REVIEW

Healthy and Sustainable Dietary Patterns in Children and Adolescents: A Systematic Review

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ABSTRACT

The need for adherence to a healthy and sustainable dietary pattern in the pediatric stage is discussed worldwide, being linked to a progressive incidence of noncommunicable diseases in adulthood. The aims of this systematic review were to summarize the healthy and/or sustainable dietary patterns, defined a priori, described in the literature for use during the pediatric stage; to evaluate the adherence to these dietary patterns; and identify the health-related benefits associated with adherence to these patterns. A literature search was carried out on Medline, Scopus, and Web of Science from 2010 up to 2021, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A total of 128 articles were included according to the following criteria: participants 2–17 y old, healthy and/or sustainable dietary patterns defined by an a priori methodology; articles written in English or Portuguese; and published since 2010. Fifty instruments with 14 adaptations that measure adherence to healthy and/or sustainable dietary patterns in children and adolescents were found. The Mediterranean Diet was the most studied dietary pattern. Adherence to healthy and/or sustainable dietary patterns has wide variations worldwide. Most of the instruments described have been little studied at pediatric ages, reducing the ability to extrapolate results. Higher adherence to these dietary patterns was associated with lower body fat, waist circumference, blood pressure, and metabolic risk. There is no consensus regarding the association with BMI. No studies have proofs of the sustainability characteristics of these instruments, it being necessary to produce a new sustainable instrument or test the association of the previous ones with, for example, the ecological footprint. Further validations of these instruments in each country and more prospective studies are needed to establish temporal relations with health-related outcomes.This systematic review was registered at www.crd.york.ac.uk/prospero/ as CRD42020221788. *Adv Nutr* 2022;13:1144–1185.

Statement of Significance: This is the first article to systematically search and review the scientific literature available on healthy and sustainable dietary patterns in children and adolescents.

Keywords: feeding behaviors, diet, children, adolescent, health, sustainability, systematic review

Introduction

According to the FAO, a dietary pattern is defined as "the quantities, proportions, and combinations of different foods and beverages in diets and the frequency of how they are habitually consumed" (1). It is estimated that diets are connected to around one-third of the human influence on climate change and land use (2). The increase of the world population as well as the changes in food consumption patterns, in particular the increase of meat consumption (3), disturb climate, food security, ecosystem health, and populations' health and nutrition (4, 5). Therefore, it is urgent to face the existence of a global unsustainable food system that produces climatic, socioeconomic, political, and financial crises (5). The world needs sustainable diets, with low-input, local, and seasonal food production and a short production–consumption distance. Although there is currently no universally agreed-upon definition of a "sustainable diet," FAO experts, in 2010, agreed that:

> Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources. (6)

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Globally, there has been a reduction in the adherence to these sustainable dietary patterns over the decades, such as the Mediterranean dietary pattern (7). This dietary pattern is widely known in the literature to be sustainable on account of having a low ecological footprint, because it is rich in fruits and vegetables and low in meat. Besides, its characterization by biodiverse, eco-friendly, and traditional consumption helps benefit future generations (8). Lower adherence to the Mediterranean Diet (MD) appears to be more prevalent among the young, and children and adolescents (<18 y old) seem to be a particular cause of concern (9, 10).

A healthy dietary pattern can be defined as one which complies with dietary guidelines' recommendations in relation to food group consumption. Adherence to healthy dietary patterns reflects achieving all nutrient and energy requirements. Nonadherence to healthy diets is linked to a progressive incidence of noncommunicable diseases such as the rise of pediatric obesity (11) and cardiovascular diseases (12). The assessment of healthy dietary patterns in children and adolescents, as well as the identification of their main modifiable determinants, are extremely important because food habits and behaviors developed in childhood and adolescence tend to track into adulthood (13, 14) and can predict adults' diet-related diseases (15).

For all these reasons, nutrition and health education regarding healthy and sustainable dietary patterns is demanded everywhere, particularly from childhood (16). It is urgent to profoundly change the world's current dietary pattern and promote culturally appropriate, biodiversity-based, ecofriendly, sustainable, and healthy diets starting in childhood (5, 6). As such, we require the ability to measure the adherence to healthy and sustainable dietary patterns. Commonly, 2 analytical approaches are used to derive dietary patterns: a posteriori and a priori. The a posteriori approach is based on statistical methods and uses dietary information collected from the sample under study. This kind of approach is occasionally difficult because different samples are expected to lead to the extraction of different components, hampering straight comparisons among populations. The a priori approach is defined based on previously established evidence/data which creates predefined dietary patterns (17). The Mediterranean Diet Score (MDS) and the Southern European Atlantic Diet (SEAD) are examples of a priori indexes that measure adherence to the MD and to the Atlantic Diet, respectively (18, 19). However, their utility and validity in pediatric populations worldwide are relatively understudied. The several adaptations of these instruments performed over time also make difficult their evaluation.

Adherence to healthy and sustainable dietary patterns, especially in adults, using a single focus (e.g., MD adherence) has been reviewed previously (20, 21). However, less has been compiled about these dietary patterns in children and adolescents. In 2011, 2 reviews explored diet quality measures in this age range (but only from developed countries) and concluded that research establishing the predictive validity of dietary pattern methods in childhood is needed (22, 23). In 2014 and recently, in 2020, 2 more systematic reviews were conducted regarding this issue (24, 25). However, none of them took into account the sustainability of the instruments found. The present study expands on the information presented in these reviews by incorporating additional studies, as well as investigating the existence of a sustainability factor in the pediatric instruments under review, thereby providing a more thorough and updated summary of the sustainable dietary pattern instruments' characteristics and uses in children and adolescents.

As such, the objectives of this systematic review are *1*) to identify and characterize the healthy and sustainable dietary patterns (defined a priori) used in children and adolescents and described in the literature, also identifying the methodology used for their construction (food items/nutrients included and scoring methods, or others); *2*) to evaluate the adherence to the healthy and sustainable dietary patterns studied in children and adolescents; and *3*) to identify the benefits associated with adherence to the studied dietary patterns. **Supplemental Table 1** presents the answers to the Population, Indicator, Comparator, Outcomes, and Study design (PICOS) question.

Methods

Study design

This systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (26), using the PRISMA guidelines (27), and is registered prospectively with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42020221788).

Search strategy

The search to respond to the systematic review objectives was performed from October to December 2021 in 3 databases, namely Medline, Scopus, and Web of Science.

Search terms were developed by a reviewerwith inputs from the research team. In PubMed, the final search results were identified by using the following expression: ("sustainable diet∗" OR "healthy diet∗" OR "dietary pattern" OR "food pattern" OR "healthy dietary pattern" OR "diet

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Supplemental Table 1 is available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/advances/.

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Abbreviations used: ACARFS, Australian Child and Adolescent Recommended Food Score; ADHD, attention deficit hyperactivity disorder; DASH, Dietary Approaches to Stop Hypertension; DQI-I, Diet Quality Index International; E-KINDEX, Electronic Kids Dietary Index; FAO, Food and Agriculture Organization of the United Nations; fMDS, food frequency–based Mediterranean Diet Score; HDS, Healthy Diet Score; HEI, Healthy Eating Index; HLD Index, Healthy Lifestyle–Diet Index; KIDMED, Mediterranean Diet Quality Index for Children and Adolescents; MD, Mediterranean Diet; MDS, Mediterranean Diet Score; NOS, Newcastle-Ottawa Scale; OPLS, Obesity-Preventive Lifestyle Score; PLD-Index, Preschoolers Diet–Lifestyle Index; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomized control trial; SEAD, Southern European Atlantic Diet; WC, waist circumference.

quality" OR "diet variety" OR "food variety" OR (behaviors, feeding[MeSH Terms])) AND (children[MeSH Terms] OR "young people" OR adolescent[MeSH Terms]) AND ("score" OR index∗ OR (abstracting and indexing[MeSH Terms]) OR "instrument" OR "indicator" OR "diet quality index" OR "diet quality indices"). A similar expression was used for the other 2 databases. Keywords were identified through the existing knowledge of the research team.

Eligibility criteria

Supplemental Table 1 presents the eligibility criteria used to identify studies of interest. In addition, only articles written in English and Portuguese and published since 2010 were included in the systematic review. Specifically in the Medline database, it was possible to search expressions in the abstract. No study design was imposed on the search. However, reviews, abstracts-only, case studies of 1 individual, books, and conference papers were not included. It is important to note that for the inclusion criteria 2 options were considered regarding the inclusion of instruments. At first, only instruments with evidence of being both healthy and sustainable, for example regarding their environmental impact through their association with the ecological footprint or water footprint, were deemed to be targeted. However, owing to the impossibility of fulfilling this criterion (because none of the instruments accomplished the sustainability criterion), this review ultimately considered all healthy instruments for use in those 2–17 y old, indicating that there is no evidence of sustainable instruments to assess dietary patterns in children and adolescents.

After the definition of the exclusion and inclusion criteria, all the references of the selected articles were checked in order to find more relevant information, using the snowballing technique procedure (28).

Study selection and data extraction

Two independent reviewers applied the eligibility criteria and selected the studies of interest for inclusion in this systematic review firstly by reading the titles and the respective abstracts. The other members of the research team confirmed the process. Two reviewers extracted the data and the others checked. Reviewers screened the full-text reports and decided whether these met the inclusion criteria. A third reviewer participated when disagreement in the selection of studies occurred. The reasons for excluding studies were reported in the PRISMA fluxogram (**Figure 1**). Neither the reviewers nor the other authors were blinded to the journal titles or to the study authors. All the necessary information to answer the study objectives had already been published within the articles, so no additional contact with authors was needed. After a full-text reading, a study was included in this review if it could answer ≥1 of the proposed objectives, despite having no data to answer the other ones. This means that an article was included if it had information on *1*) instrument structure and characteristics of a healthy and/or sustainable dietary pattern or *2*) population adherence level to the dietary pattern or *3*) health-related outcomes.

Two tables were designed to summarize the eligible studies. **Table 1** describes the adherence level to the different healthy and/or sustainable dietary patterns and the respective health-related outcomes. **Table 2** presents all the instruments included in this systematic review and their respective and detailed methodology.

The identified records were de-duplicated using Systematic Review Assistant-Deduplication (29) followed by a manual search in Endnote (30). A total of 1286 full-text studies were assessed for eligibility according to the inclusion criteria and 128 were included in the qualitative synthesis (Figure 1). In April 2021, the most recent articles from 2021 were assigned to "Additional records identified" (Figure 1), which data were important to include in this systematic review.

Quality assessment

The Newcastle-Ottawa Scale (NOS) was used to evaluate the quality of all included cohort and case–control studies (31), with an overall quality score ranging from 0 to 9 stars. The adapted NOS for cross-sectional studies was also used in this review, ranging from 0 to 8 stars (32). This adapted version has been used to analyze the quality of previous systematic reviews (33, 34). In addition, the methodological quality and risk of biases of randomized control trials (RCTs) were assessed using the Cochrane Collaboration revised tool for assessing the quality and bias of RCTs (35). Any disagreements among reviewers were resolved by consensus.

Results

Figure 1 summarizes the selection procedure. We analyzed 128 final full-text articles, which are summarized in Tables 1 and 2 (105 cross-sectional studies, 15 cohort studies, 3 case–control studies, and 5 RCTs). As a whole, the studies involved 329,898 subjects with samples varying from 2 (36–45) to 17 y old (41, 46–66). Forty-two articles were published between 2010 and 2015 and 86 between 2016 and 2021. Regarding the geographical distribution, 70 studies were conducted in Europe, followed by America (29 studies), Asia (21 studies), Oceania (7 studies), and Africa (1 study). It is important to highlight that 50 of the articles were from Mediterranean countries, in which Spain stands out, as can be seen in **Figure 2**. Thirty-four and 47 articles provided data on the first (children) or the second decade of life (adolescents), respectively, and 47 presented data regarding both children and adolescents (Table 1).

Regarding quality assessment, the mean ± SD quality score was 6.10 ± 1.01 (min: 3; max: 7) for the cross-sectional studies, 7.67 ± 1.53 (min: 5; max: 8) for the cohort studies, and 6.81 ± 1.08 (min: 6; max: 9) for the case–control studies. With respect to the RCTs, 1 study presented a low risk of bias and 3 articles a high risk of bias.

In this systematic review, 50 instruments plus 14 adaptations were identified, making a total of 64 instruments measuring adherence to healthy dietary patterns, which are presented in Table 1. It is important to consider that none of the instruments found proved to be assessing a

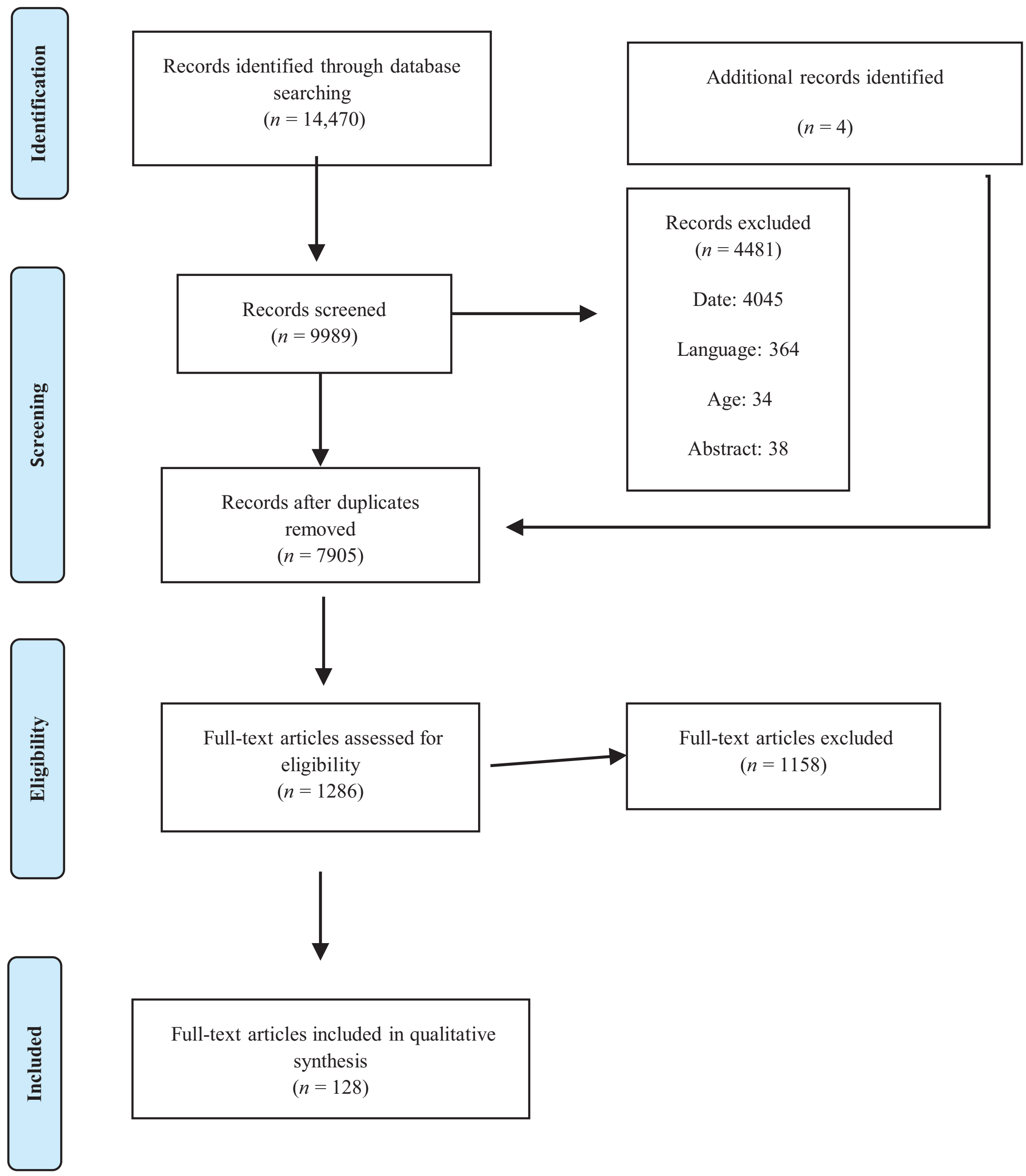

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) fluxogram.

