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Review

Effects of the Dietary Approach to Stop Hypertension (DASH) diet on blood pressure, overweight and obesity in adolescents: A systematic review

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S U M M A R Y

Background & aims: The high prevalence of overweight/obesity, and arterial hypertension (AH) in adolescence is a public health problem worldwide. The aim of the article is to perform a systematic review looking to verify the effects of DASH diet on overweight/obesity and blood pressure (BP) in adolescents.
Methods: Systematic search of the literature conducted until March 2018. Five databases were investigated. We follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) Statement. The systematic review protocol was recorded in PROSPERO (CRD42016046968). Two reviewers examined 1005 abstracts. The risk of bias was assessed using STROBE or CONSORT.
Results: Seven studies were eligible, three cross-sectional, two cohort and two randomized clinical trials (RCTs). Cross-sectional study found that a higher DASH score was associated with decreased body composition measurements; the other two did not find associations between DASH scores, body weight, and BP. Cohort studies found that the DASH diet resulted in lower levels of diastolic BP and lower body mass index gain over 10 years. One RCT showed that the DASH diet proved to be effective in improving systolic BP and another RCT observed a decrease in the prevalence of AH.
Conclusions: The DASH diet may have beneficial effects on the alterations of BP, overweight and obesity in adolescence. However, adherence to this dietary pattern is still low. It is believed that, in the future, dietary interventions based on DASH may be part of public policies to combat AH and overweight/obesity, since all age groups of the population can adopt this dietary pattern.

1. Introduction

Adolescence is often characterized by rapid and profound changes in the physiological, psychosocial, emotional, and behavioral development of human beings. World Health Organization (WHO) defines adolescence as a period between ten and nineteen years of age. The high prevalence of overweight and obesity in adolescence has been considered a global public health issue [1].

A research assessing 2416 population-based studies on weight and height measures including 31.5 million people from 5 to 19 years of age verified that the global prevalence of obesity has increased from 0.7% to 5.6% in 2016 for girls and from 0.9% in 1975 to 7.8% in 2016 for boys. Overweight/obese children and adolescents are more likely to become obese adults with higher risk of developing chronic, non-communicable diseases, including cardiovascular diseases, diabetes mellitus type 2, and Arterial Hypertension (AH) [2].

The prevalence of AH in adolescents varies from 0.8% to 8.2% [3]. Some studies report a mean prevalence of 3.5% for a repeated-measures diagnosis, mainly in overweight/obese adolescents [3–6]. An adolescent is considered hypertense when Systolic (SBP)

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and/or Diastolic Blood Pressures (DBP) are higher than 95% according to age, sex, and height percentile [6].

The first option for treating AH must be the adoption of healthy eating habits, since it has proven to be effective in the control of Blood Pressure (BP) and reduction of cardiovascular risks [7].

In this sense, the Dietary Approach to Stop Hypertension (DASH) dietary pattern, which advocates the consumption of fruits, vegetables, lean dairy products, whole grains, fish, poultry, and nuts – and rather encourages a lower consumption of red and processed meat and sugary drinks – may be a valid strategy for the reduction and treatment of AH [8,9]. Studies reported that the food intake supported by the DASH diet have led to a higher ingestion of potassium (K), magnesium (Mg), calcium (Ca), and fibers [9], and that, therefore, this type of dietary intervention has been effective in the reduction of BP and body weight [8,9]. For this reason, DASH diet has been recommended as a nutritional strategy for lowering BP, overweight, and obesity in adults in some countries, making it the gold standard dietary recommendation for non-pharmaceutical intervention in hypertensive patients [10–12]. Its efficiency, however, is still being tested in adolescents [13–16].

