



REVIEW

Dietary habits of adolescents living in North America, Europe or Oceania: A review on fruit, vegetable and legume consumption, sodium intake, and adherence to the Mediterranean Diet



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Abstract *Aims:* This review aimed at investigating fruit, vegetable and legume consumption, salt/sodium intake, and the adherence to the Mediterranean dietary pattern in adolescents, three key aspects towards the adoption of a healthy diet.

Data synthesis: Three separate searches were carried out on PubMed and Scopus, using the same procedure, searching for studies published in the previous decade with data on fruit and/or vegetable or legume consumption, salt or sodium intake, and adherence to the Mediterranean Diet assessed using the KIDMED questionnaire. The review included a total of 58 papers, which describe original investigations on healthy adolescents (10–19 years old) living in North America, Europe or Oceania, with a sample size >150 participants. The average fruit and vegetable consumption has been found strongly below the recommended values of 400 grams or 5 portions per day in almost all the examined populations. Very little is known about adolescents' legume consumption. Few available data have been found also for sodium intake and, for the majority of the screened populations, levels were far above the recommended 5 grams per day. Lastly, a medium–low adherence to the Mediterranean Diet has been found for adolescents living in Mediterranean Countries.

Conclusions: Adolescents living in North America, Europe or Oceania are far from being compliant with the nutritional recommendations for fruit, vegetables, legumes, and sodium, and they do not follow the principles of the Mediterranean Diet. Educational and behavioural interventions are required to improve adolescents' dietary patterns.

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Abbreviations: 24h-R, 24 h recall; BMI, body mass index; BW, body weight; FFQ, food frequency questionnaire; F&V, fruit and vegetables; FV&L, fruit, vegetables and legumes; MD, Mediterranean Diet.

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Introduction

In the last decades, major modifications of adolescents' lifestyle have been observed worldwide leading to substantial changes in dietary patterns and food consumption, with differences noticed among countries and age groups [1]. The impact of globalisation and urbanisation on dietary patterns has determined a rapid increase in the consumption of highly processed/energy-dense foods with a poor nutritional value as well as ready-to-eat products [1–3], thus contributing to the deterioration of dietary habits especially among youths. The shift towards Western dietary patterns has been associated with a higher incidence of chronic non-communicable diseases from childhood to adulthood [4]. With the alarming rise of overweight and obesity in adolescents, eating habits of the young deserve particular attention not only because of the direct implications on weight status [5], but also to the increased risk of cardio-metabolic conditions in adulthood, such as hypertension, metabolic syndrome and type II diabetes [6].

Among food behaviours, the consumption of plant-based foods, in particular fruit, vegetables and legumes, is considered a positive habit by virtue of the potential in the prevention of overweight and obesity and of some non-communicable diseases [7,8].

The reduction of sodium intake represents another important issue to which an increasing interest has been addressed. High sodium intake leads to an increased risk of not only cardiovascular diseases [9], such as myocardial infarction, cardiac failure and stroke, ventricular hypertrophy and proteinuria [10], but also osteoporosis [11] and stomach cancer [12]. Due to their impact on disease prevention and maintenance of the health status, international nutritional goals have been set for fruit and vegetable (F&V) consumption (≥ 400 g/day), and sodium chloride (< 5 g/day) or sodium (< 2 g/day) [13].

However, the recommendations for a healthy diet can be more effective if contextualised within a dietary pattern that convinces in terms of food acceptability, organoleptic characteristics and availability. In this perspective, the Mediterranean Diet (MD) could be a strategic dietary pattern for the prevention and control of chronic non-communicable diseases over the entire lifespan [14–16] and improvement of life expectancy and quality [17].

In keeping with this evidence, a review of the most recent literature has been carried out, with the aim of investigating fruit, vegetable and legume consumption, sodium intake, as well as the adherence to the Mediterranean dietary pattern of adolescents living in North America, Europe or Oceania. This review has been carried out in the frame of the project “*Health promotion in the third millennium: facebook, social gaming and promotion of healthy lifestyles among adolescents*”, proposed by the Italian National Agency for National and Local Health Services (AGENAS) in line with the National Prevention Plan 2014–2018 of the Italian Ministry of Health.

Methods

Literature search

This review followed the Centre for Reviews and Dissemination's guidance for undertaking reviews in health care [18] as much as possible on the basis of our study design. A comprehensive search of the literature was performed between January and February 2017 using PubMed and Scopus databases to carry out three separate searches on fruit, vegetable and legume (FV&L) consumption, sodium intake and adherence to the MD in adolescents. A combination of the following keywords were used to search the databases: 1) adolescent, teenager, pubescent, boy, girl, young, youth, 2) observational study, cross-sectional study, cohort study (longitudinal); and specific terms for each topic: for the FV&L search, 3) fruit, vegetable, legume, pulses, and 4) intake, consumption, consume; for the sodium search, 3) salt, sodium, and 4) intake, consumption, consume; for the adherence to MD search 3) Mediterranean diet; and 4) adherence, index, score, KIDMED. The search was limited to papers published during the previous decade. The search strategy models for the two databases by the above topics are reported in [Supplementary material 1](#).

Study selection and data extraction

Three distinct searches were completed using the same procedure. Two independent researchers assessed the papers using a 3-step strategy ([Supplementary Material 2](#) – flow diagram of study selection), performed data extraction using a standardised form, evaluated the accuracy of the included studies on the basis of the inclusion criteria and the precision of the extracted data, and solved discrepancies/inconsistencies through discussion. Firstly, articles were screened for eligibility by title and abstract. Those that met the inclusion criteria were recorded for full text evaluation and data extraction. Studies included in this review were peer-reviewed papers published in English from January 1st 2007 to December 31st 2017, describing original investigations on healthy adolescents living in a North America, Europe or Oceania, and with a sample size > 150 participants. This time frame was set to avoid the inclusion of works not reporting the current dietary habits of adolescents, due to the fact that accumulating evidence has shown that 1) the dietary patterns of adolescents have changed in the last decades and 2) the portion size of food has dramatically increased over time. Additional inclusion criteria were specified for the three searches respectively: FV&L consumption collected through dietary assessment instruments; salt or dietary sodium intake estimated through dietary assessment tools or urinary samples; and adherence to the MD assessed by the KIDMED questionnaire [19]. Studies referred to a specific population (e.g. patients, athletes) or to different age groups were excluded. For each article included, the following data were recorded: authors, year of publication, editorial details, study population (sample size, age,

gender distribution, period of data collection and country of residence), assessment method(s), outcomes and association between outcomes.

Results

Description of the selected studies

From the searches on electronic databases, a total of 1788 articles were found for the FV&L consumption, 2940 for the salt/sodium intake, and 742 for the adherence to the MD. After removing duplicates and articles that did not meet the inclusion criteria, the full text of 232 papers for FV&L, 85 for sodium intake, and 132 for adherence to the MD was reviewed. In addition, out of the total articles read in full, 203 (FV&L), 80 (sodium), and 108 (adherence to the MD) papers were rejected from this review since they did not fully meet the inclusion criteria. The detailed flow diagram of study selection by search topics is described in the [Supplementary Material 2](#). The final number of papers included in this review was 29 for FV&L consumption, 5 for salt/sodium intake, and 24 for adherence to MD ([Table 1](#)).