sustainable dietary pattern, in relation to the environmental impact. Geographically, concerning the 50 instruments, this systematic review presents 12 instruments that are based on recommendations from European countries, 10 based on North American recommendations, 8 based on the principles of the MD, 6 based on international recommendations such as those of the FAO and WHO, 5 based on recommendations from Oceania (Australia, New Zealand), 5 based on recommendations from Asia, and 4 based on Brazilian recommendations. The healthy and/or sustainable dietary pattern most studied in children and adolescents was the MD, with 8 different instruments and 50 articles found in this systematic review. Within these instruments, the Mediterranean Diet Quality Index for Children and Adolescents (KIDMED) was the index most often used to assess the adherence of the pediatric population to this dietary pattern, with 38 full-text articles published. It should be noted that none of these instruments have presented objective data on their sustainability, for example through the analysis of their ecological or water footprint and emission of greenhouse gases. In fact, the Chinese Children Dietary Index presented a positive association between diet quality and energy-adjusted diet cost, the economic dimension being one of the pillars of sustainability (67). Table 2 presents all instruments and the respective detailed methodologies.

In general, these scores/indexes were defined based on previous application of a dietary intake assessment method: FFQs, food records, or 24-h dietary recalls (58 out of

TABLE 1 Characteristics of the studies included, evaluating the adherence to healthy and/or sustainable dietary patterns and associated outcomes in children and adolescents[1]