An extensive search in scientific literature from electronic databases has found no ongoing or published systematic reviews on DASH diet and its effects on overweight, obesity, and/or BP in adolescents. Therefore, the main objective of this article is to perform a systematic review of scientific literature aiming to assess the effects of DASH diet on overweight, obesity, and AH in adolescence, by means of attending a DASH diet criteria or evaluation of adherence to the DASH diet. In other words, this study aims to fill this gap and help to improve scientific knowledge on nutritional intervention strategies with the purpose of lowering the prevalence of the aforementioned diseases in adolescents.

2. Methods

This study is characterized as a systematic review (SR); search was carried out until March 15, 2018 following the Preferred Reporting Items for Systematic Reviews, and Meta-Analysis (PRISMA) statement [17] guidelines, without data limitation.

The protocol of this review was registered at the Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD42016046968. Criteria used for the PICOS (Population, Intervention, Comparison, Outcome, and Study) questions are presented in Table 1.

2.1. Search strategy

Searches on electronic databases, such as PubMed (via PubMed; National Library of Medicine, Bethesda, Maryland), The Cochrane Central Register of Controlled Trials (CENTRAL) (via Cochrane Library; Wiley Online Library, New York, USA), Science Direct (via Scopus, Elsevier, Philadelphia, USA), Web of Knowledge (via Web of Science, Thomson Reuters, New York, USA), and Scientific Electronic Library Online (SciELO, São Paulo, Brazil), were performed.

Table 1
Description of the PICO criteria (Population, Intervention, Comparison, Outcome, and Studies) for systematic review.

PICO Criteria	Description
Population	Adolescents (10–19 years of age), both sexes
Intervention	DASH diet (Dietary Approach to Stop Hypertension) DASH pattern
Comparison	–
Outcome	Overweight, obesity, blood pressure, and arterial hypertension
Studies	Cohort, intervention and cross-sectional

The following search strategy was performed: ("dash diet" OR "Dietary Approaches to Stop Hypertension") AND ((Obes* OR Overweight OR Weight OR "Body mass index" OR BMI OR "waist circumference") OR ("Blood pressure" OR Hypertension)). Filters were not used in order to refine search or capture all relevant articles. In order to identify other possible eligible studies, a manual conference of the reference lists of relevant reviews on the same theme was carried out.

EndNote X7® (Thomson Reuters, *New York, USA*) was used for sorting out the articles, as well as for detecting and removing duplicates, triplicates, and quadruplicates. Two reviewers (L.P.B. and F.B.) checked the file independently.

2.2. Eligibility criteria

The two reviewers (L.P.B. e F.B.) performed an initial screening of titles and summaries of the articles in order to evaluate eligibility. Both reviewers managed to read the full articles whenever the information presented on their titles and summaries was not sufficient. Eligibility criteria included: Intervention or observational studies evaluating DASH diet in adolescents (10–19 years of age); overweight, obesity, and/or BP. In the case of potentially eligible articles with unpublished data, authors were contacted by e-mail and were asked about additional or missing information on the methodological procedures used in their studies. Exclusion criteria includes experimental studies (animals), and samples including other age groups (children, adults, elderly).

2.3. Data extraction

Two independent reviewers (L.P.B. e F.B.) read the articles exhaustively in order to allow for an adequate data extraction. The following data were extracted: name of the author, year of publication, place, study design, data for assessing risk of bias, duration, age of the participants, sample size, sex, data related to food intake, use of DASH score, outcome of interest (body mass index [BMI], body weight, and/or blood pressure, adjustment variables, confounding, and main results. Data were categorized via Microsoft Excel 2010® (Microsoft Corporation, Washington, USA).

2.4. Risk of bias and report quality evaluation

Three distinct tools were used in order to assess the risk of bias due to differences in study design (Fig. 2). Risk of bias assessment was performed independently by two reviewers (L.P.B. e F.B.) using the Cochrane [18] tool for randomized clinical trials. This tool analyzes the risk of occurrence of six bias domains. For cross-sectional studies, the tool used was the Agency for Healthcare Research and Quality (AHRQ) [19] which analyzes nine items of risk of bias. For cohort studies, the ROBINS-I [20] tool, which evaluates seven bias domains, was used. The checklists applied in the assessment process are presented in the Supplementary Table 1.

