to mitigate this trend should therefore also be prioritised even as undernutrition is emphasised.

In view of the fact that many children go to school without breakfast, interventions for dietary improvements should consider providing school meals for improved health and performance of the children. There is a need for nutrition education for school management, children, parents and the community at large to sensitise them on healthy eating habits, especially to avoid the consumption of high-calorie-dense foods and to choose healthy and diverse diets. School management should also ensure that only healthy foods are sold at school and children and adolescents are encouraged to participate in physical activities to tame the increasing levels of overweight and obesity in this population.

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