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
KIDMED	Bonaccorsi et al. (85)	Italy	Cross-sectional study	$n = 314$ 6 14 y old 47.8% males	Score range: −4 to 12. Mean ± SD: 5.91 ± 2.40. High adherence: 24.8%. Medium adherence: 56.4%. Poor adherence: 18.8%	Less adherence to the KIDMED was related to preobesity and obesity.	6[2]
	Grassi et al. (127)	Italy	Cross-sectional study	$n = 282$ 6 8 y old 55.7% males	Score range: −4 to 12. Mean ± SD: 4.93 ± 2.30. High adherence: 13.5%. Medium adherence: 59.6%. Poor adherence: 27%	—	3[2]
	Ríos-Hernández et al. (117)	Spain	Case–control study	$n = 130$ 6 16 y old 56.7% males	Score range: −4 to 12. ADHD cases: Mean ± SD: 6.2 ± 2.0. High adherence: 30%. Medium adherence: 58.3%. Poor adherence: 11.7%. Control cases: Mean ± SD: 8.1 ± 1.8. High adherence: 63.3%. Medium adherence: 36.7%. Poor adherence: 0.0%	Lower adherence to the KIDMED index was associated with ADHD diagnosis.	6[3]
	Rosi et al. (128)	Italy	Cross-sectional study	$n = 409$ 11 14 y old 54% males	Score range: −4 to 12. Mean ± SD: 6.0 ± 2.3. High adherence: 12%. Medium adherence: 60%. Poor adherence: 28%	—	5[2]
	Ojeda-Rodríguez et al. (74)	Spain	RCT 2 months follow-up	$n = 107$ 7 16 y old 37% males	Score range: −4 to 12. Mean ± SD at baseline: 5.2 ± 1.8 (usual care group); 7.2 ± 1.6 (intensive care group). Mean (95% CI) changes within group after 8 wk: 2.0 (0.9, 3.0) (usual care group); 3.0 (2.5, 3.5) (intensive care group)	—	High risk of bias[4]
	Grao-Cruces et al. (129)	Spain	Cross-sectional study	$n = 1808$ 12 16 y old 51.3% males	Score range: −4 to 12. Mean ± SD: 6.44 ± 2.38 (male); 5.95 ± 2.42 (female)	—	7[2]
	Yüksel et al. (56)	Turkey	Cross-sectional study	$n = 859$ 15 9 ± 1.3 y old 81.4% male	High adherence: 13%. Medium adherence: 54.6%. Poor adherence: 32.4%	There was no statistically significant relation between adherence to the KIDMED index and obesity and Night Eating Syndrome.[5]	4[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Arriscado et al. (97)	Spain	Cross-sectional study	$n = 321$ 11 12 y old 50.8% male	Score range: −4 to 12. Mean ± SD: 7.2 ± 1.9. High adherence: 46.8%. Medium adherence: 48.6%. Poor adherence: 4.7%	There was no statistically significant relation between KIDMED index and BMI.[5]	4[2]
	Gómez et al. (70)	Spain	RCT 15 months follow-up	$n = 2250$ 8 10 y old 48.2% male	Score range: −4 to 12. Mean ± SD at baseline: 6.7 ± 2.5 (intervention); 7.0 ± 2.3 (control). Mean ± SD at follow-up: 6.7 ± 2.4 (intervention); 6.6 ± 2.4 (control)	Promoting adherence to the KIDMED index had no significant effect on the BMI *z* score, and incidence of general and abdominal obesity.	High risk of bias[4]
	Muros et al. (73)	Chile	Cross-sectional study	$n = 515$ 10 6 ± 0.5 y old 50.5% male	Score range: −4 to 12. Mean ± SD: 6.1 ± 2.5. High adherence: 22.9%. Medium adherence: 67.6%. Poor adherence: 9.5%	Adherence to the KIDMED index was consistently and negatively associated with BMI, percentage of body fat, subscapular skinfold thickness, and WC.[5]	5[2]
	Monjardino et al. (55)	Portugal	Cohort study 4 y follow-up	$n = 1023$ 13 and 17 y old (KIDMED adherence at age 13 y and association with bone mineral density at age 17 y) 46.3% male	Score range: −4 to 12. Mean ± SD at 13 y: 5.2 ± 2.0 (male); 5.1 ± 2.1 (female)	Only among 13-y-old males, KIDMED index was significantly associated with higher bone mineral density at 17 y. No associations were found in relation to BMI at both ages.	7[6]
	Rosi et al. (76)	Italy	Cross-sectional study	$n = 690$ 9 11 y old 48.3% males	Mean ± SD: 6.5 ± 2.2 High adherence: 35.5%. Medium adherence: 55.2%. Poor adherence: 9.3%	No evidence was found of an association between the KIDMED index and BMI.[5]	5[2]
	Grigoropoulou et al. (116)	Greece	Cross-sectional study	$n = 1125$ 10 12 y old 47% males	Score range: −4 to 12. Mean ± SD: 4.7 ± 1.9 (urban areas); 5.3 ± 2.0 (rural areas)	A 1-unit increase in the KIDMED index was associated with 16% lower likelihood of having asthma symptoms.	6[2]
	Torres-Luque et al. (130)	Spain	Cross-sectional study	$n = 363$ 3 5 y old 54% males	Male: High adherence: 51.3%. Medium adherence: 48.7%. Poor adherence: 0.0%. Female: High adherence: 44.8%. Medium adherence: 50.0%. Poor adherence: 5.2%	—	4[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Korkmaz and Kabaran (86)	Turkey	Cross-sectional study	$n = 900$ 6 9 y old 60.5% males	Score range: −4 to 12. Mean ± SD: 5.0 ± 2.45. High adherence: 18.7%. Medium adherence: 45.7%. Poor adherence: 35.7%	An inverse correlation was found between KIDMED index and body weight, BMI, and waist and neck circumferences.[5]	7[2]
	Obradovic Salcin et al. (131)	Croatia	Cross-sectional study	$n = 260$ 5 6 y old 51.5% males	High adherence: 70.0%. Medium adherence: 24.0%. Poor adherence: 6.0%	—	7[2]
	Bacopoulou et al. (50)	Greece	Cross-sectional study	$n = 1610$ 12 17 y old 41.7% males	Score range: −4 to 12. Mean ± SD: 5.6 ± 2.4 (baseline); 5.8 ± 2.4 (follow-up)	Waist of circumference decreased as the KIDMED score increased.[5]	7[2]
	Mistretta et al. (87)	Italy	Cross-sectional study	$n = 1643$ 11 16 y old 53.9% males	Score range: −4 to 12. Mean ± SD: 4.3 ± 2.1. High adherence: 9.1%. Medium adherence: 61.0%. Poor adherence: 29.9%	An inverse correlation was found between the KIDMED index and BMI, WC, and fat mass. No relation with blood pressure was found.	6[2]
	Magriplis et al. (75)	Greece	Cross-sectional study	$n = 458$ 10 12 y old 49% males	Score range: −4 to 12. Mean ± SD: 3.78 ± 2.20	—	7[2]
	Calmeiro and Pereira (132)	Portugal	Cross-sectional study	$n = 782$ 7 9 ± 1.4 y old 51.8% males	Score range: −4 to 12. Mean ± SD: 5.88 ± 2.23	—	6[2]
	López-Gil et al. (88)	Spain	Cross-sectional study	$n = 370$ 6 13 y old 55.1% males	Score range: −4 to 12. Mean ± SD: 6.1 ± 2.1 (male); 6.3 ± 2.0 (female)	KIDMED < 3.8: positive association with adiposity. KIDMED > 9.3: negative association with adiposity	6[2]
	Garcia-Hermoso et al. (115)	Colombia	Cross-sectional study	$n = 1140$ 8 12 y old 69.6% males	Score range: −4 to 12. Mean ± SD: 6.42 ± 0.12 (male); 6.39 ± 0.16 (female)	Adherence to the KIDMED index was negatively associated with systolic and diastolic arterial pressure.[5]	6[2]
	Grosso et al. (89)	Italy	Cross-sectional study	$n = 1135$ 13 16 y old 45% males	Score range: −4 to 12. Mean ± SD: 4.9 ± 2.3 (male); 5.0 ± 2.1 (female)	Lower adherence to the KIDMED index was associated with being obese.	7[2]
	López-Gil et al. (133)	Spain	Cross-sectional study	$n = 370$ 6 13 y old 55.1% males	High adherence: 25.9%. Medium adherence: 65.1%. Poor adherence: 8.9%	—	7[2]
	Archero et al. (98)	Italy	Cross-sectional study	$n = 669$ 6 16 y old 48.4% males	High adherence: 19.6%. Medium adherence: 63.7%. Poor adherence: 16.7%	KIDMED score was positively associated with height. Adherence to the KIDMED index was not associated with the risk of overweight/obesity.	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Esteban-Cornejo et al. (134)	Spain	Cross-sectional study	$n = 1371$ 12.0 ± 2.5 y old 50% males	Score range: −4 to 12. Mean ± SD: 6.66 ± 2.29. High adherence: 37%. Medium adherence: 55%. Poor adherence: 8%	—	6[2]
	Mazaraki et al. (51)	Greece	Cross-sectional study	$n = 365$ 12 17 y old 58% males	High adherence: 6.8%. Medium adherence: 51.2%. Poor adherence: 42%	Adherence to the KIDMED index was positively related to BMI, WC, and systolic blood pressure and negatively associated with albuminuria.[5]	6[2]
	Costarelli et al. (36)	Greece	Cross-sectional study	$n = 396$ 2 12 y old 47.5% males	Score range: −4 to 12. Mean ± SD: 6.54 ± 2.44. High adherence: 34.8%. Medium adherence: 56.5%. Poor adherence: 8.6%	—	7[2]
	Marques et al. (77)	Portugal	Cross-sectional study	$n = 891$ 9 11 y old 51% males	High adherence: 77.6%. Medium adherence: 13.7%. Poor adherence: 0.4%	—	5[2]
	Roccaldo et al. (99)	Italy	Cross-sectional study	$n = 1740$ 8 9 y old 51.7% males	High adherence: 5%. Medium adherence: 62.5%. Poor adherence: 32.8%	The KIDMED index did not differ significantly according to BMI. [5]	5[2]
	Chacón-Cuberos et al. (135)	Spain	Cross-sectional study	$n = 1059$ 14 16 y old 49.4% males	High adherence: 76.8%. Medium adherence: 22.7%. Poor adherence: 0.6%	—	6[2]
	Azekour et al. (100)	Morocco	Cross-sectional study	$n = 3684$ 9 8 ± 2.1 y old 48.7% males	High adherence: 40%. Medium adherence: 57.9%. Poor adherence: 2.1%	No relation was found between the KIDMED index and BMI.	7[2]
	Martin-Calvo et al. (71)	Spain	Cohort study 2–3 y of follow-up	$n = 10,918$ 8 15 y old 45% males	At baseline: High adherence: 0.8%. Medium adherence: 17.8%. Poor adherence: 81.4%. Follow-up: 2-point increase in the score.	A 2-point increase in the KIDMED index was negatively associated with BMI.	6[6]
	Bawaked et al. (72)	Spain	Cohort study 15 months follow-up	$n = 1639$ 8 10 y old 51.8% males	Score range: −4 to 12. At baseline: Mean ± SD: 6.8 ± 2.4. High adherence: 40.4%. Medium adherence: 50.0%. Poor adherence: 9.6%	—	6[6]
	Labayen Goñi et al. (101)	Spain	Cross-sectional study	$n = 619$ 4 7 ± 0.8 y old 51.4% males	High adherence: 62%	Higher KIDMED index was significantly related to lower WC. No significant association was observed between KIDMED index and BMI.	6[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Sahingoz and Sanlier (136)	Turkey	Cross-sectional study	$n = 890$ 10 14 y old 52.1% males	High adherence: 22.9%. Medium adherence: 59.2%. Poor adherence: 17.9%	—	5[2]
	del Mar Bibiloni et al. (52)	Spain	Cross-sectional study	$n = 1231$ 12 17 y old 43.4% males	High adherence: 28.4%. Medium adherence: 55.9%. Poor adherence: 15.7%	—	7[2]
	Zervaki et al. (57)	Greece	Cross-sectional study	$n = 400$ 14 17 y old 49.5% males	Score range: −4 to 13. Mean ± SD: 5.1 ± 1.8	—	5[2]
Krece Plus test	Delgado Floody et al. (137)	Chile	Cross-sectional study	$n = 634$ Female: 11.9 ± 0.8 y old Male: 12.0 ± 0.9 y old 55.5% males	High adherence: 35%. Medium adherence: 47.5%. Poor adherence: 15.9%	—	6[2]
MDS	Arouca et al. (58)	European countries (Austria, Belgium, France, Germany, Greece Hungary, Italy, Spain, and Sweden)	Cross-sectional study	$n = 562$ 13 17 y old 46.8% males	Score range: 0–8. Mean ± SD: 4.15 ± 1.45	Greater adherence to the MDS was associated with lower blood C-reactive protein concentrations.	6[2]
	Winpenny et al. (54)	United Kingdom	Cohort study 3 y follow-up	$n = 603$ 14 and 17 y old 40% males	Score range: 0–8. Mean ± SD at 14 y: 4.88 ± 1.78	The MDS was not associated with depressive symptoms.	7[6]
	Martínez et al. (53)	Spain	Cross-sectional study	$n = 1231$ 12–17 y old 56.9% males	Low adherence: 44.1% (% of adherence below the lower quartile). High adherence: 5.4% (% of adherence above the upper quartile).	—	7[2]
	Jennings et al. (78)	England	Cross-sectional study	$n = 1700$ 9 10 y old 43.8% males	Score range: 0–8. Mean ± SD: 4.1 ± 1.6.	The MDS was not associated with BMI, WC, and waist-to-height ratio.	5[2]
	Rivas et al. (68)	Spain	Cross-sectional study	$n = 132$ 6 8 y old 43% males	Score range: 1–13. Mean: 8.24.	—	4[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
fMDS	Tognon et al. (37)	European countries (Sweden, Germany, Hungary, Italy, Cyprus, Spain, Belgium, and Estonia)	Cohort study 2 y follow-up	$n = 16{,}220$ 2 9 y old 50.9% males	fMDS>3: Sweden: 56.7%. Italy: 37.5%. Germany: 35.1%. Spain: 31.8%. Hungary: 32.2%. Belgium: 32.7%. Estonia: 26.3%. Cyprus: 24.2%	In a pooled analysis, higher scores of the fMDS were inversely associated with overweight, obesity, and percentage of fat mass	7[6]
Mediterranean Adequacy Index (MAI)	Pastor et al. (138)	Spain	Cross-sectional study	$n = 130$ 6 12 y old 53% males	Score $\geq$ 0. Mean ± SD: 0.87 ± 0.4666	—	7[2]
Italian Mediterranean Index (IMI)	Zani et al. (139)	Italy	Cross-sectional study	$n = 1164$ 6 8 y old 50.8% males	High adherence: 10.9%. Medium adherence: 30.1%. Poor adherence: 59%	—	4[2]
Mediterranean-Style Dietary Pattern Score (MSDPS)	Neshatbini Tehrani et al. (49)	Iran	Cross-sectional study	$n = 297$ 16.1 ± 0.9 y old 100% females	Score: 0–100. Median [IQR]: 15.2 [11.9–19.5]. High adherence: 51.2%. Low adherence: 48.8%	—	7[2]
DQI-I adapted to Mediterranean Diet	Mariscal-Arcas et al. (69)	Spain	Cross-sectional study	$n = 3190$ 8 15 y old 49.4% males	Score range: 0–100. Mean ± SD: 58.37 ± 7.74	—	5[2]
	Silva et al. (66)	Portugal	Cross-sectional study	$n = 669$ 10 17 y old 50% males	Score range: 0–100. Mean ± SD: 49.7 ± 7.0	—	5[2]
BSDS	Eloranta et al. (81)	Finland	Cross-sectional study	$n = 402$ 6 8 y old 50.7% males	Score range: 0–25. Mean ± SD: 11.5 ± 4.4 (male); 12.0 ± 4.3 (female).	BSDS was not associated with cardiometabolic risk. Higher BSDS score was associated with lower concentration of plasma HDL cholesterol in females.	5[2]
SEAD score	Moreira et al. (47)	Portugal	Cross-sectional study	$n = 468$ 16.5 ± 0.9 y old 41.7% males	High adherence: 57.1%. Low adherence: 42.9%	Low adherence to the SEAD was associated with higher values of a metabolic risk score. Fit adolescents with high adherence to the SEAD showed the lowest prevalence of high metabolic risk score	5[2]
	Agostinis-Sobrinho et al. (113)	Portugal	Cross-sectional study	$n = 437$ Mean: 16.5 y old 41.1% males	Score range: 0–8. Mean ± SD: 4.74 ± 1.88	Adolescents with low adherence to the SEAD had the highest odds of having a high cardiometabolic risk score.	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
Diet Score based on the Norwegian Health Directorate	Handeland et al. (140)	Norway	Cross-sectional study	$n = 472$ 14 15 y old 47.5% males	High adherence: 24.8%. Medium adherence: 47.9%. Poor adherence: 26.9%	—	6[2]
HuSKY	Truthmann et al. (46)	Germany	Cross-sectional study	$n = 5198$ 12 17 y old 50.9% males	Score range: 0–100. Mean: 53.1	A negative association was found between the HuSKY and homocysteine concentrations.	7[2]
	Egmond-Fröhlich et al. (62)	Germany	Cross-sectional study	$n = 11,676$ 6 17 y old No information on sex %	Score range: 0–100. Mean ± SD: 55.0 ± 11.0	The HuSKY score had a negative association with ADHD symptoms.	7[2]
Diet Quality Index for Children	Huybrechts et al. (141)	Belgium	Cross-sectional study	$n = 169$ 2 5–6.5 y old No information on sex %	Score range: −25 to 100. Mean ± SD: 72.0 ± 11.0	—	5[2]
DQI-A	Vyncke et al. (41)	European countries (Austria, Belgium, France, Germany, Greece, Italy, Spain, and Sweden)	Cross-sectional study	$n = 1807$ 12.5–17.5 y old 47.4% males	Score range: 0–100. Mean ± SD: 49.0 ± 17.0 (male); 53.3 ± 15.9 (female)	—	7[2]
DQI-A adapted to Brazil	Ronca et al. (65)	Brazil	Cross-sectional study	$n = 71,533$ 12–17 y old 50.2% males	Score range: −33 to 100. Mean ± SD: 19.0% ± 6.3% (male); 14.8% ± 6.1% (female)	—	7[2]