Characteristics of the included studies

[Table 1](#) shows the 58 articles included in the revision, with the description of populations and countries. Papers describe at least one data referred to the consumption of fruit and/or vegetables or legumes, the salt or sodium intake, and the adherence to the MD of healthy adolescents living in North America, Europe or Oceania. Specifically, the studies were carried out in Greece (10), Spain (9), Italy (8), USA (8), Australia (4), UK (4), Canada (3), Norway (3), Portugal (3), Germany (2), Cyprus (1), Netherlands (1), New Zealand (1), and Poland (1). Papers describing the same population, even if reported in different publications, were considered as one study and all individual analyses were included, so collecting all outcomes of the same cohort. For articles reporting more age groups only data referred to adolescents were reviewed. Participant sample size varied notably among studies, ranging from 178 to 29,152 volunteers. When all the populations were evaluated, after considering only once the cohorts described in more papers, the data referred to a total of 127,533 participants for the FV&L consumption, of 8600 for sodium intake, and of 20,005 for the adherence to the MD. The age range was 10–19 years, corresponding to the adolescent definition of the WHO and the populations were composed by both genders.

Eating habits of adolescents living in North America, Europe or Oceania

Fruit, vegetable and legume consumption

The total consumption of F&V was reported in 13 papers, while F&V consumption, collected as distinct data, in 16 publications. Moreover, 1 publication reported data referred to fruit only and another one to vegetables only. Legumes were investigated and reported as distinct data in

only 1 study, whereas were encompassed in F&V in another paper. FV&L consumption was collected using different dietary assessment tools: dietetic interview (1), self-administered quantitative food frequency questionnaire (FFQ) or semi-quantitative FFQ (21), semi-quantitative FFQ in combination with two 24 h recall (24h-R) (1), 24h-R (5), 7-day food diary (1). FV&L consumption was differently expressed among studies: grams of product consumed per day (3), percentage of energy provided compared to the daily energy intake (1), daily or weekly consumption of standard portions (12), or daily or weekly consumption without considering the consumed amount (13). In addition, associations between FV&L and gender, age, or behavioural and socio-cultural variables were investigated in many publications. Assessment methods, data on FV&L consumption, and other variables and outcomes are reported for each population in [Table 2](#).

Cross-sectional studies. Two cross-sectional studies reported the grams of FV&L consumed per day. Participants in the “Evaluation of Diet Habits in Adolescents” Italian survey ($n = 565$, 12–19 y) were found to consume an average of 165 and 193 grams per day of fruit and dried fruit, 171 and 129 grams per day of vegetables, and 5 and 17 grams per day of legumes, respectively if they were females or males [20]. Similarly, in a cross-sectional survey carried out on Spanish adolescents living on the Balearic Islands ($n = 956$, 12–17 y), the mean total F&V intake was around 300 grams per day, with an average of 173 grams per day of fruit and 130 grams per day of vegetables [21]. Moreover, three longitudinal studies reporting F&V intake values were considered as cross-sectional as they referred to a single time point [22–24]. In the first, a cohort of Australian adolescents ($n = 699$, 17 y) stratified by their frequency of takeaway food consumption at 12 years: those who ate takeaway one or more times a week had a lower fruit and vegetable intake than those who ate takeaway less than once a week (204 and 247 grams of fruit, and 223 and 257 grams of vegetables per day, respectively) [22]. In the second study, a very low consumption of both F&V was reported in the UK “Avon Longitudinal Study of Parents and Children” (ALSPAC) cohort ($n = 3620$, 13 y), with a mean intake of 9.5 portions per week [23]. In the last study, the UK Household Longitudinal Study ($n = 3914$, 10–15 y), only 14% of males and 16% of females reached the minimum recommended amount of 5 portions of F&V per day, 29% and 44% consumed 3–4 portions per day, 41% and 36% 1–2 portions per day, while 6% and 4% did not reach any portion per day [24]. In a cross-sectional study carried out in Minnesota, 340 participants (11–19 y) reported consuming on average 3 portions per day of F&V [25]. In a Canadian cohort ($n = 448$, 10–17 y), subjects consumed 5 portions per day of F&V, with 70% of the population not reaching the recommended portions per day [26]. When another population of Canadian students ($n = 3494$, 13–14 y) was stratified by family income, adolescents belonging to the highest quintile consumed 3 portions per day of F&V, while participants

Table 1 Main characteristics of the publications considered in the literature review.