A verification list based on the Consolidated Standards of Reporting Trials (CONSORT) [21] declaration, made of 25 items and 12 sub items, was applied for analyzing the quality of the reports. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) [22] declaration was used for the sake of observational studies, and was composed of 18 items common to observational studies and four specific items for each design (Supplementary Table 2).

3. Results

Searches identified 1005 articles; out of those, 564 were excluded for being duplicates, triplicates, or quadruplicates. After

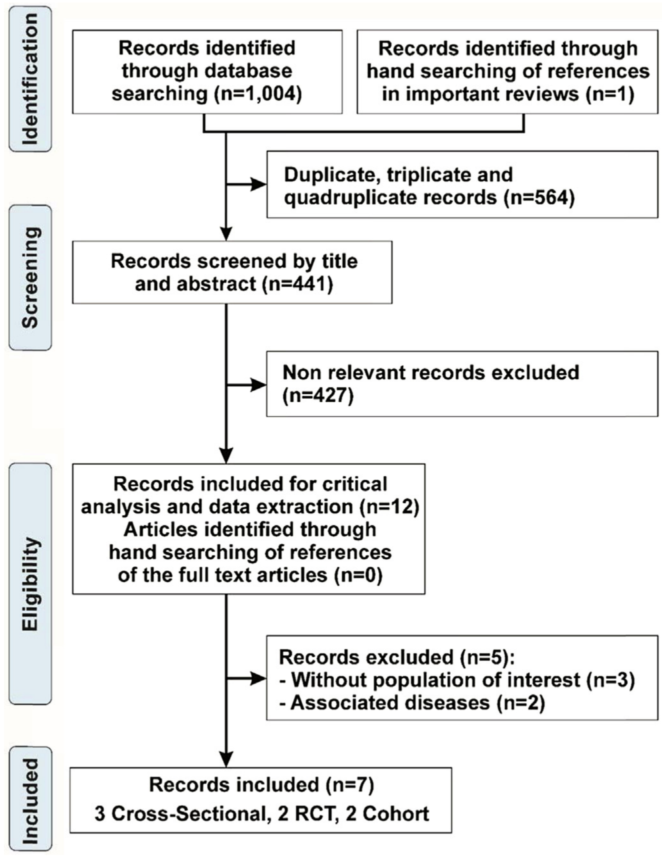

Fig. 1. Flowchart of selection of studies. Abbreviations: RCT – Randomized controlled trials.

reading the titles and summaries, 429 articles were excluded; twelve articles were left for assessment. However, only seven have fulfilled all the eligibility requirements and were, therefore, included in the systematic review, as shown in Fig. 1.

3.1. Characteristics of the studies included in the SR

The studies were published between 2008 and 2017. Regarding their countries, one research was carried out in Canada [15], four in the United States of America (USA) [14,23–25] and two in Iran [13,26]. As far as the study design goes, three of them are cross-sectional [15,25,26], two are cohort studies [14,23] and the other two are randomized clinical trials [13,24], being one parallel [24] and the other cross-sectional [13]. Three studies included only girls [13,14,23]; the other ones included adolescents from both sexes [15,24–26]. The mean age of the subjects included in such studies varies from 10 to 15 years of age. The duration of the non-cross-sectional studies varies from six weeks (for the randomized clinical trials) to 10 years (cohort studies). Sample size varies from 57 to 6801 individuals or adolescents.

Data related to basal BMI were displayed in five articles [13,15,23,24,26], and varies from 18.42 to 29.25 kg/m^2. BMI data after intervention are presented in the randomized clinical trial [24]. Data related to BP are presented in three articles [13,24,25]. SBP varied from 108.1 to 128.7 mmHg and DBP varied from 58.5 to 80.6 mmHg. The characteristics of the articles included in this systematic review are presented in Table 2.