Dietary Quality Score for Ireland	Keane et al. (142)	Ireland	Cross-sectional study	$n = 8561$ 9 y old 51.2% males	Score range: −5 to 25. Mean ± SD: 9.4 ± 4.2	—	7[2]
CIDQ	Röytiö et al. (40)	Finland	Cohort study, cross-sectional analysis	$n = 400$ 2 6 y old 48% males	High adherence: 19.8%. Medium adherence: 58.0%. Poor adherence: 22.2%	The CIDQ score was associated with lower total cholesterol concentrations.[5]	6[6]
SHEIA 2015	Moraeus et al. (94)	Sweden	Cross-sectional study	$n = 2905$ Mean 12 y old 44% males	High adherence: 30.0%. Medium adherence: 48.8%. Poor adherence: 24.4%	No association was found between the SHEIA 2015 and BMI.	7[2]
RADDS	Moraeus et al. (94)	Sweden	Cross-sectional study	$n = 2905$ Mean: 12 y old 44% males	High adherence: 17.9%. Medium adherence: 56.8%. Poor adherence: 25.3%	RADDS score was inversely associated with BMI	7[2]
Finish Children Healthy Eating Index (FCHEI)	Eloranta et al. (143)	Finland	Cross-sectional study	$n = 367$ 6 8 y old 51.2% males	Score range: 5–40. Mean ± SD: 23.0 ± 7.0	—	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
DASH	Robson et al. (80)	San Diego	Cross-sectional study	$n = 698$ 6 12 y old 49.3% males	Score range: 0–80. Mean ± SD: 43.4 ± 9.0	—	7[2]
	Monjardino et al. (55)	Portugal	Cohort study 4 y follow-up	$n = 1023$ 13 and 17 y old 46.3% males	Score range: 8–40. Mean ± SD: 23.7 ± 4.5 (male); 23.7 ± 4.5 (female)	No association was found between the DASH score and BMI and bone mineral density.	7[6]
	Bricarello et al. (59)	Brazil	Cross-sectional study	$n = 71{,}553$ 12–17 y old 44.5% males	Score range: 8–40. Mean: 15.7. Minimum: 5.4. Maximum: 34.5	No associations were found between the DASH score and hypertension.	7[2]
	Asghari et al. (60)	Iran	Cohort study 3.6 y follow-up	$n = 425$ 10–17 y old 42% males	Score range: 8–40. Baseline mean ± SD: 24.1 ± 4.3	High adherence to the DASH diet was associated with lower levels of metabolic syndrome, hypertension, high fasting plasma glucose, and abdominal obesity.	5[6]
	Eloranta et al. (81)	Finland	Cross-sectional study	$n = 402$ 6 8 y old 50.7% males	Score range: 0–80. Mean ± SD: 20.3 ± 4.4 (male); 21.8 ± 4.2 (female)	High adherence to the DASH diet was associated with lower concentrations of serum insulin and triglyceride in males and a lower concentration of plasma HDL cholesterol in females.	5[2]
	Rostami et al. (48)	Iran	Cross-sectional study	$n = 488$ 12–17 y old No information on sex %	20% was in the first quintile of adherence to the DASH diet.	High adherence to the DASH diet was associated with lower levels of insomnia.	7[2]
	Najafi et al. (79)	Iran	Cross-sectional study	$n = 407$ 6 12 y old 47.4% males	33.4%: lowest tertile. 33.2%: highest tertile	A higher adherence (highest tertile) to the DASH score was significantly related to lower levels of systolic blood pressure.	7[2]
	Pérez-Gimeno et al. (82)	Spain	Cross-sectional study	$n = 687$ 5 16 y old No information on sex %	Score range: 7–35. Males: Mean ± SD: 17.3 ± 4.7 (prepubertal); 17.8 ± 5.3 (pubertal). Females: Mean ± SD: 18.5 ± 5.1 (prepubertal); 19.4 ± 4.7 (pubertal)	—	7[2]
HLD Index	Manios et al. (114)	Greece	Cross-sectional study	$n = 729$ 10–12 y old No information on sex %	Score range: 0–40. Mean ± SD: 20.0 ± 4.4.	<3.16 points → 20.9% of participants were found to be insulin resistant.	5[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Manios et al. (90)	Greece	Cross-sectional study	$n = 2660$ 9–13 y old 50.6% males	Score range: 0–48. Mean ± SD: 17.12 ± 4.50.	A 1-unit increase in the HLD Index score was associated with 6% lower odds of obesity.	7[2]
PDL-Index	Manios et al. (38)	Greece	Cross-sectional study	$n = 2287$ 2–5 y old 51.5% males	Score range: 0–44. Mean ± SD: 18.2 ± 4.8.	Participants in the third tertile of the PDL-Index were less likely to be overweight than those in the first tertile.	5[2]
E-KINDEX	Lazarou et al. (92)	Greece	Cross-sectional study	$n = 634$ 10–13 y old No information on sex %	Score range: 1–87. Mean ± SD: 58.2 ± 7.8.	The highest E-KINDEX category (>60 points) was associated with 85% less likelihood of a child being obese or overweight and 86% less likelihood of having a WC >75th percentile.[5]	5[2]
HEI-1995	Azadbakht et al. (84)	Iran	Cross-sectional study	$n = 265$ 11–13 y old 100% females	Score range: 0–100. Mean ± SD: 63.90 ± 19.86.	HEI-1995 was not associated with BMI and blood pressure.[5]	6[2]
	Drenowatz et al. (111)	USA	Cross-sectional study	$n = 354$ Mean ± SD: 10.4 ± 0.4 y old 41.5% males	Score range: 0–100. Mean ± SD: 62.0 ± 8.9	HEI-1995 was not associated with HDL cholesterol, blood pressure, and body fat.	7[2]
HEI-2005	Loprinzi et al. (61)	USA	Cross-sectional study	$n = 2629$ 6–17 y old No information on sex %	Score range: 0–100. Mean: 50.2 (children); 49.8 (adolescents)	A higher HEI-2005 score was associated with lower WC, C-reactive protein concentrations, and triglyceride concentrations.	7[2]
	Rydén and Hagfors (144)	Sweden	Cross-sectional study	$n = 2494$ 4, 8, and 11 y old 51% males	Score range: 0–100. Mean ± SD: 59.99 ± 7.80	—	7[2]
	Torres et al. (145)	Puerto Rico	Cross-sectional study	$n = 1150$ 12 y old 45.5% males	Score range: 0–100. Mean ± SD: 40.9 ± 0.9	—	7[2]
	He et al. (146)	Canada	Cross-sectional study	$n = 810$ 11–14 y old 49% males	Score range: 0–100. Mean ± SD: 39.1 ± 7.8	—	7[2]
	Burke et al. (147)	South Carolina	Cross-sectional study	$n = 171$ 9–15 y old 49.1% males	Score range: 0–100. Mean ± SD: 52.4 ± 0.85	—	6[2]
HEI-2010	Anderson Steeves et al. (148)	USA	Cross-sectional study	$n = 278$ 9–15 y old 47% males	Score range: 0–100. Mean ± SD: 55.5 ± 9.6	—	6[2]
	Mellendick et al. (63)	USA	Cross-sectional study	$n = 163$ 16–17 y old 40% males	Score range: 0–100. Mean ± SD: 49.2 ± 12.0	HEI-2010 had no association with BMI, WC, blood pressure, and lipid profile.	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Dave et al. (104)	USA	RCT 6 wk follow-up	*n* = 120 9–12 y old 40.8% males	Score range: 0–100. Mean ± SD: 55.72 ± 1.98 (baseline intervention); 57.34 ± 1.79 (baseline control); 56.54 ± 1.99 (posttest cases); 53.74 ± 1.80 (posttest control)	No differences were found between the intervention group and the control group with regard to BMI after 6 wk of follow-up.	Low risk of bias[4]
	Au et al. (149)	San Diego	Cross-sectional study	*n* = 3944 9.8 ± 0.7 y old 49.3% males	Score range: 0–100. Mean ± SD: 47.4 ± 11.9	—	7[2]
	Santiago-Torres et al. (150)	Spain	Cross-sectional study	*n* = 187 10–14 y old 47% males	Score range: 0–100. Mean ± SD: 59.4 ± 8.8	—	5[2]
	Arandia et al. (151)	Spain	Cross-sectional study	*n* = 1466 8–16 y old 50.7% males	Score range: 0–100. Mean: 53.8	—	7[2]
	Arcan et al. (152)	USA	RCT	*n* = 160 8–12 y old 85% males	Score range: 0–100. Mean ± SD: 53.7 ± 11.3	After the intervention, parents reported their children had half their plates filled with fruit and vegetables at dinner on average 2.7 times in the past week (although not related to the aims of this article).	High risk of bias[4]
	Clennin et al. (83)	USA	Cross-sectional study	*n* = 828 Mean ± SD: 10.6 ± 0.05 y old 45.3% males	Score range: 0–100. Mean ± SD: 30.1 ± 5.38	—	6[2]
HEI-2010 adapted to Brazil	Horta et al. (153)	Brazil	Cross-sectional study	*n* = 1357 8–12 y old 51% males	Score range: 0–100. Mean: 51.8	—	7[2]
HEI-2010 adapted to Singapore Health Promotion Board	Brownlee et al. (105)	Malaysia	Cross-sectional study	*n* = 561 6–12 y old 47.4% males	Score range: 0–100. Median (IQR) 65.4 (57.1; 73.0)	HEI had no association with BMI.[5]	4[2]
HEI-2015	Hayuningtyas et al. (109)	Indonesia	Cross-sectional study	*n* = 85 3–5 y old 48.2% males	Score range: 0–100. Mean ± SD: 33.2 ± 8.3	A 1-point increase in the HEI-2015 was associated with an increase in serum adiponectin.	5[2]
	Khan et al. (154)	USA	Cross-sectional study	*n* = 57 4 and 5 y old 59.6% males	Score range: 0–100. Mean ± SD: 54.2 ± 14.2	—	5[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Hopkins et al. (155)	USA	Cohort study 4 months follow-up	*n* = 100 3–12 y old 53% males	Score range: 0–100. Mean ± SD: 46.51 ± 1.72 (baseline); 46.51 ± 1.27 (first phase); 51.13 ± 1.46 (second phase)	—	6[6]
YHEI	Gingras et al. (45)	USA	Cohort study 7.9 y follow-up	*n* = 1051 2 y old 50.3% males	Score range: 0–85. Mean ± SD: 55.4 ± 9.4	—	8[6]
	Protudjer et al. (118)	Canada	Case–control study	*n* = 476 12.6 ± 0.5 y old 56.7% males	Score range: 0–85. Median (IQR) 33.85 (29.85; 38.12)	YHEI had no association with asthma.	9[3]
Diet Quality Index Canadian (DQI-C)	Jarman et al. (156)	Canada	Cross-sectional study	*n* = 1260 3 y old 52% males	Score range: 0–6. Mean ± SD: 3.69 ± 0.6	—	7[2]
Healthy Dietary Variety Index	Barros et al. (96)	Portugal	Cohort study	*n* = 3962 4 y old 51.5% males	Score range: 0–1. Mean ± SD: 0.78 ± 0.11	The score was inversely related to BMI.	8[6]
School Child Diet Index (ALES)	Molina et al. (157)	Brazil	Cross-sectional study	*n* = 1282 7–10 y old 42% males	Score range: −10 to 10. Mean ± SD: 4.3 ± 3.5. Low adherence/diet quality: 41%	—	6[2]
Brazilian Healthy Eating Index Revised (BHEI-R)	Toffano et al. (158)	Brazil	Cross-sectional study	*n* = 167 9–13 y old 47.3% males	Score range: 0–100. Median (IQR): 54.3 (31.0–81.0)	—	5[2]
	Wendpap et al. (110)	Brazil	Cross-sectional study	*n* = 1326 10–14 y old 50% males	Score range: 0–100. Median (IQR): 75.1 (74.8–75.5)	There was a positive association between the score and BMI.[5]	7[2]
	Prado et al. (159)	Brazil	Cross-sectional study	*n* = 201 7–10 y old 43.5% males	Score range: 0–100. Mean ± SD: 62.4 ± 8.68	—	6[2]
Recommended Food Score	Coelho et al. (103)	Brazil	Cross-sectional study	*n* = 661 6–14 y old 52.2% males	Score range: 0–50. Mean ± SD: 16.00 ± 6.82. Low adherence: 77.2% (<80th percentile)	The score had no association with BMI.	7[2]
Healthy Eating Index (Brazil)	Leal et al. (39)	Brazil	Cross-sectional study	*n* = 556 2–5 y old 53.6% males	Score range: 0–100. Mean ± SD: 74.4 ± 0.4	—	6[2]
ACARFS	Marshall et al. (102)	Australia	Cross-sectional study	*n* = 691 11.0 ± 1.1 y old 43.8% males	Score range: 0–73. Mean ± SD: 25 ± 13	ACARFS was not related to BMI.	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
DGI-CA	Ping-Delfos et al. (64)	Australia	Cohort study 3 y follow-up	14 y old $n = 1419$ 51.4% males 17 y old $n = 843$ 46.5% males	Score range: 0–100. Mean ± SD: 47.1 ± 10.4 (14 y); 47.7 ± 11.0 (17 y)	From baseline at 14 y to the follow-up at 17 y, DGI-CA was positively related to BMI and negatively related to waist-to-height ratio and triglyceride concentrations. No relation with blood pressure was found.	8[6]
	Golley et al. (123)	Australia	Cross-sectional study	$n = 3416$ 4–16 y old No information on sex %	Score range: 0–100. Mean ± SD: 53.6 ± 0.4.	8–11 y: There was no relation between the score and body mass and WC. 4–10, 12–16 y: A positive relation was found between the score and BMI and WC.	7[2]
Prior derived Diet Quality Index	Lioret et al. (93)	Australia	Cohort study 3 y follow-up	$n = 216$ 5–12 y old 44% males	Score range: 0–100. Mean ± SD: 64.2 ± 10.3 (baseline); 59.7 ± 12.4 (posttest)	The score was inversely related to BMI only in children with overweight at baseline.	8[6]
Australian Recommended Food Scores for Pre-Schoolers (ARFS-P)	Burrows et al. (160)	Australia	Cross-sectional study	$n = 146$ 2–5 y old 54% males	Score range: 0–73. Median (IQR) 32.0 (22.9–42.0)	—	6[2]
Revised Children's Diet Quality Index (RC-DQI)	Collins et al. (161)	Australia	RCT 3.5 y follow-up	$n = 244$ 3.5 y old 50.4% males	Score range: 0–85. Mean ± SD: 62.8 ± 8.3	—	High risk of bias[4]
Dietary Index for a Child's Eating (DICE)	Delshad et al. (42)	New Zealand	Cross-sectional study	$n = 65$ 2–8 y old 44.6% males	Score range: 0–100. Mean ± SD: 78.2 ± 11.5	—	4[2]
Modified version of Revised Children's Diet Quality Index (M-RCDQI)	Keshani et al. (162)	Iran	Cross-sectional study	$n = 1124$ 13–15 y old 53.3% males	Score range: 0–90. Mean ± SD: 58.91 ± 8.58	—	7[2]
Diet Quality Index for Indian Children (DQIIC)	Chamoli et al. (163)	India	Cross-sectional study	$n = 100$ 7–9 y old 53% males	Unhealthy diet: 33%. Moderate diet quality: 41%. Healthy diet: 26%	—	6[2]
Chinese's Children's Dietary Index (CCDI)	Zhang et al. (67)	China	Cross-sectional study	$n = 2043$ 7–15 y old 51.6% males	Score range: 0–160. Mean ± SD: 88.9 ± 15.1 (adherence was positively associated with energy adjusted for diet cost)	—	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Duan et al. (164)	China	Cohort study 4.2 y follow-up	*n* = 3983 Mean: 7 y old 56% males	Score range: 0–160. Male range: 56.2–136.3. Female range: 46.1–131.5	—	7[6]
Japanese Food Guide Spinning Top Score (JFGST)	Shinsugi et al. (112)	Japan	Cross-sectional study	*n* = 110 Mean ± SD: 4.8 ± 0.4 y old 51.6% males	Score range: 0–70. Mean ± SD: 55.7 ± 7.5	There was no association between the score and waist-to-height ratio.	7[2]
Malaysian Healthy Eating Index	Appannah et al. (106)	Malaysia	Cross-sectional study	*n* = 337 13 y old 29% males	Score range: 0–100. Mean ± SD: 49.1 ± 14.5	There was no association between the index and BMI, WC, or fasting blood glucose, cholesterol, and insulin concentrations.	6[2]
	Rezali et al. (165)	Malaysia	Cross-sectional study	*n* = 376 13–16 y old 35.1% males	Score range: 0–100. Mean ± SD: 37.9 ± 9.1	—	7[2]
OPLS	Papoutsakis et al. (91)	Greece	Cross-sectional study	*n* = 514 5–11 y old No information on sex %	Score range: 0–18. Mean ± SD: 8.6 ± 2.9 (asthma cases); 9.3 ± 2.7 (control cases)	OPLS was negatively associated with BMI, WC, and hip circumference. A high OPLS was protective against diagnosed asthma.	7[2]
HEI based on WHO guidelines	da Costa et al. (166)	Portugal	Cohort study 3 y follow-up	*n* = 5013 4 and 7 y old No information on sex %	Score range: 8–32. Mean ± SD: 21.4 ± 3.53 (4 y); 20.3 ± 3.36 (7 y)	—	8[6]
DQI-I	Tur et al. (108)	Italy	Cross-sectional study	*n* = 1643 12.4 ± 0.4 y old 53.9% males	Score range: 0–100. Mean ± SD: 52.31 ± 8.89	DQI-I was positively related to BMI.	7[2]
Healthy Dietary Adherence Score	Arvidsson et al. (43)	European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden)	Cohort study 2 y follow-up	*n* = 7675 2–9 y old 51% males	High adherence: 52%	—	5[6]
DDS	Jiang et al. (167)	China	Cross-sectional study	*n* = 697 3–7 y old 50.6% males	Score range: 0–9. Mean ± SD: 7.0 ± 1.3	—	6[2]
	Mak et al. (168)	Philippines	Cross-sectional study	*n* = 6460 6–12 y old 48.5% males	Score range: 0–9. Mean ± SD: 4.1 ± 1.3	—	6[2]
	Bi et al. (169)	China	Cross-sectional study	*n* = 1328 3 or 5 y old 51.6% males	Score range: 0–9. Median (IQR) 5.77 (5.70–5.83).	—	7[2]