Search topic	Country	Sample size	Male/Female	Age ^a
Fruit, vegetables and legumes				
Noale et al. (2014) [20]	Italy	565	287/278	12–19
Llull et al. (2011) [21]	Spain	956	426/530	12–17
Gopinath et al. (2016) [22]	Australia	699	319/380	17
Fraser et al. (2011) [23]	UK	3620	1711/1909	13
McAloney et al. (2014) [24]	UK	3913	2000/1913	12.5
Laska et al. (2010) [25]	USA	334	164/170	15.4 ± 1.7
Setayeshgar et al. (2017) [26]	Canada	448	179/269	12.5 ± 1.6
Lord et al. (2015) [27]	Canada	3467	Not available	14.5 ± 0.4
Leatherdale and Laxer (2013) [28]	Canada	178	84/94	14–15
Ntalla et al. (2015) [29]	Greece	C1: 857 C2: 1072	C1: 388/469 C2: 495/577	C1: 13.4 ± 0.9 C2: 11.2 ± 0.7
Loucaides et al. (2011) [30]	Cyprus	1966	1030/936	14.7 ± 2.2
Sidoti et al. (2010) [31]	Italy	250	123/127	17–19
Levin et al. (2015) [32]	UK	6493	3231/3262	11–15
Bak-Sosnowska and Skrzypulec-Plinta (2012) [33]	Poland	711	263/448	14–15
Longacre et al. (2014) [34]	USA	1542	804/738	14.4 ± 1.04
Terry-McElrath et al. (2014) [35]	USA	29,152	Not available	13–18
Iannotti and Wang (2013) [36]	USA	C1: 14,607 C2: 9150 C3: 10,848	C1: 6977/7630 C2: 4431/4719 C3: 5587/5261	C1: 13.9 (0.1) C2: 14.1 (0.1) C3: 13.9 (0.1)
Harris et al. (2015) [37]	Germany	1232	589/643	B: 11.0 ± 0.5 FU: 15.5 ± 0.3
Falbe et al. (2014) [38]	USA	8272	3668/4604	11–18
Pearson et al. (2009) [39]	Australia	1844	840/1044	12–15
Pearson et al. (2011) [40]	Australia	1729	774/955	B: 12–15 FU: 14–17
Stephens et al. (2014) [41]	Australia	521	225/296	14–17
Oza-Frank et al. (2012) [42]	USA	7445	3730/3715	B: 10–11 FU: 13–14
Bjelland et al. (2011) [43]	Norway	1437	703/734	11.2 ± 0.3
Totland et al. (2013) [44]	Norway	885	466/419	11–13
Gebremariam et al. (2013) [45]	Norway	908	Not available	11–13
de Winter et al. (2016) [46]	Netherlands	B: 2149 FU: 1816	Not available	B: 13.6 ± 0.5 FU: 16.3 ± 0.7
Lipsky et al. (2015) [47]	USA	B: 2785	B: 1267/1518	B: 16.3 (0.0)
Deforche et al. (2015) [48]	Germany	291	97/194	B: 17.2 ± 0.5 FU: 18.7 ± 0.5
Sodium				
Quader et al. (2017) [49]	USA	1184	Not available	11–18
He et al. (2008) [50]	UK	496	234/262	14–18
Magriplis et al. (2011) [51]	Greece	4580	2244/2336	10.9 ± 0.75
Thomson (2009) [52]	New Zealand	1143	567/576	11–14
Campanozzi et al. (2015) [53]	Italy	551	235/316	10–18
Mediterranean Diet				
Magriplis et al. (2011) [51]	Greece	4580	2244/2336	10.9 ± 0.75
Agostinis-Sobrinho et al. (2016a) [56]	Portugal	529	262/267	14.3 ± 1.7
Agostinis-Sobrinho et al. (2016b) [57]	Portugal	529	262/267	14.3 ± 1.7
Da Rocha Leal et al. (2011) [58]	Portugal	390	175/215	13.5 ± 1.0
Asensi et al. (2015) [59]	Spain	379	207/172	12–16
Grao-Cruces et al. (2014b) [60]	Spain	1988	1005/983	13.9 ± 1.3
Grao-Cruces et al. (2015) [61]	Spain	1897	956/941	13.9 ± 1.3
Grao-Cruces et al. (2014a) [62]	Spain	1808	924/884	14.3 ± 1.3
Esteban-Cornejo et al. (2016) [63]	Spain	1371	686/685	12.0 ± 2.5
Bibiloni et al. (2016) [64]	Spain	1321	573/658	12–17
Fauquet et al. (2016) [65]	Spain	1381	734/647	14.1 ± 1.1
Santomauro et al. (2014) [66]	Italy	1127	621/506	16.8 ± 1.6
Grosso et al. (2013) [67]	Italy	1135	627/508	13.0 ± 0.5
Buscemi et al. (2016) [68]	Italy	1643	886/757	12.4 ± 0.7
Ferranti et al. (2016a) [69]	Italy	1586	870/716	12.0 ± 0.7
Ferranti et al. (2016b) [70]	Italy	1586	870/716	12.0 ± 0.7
Mistretta et al. (2016) [71]	Italy	1643	885/758	12.4 ± 0.7
Kontogianni et al. (2010) [72]	Greece	554	244/310	15.5 ± 1.6
Kontogianni et al. (2008) [73]	Greece	554	244/310	15.5 ± 1.6
Costarelli et al. (2013) [74]	Greece	359	166/193	13.1 ± 0.5
Papadaki & Mavrikaki (2015) [75]	Greece	525	209/316	14.7 ± 1.7
Bargiota et al. (2013) [76]	Greece	350	161/189	12–18

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Table 1 (continued)

Search topic	Country	Sample size	Male/Female	Age ^a
Mazaraki et al. (2011) [77]	Greece	365	212/153	12–17
Tsartsali et al. (2009) [78]	Greece	200	97/103	15.8 ± 0.6

^a Data are reported as age range or average age ± standard deviation or average value (standard error). B: baseline; FU: follow-up; C: cohort.

in the lowest quintile ate 2.5 portions per day [27]. Canadian adolescents ($n = 178$, 14–15 y) reported eating 3 portions of fruit and 3.5 portions of vegetables per week [28]. Participants from both the Attica region in Greece belonging to the TEENs of Attica Genes and Environment cohort ($n = 857$, 12–14 y) and the GENE and Diet Attica Investigation on childhood obesity ($n = 1072$, 10–12 y) consumed on average around 2 servings of F&V per day [29]. Similarly, only 19% of Cypriot adolescents ($n = 1966$, 11–17 y) stated consuming 5 or more portions of F&V every day, while 4% did not consume F&V at all, 11% ate one portion, 25% 2 portions, 26% 3 portions and 14% 4 portions per day [30]. An analogous situation was also found in an Italian high school cohort ($n = 250$, 17–19 y) of whom only 25% met the F&V recommendation of 5 portions per day, 22% ate 3 portions, 16% 1 portion, and 37% rarely consumed F&V [31]. Moreover, without considering adolescents resident in Glasgow, around 34% of males and 40% of females of the Scottish HBSC cohort ($n = 6593$, 11, 13, and 15 y) had a daily intake of F&V. Of young Glaswegians, 31% reported a daily intake of fruit, while daily vegetable consumption was reported by 29% of females and 24% of males [32].

Other studies did not report the consumed amount or the frequency of consumption of a standard portion but described only the intake in terms of times of consumption per day or week without referring to the amount eaten during these occasions. Polish adolescents ($n = 711$, 14–15 y) had an average daily intake of 2.5 fruit and 2.3 vegetables [33]. During phone interviews, more than 1500 participants (average age 14 y) declared having eaten F&V 8 times in the previous week [34]. In the largest cohort ($n = 29,152$, 13–18 y) included in this review, an average consumption classified as “often- almost every day” for fruit and as “often” for vegetables was registered [35]. Every four years, US adolescents (11–16 y) were enrolled in the “Health Behaviour in School-aged Children” (HBSC) study. F&V intakes were around 3–4 times per week in the first cohort assessed ($n = 14,607$), between 4 and 5 times per week in the second cohort ($n = 9150$), while it was 4–6 times per week the last assessed cohort ($n = 10,848$) [36].

Longitudinal studies. The German GINIplus birth cohort ($n = 1232$, 15 y) study is the only study in which F&V consumption was reported as percentage of the daily energy intake, with fruit intake corresponding to 4% and 2%, and vegetable intake to 2% and 1% of the total energy intake, in females and males respectively [37]. Adolescents had been followed from 5 years previously, when fruit

contributed for 4% and 3% while vegetables for 2% and 1%, respectively in females and males [37].

Around 3 servings per day of F&V were registered at baseline in an American cohort of more than 8000 participants (11–19 y), and the consumption tended to slightly increase after 2 years [38]. In an Australian cohort ($n = 1844$, 12–15 y) enrolled in the Youth Eating Patterns study, 61% of the participants reported eating vegetables 3 or more times a day and only 26% indicated consuming fruit 3 or more times a day at baseline [39,40]. The majority of the participants, around 72% for vegetables and 77% for fruit, did not change their F&V intakes over 2 years, showing a median intake of 1 portion a day for both fruit and vegetables [39,40]. When a sub-group of the same Australian cohort was selected to obtain a sample of socio-economically disadvantaged adolescents ($n = 521$, 14–16 y), F&V consumption was found to remain below the recommendations and vegetable consumption to worsen over time. In particular, 33% and 36% reported eating fruit at least once a day and 29% and 24% vegetables at least twice a day respectively at baseline and after 2 years follow-up [41]. A slightly higher consumption was observed in 7445 adolescents (13–14 y) who reported having eaten 7 portions of fruit and 9 portions of vegetables in the previous week, while 3 years before the consumption was around 8 and 10 portions of fruit and vegetables, respectively [42].