The study by Saneei et al. [13] has not specified its adjustments in the statistical analysis and the variables used in their research. The study by Couch et al. [24] carried out an adjustment by using BMI (Z score). When the outcome of interest was body weight, two cross-sectional [15,26] and one cohort study [14] have adjusted their analysis to: age [26], birth order [15], sex [26], race/ethnicity [14], level of physical activity [14,26], energy and nutrients ingestion [14,26], BP [15], socio-economic level [14,15], screen time [14], level of education of the mother [15], BMI of the mother [15], peak height velocity [15] height for age [14]. The outcome of interest analyzed by Moore et al. [23] corresponded only to BP and their analyzes were adjusted to: age, race/ethnicity, level of physical activity, BMI, height, nutrients ingestion, socio-economic level, and screen time. The study by Cohen et al. [25] assessed the outcomes for body weight and BP, and made use of the following variables for adjustment: age, sex, race/ethnicity, weight, height, and family income (Table 2).

3.2. Attending a DASH diet criteria or DASH diet adhesion evaluation

The relation between diet and health can be evaluated by the level of some food components (nutrients), kind of food, group or food groups and dietary patterns. The association between these parameters and some chronic diseases can be examined by dietary instruments of global diet assessment and some scores have been considered for this purpose [14,15]. A few methods in the literature included in this review can be detected in order to evaluate DASH and adhesion to its pattern: the utilization of the DASH score based on food intake [14,15,25,26]; evaluation of the compliance with the food standards recommended by DASH [23,24]; and quantification of serum vitamin C [13].

Data related to food intake from the cohort studies [14,23] selected were collected during eight visits for a period of ten years, making use of three-day food records. In two cross-sectional studies [15,26] data were obtained by means of a Food Frequency Questionnaires (FFQ); for the other study [25], a 24-h dietary recall was applied using the multiple pass method [27]; a second 24-h dietary recall was applied to a sub-sample. A three-day food record was applied in the cross-sectional randomized clinical trial [13]. The parallel RCT [24] made use of three 24-h dietary recall by means of the multiple-pass method [27]. Such reminders were collected in a period of two weeks (Table 2).

To understand the extent to what extent the practices of individuals address what the recommendations advocate, an *a priori* approach has been used: the food components are classified and weighted, resulting in scores that reflect their overall quality. A scoring system was adopted by four studies in order to evaluate the adhesion to DASH diet [14,15,25,26]. This system was build based on three-day reminders [14], FFQ [15,26], and 24-h hour dietary recall [25].

3.3. Cohort studies

The study by Berz et al. [14] created a score of food components based on the publication by Levitan et al. [28], in which seven components related to the DASH pattern were evaluated: fruits, vegetables, low-fat products, total and whole fats, lean meats and nuts, seeds, and legumes. Each food component received a score, which varying from 0 to 1 (maximum was 7). Levitan et al. [28] compared such score with another DASH score developed by Fung et al. [29] and have verified that they are moderately well-connected ($r = 0.61$), in a research carried out with adults. The study [14] has reported that adolescents whose dietary patterns were very similar to the one by DASH had lower BMI gain during 10 years (24.4 *vs* 26.3 kg/m^2, $p < 0.05$). This study has also shown that the higher the intake of low-fat dairy products, the lower the BMI (25.7 *vs* 23.2 kg/m^2 for <1 portion/day *vs* $\geq$ 2 portions/day,