(*Continued*)

TABLE 1 (*Continued*)

Instrument	Authors (reference)	Country	Study design	Sample size, age, and sex	Adherence level	Health outcomes associated with adherence level	Quality assessment score
	Zhao et al. (107)	China	Cross-sectional study	$n = 1694$ 3–12 y old 51.8% males	Score range: 0–9. Mean ± SD: 6.3 ± 1.6	There was no relation between DDS and BMI.[5]	5[2]
	Miller et al. (170)	Nepal	Case–control study	$n = 269$ 55.9 ± 6.5 months 46.8% males	Score range: 0–48. Mean: 26 points	—	8[3]
	Cabalda et al. (44)	Philippines	Cross-sectional study	$n = 200$ 2–6 y old No information on sex %	Score range: 0–10. Mean ± SD: 6.12 ± 0.17 (with garden); 5.62 ± 0.17 (without garden)	—	6[2]
HDS	Shang et al. (95)	China	Cross-sectional study	$n = 5676$ 6–13 y old 46.6% males	HDS ≥ 8: 5.3%. HDS ≤ 3: 15.2%	An HDS ≥ 8 was inversely related to BMI, blood pressure, mean arterial pressure, fasting glucose and insulin concentrations, and HOMA values compared with HDS ≤ 3.	7[2]

[1] ACARFS, Australian Child and Adolescent Recommended Food Score; ADHD, attention deficit hyperactivity disorder; BSDS, Baltic Sea Diet Score; CIDQ, Children's Index of Diet Quality; DASH, Dietary Approaches to Stop Hypertension; DDS, Dietary Diversity Score; DGI-CA, Dietary Guideline Index for Children and Adolescents; DQI-A, Diet Quality Index for Adolescents; DQI-I, Diet Quality Index International; E-KINDEX, Electronic Kids Dietary Index; fMDS, food frequency–based Mediterranean Diet Score; HDS, Healthy Diet Score; HLD Index, Healthy Lifestyle–Diet Index; HuSKY, Healthy Nutrition Score for Kids and Youth; KIDMED, Mediterranean Diet Quality Index for Children and Adolescents; MDS, Mediterranean Diet Score; NOS, Newcastle-Ottawa Scale; OPLS, Obesity-Preventive Lifestyle Score; PDL-Index, Preschoolers Diet–Lifestyle Index; RADDS, Riskmaten Adolescents Diet Diversity Score; SEAD, Southern European Atlantic Diet; SHEIA, Swedish Healthy Eating Index for Adolescents; WC, waist circumference; YHEI, Youth Healthy Eating Index.
[2] The NOS for cross-sectional studies (varying from 0 to 8 stars).
[3] The NOS for case–control studies (varying from 0 to 9 stars).
[4] Tool of the Cochrane Collaboration for randomized control trials (low, medium, or high risk of bias).
[5] Associations with outcomes obtained only by correlations.
[6] The NOS for cohort studies (varying from 0 to 9 stars).