F&V consumption in the Norwegian HHealth In Adolescents (HEIA) cohort was described in 3 papers [43–45]. At baseline ($n = 1437$, 11 y) participants reported eating 1.5 portions of fruit, 1 portion of raw vegetables and little more than a half portion of cooked vegetables per day [43]. Not only did the sample size decrease to 900 adolescents during the 2 years follow-up, but also the frequency of F&V consumption that diminished to 9 portions of fruits and 10 portions of vegetables per week when participants were 13 y [44,45]. Out of the total sample of adolescents enrolled in the prospective Dutch study “Tracking Adolescents’ Individual Lives Survey” ($n = 1821$, 13–17 y), 55% consumed less than 5 portions of fruit and 22% less than 5 portions of vegetables per week and between 1 and 4 years after this assessment, the percentage increased respectively to 57% and 23% [46]. In the American “NEXT Generation Health Study”, the consumption of F&V and beans all together decreased from 4.0 to 3.4 times per day over 4 years when participants ($n = 2785$) were 16 to 20 years [47]. A decrease in the F&V consumption was also observed in 291 Belgian students (17–19 y) from the last year of high school, when males consumed F&V 18 times per week and females 22 times per week, to the first year

Table 2 Adolescents' consumption of fruit, vegetables and legumes and associations between intakes and other variables.

Author (year)	Method	Fruit	Vegetables	Fruit & vegetables	Legumes	Note
grams per day						
Noale et al. (2014) [20]	Semi-quantitative FFQ	F 165.2 M 192.9	F 171.4 M 128.6		F 5.3 M 16.8	
Llull et al. (2011) [21]	Semi-quantitative FFQ + 2 × 24h-R	172.8 ± 164.2	130.1 ± 144.4	303.2 ± 247.7		Higher F&V intake and of vegetables in females than in males; no differences between genders for fruit.
Gopinath et al. (2016) [22]	FFQ	Group 1 253.0 [224.6–282.5] Group 2 220.3 [187.0–253.7]	Group 1 247.7 [222.6–272.8] Group 2 213.2 [185.0–241.4]			Negative association between F&V intake and habit of eating takeaway food 5 years previously.
<i>Participants are grouped on the basis of usual intake of takeaway meals (group 1 = less than once a week; group 2 = 1 or more times per week)</i>						
% of daily energy intake						
Harris et al. (2015) [37]	FFQ	<i>Baseline</i> F 4.2 (2.7–6.1) M 3.3 (1.9–4.9) <i>Follow up</i> F 3.9 (2.3–6.4) M 2.2 (1.1–3.8)	<i>Baseline</i> F 1.6 (1.0–2.4) M 1.2 (0.7–1.8) <i>Follow up</i> F 1.9 (1.1–3.0) M 1.2 (0.6–1.8)			Increased intake of vegetable (but not of fruit) in females; decreased intake of starchy vegetables in females and of fruit and starchy vegetables in males.
number of portions per day						
Laska et al. (2010) [25]	24h-R		2.3 ± 1.6	2.9 ± 1.8		No association between F&V intake and characteristics of residential neighbourhood food environment.
Setayeshgar et al. (2017) [26]	24h-R			4.8 ± 3.4		No association between F&V intake and 2-year prospective change in cardio-metabolic risk factors.
Lord et al. (2015) [27]	FFQ			HIQ 3.0 ± 1.6 MIQ 2.6 ± 1.5 LIQ 2.5 ± 1.7		Positive association between F&V intake and family's income; no association between F&V intake and residence in a rural or urban area.
<i>Participants are grouped on the bases of their family income (HIQ: highest income quintile; MIQ: middle income quintile; LIQ: lowest income quintile)</i>						
Leatherdale & Laxer (2013) [28]	Food diary			3.5 ± 2.4		
Ntalla et al. (2015) [29]	24h-R			Cohort 1: 1.8 ± 1.7 Cohort 2: 2.3 ± 1.9		No association between F&V intake and BMI in both cohorts.
Loucaides et al. (2011) [30]	FFQ	1.6 ± 1.0	1.5 ± 1.0	3.1 ± 1.7		Positive association between F&V consumption and preference for F&V, family eating patterns, friends' F&V intake, and school support for F&V consumption.

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Table 2 (continued)

Author (year)	Method	Fruit	Vegetables	Fruit & vegetables	Legumes	Note
Falbe et al. (2014) [38]	FFQ			<i>Baseline</i> F 3.1 ± 1.5 M 2.9 ± 1.3 <i>Follow up</i> F +0.1 ± 1.5 M +0.1 ± 1.3		Slight increase (not significant) of F&V intake over time. Negative association between F&V intake and time spent in sedentary activities in front of a screen.
Pearson et al. (2011) [40]	FFQ	<i>Baseline</i> F 1.0 ± 0.9 M 0.8 ± 0.8 <i>Follow up</i> F 1.1 ± 0.9 M 0.8 ± 0.8				Higher intake of fruit in females than in males at baseline; no effect of time on intake.
number of portions per week						
Fraser et al. (2011) [23]	FFQ	9.5 ± 7.0	9.5 ± 7.0			Negative association between F&V intake and habit of eating at fast food.
% of participants having the specific number of portions per day						
McAloney et al. (2014) [24]	Single item question			≥5 portions/die F 16.1; M 13.6 3–4 portions/die F 44.0; M 38.8 1–2 portions/die F 36.1; M 41.5 0 portion/die F 3.8; M 6.1		F&V intake seems higher in females than in male, but no significant association between gender and F&V intake.
Sidoti et al. (2010) [31]	Specific FFQ with interview			5 portions/die 25.2 3 portions/die 22.0 1 portion/die 16.0 <1 portion/die 36.8		Positive association between F&V intake and PAL.
Pearson et al. (2009) [39]	FFQ	≥3 portion/die 25.8% ≤2 portion/die 74.2%	≥3 portion/die 61.2% ≤2 portion/die 38.8%			Higher F&V intake in females than in males; positive association between vegetable consumption and maternal education level, and family circumstances (having brothers/sisters or a dual-parent family).
number of times per day						
Bak-Sosnowska & Skrzypulec-Plinta (2012) [33]	10-item FFQ	2.5 ± 0.6	2.3 ± 0.7			
Bjelland et al. (2011) [43]	FFQ	F 1.5 ± 1.0 M 1.3 ± 1.0	Fresh: F 1.0 ± 0.9 M 0.9 ± 0.9 Cooked: F 0.6 ± 0.6 M 0.6 ± 0.6			No association between F&V intake and parental education; positive correlation between adolescents' and parents' vegetable intake, and between fruit intake of mothers for girls and of fathers for boys.