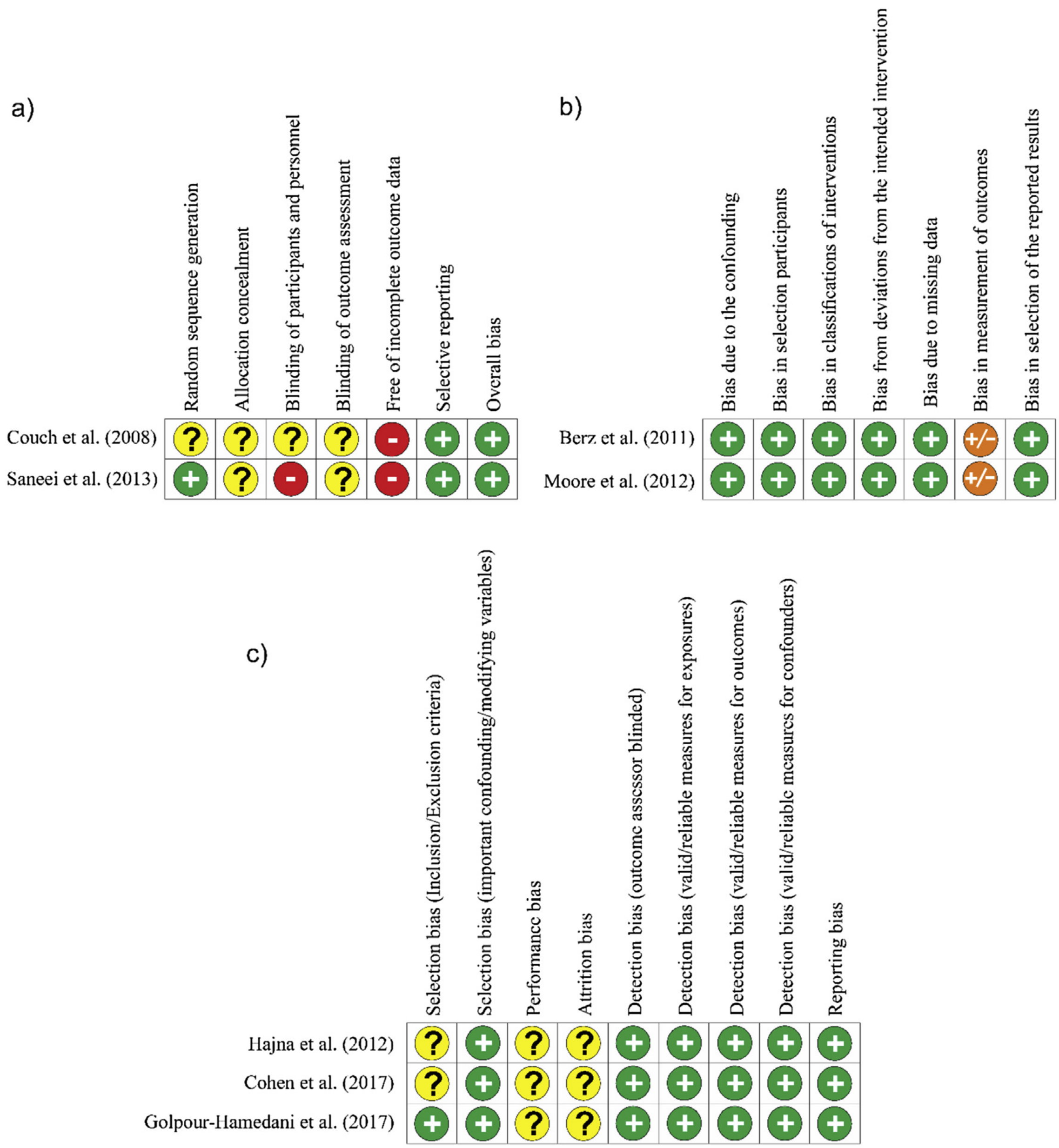

Fig. 2. Summary of risk of bias according to the study design: a) the Cochrane Collaboration's tool for clinical trials; b) the ROBINS-I tool for cohort studies; c) the AHRQ tool for cross-sectional studies. Legend: (+) Low risk; (+/−) Moderate risk; (−) High risk; (?) Unclear risk.

$p < 0.001$). Besides, the intake of ≥2 portions of fruit per day showed lower BMI gain over time and lower BMI at the end of follow-up. (26.0 *vs* 23.6 kg/m^2 for <1 portion/day *vs* ≥ 2 portions/day, $p < 0.001$) (Table 2).