TABLE 2 Description of the instruments identified in the literature and detailed methodology for assessment of healthy and/or sustainable dietary patterns in children and adolescents[1]

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Based on the principles of the MD									
Mediterranean Diet Quality Index for Children and Adolescents (KIDMED)	16 items of "yes or no" questions	No	Yes	*1)* Fruit, *2)* vegetables, *3)* fish/seafood, *4)* fast-food restaurants, *5)* pulses, *6)* pasta/rice, *7)* cereal products, *8)* nuts, *9)* olive oil, *10)* breakfast, *11)* dairy products for breakfast, *12)* commercially baked goods or pastries for breakfast, *13)* yogurts/cheese, *14)* sweets/candies.	Positive answers to questions with a negative connotation with MD adherence ($n = 4$) are scored −1 point, whereas questions with a positive connotation ($n = 12$) are scored +1 point.	No	Sum of the components, ranging from −4 to 12.	High adherence: ≥8 points; medium adherence: 4–7 points; poor adherence: ≤3 points	(36, 50–52, 56, 57, 70–77, 85–89, 97–101, 115, 116, 127–136)
KIDMED adaptation	FFQ	No	Yes	Removal of the breakfast component.	24-h dietary recall	24-h dietary recall	−4 to 13	Use of the 33rd percentile	(55)
Krece Plus test	15 "yes or no" questions	No	Yes	*1)* Olive oil, *2)* having breakfast, *3)* vegetables, *4)* pasta/rice, *5)* fish, *6)* fruits, *7)* cereals at breakfast, *8)* yogurts/cheese, *9)* nuts, *10)* commercially baked goods or pastries for breakfast, *11)* sweets/candies, *12)* takeaway.	Each item has a score of +1 or −1, depending on whether or not one follows the principles of the MD.	No	Sum of the components, ranging from −15 to 15.	Low nutritional level: ≤5 points; moderate nutritional level: 6–8 points; high nutritional level: ≥9 points	(137)
MDS	FFQ, dietary records, or 24-h recalls	No	No	*1)* Ratio of MUFAs to SFAs (mainly olive oil), *2)* vegetables, *3)* fruits and nuts, *4)* fish, *5)* cereals, *6)* pulses, *7)* meat and meat products, *8)* dairy products, *9)* alcohol.	Score of 0 or 1 using the sex-specific sample medians as cutoffs. *1–6)*: < median: 0 points; ≥ median: 1 point. 7–8): ≥ median: 0 points; < median: 1 point. *9)* 0 g: 1 point; >0 g: 0 points.	No	Sum of the components, ranging from 0 to 8.	Higher scores indicate greater adherence. Participants can be categorized into 2 groups: low (<4 points) and high (≥4 points) adherence.	(58)
MDS adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	Alcohol intake was removed.	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	(54)
	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	Dairy products are scored as a beneficial component.	24-h dietary recall	24-h dietary recall	24-h dietary recall	(53, 78)
	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	MDS is calculated as a continuous variable using standardized *z* scores.	24-h dietary recall	Use of quartiles.	24-h dietary recall	(53)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
	Semiquantitative questionnaire applied by face-to-face interview	Yes	Yes	*1*) Olive oil, *2*) butter, margarine, or cream, *3*) sweet or carbonated beverages, *4*) commercial sweets or pastries, *5*) preference of lean meat over red meat, *6*) sofrito (sauce with tomato and onion, leek, or garlic simmered in olive oil).	According to the MD recommendations 1 or 0 points.	24-h dietary recall	Sum of the components, 1–13.	Higher scores indicate greater adherence.	(68)
fMDS	FFQ	No	No	*1*) Vegetables and legumes, *2*) fruit and nuts, *3*) cereals, *4*) fish, *5*) dairy products, *6*) meat products.	Score of 0 or 1 using the sex-specific medians as cutoffs. *1–4*): < median: 0 points; > median: 1 point. *5–6*): > median: 0 points; < median: 1 point.	No	Sum of the components, 0–6.	High adherence levels to the fMDS when fMDS > 3.	(37)
MAI	Three 24-h dietary recalls	No	No	*1*) Bread, *2*) whole cereals, *3*) pulses, *4*) potatoes, *5*) vegetables, *6*) fresh fruit, *7*) nuts, *8*) fish, *9*) olive oil, *10*) wine, *11*) milk, *12*) cheese, *13*) meat, *14*) eggs, *15*) animal fats and seed oils, *16*) sweetened beverages, *17*) cakes and cookies, *18*) sugar, *19*) other dairies, *20*) ready or prepared meals.	MAI is obtained by dividing the sum of the percentage of total energy from typical Mediterranean food groups (bread + whole cereals + pulses + potatoes + vegetables + fresh fruit + nuts + fish + olive oil + wine) by the sum of the percentage of total energy from nontypical Mediterranean food groups (milk + cheese + meat + eggs + animal fats and seed oils + sweetened beverages + cakes and cookies + sugar + other dairies + ready or prepared meals).	No	Score ≥ 0.	The higher the score, the greater the adherence to the MAI.	(138)
Italian Mediterranean Index (IMI)	FFQ	No	No	*1*) Pasta, *2*) vegetables, *3*) fruit, *4*) pulses, *5*) olive oil, *6*) fish, *7*) sugar-sweetened beverages, *8*) butter, *9*) red meat, *10*) potatoes.	*1–6*) 3rd tertile: 1 point; all other intakes received 0 points. *7–10*) 1st tertile: 1 point; all other intakes received 0 points.	No	Sum of the components, 0–10.	MD adherence was classified as low (≤3), medium (4–5), and high (≥6).	(139)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
MSDPS	FFQ	Yes	Yes	*1*) Whole-grain cereals, *2*) fruits, *3*) vegetables, *4*) dairy products, *5*) fish/seafood, *6*) poultry, *7*) olives, legumes, and nuts, *8*) potatoes and other starchy roots, *9*) eggs, *10*) sweets, *11*) meat, *12*) olive oil.	Based on daily/weekly recommendations presented by the food guide pyramid. Except for olive oil, other MSDPS components are scored continuously from 0 to 10. Exclusive olive oil intake has a score of 10, olive oil besides other vegetable oils scores 5, and no olive oil intake scores 0.	For participants with the number of consumed servings above recommendation, a penalty score was assigned. A 0 score was considered for those who had a negative total MSDPS because of the overconsumption penalty.	0–100. Equation based on the total score of the MSDPS components dividing by 120, multiplying by 100%, and, finally, multiplying by the proportion of total energy intake in the MD pyramid.	MD adherence was classified as low (15) and high (≥15).	(49)
DQI-I adapted to MD	FFQ	Yes	Yes	*1*) Variety (overall food group variety; within-group variety for protein sources), *2*) adequacy (vegetable group, fruit group, cereal group, fiber, protein, iron, calcium, vitamin C), *3*) moderation (total fat, saturated fat, cholesterol, sodium, empty calorie foods), *4*) overall balance (macronutrient ratio, fatty acid ratio).	According to the MD recommendations. Variety: 0–15 or 0–5 each item Adequacy: 0–5 each item Moderation: 0–6 each item Overall balance: 0–4 or 0–6 each item	No	Sum of the components, 0–100 points. Variety: 0–20 points Adequacy: 0–40 points Moderation: 0–30 points Overall balance: 0–10 points	Higher scores indicate greater adherence.	(66, 69)
Based on European recommendations and/or applied in European countries									
BSDS	Food records	No	No	*1*) Fruits and Nordic berries, *2*) vegetables (including legumes and roots; potatoes excluded), *3*) cereals, *4*) low-fat milk, *5*) fish (salmon, Baltic herring, and mackerel), *6*) meat and processed meat products, *7*) diet total fat, *8*) ratio of PUFA:SFA.	Use of quartiles. *(1)–(5)* and *(8)*: 1st quartile: 0; 4th quartile: 3. *(6)–(7)*: 1st quartile: 3; 4th quartile: 0.	No	Sum of the components, 0–25.	Higher points indicate higher adherence to the BSDS.	(81)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Southern European Atlantic Diet (SEAD) score	FFQ	No	No	*1*) Fresh fish (excluding cod), *2*) cod, *3*) red meat/meat products, *4*) dairy products, *5*) vegetables and legumes, *6*) vegetables soup, *7*) potatoes, *8*) bread.	Each component is measured as grams per 1000 kcal per day. Score of 0 or 1 using the sex-specific medians as cutoffs: $<=0$ points; $\geq=1$ point.	No	Sum of the components, 0–8 points.	Higher points indicate higher adherence. Split into 2 groups: low (≤4 points) and high (≥5 points).	(47, 113)
Diet Score based on the Norwegian Health Directorate	FFQ	No	Yes	*1*) Fruit and vegetables, *2*) fish, *3*) lean meat and meat products, *4*) low-fat dairy products, *5*) sugar, *6*) water, *7*) physical activity, *8*) whole products.	When the Norwegian Health Directorate recommendation is fulfilled, 1 point is given; when it is not, 0 points.	No	Sum of the components, 0–8.	Low (0–3 points), moderate (4–5 points), or high (6–8 points) adherence to the dietary recommendations.	(140)
HuSKY	FFQ	No	Yes	*1*) Beverages, *2*) fruit, *3*) vegetables, *4*) pasta, rice, potatoes, *5*) bread/cereals, *6*) dairy products, *7*) eggs, *8*) meat, *9*) fish, *10*) fats, *11*) sweets/fatty snacks/sugar-rich soft drinks.	For most food groups an intake below the Optimized Mixed Diet for German Children and Adolescents recommendation is assessed proportionally (0–10). Only for meat, fats, and sweets/fatty snacks/sugar-rich soft drinks, 10 points are given when the intake is below or equal to the tolerable consumption.	When more than twice the recommended amount was consumed, points were proportionally subtracted from 100. For meat, fats, and sweets/fatty snacks/sugar-rich soft drinks points were proportionally subtracted from 100 if consumption exceeded the recommendations.	Single points were added together and standardized to a scale from 0 to 100 (HuSKY = Σscorex/number of scorex).	A higher score implies a better overall dietary quality.	(46, 62)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Diet Quality Index for Children	FFQ	Yes	Yes	Dietary *1*) diversity, *2*) quality, *3*) equilibrium, and *4*) moderation are evaluated by the main food groups: - beverages, - bread and cereals, - potatoes and grains, - vegetables, - fruits, - milk products, - meat and substitutes, - snacks.	The sum of the 4 scores dividing by 4. According to the Belgium Health Council.	No	−25 to 100	A higher score implies a better overall dietary quality.	(141)
DQI-A	24-h dietary recall	Yes	Yes	*1*) Water, *2*) bread and cereals, *3*) grains and potatoes, *4*) vegetables, *5*) fruits, *6*) milk products, *7*) cheese, *8*) meat, fish, eggs, and substitutes, *9*) fats and oils.	According to the Belgium Health Council and WHO (0–9 for each component).	No	0–100	A higher score implies a better overall dietary quality.	(41)
DQI-A in Brazil adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	In relation to the DQI-A, addition of: - snacks and candies - sugared drinks and alcoholic beverages.	According to the Brazilian Ministry of Health.	24-h dietary recall	−33% to 100%	24-h dietary recall	(65)
Dietary Quality Score for Ireland	20-item FFQ reported by parents	No	Yes	According to the Irish dietary guidelines, each food item was defined as "healthy" or "unhealthy." Healthy items: *1*) fresh fruit, *2*) vegetables, *3*) meat, *4*) eggs, *5*) bread, *6*) cereals, *7*) potatoes, *8*) dairy products, and *9*) water. Unhealthy items: 1) meat pie, 2) hot chips, 3) crisps, 4) biscuits, and 5) soft drinks.	For each component a score of 1 = one; 2 = more than one; 3 = not at all; 4 = don't know. For consumption of each healthy item, a value of 0 for not eaten at all, 1 for eaten 1 portion, and 2 for eaten more than once were assigned. Unhealthy items were given a value of −2 for eaten more than once, −1 for eaten once, and 0 for not eaten at all.	No	−5 to 25	A higher score value implies a better overall dietary quality.	(142)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Children's Index of Diet Quality (CIDQ)	7-d food records + original questionnaire	Yes	No	*1*) Cereals and fiber, *2*) SFA, *3*) MUFA, *4*) PUFA, *5*) sucrose, *6*) vegetables and fruits, *7*) calcium.	According to the Nordic Nutrition recommendations	No	Standardized for 0–21	Low adherence: 0–2 components fulfilled. Medium adherence: 3 or 4 components fulfilled. High adherence: ≥5 components fulfilled.	(40)
Swedish Healthy Eating Index for Adolescents 2015 (SHEIA 2015)	24-h dietary recall	Yes	No	*1*) Vegetables, *2*) pulses, *3*) fruits, *4*) fiber, *5*) whole meal, *6*) fish and shellfish, *7*) PUFA, MUFA, and SFA, *8*) red and processed meat, *9*) added sugar.	According to the Nordic Nutrition recommendations. 0 or 1 for each component.	No	0–9	A higher score implies a better overall dietary quality. Use of tertiles for adherence.	(94)
Riskmaten Adolescents Diet Diversity Score (RADDS)	24-h dietary recall	Yes	No	*1*) Vegetables, *2*) pulses, *3*) fruits, *4*) pasta, rice, grains, and bread, *5*) red meat, *6*) poultry, *7*) eggs, *8*) white fish, *9*) oil fish, *10*) shellfish, *11*) dairy products.	Each component varies between 1 and 17 points; 1 point is given if consumption is <5 g and proportionally until the recommendation is reached (17 points). According to the Nordic Nutrition recommendations.	No	Standardized for 1–17	A higher score value implies a better overall dietary quality. Use of tertiles.	(94)
Finnish Children Healthy Eating Index (FCHEI)	Food records	Yes	No	*1*) Vegetables, *2*) fruits and berries, *3*) oils and vegetable oils, *4*) fish and skimmed milk, *5*) foods with high amounts of sugar.	Consumption is divided by energy intake and categorized according to its variation (deciles), according to the Finnish dietary guidelines for children.	No	5–40	A higher score implies a better overall dietary quality.	(143)
Based on US recommendations									
DASH score	FFQ, food records, or 24-h dietary recall	No	Yes	*1*) Grains, *2*) vegetables, *3*) fruits, *4*) dairy products, *5*) nuts, seeds, legumes, *6*) red and processed meat, *7*) fats/oils, *8*) sweets.	There is a maximum component score of 10 for each food group when intake meets recommendations, with lower intakes scored proportionately. Reverse scoring is used when lower intakes are favored.	No	Sum of the components, 0–80	Higher scores indicate greater adherence.	(80, 81)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
DASH score adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	- Removal of the fats/oils. - Inclusion of low sodium intake. - Inclusion of sugar-sweetened beverages.	Use of quintiles. *1) to (5)*: quintile 1 is assigned 1 point and quintile 5, 5 points. Other components: low intake was desired.	24-h dietary recall	Sum of the components, 8–40	Higher scores indicate greater adherence OR Use of centiles (tertiles, quartiles, quintiles).	(48, 55, 59, 60, 79)
	24-h dietary recall	24-h dietary recall	24-h dietary recall	- Inclusion of high-sugary foods and sugar-sweetened beverages component. - Removal of the fats/oils.	Use of quintiles	24-h dietary recall	Sum of the components, 7–35	24-h dietary recall	(82)
HLD Index	24-h dietary recalls	No	Yes	*1)* Fruits, *2)* vegetables, *3)* grains, *4)* dairy products, *5)* meat, *6)* fish/seafood, *7)* soft drinks, *8)* sweets, *9)* watch TV/play computer, *10)* moderate to vigorous physical activity.	A 0–4 scoring system is used to assign the appropriate score to each index component according to the USDA recommendations.	No	Sum of the components, 0–40	Tertiles could be considered (a) "unhealthy diet–lifestyle pattern" (first tertile); (b) "moderate healthy diet–lifestyle pattern" (second tertile); (c) a "healthy diet–lifestyle pattern" (third tertile).	(114)
HLD Index adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	Two components were added to the original HDL index: legumes and eggs.	24-h dietary recall	24-h dietary recall	Sum of the components, 0–48	24-h dietary recall	(90)
Preschoolers Diet–Lifestyle Index (PDL-Index)	24-h dietary recall or food diaries	No	Yes	*1)* Fruits, *2)* vegetables, *3)* total grains, *4)* dairy products, *5)* red meat, *6)* white meat/legumes, *7)* fish and seafood, *8)* unsaturated fats, *9)* sweets, *10)* time spent watching TV/vídeo, *11)* moderate-to-vigorous physical activity.	A 0–4 scoring system was used to assign the appropriate score to each index component according to USDA recommendations.	24-h dietary recall	Sum of the components, 0–44	Use of tertiles.	(38)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Electronic Kids Dietary Index (E-KINDEX)	FFQ and supplementary questions	No	Yes	*1*) Bread, *2*) cereals (excluding bread), *3*) fruits and fruit juices, *4*) vegetables, *5*) legumes, *6*) milk, *7*) fish, seafood, *8*) meats, *9*) salted and smoked meat foods, *10*) sweets and junk food, *11*) soft drinks, *12*) grilled foods, *13*) fried foods, *14*) breakfast, *15*) fast food, *16*) number of main meals and snacks, *17*) frequency of school meals in the afternoon.	A 4-point scoring system (0–3 or the reverse) is used for most components of the index according to the 1990 USDA recommendations.	No	Sum of the components, 1–87	Higher values indicate higher adherence.	(92)
HEI-1995	FFQ	Yes	Yes	*1*) Grains, *2*) vegetables, *3*) fruits, *4*) milk, *5*) meat, *6*) total fat, *7*) SFA, *8*) cholesterol, *9*) diet variety, *10*) sodium.	Each component scores 0–10 points according to the Food Guide Pyramid (USDA) recommendations.	No	0–100	Higher values indicate higher adherence. >80: "good"; 51–80: "needs improvement"; ≤50: "poor".	(84, 111)
HEI-2005	24-h dietary recall or 4-d food records	Yes	Yes	*1*) Total fruit, *2*) whole fruit, *3*) total vegetables, *4*) dark and orange vegetables and legumes, *5*) total grain, *6*) whole grain, *7*) milk, *8*) meat and beans, *9*) oil, *10*) saturated fats, *11*) sodium, *12*) calories from solid fats, alcoholic beverages, and added sugar.	Depending on the components, a score of 0–5, 0–10, or 0–20 points is given, according to the USDA recommendations. All components are calculated per 4184 kJ (1000 kcal).	No	0–100	Higher values indicate higher adherence. >80: "good"; 51–80: "needs improvement"; ≤50: "poor".	(61, 144–147)
HEI-2010	24-h dietary recall	Yes	Yes	*1*) Total fruits, *2*) whole fruit, *3*) total vegetables, *4*) greens and beans, *5*) whole grains, *6*) dairy, *7*) total protein foods, *8*) seafood and plant proteins, *9*) fatty acids, 10) refined grains, 11) sodium, 12) empty calories.	Each component can receive a score ranging from 0 to 20 points, depending on the assigned maximum point total according to the 2010 Dietary Guidelines for Americans. Each average intake is standardized to an intake per 1000 kcal.	0	0–100	Higher values indicate higher adherence. >80: "good"; 51–80: "needs improvement"; ≤50: "poor".	(63, 83, 104, 148–152)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
HEI-2010 adapted to Brazil adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	According to the Brazilian Ministry of Health recommendations.	24-h dietary recall	24-h dietary recall	24-h dietary recall	(153)
HEI-2010 adapted for Singapore Health Promotion Board adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	*1)* Rice, *2)* whole grains, *3)* fruits, *4)* vegetables, *5)* meats and alternatives, *6)* dairy products, *7)* sodium, *8)* energy and total fat, *9)* saturated fat, *10)* added sugar.	Each component is given 0–10 points according to the Singapore dietary recommendations.	24-h dietary recall	24-h dietary recall	24-h dietary recall	(105)
HEI-2015	24-h dietary recall	Yes	Yes	*1)* Total fruits, *2)* whole fruits, *3)* total vegetables, *4)* greens and beans, *5)* whole grains, *6)* dairy, *7)* total protein fruits, *8)* seafood and plant proteins, *9)* fatty acids, *10)* refined grains, *11)* sodium, *12)* added sugar, *13)* saturated fats.	Depending on the components, a score of 0–5 or 0–10 points is given, according to the 2015–2020 Dietary Guidelines for Americans recommendation. The amounts are adjusted per 1000 kcal.	No	0–100	Higher values indicate higher adherence.	(109, 154, 155)
Youth Healthy Eating Index (YHEI)	FFQ + questionnaire	No	Yes	*1)* Whole grains, *2)* vegetables, *3)* fruits, *4)* dairy, *5)* meat ratio, *6)* snack foods, *7)* soda and drinks, *8)* multivitaminic use, *9)* margarine and butter, *10)* fried foods outside home, *11)* visible animal fat, *12)* dinner with family, *13)* fish.	Depending on the components, a score of 0–5 or 0–10 points is given, according to USDA recommendations.	No	0–85	Higher values indicate higher adherence.	(45, 118)
Diet Quality Index Canadian (DQI-C)	FFQ	Yes	Yes	*1)* Vegetables and fruits, *2)* grain, *3)* milk and alternatives, *4)* meat and alternatives, *5)* candy and snacks, *6)* sugar-sweetened beverages.	Each component is given a score of 0 or 1 according to the Canada's Food Guide recommendations.	No	0–6	Higher values indicate higher adherence. ≤72: unhealthy diet; 73–77: moderate diet quality; ≥78: healthy diet.	(156)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Healthy Dietary Variety Index	FFQ	No	Yes	*1*) Starchy food (including potatoes), *2*) fruits, *3*) vegetables, *4*) meat, fish, and alternatives, *5*) dairy foods.	Foods are allocated into 1 of the 5 groups according to similar composition. Within each group the contribution of a particular food is truncated at 33%. The recommended number of servings is multiplied by 33%. Considering the USDA recommendations.	No	0–1	Higher values indicate higher adherence.	(96)
Based on Brazilian recommendations									
School Child Diet Index (ALES)	FFQ	No	Yes	*1*) Fruits, *2*) vegetables, *3*) beans, *4*) milk, *5*) candies, *6*) soft drinks, *7*) fried foods, *8*) instant noodles, *9*) hamburgers, *10*) mayonnaise.	According to the recommendations of the Brazilian Ministry of Health. Scores of +1 or −1 to each food component.	No	−10 to 10	Use of tertiles. <3, poor quality; 3–6, average quality; ≥6, good quality.	(157)
Brazilian Healthy Eating Index Revised (BHEI-R)	24-h dietary recall	Yes	Yes	*1*) Total grains, *2*) whole grains, *3*) total vegetables and legumes, *4*) dark and yellow vegetables and legumes, *5*) fruits, *6*) meat, eggs, and legumes, *7*) dairy, *8*) oils, *9*) saturated fat, *10*) sodium, *11*) calories from solid fat, alcohol, and added sugar.	Depending on the components, a score of 0–5, 0–10, or 0–20 points is given, according to the Brazilian recommendations.	No	0–100	Higher values indicate higher adherence.	(110, 158, 159)
Recommended Food Score	FFQ	No	Yes	*1*) Vegetables, *2*) fruits, *3*) lean meat, *4*) cereals, *5*) dairy products.	Selection of 50 foods from 120 of the FFQ to compose the index groups. The score is calculated by adding 1 point for each food that complied with the recommendations of the Brazilian Ministry of Health. When the recommendation was not fulfilled, the component has 0 points.	No	0–50	Higher values indicate higher adherence. >80th percentile: high adherence; <80th percentile: low adherence.	(103)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Healthy Eating Index (Brazil)	FFQ	Yes	Yes	*1)* Cereals, *2)* vegetables, *3)* fruits and fruit juices, *4)* dairy products, *5)* meat and eggs, 6) legumes, 7) oils and fats, 8) sugar, candies, chocolates, and snacks, 9) total fat, 10) saturated fat, 11) cholesterol, 12) sodium, 13) diet variety.	Each component is scored from 1 to 10 according to the recommendations of the Brazilian Ministry of Health. Components *1–8)* contribute 50% of the total score and *9–13)* the other 50%.	No	Standardized, 0–100	Higher values indicate higher dietary quality. >80: "good"; 51–80: "needs improvement"; ≤50: "poor".	(39)
Based on Oceania (Australia and New Zealand) recommendations									
Australian Child and Adolescent Recommended Food Score (ACARFS)	70 questions	No	Yes	*1)* Vegetables, *2)* fruits, *3)* protein food (meat and nonmeat protein), *4)* cereals, *5)* dairy products, *6)* water, *7)* spreads/sauce.	The maximum possible score for each component was determined by the number of suitable FFQ items. Score according to the Australian Guide to Healthy Eating	No	Sum of the components, 0–73	Higher values indicate higher adherence.	(102)
Dietary Guideline Index for Children and Adolescents (DGI-CA)	24-h dietary recalls, FFQ	No	Yes	*1)* Variety, *2)* fruits, *3)* vegetables, *4)* bread and cereals, *5)* whole-grain cereals, *6)* meat and alternatives, *7)* dairy, *8)* water, *9)* extra foods (moderation of salt and sugar), *10)* healthy fats (ex. olive oil, nuts).	Depending on the components, a score of 0–5, 0–10, or 0–20 points is given, according to the 2003 Australian Dietary Guidelines for Children and Adolescents.	No	0–100	Higher values indicate higher adherence.	(64, 123)
Prior derived Diet Quality Index adaptation	FFQ	24-h dietary recall	24-h dietary recall	Instead of *10)* healthy fats, it includes a "Saturated fats" component.	Each component was scored from 1 to 10.	24-h dietary recall	24-h dietary recall	24-h dietary recall	(93)
Australian Recommended Food Scores for Pre-Schoolers (ARFS-P)	FFQ for parents	No	Yes	*1)* Vegetables, *2)* fruits, *3)* meat, *4)* meat alternatives, *5)* grains, *6)* dairy products, *7)* condiments.	According to the Australian Recommended Food Score. The component scores vary from 0 to the number of questions in that component, plus 1 more possible for vegetables, low-fat dairy, and whole grains.	No	0–73	Higher values indicate higher adherence.	(160)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Revised Children's Diet Quality Index (RC-DQI)	24-h recall	Yes	Yes	*1)* Total fat, *2)* linoleic acid, *3)* α-linolenic acid, *4)* EPA and DHA, *5)* iron, *6)* total grains, *7)* whole grains, *8)* dairy, *9)* fruits, *10)* vegetables, *11)* electronic media use and energy intake interaction.	Depending on the components, a score of 0–2.5, 0–5, or 0–10 points is given, according to the Nutrient Reference Values for Australia and New Zealand.	No	0–85	Higher values indicate higher adherence.	(161)
Dietary Index for a Child's Eating (DICE)	Original questionnaire to parents	No	Yes	*1)* Fruits, *2)* vegetables, *3)* dairy products, *4)* meat and alternatives, *5)* bread, *6)* cereals.	Each component was scored from 1 to 10 according to the New Zealand Ministry of Health Food and Nutrition Guidelines for 2–18 y.	No	0–100	Higher values indicate higher adherence.	(42)
Based on Asian recommendations									
Modified version of Revised Children's Diet Quality Index (M-RCDQI)	FFQ	Yes	No	*1)* Added sugar, *2)* total fat, *3)* linoleic acid, *4)* α-linolenic acid, *5)* EPA and DHA, *6)* total grains, *7)* fiber, *8)* fruits, *9)* vegetables, *10)* dairy, *11)* salty snacks, *12)* iron, *13)* energy.	According to Iranian recommendations (children consuming within the recommended amounts receive full points, varying from 2.5 to 10 points depending on the component).	No	0–90	Higher values indicate higher adherence.	(162)
Diet Quality Index for Indian Children (DQIIC)	21 questions	Yes	Yes	*1)* Cereals, *2)* pulses, *3)* meat and meat products, *4)* dairy, *5)* vegetables, *6)* fruits, *7)* sugar, *8)* roots and tubers, *9)* empty calories foods, *10)* frequency of breakfast consumption, *11)* frequency of meal given in lunch box, *12)* number of meals per day, *13)* frequency of consumption of favorite meal, *14)* eat out of home in the past 2 d, *15)* dietary behavior regarding consumption of advertised foods, *16)* consumption of home-food, *17)* sodium, *18)* total energy from fat.	Depending on the components, a score of 0–4, 0–6, 0–2, 0–10, or 0–8 points is given, according to the Dietary Guidelines for Indian Children.	No	Standardized, 0–90	Higher values indicate higher adherence. ≤72: unhealthy diet; 73–77: moderate diet quality; ≥78: healthy diet.	(163)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
Chinese's Children's Dietary Index (CCDI)	24-h dietary recall	Yes	Yes	*1)* Grains, *2)* vegetables, *3)* fruits, *4)* dairy products, *5)* soybeans and soy products, *6)* meat, *7)* fish and shrimp, 8) eggs, 9) water, 10) sugar-sweetened beverages, 11) vitamin A, 12) fatty acids, 13) fiber, 14) dietary variety, 15) energy balance, 16) regularly eating breakfast or dinner with parents.	Each component was scored from 1 to 10 according to the Chinese healthy recommendations.	0	0–160	Higher values indicate higher adherence.	(67, 164)
Japanese Food Guide Spinning Top Score (JFGST)	FFQ	Yes	Yes	*1)* Grain dishes, *2)* vegetable dishes, *3)* fish and meat dishes, *4)* milk, *5)* fruits, *6)* total energy, *7)* snacks and beverages.	Each component was scored from 1 to 10 according to the 2000 Dietary Guidelines for Japanese.	No	0–70	Higher values indicate higher adherence. Use of tertiles.	(112)
Malaysian Healthy Eating Index	FFQ or 2-d dietary record	Yes	Yes	*1)* Cereals and grains, *2)* vegetables, *3)* fruits, *4)* dairy products, *5)* poultry, meat, and eggs, *6)* fish, *7)* legumes, *8)* energy from total fat, *9)* sodium.	Each component was scored from 1 to 10 according to the Malaysian Dietary Guidelines for Children and Adolescents.	No	0–100 (total score of 9 components/9 × 10) × 100%	Higher values indicate higher adherence. ≤46: high risk of a poor dietary quality; ≥47: low risk of a poor dietary quality	(106, 165)
Based on the principles of international entities or others									
Obesity-Preventive Lifestyle Score (OPLS)	FFQ	No	Yes	*1)* Fruits, *2)* vegetables, *3)* sugar-sweetened beverages, *4)* breakfast, *5)* restaurants/fast food, *6)* screen time, *7)* moderate/ intense physical activity, *8)* school sport physical activity, *9)* active commuting.	Tertiles and assigned ascending values (0, 1, 2) for favorable behaviors and descending values (2, 1, 0) for unfavorable behaviors.	No	Sum of the components, 0–18	Higher values indicate healthier lifestyles.	(91)
HEI based on WHO recommendation	FFQ	No	Yes	*1)* Fruits, *2)* vegetables, *3)* dairy products, *4)* fish, *5)* eggs, *6)* meat and meat products, *7)* salty snacks, *8)* sweet foods and soft drinks.	Each food group is assigned 1–4 points. *(1)* to *(5)* components: 1st quartile: 1 point; 4th quartile: 4 points. *(6)* to *(8)* components: 1st quartile: 4 points; 4th quartile: 1 point.	No	8–32	Higher values indicate higher adherence. Use of quartiles.	.(166)