Lipsky et al. (2015) [47]	FFQ			Baseline 4.0 {0.2} Follow up 1 (+1 year) 3.9 {0.1} Follow up 2 (+2 years) 3.7 {0.1} Follow up 3 (+3 years) 3.4 {0.2} Follow up data considered also beans	F&V intake reduction during 3 years; positive association between F&V intake and habit of eating at home and between F&V intake and breakfast habit; negative association between F&V intake and habit of eating at fast food; no association between F&V intake and watching television during meals.
% of participants having the specific number of times per day					
Levin et al. (2015) [32]	FFQ	1 time/die Glasgow F 31.2 {3.1} M 30.6 {4.5} Rest of Scotland F 40.4 {1.2} M 33.9 {1.2}	1 time/die Glasgow F 28.8 {2.7} M 24.1 {3.1} Rest of Scotland F 40.5 {1.1} M 34.4 {1.1}		No association between gender and F&V daily intake; lower F&V intake in adolescents living in Glasgow compared to the rest of Scotland.
Stephens et al. (2014) [41]	FFQ	≥1 times/die 36	≥2 times/die 24		Reduction of vegetable intake after two years; increase of fruit intake but not significant.
number of times per week					
Longacre et al. (2014) [34]	7-day fruit and vegetable recall			8.0 ± 5.9	Lower F&V intake in males than in females; positive association between F&V intake and household income in adolescents not exposed to school food; no association between F&V intake and family income in adolescents exposed to school food. Decrease of F&V intake with respect to 3 years previously.
Oza-Frank et al. (2012) [42]	7-day fruit and vegetable recall	Baseline 7.7 Follow up 7.2	Baseline salad 2.2 carrots 2.8 other veggies 5.2 Follow up salad 2.6 carrots 1.9 other veggies 4.9		
Totland et al. (2013) [44]	FFQ	Baseline M 9.5 [8.8–10.1] F 10.1 [9.5–10.8] Follow up 1 M 9.6 [8.9–10.2] F 10.4 [9.8–11.1] Follow up 2 M 9.0 [8.3–9.6] F 10.0 [9.4–10.7]	Baseline M 10.7 [9.8–11.6] F 11.5 [10.6–12.4] Follow up 1 M 11.0 [10.1–11.9] F 11.2 [10.4–12.1] Follow up 2 M 10.2 [9.4–11.1] F 10.7 [9.9–11.6]		No changes over time in F&V intake; no association between F&V consumption and parental education level.

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Table 2 (continued)

Author (year)	Method	Fruit	Vegetables	Fruit & vegetables	Legumes	Note
Gebremariam et al. (2013) [45]	FFQ	<i>Baseline</i> 9.8 [9.4–10.3] <i>Follow up</i> 9.6 [9.1–10.0]	<i>Baseline</i> 11.1 [10.4–11.7] <i>Follow up</i> 10.50 [9.9–11.1]			Inverse association between changes in time spent watching TV/DVD and in vegetable consumption, and between baseline computer/games use and F&V consumption.
Deforche et al. (2015) [48]	FFQ			<i>Baseline</i> F 21.7 ± 7.0 M 17.8 ± 7.8 <i>Follow up</i> F 18.6 ± 8.3 M 14.1 ± 8.0		Reduction of F&V intake from high school to university; no difference between genders.
% of participants having fruit and vegetables less than 5 days per week						
de Winter et al. (2016) [46]	FFQ	<i>Baseline</i> 55.4 <i>Follow up</i> 57.3	<i>Baseline</i> 21.5 <i>Follow up</i> 23.1			
Mixed daily/weekly frequencies						
Terry-Mcelrath et al. (2014) [35]	FFQ	Middle high school students 3.7 ± 0.0 High school students 3.4 ± 0.1	Middle high school students 3.2 ± 0.0 High school students 3.1 ± 0.0			Positive association between F&V intake and availability or accessibility, and social economic status; inverse association between regular fruit consumption and accessibility of candies/fat-snacks in middle school students only.
<i>0: never; 1: almost never; 2: some days; 3: lots of days; 4: almost every day; 5: every day</i>						
Iannotti & Wang (2013) [36]	FFQ	Cohort 1: 4.3 (0.0) Cohort 2: 4.7 (0.1) Cohort 3: 4.9 (0.0)	Cohort 1: 4.3 (0.0) Cohort 2: 4.5 (0.0) Cohort 3: 4.6 (0.0)			Higher F&V intake in girls than in boys; inverse association between F&V consumption and age; increase in F&V consumption over time comparing data of the 3 cohorts.
<i>1: never; 2: <1/week; 3: once/week; 4: 2–4 days/week; 5: 5–6 days/week; 6: once/day; 7: every days, >once/day</i>						

The consumption of fruit and/or vegetables and legumes are reported as average value ± standard deviation, average value [confidence interval of 95%], median value (interquartile range), average value without dispersion values if not available, average value {standard error}, or percentages. 24h-R: 24-h recall; FFQ: food frequency questionnaire; F: female; M: male; F&V: fruit and vegetable; PAL: physical activity level.

Table 3 Adolescents' salt and sodium intakes and associations between intakes and other variables.

Author (year)	Method	Salt	Sodium	Note
Quader et al. (2017) [49]	24h-R		Age 11–13 years 3.1 ± 0.2 g/die 1.7 ± 0.0 g/1000 kcal Age 14–18 years 3.6 ± 0.1 g/die 1.6 ± 0.0 g/1000 kcal	Higher sodium intake among 14–18 years adolescents.
He et al. (2008) [50]	7-day food diary	Tertile1 4.5 ± 0.1 g/die Tertile2 6.5 ± 0.0 g/die Tertile3 9.3 ± 0.1 g/die <i>Participants were grouped by tertiles of salt intake</i>	Tertile1 1.8 ± 0.0 g/die Tertile2 2.6 ± 0.0 g/die Tertile3 3.7 ± 0.1 g/die	Association between salt intake and pulse pressure, after adjustment for age, sex, BMI.
Magriplis et al. (2011) [51]	Semi-quantitative FFQ		<1.5 g/die: 56.1% 1.5–2.2 g/die: 20.9% >2.2 g/die: 23.0%	No difference among age groups, or between urban or rural region; no association between sodium intake and BP levels; higher intake in males than in females; positive association between sodium intake and BMI, PAL, and ADM; negative correlation between sodium intake and body fat mass.
Thomson (2009) [52]	14-day simulated diet based on 24h-R	<i>Males</i> 5.3 [0.0–31.8] g/die <i>Females</i> 4.2 [0.0–40.6] g/die		
Campanozzi et al. (2015) [53]	24 h urine collection ^a		<i>Males</i> 136 (102–192) mmol/die <i>Females</i> 126 (93–172) mmol/die	Higher urinary sodium in males than females; higher urinary potassium in males; mean sodium/potassium ratio similar among genders.

Values are reported as mean value ± standard deviation, median value (interquartile range), mean value [minimum–maximum value], or percentages. AMD: adherence to the Mediterranean Diet; BMI: body mass index; PAL: physical activity level; BP: blood pressure.

^a Data are referred to the excretion values.

of university, when males and females had F&V 14 and 19 times per week, respectively [48].

Salt/sodium intake

The selected publications collected data using different dietary assessment tools: 7-day food diary (1), 24h-R (1), 14-day simulated diet based on 24h-R data (1), semi-quantitative FFQ (1); and by 24 h urine collection (1). Four publications only considered not-discretionary salt intake and just one both discretionary (salt added during cooking or at the table) and not-discretionary salt ingestion. Furthermore, some selected studies indicated food categories contributing to sodium intake and the relationship between salt intake and other variables. All this information is presented in Table 3, reporting data referred to the adolescent populations only.