The study by Moore et al. [23] assessed the DASH pattern with the combined consumption of low-fat dairy products, fruits and vegetables. This study [23] has verified that girls who had an intake of two or more daily portions of low-fat dairy products, or three or more portions of fruits and vegetables, presented 36% lower risk of increased BP by the end of adolescence (CI 95%: 0.43, 0.97). In the longitudinal model, two dietary factors were associated with lower BP in adolescence: two or more daily portions of low-fat dairy products ($p < 0.0001$) and DASH pattern ($p = 0.0002$). DASH was the only diet that helped lower diastolic BP levels ($p = 0.0484$). Female adolescents whose diets were rich in low-fat dairy products, as well as fruits and vegetables, during their initial years and mid adolescence, were less likely to have their BP levels increased by the end of adolescence (18–20 years of age) (Table 2).

3.4. Cross-sectional studies

In the study by Hajna et al. [15], the consumption of fruits, vegetables, nuts and legumes, low-fat whole grains and dairy products with low calcium ingestion, red and processed meat, and sugary drinks was adapted to the Gunther et al. [30] e Liese et al. [31] scores for adolescents and young adults. A maximum score of 10 was reached whenever the diet recommendation was fulfilled. A lower consumption in relation to the diet recommendation led to a proportionally lower score. The scores of each food component were summed up in order to produce a DASH score: the higher the score, the higher the conformity with the DASH pattern. The study [15] has verified that, after age adjustment, peak height velocity,

Table 2
Characteristics of the studies included in the systematic review.

Author, Year	Country	Study design/Report quality (fulfilled items)	Duration of the study	Age (years)	Total Sample size	Sex	Mean BMI (kg/m^2)	SBP DBP (mmHg)	Food intake evaluation	DASH Score	Outcome/Adjustment-confounding variables	Main results
Couch et al., 2008 [24]	USA	Parallel Randomized clilical trial Adolescents with pre-hypertension or AH were randomly designated to DASH or RC CONSORT: 24 items fulfilled out of 31	6 months	Baseline DASH Group: 14.3 RC: 14.4	57	F/M	Basal DASH 29.1 RC 29.4 3M DASH 29.2 RC 28.9 DASH 28.7 RC 28.8 6M DASH 29.1 RC 29.5 DASH 30.0 RC 28.9	Basal SBP DASH 131.3 RC 126.1 DBP DASH 79.4 RC 81.8 3 months SBP DASH 131.5 RC 125.0 DASH 120.9 RC 123.1 DBP DASH 79.5 RC 82.3 DASH 72.7 RC 75.9 6 months SBP DASH 129.4 RC 124.3 DASH 120.1 RC 120 DBP DASH 80.4 RC 81.7 DASH 75.2 RC 76.4	3 24-h dietary recall during 2 weeks (2 weekdays e 1 weekend day) before each evaluation visit using the multiple-pass method Telephone interview: trained nutritionist DASH pattern: 8 daily portions of FV, 3 portions of low-fat dairy products and <30% calories from lipids	Did not use	BP/ BMI − Z Score	DASH versus RC lowered the Z scores of SBP from baseline to post-treatment ($p < 0.01$) and also tends to lower the Z scores of SBP from baseline to counseling ($p = 0.07$) Z Scores of DBP changed equally from baseline to follow-up Regarding RC, DASH group showed an increase in fruit intake ($p < 0.001$), K and Mg ($p < 0.01$), and less total fat ($p < 0.05$) DASH proved to be more efficient than RC when it comes to improving SBP in adolescents with adolescentes with high BP
Berz et al., 2011 [14]	USA	Cohort Data from the National Heart Lung and Blood Institute's Growth and Health Study STROBE: 26 items fulfilled out of 29	10 years	10	2327	F	Presented in figures inside the article	Not verified.	Dietary data were collected from 3-day records (2 weekdays and 1 weekend day) during 8 visits DASH Score varied from 0 to 7	Yes Adapted from Levitan et al., 2009 [28]	Body weight/ Race/ethnicity, height-age, socioeconomic level, level of physical activity, screen time, total energy intake and other dietary factors	Girls at the highest quintile of the DASH diet: lower BMI gain over time and at the end of follow-up 24.4 *vs* 26.3 kg/m^2 ($p < 0.05$) Intake $\geq$ 2 fruit portions/day: lower BMI gain over end of follow-up (Mean BMI, 26.0 *vs* 23.6 kg/m^2 for <1 *vs* $\geq$ 2 portions/day; $p < 0.001$) Higher intake of low-fat dairy products: lower BMI gain over time (Mean BMI, 25.7 *vs* 23.2 kg/m^2 for <1 *vs* $\geq$ 2 portions/day; $p < 0.001$)
Moore et al., 2012 [23]	USA	Cohort Data from the National Heart Lung and Blood Institute's Growth and Health Study	10 years	10	2185	F	Basal 18.42	Presented in figures inside the article	Diet was evaluated during 8 visits (1–5, 7, 8 e 10 years) making use of 3-day food intake records. They were classified	Did not use	BP/ Age, socioeconomic level, race/ethnicity, height, BMI, physical activity, watching TV/	Girls who had an intake of $\geq$2 daily portions of low-fat dairy products $\geq$3 portions of FV: 36% lower risk of high BP at the end of adolescence (CI 95%: 0.43, 0.97)