(*Continued*)

TABLE 2 (*Continued*)

Instrument	Method for food assessment	Quantitative portions of food	Consumption frequency	Components in analysis	Scoring methods	Score penalty	Score range	Adherence level	References
DQI-I	FFQ	Yes	Yes	*1*) Variety (overall food group variety; within-group variety for protein sources), *2*) adequacy (vegetables, fruits, grains, fiber, iron, protein, calcium, vitamin C), *3*) moderation (total fat, saturated fat, cholesterol, sodium, empty calories food), *4*) overall balance (macronutrient ratio, fatty acid ratio).	Depending on the components, a score of 0–10, 0–20, 0–30, or 0–40 points is given, according to the USDA Dietary Guidelines and 1996 WHO recommendations,	No	0–100	Higher values indicate higher adherence. <50: poor diet; 50–70: moderate diet quality; >70: high diet quality.	(108)
Healthy Dietary Adherence Score (HDAS)	FFQ	Yes	Yes	*1*) Refined sugars, *2*) fat intake, *3*) whole meal, *4*) fruits, *5*) vegetables, *6*) fish.	Each component was scored from 1 to 10 according to the guidelines common to all 8 countries participating in the study.	No	0–50	Higher values indicate higher adherence.	(43)
DDS	24-h dietary recall	Yes	No	*1*) Cereals, roots, and tubers, *2*) vitamin A–rich fruits and vegetables, *3*) other fruits and vegetables, *4*) legumes, pulses, and nuts, *5*) oils and fats, *6*) dairy, *7*) meat and fish, *8*) eggs, *9*) foods rich in sugar.	0 or 1 point for each component according to the guidelines of the FAO.	No	0–9	Higher values indicate higher adherence.	(107, 167–169)
DDS adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	0–48	24-h dietary recall	(170)
DDS adaptation	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	24-h dietary recall	0–10	24-h dietary recall	(44)
Healthy Diet Score (HDS)	24-h recall or record diaries	No	No	*1*) Refined grains, *2*) seafood, *3*) fried foods, *4*) sugar-sweetened beverages, *5*) meat, *6*) rice, *7*) fungi and algae, *8*) roots and tubers, *9*) wheat.	Computed by summing subscores with each of the leading dietary predictors as 1 point according to the association with cardiometabolic risk. Example: for ≥ median intake of fruit a score of 1 is given and 0 for < median, if fruit intake is inversely related to cardiometabolic risk.	No	0–9	Higher values indicate healthier lifestyles.	(45)

[1]BSDS, Baltic Sea Diet Score; DASH, Dietary Approaches to Stop Hypertension; DDS, Dietary Diversity Score; DQI-A, Diet Quality Index for Adolescents; DQI-I, Diet Quality Index International; FAO, Food and Agriculture Organization of the United Nations; fMDS, food frequency–based Mediterranean Diet Score; HEI, Healthy Eating Index; HLD Index, Healthy Lifestyle–Diet Index; HuSKY, Healthy Nutrition Score for Kids and Youth; MAI, Mediterranean Adequacy Index; MD, Mediterranean Diet; MDS, Mediterranean Diet Score; MSDPS, Mediterranean-Style Dietary Pattern Score.

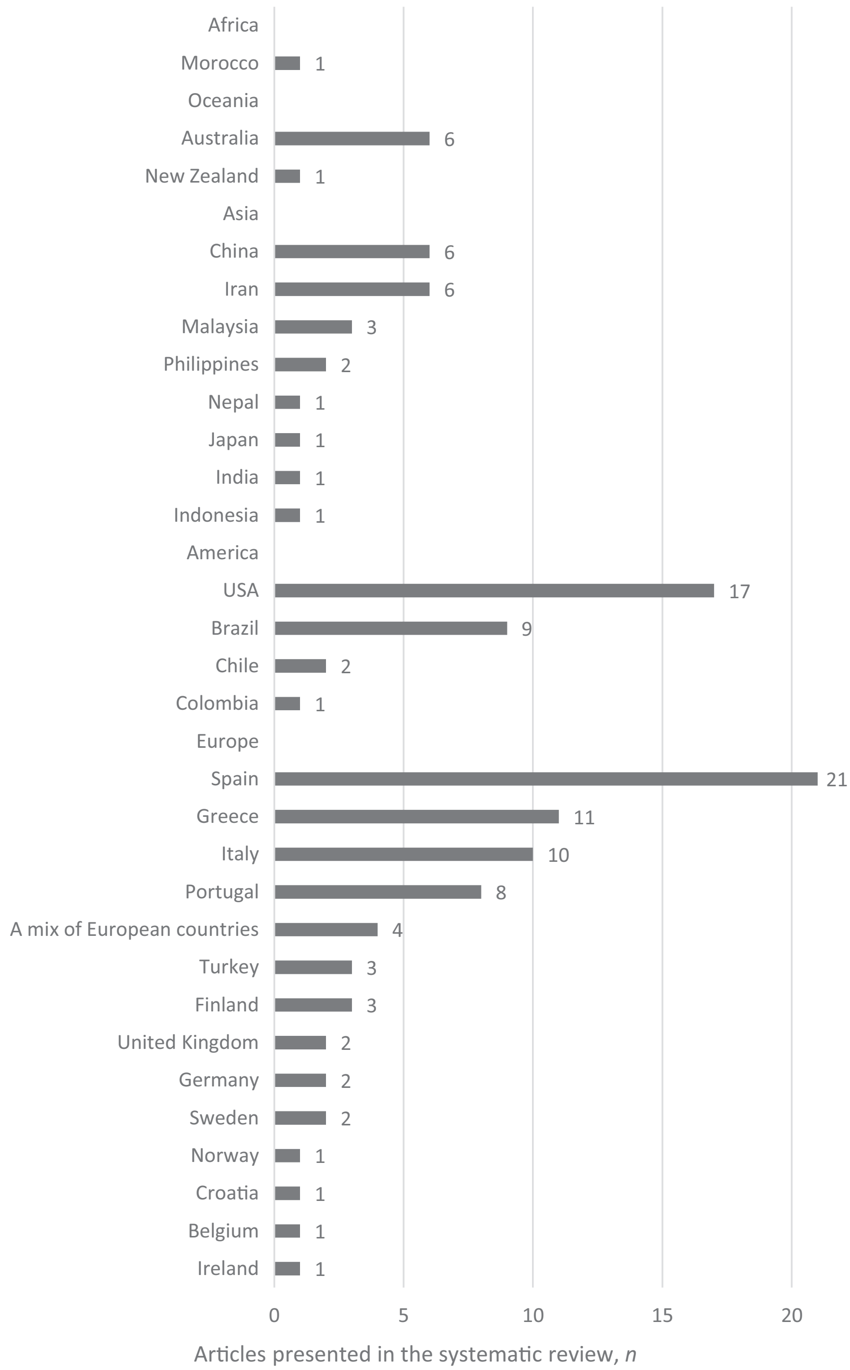

FIGURE 2 Geographical distribution of the studies included.

65 instruments). However, some instruments such as the KIDMED had already a predefined list of "yes or no" questions to measure the adherence to the dietary pattern. More than half (53.1%; 34 out of 64 instruments) did not take into account quantitative data (e.g., portions, amounts) of the included components and 73.4% (47 out of 64 instruments) considered recommended food consumption frequencies. In **Figure 3**, it can be observed that the components that were present in at least half of the revised instruments were the following, in descending order: vegetables, fruit, dairy products, meat and meat products, cereal products, and fish. Revised instruments were based on national recommendations or principles of dietary patterns known a priori (e.g., MD, national and international recommendations). Only 2 instruments took into account the penalty for exceeding the recommended values (46, 49). For the scoring method, several methodologies were followed such as the determination of cutoffs or *z* scores. The instruments had very different boundaries and, in all of them, the higher the final score (usually the sum of all individual components'

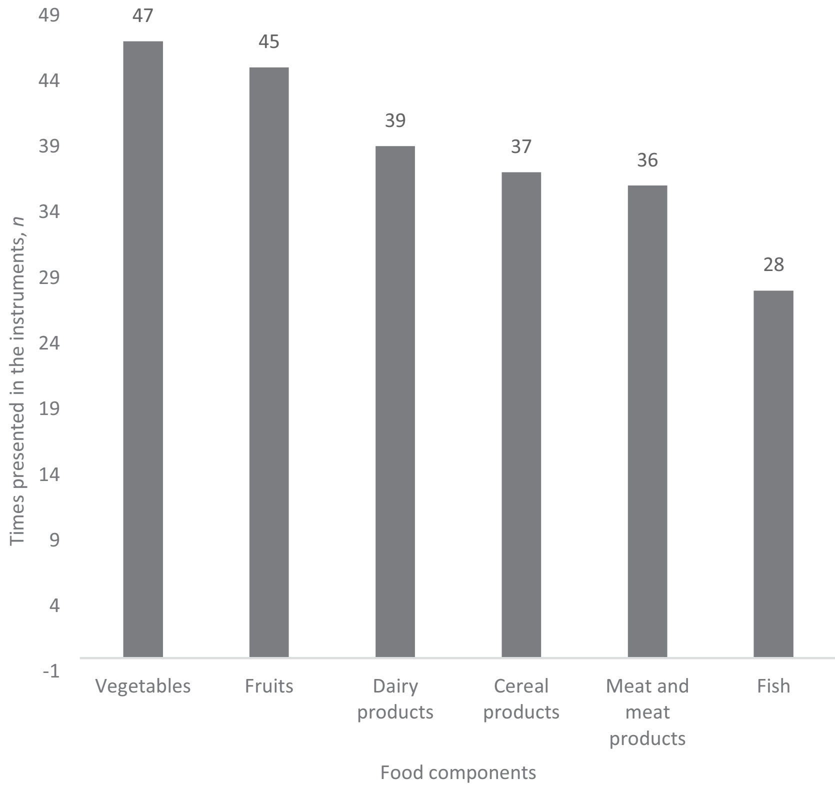

FIGURE 3 Food components identified in at least half of the 50 instruments identified in the literature to measure the adherence to healthy and/or sustainable a priori dietary patterns.

scores), the greater the adherence to the dietary pattern. In addition, some instruments made use of percentiles (medians, quintiles, quartiles, or tertiles) or other specific cutoffs to determine the adherence level (e.g., low, moderate, high) (Table 2).

Adherence to the a priori dietary patterns identified

In this systematic review it was found that the adherence to the MD in children and adolescents was measured by 8 different instruments plus 6 adaptations. Of these, only 3 took into account the recommended quantitative portions (49, 68, 69) (Table 2). Table 1 shows the results on MD adherence (as mean and/or categories of poor compared with high adherence) that were collected from the selected articles. The KIDMED index, ranging in general from −4 to 12 points, was used in 38 studies with participants ranging between 2 and 17 y old. Of these, 32 studies were cross-sectional, 5 were cohort studies (55, 70–73), and 1 was an RCT (74). Twelve studies expressed the results as mean values and categorical values; 12 studies stated the results only as mean ± SD values which varied from 3.78 ± 2.20 in Greek adolescents (75) to 7.2 ± 1.9 in Spanish adolescents (76). In 24 studies the distribution of the KIDMED score into categories (high, medium, and poor adherence) was reported. High adherence varied from 0.8% in Spanish individuals at baseline (71) to 77.6% in Portuguese individuals (77). The MDS, ranging in general from 0 to 8 points and used in 5 studies, varied in terms of mean scores from 4.1 in English participants 9–10 y of age (78) to 8.24 in Spanish children (68) (Table 1).

With participants ranging from 5 to 17 y of age, the Dietary Approaches to Stop Hypertension (DASH) score, ranging in general from 0 to 80 points, was used in 8 studies and often in Iran (48, 60, 79), 6 of which were cross-sectional (48, 59, 79–82) and 2 cohort studies (55, 60). Six studies expressed the results as mean ± SD values, which varied from 15.7 ± 50.0 in Brazilian adolescents (59) to 43.4 ± 49.0 in San Diego individuals 6–12 y of age (80). Most of these studies showed levels of adherence according to tertile (48, 55, 59, 60, 79, 81) or continuous scores (80–82). Regarding the Healthy Eating Index (HEI) from 1995 to 2015, ranging in general from 0 to 100 points, the mean ± SD adherence varied from 30.1 ± 5.38 in American adolescents (83) to 63.90 ± 19.86 in Iranian adolescents (84). In relation to the other instruments, it was not possible to make an analysis of adherence to each instrument because each had been applied in only a few studies. However, most of these instruments were applied in cross-sectional studies, in which the higher the score, the greater the level of adherence to the dietary pattern under study (Table 1).

Associations between the dietary patterns identified and the health-related outcomes

Relations with clinical outcomes were found in 62 articles. In most of them (40%), body fat, waist circumference

(WC), blood pressure, and metabolic risk were negatively related with adherence to healthy and/or sustainable dietary patterns. Of these, 29 included only adolescents, whereas the rest contained children or children and adolescents. Fifteen only used crude correlations to describe the associations found.