Daily sodium intake (estimated as not-discretionary salt) was slightly over 3 grams per day for 11–13 year old subjects and slightly over 3.5 grams per day for 14–18 year olds (1651 and 1639 mg/1000 kcal, respectively) in American adolescents enrolled in the National Health and Nutrition Examination Survey ($n = 1184$, 10–18 y) [49]. Food items mostly contributing to sodium intake were pizza, Mexican dishes, sandwiches, bread, processed meats, soups, savoury snacks, and cheese [49]. In Great Britain, salt intake reached nearly 7 grams per day not including discretionary salt (sodium intake 2.7 ± 0.8 g/day) in the National Diet and Nutrition Survey ($n = 496$, 14–18 y) [50]. Whereas, in the Greek Childhood Obesity

study cohort ($n = 4580$, 10–12 y), 23% of the sample showed a sodium intake of over 2.2 grams per day, not-considering the discretionary salt, with major sources of sodium intake being bread, cereals and dairy products [51]. Elevated sodium intakes were assessed also for adolescents living in New Zealand ($n = 1143$, 11–14 y), for which not-discretionary salt intakes were around 5 and 4 grams per day for males and females (2.1 and 1.7 g/day sodium intake, respectively), excluding discretionary salt [52]. Of total sodium exposure, 80–86% was attributable to 42 manufactured foods with bread as the greatest contributor to sodium exposure followed by sausages, meat pies, pizza, instant noodles, and cheese [52]. In the MINISAL Italian survey ($n = 551$, 10–18 y), the only study in which both not-discretionary salt and salt added in cooking or at table were considered, around 90% of the Italian adolescents showed an average sodium intake higher than the age-specific recommended dietary target of 2 g/d [53,54].

Adherence to the Mediterranean Diet

According to the inclusion criteria, adherence to the MD was evaluated through the KIDMED questionnaire, the most used tool to assess adherence in young populations [55]. The KIDMED questionnaire was developed by Serra-Majem et al. [19]. Briefly, it is an easy-to-use, auto-fillable questionnaire composed of 16 dichotomous yes/no questions related to both MD and non-MD dietary habits, and it could be used to define the KIDMED score (0–12

points) attributing +1 point or -1 point respectively to the questions that have positive or negative connotations in respect of the MD dietary habits. On the basis of the score, adherence to the MD diet of children and adolescents could be defined as low (≤ 3 points), medium (4–7 points), or high (≥ 8 points). Adherence was reported as a score for 13 populations and as a percentage of the population having a low, medium or high adherence to the Mediterranean dietary pattern for 16 populations (Table 4). Moreover, associations between adherence to the MD and gender, age, or behavioural and socio-cultural variables were reported in the majority of the papers (Table 4).

All publications included in this review assessed the adherence to the MD of adolescents living in South European Mediterranean Countries. The highest adherence to the Mediterranean dietary pattern was found for the Portuguese youth population, with participants ($n = 529$, 12–18 y) showing a KIDMED score slightly over 7 points [56,57]. Moreover, 51% and 42% of adolescents living in Northern Portugal ($n = 390$, 12–14 y) had a medium and high adherence to the MD, respectively [58]. In general, Spanish adolescents had a medium adherence with the mean KIDMED score ranging between 6 and 7 points. The lowest score was found to be around 6 points in adolescents living in the south of Spain ($n = 379$, 12–16 y) [59] and in participants living in Andalusia ($n = 1808$ and $n = 1988$, 12–16 y) [60–62]. Among them, the majority showed a medium adherence to MD, while 31% of them obtained a high adherence [60–62]. A medium adherence was also found in other Spanish cohorts for participants of the multi-centre (Cadiz and Madrid) UP&DOWN study ($n = 1371$, 10–14 y) [63] and for Catalanian ($n = 1381$, 13–17 y) and Balearic Islands' adolescents ($n = 1321$, 12–17) [64,65]. Overall, Italian adolescents showed a medium adherence to the MD. Likewise, 60% of adolescents ($n = 1127$, 14–19 y) living in Florence (Tuscany) reported a diet with a medium adherence to the MD [66]. Similar results were observed in two cohorts of adolescents living in Sicily. In the first cohort ($n = 1135$, 13–16 y), 65% of participants showed a medium adherence to the MD [67]. In the other cohort ($n = 1643$, 11–16 y), analysed in four different publications, 61% had a medium adherence and only 9% a high adherence [68–71]. In the young Greek population ($n = 4580$, 10–12 y), a low–medium adherence was found [51]. A similar result was observed in another Greek cohort ($n = 554$, 13–18 y), in which only 8% of the adolescents had a high adherence to the MD [72,73]. A medium adherence was also found for 54% of the participants ($n = 359$, 13–16 y) enrolled in a multi-centre Greek study carried out in the area of Athens and Dodecanese [74], and for 61% of the individuals ($n = 525$, 12–18 y) living in Athens or Heraklion (Crete) [75]. Similarly, a medium adherence to the MD was reported in other two studies, respectively by 45% ($n = 382$, 12–18 y) [76] and 51% ($n = 365$, 12–17) [77] of Greek adolescents. Lastly, a very poor adherence to the Mediterranean pattern was found for 60% of the adolescents living on Chios Island ($n = 200$, 15–17 y) [78].

Factors associated to the adolescents' eating habits

Age and time effect

Changes in F&V intake from baseline to 2–5 year follow up assessments, when participants reached the age of 13–19 years, were reported in several publications. A reduction of vegetable consumption was assessed after 2 years follow up [41], while a decrease of F&V intake was observed during 3 years [42,47]. Whereas, comparing baseline to the subsequent 5-year data, for the female population an increased consumption of total vegetables but a decreased intake of starchy vegetables was reported, while for males a decrease in fruit and starchy vegetables was observed [37]. A moderate decrease in F&V intake was observed from high school to university [48]. Lastly, no differences over time for F&V consumption [38,40,44] and for fruit only [41] were reported. In addition, comparing age-groups cross-sectionally, an inverse association was found between F&V consumption and age [36]. No differences were reported for sodium intake among age groups in one study [51], while a direct association was observed in another [49]. A higher KIDMED score was observed for younger adolescents [58,72,73,75,76]. Similarly, an inverse correlation between the KIDMED score and age was found in another study [64], but only in boys and not in girls. On the contrary, no differences among age groups were noted in another study [77].

Gender

Female adolescents showed a higher intake of F&V [21,34,36,39] and of fruit only [40] or vegetables only [21]. Whereas, no differences between genders were observed in four studies for F&V intake [24,32,43,45] and in another study for fruit only [21]. Higher values of sodium intake were found in males than in females [51], as well as for urinary sodium excretion [53]. Adherence to the MD was found to be higher in females than in males in 4 studies [72,73,76,77], higher in boys in other 5 studies [60–64], while no differences were reported in 9 studies [51,58,59,66,67,71,74,75,78].

Geographical area

No association was found between F&V or vegetables alone and the characteristics of the residential neighbourhood food environment [25], nor between F&V intake and living in a rural or urban area [27]. Similarly, no differences were found in sodium intake [51] and in adherence to the MD [59] between adolescents living in rural and urban areas, while in another study adherence was positively associated with living in rural areas [67]. Moreover, a higher adherence to the MD was observed in adolescents residing in a smaller city [75].

Socio-economic and family/school environment characteristics

F&V intake was positively associated with the family's income [27], but differences were reported among incomes on the basis of school food exposure: a positive association was reported between F&V consumption and household

Table 4 Adolescents' adherence to the Mediterranean Diet and associations between adherence and variables.