(*continued on next page*)

Table 2 (*continued*)

Author, Year	Country	Study design/Report quality (fulfilled items)	Duration of the study	Age (years)	Total Sample size	Sex	Mean BMI (kg/m^2)	SBP DBP (mmHg)	Food intake evaluation	DASH Score	Outcome/Adjustment-confounding variables	Main results
		STROBE: 23 items fulfilled out of 29							according to the DASH pattern, which combines daily intakes of dairy products and FV		videos, daily intake of lean meat, nuts, seeds and legumes, daily intake of whole grains	Higher intake (≥2 daily portions) of dairy products ($p < 0.0001$) and DASH pattern ($p = 0.0002$): lower SBP values DASH pattern: lower DBP levels ($p = 0.048$) Low-fat dairy products and FV during the beginning and mid adolescence: lower levels of BP at the end of this phase
Hajna et al., 2012 [15]	Canada	Cross-sectional study Data collected from September 2007 to June 2008 STROBE: 25 items fulfilled out of 28	–	12.4	1570	F/M	F: 20.32 M: 20.37	Not verified	CFG and DASH score were obtained from a FFQ questionnaire The higher the score, the higher the conformity with CFG and DASH diet. DASH score varied from 0 to 80	Yes Adapted from Gunther, 2009 [29] and Liese 2009 [30]	Body weight/ Peak height velocity, total BP, birth order, mother's BMI, mother's education level, and socioeconomic level	Higher DASH scores were associated with lower measurements of body composition for both sexes DASH score was negatively associated with BMI girls: $\beta = -0.07$, CI95% -0.10, -0.04; boys: $\beta = -0.05$, CI95% -0.08, -0.02), WHR (girls: $\beta = -0.001$, CI95% -0.002, -0.001; boys: $\beta = -0.001$, CI95% -0.002, -0.0004), RCQ (girls: $\beta = -0.001$, CI95% $- 0.002$, -0.001; boys: $\beta = -0.001$, CI95%, -0.001, -0.00004), WC (girls: $\beta = -0.24$, CI95%, -0.31, -0.16; boys: $\beta = -0.15$, CI95% -0.24, -0.07) e HC (girls: $\beta = -0.15$, CI95% -0.23, -0.07; boys: $\beta = -0.12$, CI95% -0.19, -0.04) Higher DASH scores were associated with lower chances of overweight in girls (OR = 0.70, CI95% 0.56, 0.87) and boys (OR = 0.76, CI95% 0.62, 0.93)
Saneei et al., 2013 [13]	Iran	Cross-sectional randomized clinical trial Post-pubescent adolescent girls with MS were distributed to get recommendations on DASH or UDA	6 weeks	14.2	60	F	Basal 27.3	Basal SBP 120.6 DBP 73.3	3-day food intake reminder DASH group received a sample of the DASH diet menu with a list of substitutions; UDA group received oral and written orientations and no menu	Did not use	Body weight and BP/ Not informed	Serum vitamin C tended to be higher at DASH phase versus UDA ($p = 0.06$) Alterations in body weight, WC, and BMI were the same for both phases ($p = 0.13$) DASH phase prevented BP increase in relation to UDA ($p = 0.01$)