Anthropometric/clinical factors

Seventeen studies showed a significant negative association between BMI and the following dietary patterns: the KIDMED index (71, 73, 85–89), the food frequency–based Mediterranean Diet Score (fMDS) (37), the DASH score (60), the Healthy Lifestyle–Diet Index (HLD Index) (90), the Preschoolers Diet–Lifestyle Index (PLD-Index) (38), the Obesity-Preventive Lifestyle Score (OPLS) (91), the Electronic Kids Dietary Index (E-KINDEX) (92), the Prior Derived Diet Quality Score (93), the Riskmaten Adolescents Diet Diversity Score (94), the Healthy Diet Score (HDS) (95), and the Healthy Dietary Variety Index (96). However, 20 studies found no significant relation of BMI with the KIDMED index (55, 56, 70, 76, 97–101), MDS (78), DASH diet (55), Australian Child and Adolescent Recommended Food Score (ACARFS) (102), Recommended Food Score (103), HEI-1995 (84), HEI-2010 (63, 104, 105), Malaysia Healthy Eating Index Score (106), Swedish Healthy Eating Index for Adolescents (94), and the Dietary Diversity Score (107). Finally, 5 articles described a positive association of BMI with the KIDMED index (51), Diet Quality Index International (DQI-I) (108), HEI-2015 (109), Brazilian Healthy Eating Index Revised (110), and Dietary Guideline Index for Children and Adolescents (64); within these articles, 4 were cross-sectional and 1 was a cohort study in which no adjustments were made for multiple comparisons (Table 1).

The KIDMED index was negatively related to body fat mass in 2 studies (73, 87), to WC in 5 studies (50, 73, 86, 87, 101), to subscapular skinfold thickness (73), and to neck circumference (86). The KIDMED index was positively related to height in 1 article (98), to WC in 1 article (51), and had no association with waist-to-height ratio (78). Fat mass was also negatively related with the fMDS (37), but it was not associated with the HEI-1995 (111). WC was also negatively related to the E-KINDEX (92), OPLS (91), and HEI-2005 (61). No association was found between the WC and the MDS (78), HEI-2010 (63), and Malaysia Healthy Eating Index Score (106). Hip circumference was negatively related to OPLS in 1 study (91). Waist-to-height ratio was negatively associated with the Japanese Food Guide Spinning Top Score (112), but did not have a significant relation with the Dietary Guideline Index for Children and Adolescents (64) (Table 1).

Cardiometabolic risk was negatively associated with the DASH score (60) and the SEAD (47, 113). On the other hand, the Baltic Sea Diet Score was not related to cardiometabolic risk (81). The DASH score, Baltic Sea Diet Score, and Children's Index of Diet Quality were associated with lower concentrations of blood cholesterol (40, 81), whereas the HEI-2005 (19) and Malaysia Healthy Eating Index Score (106) did not present any association. The HLD Index (114), DASH score (60, 81), and HDS (95) were suggested to be protective in relation to insulin resistance and, as such, to an adequate concentration of glucose and insulin in the blood, unlike the Malaysia Healthy Eating Index Score (106) which had no relation. The concentration of triglycerides was negatively associated with the HEI-2005 (61) and the Dietary Guideline Index for Children and Adolescents (64), despite not having any relation with the HEI-2010 (63). The KIDMED index and the Healthy Nutrition Score for Kids and Youth were negatively related to albuminuria (51) and homocysteine concentrations (46), respectively. Greater scores on the KIDMED index (58) and the HEI-2005 (61) were associated with a lower C-reactive protein blood concentration (Table 1).

Concerning blood pressure individually, a negative relation was reported with the DASH score in 2 articles (60, 79), KIDMED index in 1 article (115), and HDS in another 1 (95). However, no associations were found of blood pressure with the DASH score in 1 article (59), KIDMED index in 1 article (87), HEI-2010 (63), HEI-1995 (84, 111), and Dietary Guideline Index for Children and Adolescents (64). However, 1 article correlated positively the KIDMED index with blood pressure (article quality: 6 points) (51) (Table 1).

Regarding diagnosed disease occurrence, the KIDMED index was negatively associated with asthma (116) and attention deficit hyperactivity disorder (ADHD) (117) and positively with bone mineral density (55). Asthma was also negatively related to the OPLS (91) and had no relation with the Youth Healthy Eating Index (118). ADHD diagnosis was also negatively associated to the Healthy Nutrition Score for Kids and Youth (62). The DASH score did not present any association with bone mineral density (55), but it was negatively related to insomnia (48). Depression and Night Eating Syndrome had no association with the MDS (54) and the KIDMED index (56) (Table 1).

Discussion

In the present study, a systematic review was carried out, which, to our knowledge, is the first to combine the search for simultaneously healthy and sustainable a priori dietary patterns used in children and adolescents with the additional purpose of combining benefits and health outcomes associated with them. In this review, 50 instruments plus 14 adaptations were identified. In general, the articles included a high-quality average score, which is extremely important for the discussion of results.

The MD pattern is the dietary pattern most described in this systematic review (50 out of 128 articles), followed by the HEI-2010 (9 of 128) and the DASH diet (8 of 128). Among the instruments described for evaluating MD adherence among children/adolescents, the KIDMED index is the most used in Mediterranean countries, such as Spain, Italy, Greece, Portugal, and Turkey. The MDS is also used in non-Mediterranean countries (3 out of 5 articles). Geographically, adherence to the MD is studied in all the continents of the world, which highlights its global importance, being more studied over the last decade in the European and American continents. Some of the instruments described were developed specifically for children and adolescents as is the case of the KIDMED index (119), whereas others were modified from those used in adults (19, 120–122).

All of the dietary patterns identified are based on a priori criteria supported by scientific knowledge and differ between themselves with regard to the number of items, included components, cutoffs for scoring, and inclusion of quantitative food portions or food frequencies, which hampers straight comparisons between them. Most of them have in common the characteristics of a healthy and sustainable diet, stated by the EAT–*Lancet* Commission (5). However, none of these instruments has been proven to have sustainable characteristics, so instruments are only considered sustainable owing to their a priori classification in the literature or based on the inclusion of specific food groups that are known to have a lower ecological footprint, such as fruit and vegetables. The need to adhere to more sustainable diets is urgently growing. According to the EAT–*Lancet* Commission, these diets must have an adequate caloric intake and consist of consumption of a diversity of plant foods, low amounts of animal source foods, unsaturated fats instead of saturated fats, and small amounts of refined grains, highly processed foods, and added sugars (5). It is crucial to develop strategies for increasing adherence to healthy and sustainable dietary patterns all around the world. In fact, this transformation for 2050 will require a >50% reduction in global consumption of unhealthy foods, such as red meat and sugar, and a >100% increase in consumption of healthy foods, such as vegetables, fruit, nuts, and pulses (5). As such, it becomes relevant and essential to produce evidence that instruments that measure adherence to dietary patterns for children and adolescents are also sustainable, for example through associations of the dietary pattern represented with greenhouse gas emissions, land use, or a water footprint. Future research could produce a new instrument that sets at the same time a healthy and sustainable dietary pattern for children and adolescents.

Adherence to the dietary patterns identified

A narrative review suggested that MD adherence is poor in children and adolescents living in the Mediterranean countries (10). In this research, data on MD adherence were mainly provided by studies using the KIDMED index. MD adherence, in this study, even using the same index and concerning the same country, suffers great fluctuations, as already described in a systematic review (9). MD adherence cannot be directly compared across the different instruments identified. The pediatric population's adherence to the DASH score and the different instruments also vary widely in this review. According to our knowledge, this is the first time that adherence to other dietary patterns (beyond the MD) has been summarized in children and adolescents aged 2–17 y and, therefore, adherence data to be discussed are scarce.

There is no consensual and easy explanation for the wide variations in adherence to healthy and/or sustainable dietary patterns, even within the same country. These variations may be due to methodological constraints, namely different characteristics in terms of sample size, age range, percentage of males compared with females, method of food consumption assessment (questionnaire application, food diaries, FFQs, 24-h dietary recalls), the cutoffs used for scoring (based on different recommendations or different percentiles), and the study type (cross-sectional, cohort, case control, and RCT). Finally, the fact that most instruments are not adapted/validated for the countries in use makes adherence results found in the literature less reliable.

Health-related outcomes associated with the dietary patterns identified

Pediatric dietary patterns can predict adults' diet-related disease (15) and it is known that unhealthy and unsustainable diets are related to noncommunicable diseases, including cardiovascular diseases, obesity, and diabetes, among adults (5). However, our article showed conflicting results: 17 articles showed a negative association between adherence to these dietary patterns and BMI, whereas 20 did not find any association and 5 reported a positive relation with children's BMI. These inconsistent associations have been previously described in a review regarding the MD in children and adolescents (9). Firstly, it should be underlined that, in this systematic review, 33 out of the 40 articles that studied BMI were cross-sectional, which makes less accurate the assessment of cause–effect associations. With respect to the 7 prospective studies which studied BMI, 5 of them reported a negative association (37, 60, 71, 93, 96). Secondly, different criteria for obesity definition were taken into account in this review, for example from the WHO (70), International Obesity Task Force gender- and age-related cutoffs (76), and British Growth Reference (102). Thirdly, some of the articles from this review that analyzed BMI effects used instruments that did not consider quantitative food data, which we know will influence individuals' weight. Fourthly, the use of z scores of BMI (70) or not (85) can also explain discrepancies between results. Finally, associations with BMI also depend on the variables for which the analyses were adjusted. In general, the studies that analyzed BMI adjusted for multiple confounders; however, there is always a minority that only make simple correlations. In addition, in this review, a study showed different results (no association compared with a positive association between BMI and adherence to the Dietary Guideline Index for Children and Adolescents) according to stratification by the ages of the participants (123).

Other anthropometric indicators have been studied, such as WC for which a negative association with adherence to dietary patterns was found in all the 7 studies reported, but they are scarcer and limited. In 2 prospective studies it was possible to observe a decrease in WC and an improvement in body composition when adhering to healthier dietary patterns in children and adolescents (124, 125), meeting the main results obtained in this review in relation to these variables. Also, for cardiometabolic risk some evidence seems to support better cardiometabolic health being an effect of these dietary patterns, particularly when considering the KIDMED index and the DASH score. Indeed, some dietary patterns such as the MD, DASH, and the Nordic Diet are being related to reduced risks of cardiovascular disease in the literature (126). Regarding diagnostic diseases, a reduced number of articles were conducted, hampering further conclusions. It is also worthy of note that because many of the studies focused on adherence to the MD (50 of 128), it is important to consider a possible data bias with regard to the described associations with health outcomes.

Final remarks

To the best of our knowledge, this is the first article that has systematically searched and reviewed the scientific literature available on healthy and/or sustainable dietary patterns in children and adolescents, all over the world. To make this review more comprehensive, instruments were examined in detail at the methodology level, for example by performing analysis of the number of items, food and nonfood components included, cutoffs used in the scoring method, and categorization criteria for adherence classification. This work is also the first review which aimed to investigate the health-related outcomes associated with healthy and/or sustainable dietary patterns in children and adolescents. This systematic review scientifically supports the need to promote adherence to these dietary patterns from an early age and to understand how health education may benefit in the future these children and adolescents. In addition, this work upholds the need to consider the penalty for exceeding the recommended values, in order to measure more accurately adherence to dietary recommendations. Finally, none of the instruments have been duly proven to be sustainable, so the creation of a new instrument with sustainable characteristics or showing the associations of previous dietary patterns with, for example, the ecological and water footprints is highly demanded.

This systematic review has also some limitations. Firstly, most of the studies found were cross-sectional, which makes it impossible to establish temporal relations, which reduces the robustness of the results on the associations between the dietary patterns and the health-related outcomes. For this reason, more prospective cohorts and intervention studies are necessary to better understand the relation between adherence to these dietary patterns and health. Secondly, only MD instruments have several studies focused on the pediatric population. All the other studies identified instruments that need further application and investigation. Thirdly, most of the instruments described were not validated/adapted for the countries under study, which compromises the internal consistency of the described results, making validation/adaptation of these instruments in each country truly recommended and needed.

Conclusions

In this systematic review, 50 instruments measuring the adherence to healthy/or sustainable dietary patterns in children and adolescents were found: KIDMED, Krece Plus Test, MDS, fMDS, Mediterranean Adequacy Index, Italian Mediterranean Index, Mediterranean-Style Dietary Pattern Score, DQI-I adapted to MD, DASH score, Baltic Sea Diet Score, SEAD score, HLD Index, PLD-Index, OPLS, E-KINDEX, School Child Diet Index, HEI-1995, HEI-2005, HEI-2010, HEI-2015, HEI based on WHO recommendation, HDS, Healthy Dietary Adherence Score, Healthy Nutrition Score for Kids and Youth, Healthy Eating Index (Brazil), Malaysia Healthy Eating Index Score, Finnish Children Healthy Eating Index, Swedish Healthy Eating Index for Adolescents, Diet Quality Index for Adolescents, Riskmaten Adolescents Diet Diversity Score, Healthy Dietary Variety Index, Brazilian Healthy Eating Index Revised, Chinese's Children's Dietary Index, Children's Index of Diet Quality, Dietary Index for a Child's Eating, Youth Healthy Eating Index, modified version of Revised Children's Diet Quality Index, Dietary Diversity Score, Diet Score based on the Norwegian Health Directorate, DQI-I, Diet Quality Index for Children, Diet Quality Score for Ireland, Diet Quality Index Canadian, Diet Quality Index for Indian Children, Japanese Food Guide Spinning Top Score, Dietary Guideline Index for Children and Adolescents, Revised Children's Diet Quality Index, Recommended Food Score, ACARFS, and Australia Recommended Food Score for Pre-Schoolers. Of these, 14 adaptations were found.

Concerning the methodological approach, most of the instruments were based on previous application of an FFQ, food records, or 24-h dietary recalls. Out of the total instruments found ($64 = 50 + 14$), 29 took into account the quantitative consumption data of the included components and 47 considered the recommended food consumption frequencies. Vegetables, fruit, dairy products, meat and meat products, cereal products, and fish were the components presented in at least half of the revised instruments. Scoring was based on different methods such as national recommendations or principles of dietary patterns known a priori. The scoring methods were based on percentiles (medians, quintiles, quartiles, tertiles) or z scores. Only 2 instruments took into account the penalty for exceeding the recommended values.

The MD was the most studied dietary pattern among those aged 2–17 y (50 of 128 articles). This review shows that adherence to the dietary patterns exhibits wide variation all over the world, and ultimately depends on subjective factors, reflected in the food habits of a country. Moreover, most of the instruments described have still been little studied in children and adolescents, reducing the external validity of the results.

The dietary patterns described have primarily been associated with BMI, for which no consistent associations have been found. Other inverse relations were described, for instance with body fat, WC, and blood pressure, but evidence is still scarce.

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paper and had primary responsibility for the final content; CA, SR, and AO: reviewed and edited the paper; and all authors: read and approved the final manuscript.

Data Availability

Supllementary Data are freely available without restriction at https://doi.org/10.1093/advances/nmab148.

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