Author (year)	KIDMED score			Adherence to MD			Note
	Total	Males	Females	Low	Medium	High	
Magriplis et al. (2011) [51]	3.8 ± 2.2			62.8	37.2		No difference between genders nor in BMI and in % of body fat; direct association between AMD and PAL, and sodium intake.
Agostinis-Sobrinho et al. (2016a) [56]	7.1 ± 2.1	7.0 ± 2.1	7.2 ± 2.0	–	–	–	
Agostinis-Sobrinho et al. (2016b) [57]							
Da Rocha Leal et al. (2011) [58]	–	–	–	7.2	50.8	42.1	Positive association between AMD and cooking habits and cooking skills; inverse association between KIDMED score and age; no difference between genders.
Asensi et al. (2015) [59]	5.8 ± 2.1	6.0 ± 2.1	5.6 ± 2.2	15.6	64.1	20.3	No difference in AMD between adolescents living in rural and urban areas, or between genders.
Grao-Cruces et al. (2014b) [60]	6.2 ± 2.3	6.4 ± 2.4	6.1 ± 2.3	12.2	56.9	30.9	Higher ADM in males than in females; positive association between AMD and PAL, aerobic capacity, and time devoted to homework; inverse association between AMD and screen-time.
Grao-Cruces et al. (2015) [61]							
Grao-Cruces et al. (2014a) [62]	–	6.4 ± 2.4	6.0 ± 2.4	–	–	–	Higher ADM in males than in females; low level of physical self-concept increases the risk of having a low level of AMD.
Esteban-Cornejo et al. (2016) [63]	6.7 ± 2.3	6.8 ± 2.3	6.5 ± 2.3	8.0	55.0	37.0	KIDMED score higher in males than in females; positive association between AMD and academic performance.
Bibiloni et al. (2016) [64]	6.0 ± 2.5	6.3 ± 2.4	5.7 ± 2.5	15.7	55.9	28.4	Higher percentages of high AMD and lower percentages of poor AMD in boys than girls; lowest KIDMED score in adolescents who reported attention to mass media during mealtime, skipping breakfast frequently and reported ≤3 daily meals and snacks; inverse correlation between KIDMED score and media screen time; direct correlation between KIDMED score and parental educational level and PAL; inverse correlation between KIDMED score and age in boys.
Fauquet et al. (2016) [65]	–	–	–	16.2	57.9	25.9	Positive association between AMD and PAL; inverse association between ADM and screen-time; positive association between ADM and parents' educational level. No effect of parents' employment status.
Santomauro et al. (2014) [66]	–	–	–	23.0	60.5	16.5	No difference between genders; inverse association between AMD and being not physically active, underweight, underachieving in school, attending technical high schools, having a suboptimal relationship with their families, belonging to low/middle class families, and maternal education level.
Grosso et al. (2013) [67]	–	4.9 ± 2.3	5.0 ± 2.1	25.6	65.1	9.3	No difference between genders; positive association between AMD and socioeconomic status, PAL, and the intake of fruit, vegetables, pasta, fish and cheese; inverse association between AMD and living in urban area, BMI, and the intake of sweets, fast foods, fried foods and sugary drinks.
Buscemi et al. (2016) [68]	4.3 ± 2.1	4.4 ± 2.2	4.3 ± 2.1	29.9	61.0	9.1	No difference between genders; linear association between KIDMED score and sleep time and sleep quality; positive association between KIDMED score and diet quality; inverse correlation between KIDMED score and BMI, WC, and fat mass; no association between KIDMED score and BP; negative association between AMD and BW misperception.
Ferranti et al. (2016a) [69]							
Ferranti et al. (2016b) [70]							
Mistretta et al. (2016) [71]							

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Table 4 (continued)

Author (year)	KIDMED score			Adherence to MD			Note
	Total	Males	Females	Low	Medium	High	
Kontogianni et al. (2008) [72] Kontogianni et al. (2010) [73]	4.8 ± 2.1	4.6 ± 2.0	4.9 ± 2.1	27.0	68.6	8.3	Higher KIDMED score in females, in younger, and in more active adolescents; positive association between AMD and parents' educational level, and eating frequency; negative association between KIDMED score and BMI, time spent in sedentary activities, and energy density of diet.
Costarelli et al. (2013) [74]	6.3 ± 2.4	6.3 ± 2.5	6.2 ± 2.5	12.3	54.3	33.4	No difference between genders; positive association between AMD and health-related quality of life.
Papadaki & Mavrikaki (2015) [75]	—	5.8 ± 2.3	5.5 ± 2.3	18.0	61.0	21.0	No difference between genders, positive association between AMD and mother's educational level, living with both parents, and residing in a smaller city; negative association between AMD and age and lack of physical activity; no correlation between AMD and BMI. Higher AMD in female; negative association between AMD and age; positive association between AMD and maternal educational level.
Bargiota et al. (2013) [76]	4.5 ± 2.7	—	—	39.0	45.0	16.0	No difference in KIDMED score for age, diastolic BP, and heart rate; negative association between KIDMED score and male sex, hours spent in watching television, frequency of eating outside home, and albumin to creatinine ratio; positive association between KIDMED score and BMI, WC, systolic BP, pulse pressure, and PAL.
Mazaraki et al. (2011) [77]	—	—	—	42.0	51.2	6.8	No difference between genders; no association between AMD and BMI, and family income; positive association between AMD and MD knowledge.
Tsartsali et al. (2009) [78]	—	—	—	59.5	28.0	12.5	No difference between genders; no association between AMD and BMI, and family income; positive association between AMD and MD knowledge.

Data are KIDMED scores expressed as mean ± SD for the total population, males, and females. Adherence to the MD is described as % of the total population. AMD: adherence to the Mediterranean Diet; BMI: body mass index; BP: blood pressure; BW: body weight; PAL: physical activity level; WC: waist circumference.

income in adolescents not receiving school-meals, while no association with the family income was observed in adolescents receiving school-meals [34]. Moreover, F&V consumption was directly associated with school support for F&V consumption [30]. Conversely, no association was reported between F&V intake and parental education [43,44]. However, a positive association was observed between vegetable consumption and maternal education, and having a dual-parent family or having brothers and sisters [39]. In addition, a positive correlation was found between adolescents' F&V consumption and family healthy eating patterns, friends' F&V intakes [30], and parental vegetable intake [43]. However, fresh fruit intake was positively associated with the mothers' intake for girls and the fathers' intake for boys [34]. Adherence to the MD was positively associated with better socio-economic status [67] and inversely associated with belonging to low/middle class families [66]. However, in another study no association was found between adherence to the MD and family income [78]. A direct correlation was found between adherence to the MD and parents' educational level [64,65,72,73], while adherence to the MD was positively correlated only to the maternal educational level in other studies [66,75,76]. On the other hand, the parents' employment status did not impact on adherence to the

MD [65]. Moreover, a positive association was found between adherence to the MD and living with both parents [75], while adherence to the MD was negatively associated with having a suboptimal relationship with the family [66].

Body composition and health outcomes

No association between F&V consumption and participants' BMI was reported [29]. In addition, 2-year prospective change in cardio-metabolic risk factors was not associated with adolescents' F&V intake [26]. A positive association was observed between sodium intake and BMI, while it was inversely correlated to body fat mass [51]. Sodium intake was not associated to BP levels in a study [51], but it was positively associated with pulse pressure, after adjustment for age, sex, BMI in a different study [50]. An inverse association between adherence to the MD and BMI [66,67,69,71–73], waist circumference, and fat mass [69,71] was found. On the contrary, in other studies no differences in BMI [51,75,78] nor in percentage of body fat were observed [51]. However, a positive relationship was pointed out between adherence to the MD and BMI and waist circumference in another study [77]. In addition, adherence to the MD was inversely related to an overestimation of body weight in normal weight subjects [68].

The KIDMED score was not associated to blood pressures in one study [71] and only with diastolic BP and heart rate in another [77], while adherence to the MD was inversely related to systolic BP and pulse pressure [77]. Adherence to the MD was also positively correlated with the individual's perception and subjective evaluation of the health-related quality of life [74]. Finally, a negative association was detected between the KIDMED score and albumin to creatinine ratio [77].

Physical activity

F&V consumption was positively associated with physical activity level [31], while a negative association was observed between F&V intake and time spent in sedentary activities in front of a screen [38]. Moreover, an inverse association was found between F&V intake and time spent using computer/videogames and between changes in vegetable consumption and in time spent watching television [45]. Sodium intake was also found to be positively associated with the physical activity level [51]. Similarly, a direct correlation was reported between adherence to the MD and physical activity level in 10 studies [51,60,61,64–67,72,73,77], and an inverse association was demonstrated between adherence to the MD and time spent in sedentary activities and screen-time [60,61,64–66,72,73,75,77]. Moreover, a positive association was found between adherence to the MD and aerobic capacity, and time devoted to homework [60,61]. In addition, a low adherence to the MD was directly linked to a low level of aerobic capacity [60,61] and to a low level of physical self-concept [62].

Dietary habits

The consumption of F&V was negatively associated with the frequency of consumption of takeaway food 5 years previously [22]. Moreover, F&V intake was also inversely associated with the habit of eating at fast food restaurants [23,47]. On the contrary, there was a positive association between F&V intake and the habit of eating at home [47], having breakfast [47], adolescents' preferences for F&V [30], and F&V availability or accessibility [35]. No associations were found between consuming F&V and watching television during meals [47]. A positive association was observed between the KIDMED score and diet quality assessed through the Diet Quality Index-International (DQI-I), a tool used for an overall evaluation of diet quality [69,70]. A positive association was also found between adherence to the MD and the intake of fruit, vegetables, pasta, fish and cheese, while the KIDMED score was inversely associated to the intake of sweets, fast foods, fried foods and sugary drinks [67]. Moreover, adherence to the MD was inversely associated with the energy density of the diet and positively associated with the number of daily meals [72,73] and sodium intake [51]. Conversely, a negative association was found between the KIDMED score and frequency of eating outside home [77]. In addition, adherence to the MD was positively associated with better cooking habits and cooking skills [58]. Last, a lower

KIDMED score was assessed in adolescents who reported attention to mass media during mealtime, skipping breakfast frequently and reported ≤ 3 daily meals and snacks [64].

Other lifestyle factors

A positive association was observed between adherence to the MD and sleep quantity and quality [69,70]. In addition, adherence to the MD was positively associated with academic performance [63], and inversely associated with underachieving in school and attending technical high schools [66]. A positive association was also found between adherence to the MD and MD actual knowledge [78].

General conclusions

This literature review offers a summary of the most recent scientific information regarding the eating habits of adolescents living in North America, Europe or Oceania.

The average F&V consumption has been found strongly below the recommended values in almost all the populations. F&V consumption seems positively associated with the physical activity level of adolescents, while strong and consistent evidence has not been found on the relationship between F&V consumption and gender, age, socio-economic characteristics of the family, or residence area. Since the consumption of legumes has been poorly explored, general conclusions on adolescents' intake and on the possible association with other variables could not be drawn.

The analysis of the selected articles showed that the sodium intake levels of the adolescent populations assessed are above the recommendations. This aspect is more alarming when considering that 4 out of 5 studies reported not-discretionary salt intake only. Nevertheless, the amount of salt discretionarily added to food during cooking or at the table is usually small compared to the salt added to processed food, so the additional discretionary salt would result in little increases to total intake. In any case, focus should be paid to the fact that adolescents are not compliant with recommendations in terms of sodium intake. The main sources of dietary sodium are processed products enriched in sodium during processing. Among these, bread is the major source of not-discretionary salt (both due to the medium–high salt content per gram of product and for the portion-size of bread consumed), along with ready-to-eat meals, cured meats and cheeses.

With regard to adherence to the MD in the European Mediterranean Countries, Italian and Greek adolescents showed a low–medium adherence, with differences among geographical areas, while a better adherence (medium–high) has been reported for Spanish and Portuguese adolescents. Some robust insights have been found for the positive association between adherence to the MD and physical activity level, adherence and parents' educational level, and adherence and healthy eating

patterns, and for the negative association between adherence and age. However, the relationship between adherence to the MD and BMI, and adherence and gender are not well established.

In summary, this work indicates that adolescents living in North America, Europe or Oceania are far from being compliant with the nutritional recommendations and the principles of the MD. Life changes typical of adolescence may lead to a worsening in dietary habits, with further consequences in adulthood. For this reason, nutrition education and national policy programmes targeting children, adolescents and their parents, are required to guarantee the adherence of adolescents to healthy dietary patterns.

Strengths and limitations

The analysis of FV&L consumption, sodium intake and adherence to the MD was conducted by comparing different populations, where possible, and by looking for general conclusions about young people in different geographical areas. Only a limited amount of the publications originally identified for the review was actually included, but the strict definition of inclusion/exclusion criteria was considered necessary to standardise data and to avoid extremely small samples of adolescents living in North America, Europe or Oceania. Nevertheless, comparisons among different populations were difficult, since the sample size widely varied among the included studies. Moreover, in the case of FV&L consumption, the employed dietary assessment tools were characterised by different accuracy, leading to the collection of quantitative or only semi-quantitative data (grams per day, % of daily energy intake, number of standard portions per day/week, and number of times of consumption per day/week). Similarly, a variety of methods for quantifying sodium intake are currently used, as direct dietary assessment or urinary excretion values. In addition, the definition of “fruit and vegetables” was not constant throughout the selected studies, with fruit juices sometimes categorised as fruit, or nuts falling within the fruit category in some cases, while considered as legumes in another study. A more robust comparison among studies was performed for the adherence to the Mediterranean dietary pattern, as the use of only the KIDMED questionnaire brought homogeneous data.

In keeping with all these considerations, to the best of our knowledge, this is the first time in which data on fruit and vegetable consumption, sodium intake, and adherence to the Mediterranean dietary pattern are jointly reported for adolescent populations. These results are of interest for the whole scientific community in the fields of nutrition and health due to the importance of these topics.

Conflicts of interest

All authors have no conflict of interest influenced the work presented herein. The findings and conclusions in this report are those of the authors and do not represent the official views or positions of the supporting company.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.numecd.2019.03.003>.

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