		CONSORT: 23 items fulfilled out of 31							Diet adhesion evaluated by the quantification of vitamin C plasma levels			When compared to UDA, DASH group presented lower prevalence of MS and high BP
Cohen et al., 2017 [25]	USA	Cross-sectional study Data from NHANES 2003–2012 STROBE: 27 items fulfilled out of 28	–	14.5	6.801 11–13 – 2.211 14–18 - 4.590	F/M	Not displayed	SBP 11–13 – 105.9 DBP 11–13 – 56.2 SBP 14–18 – 110,3 DBP 14–18 -60.9	24-h reminder using the multiple-pass method, A second 24-h reminder was applied to a sub-sample DASH score based on 9 categories of nutrients: Total fat, saturated fat, protein, cholesterol, fiber, calcium, magnesium, potassium, and sodium Recommendations were adapted for children and adolescentes DASH score varied from 0 to 9	Yes Adapted from Appel et al., 1997 [9]	Body weight and BP/ Age, sex, race/ethnicity, family income, weight, and height	There were no significant associations between DASH scores and body weight/WC DASH score was inversely associated with SBP for the 14–18 yo group ($\beta = -0.46$; CI 95% -0.83 to -0.09), a 1-point increase in DASH score was associated with a 0.46-mmHg-decrease in SBP.There were no significant differences related to DBP An inverse association between DASH score and SBP was observed in the 11–13 yo group ($\beta = -0.57$; CI 95% -1.02 a -0.12) for the sub-sample with a second 24-h reminder
Golpour-Hamedani et al., 2017 [26]	Iran	Cross-sectional study STROBE: 27 items fulfilled out of 28	–	14	456	F/M	20.7	Not verified	Dietary food intake was evaluated by a validated self-administered FFQ DASH score was build up by focusing on 8 Fcomponents: high intake of fruits, vegetables, nuts and legumes, whole grains, and low-fat dairy products, low intake of sodium, red and processed meat, and sugary drinks DASH score varied from 8 to 40	Yes. Adapted from Fung et al., 2008 [31]	Body weight/ Age, sex, level of physical activity (low, moderate, high), energy consumption (kcal), and nutrients	Adhesion to DASH diet was associated with obesity in the crude model (CI95%: 1.28–8.75) When models were adjusted to confounding variables, this association was statistically insignificant (CI 95%: 0.35–31.21) There was a tendency of lower adhesion to DASH diet related to abdominal obesity; it was, however, statistically insignificant

USA: United States of America; RCT: Randomized Clinical Trial; FV: Fruits and Vegetables; MS: Metabolic Syndrome; AH: Arterial Hypertension; DASH: Dietary Approach to Stop Hypertension; UDA: Usual Dietary Advice; BP: Blood Pressure; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; M: Male, F: Female; HC: Hip Circumference; WC: Waist Circumference; WHR: Waist Height Ratio; WHR: Waist Hip Ratio; BMI: Body Mass Index; CI: Confidence Interval 95%; OR: Odds Ratio; FFQ: Food Frequency Questionnaire; CFG: Canada's Food Guide; RC: Routine Care; K: Potassium; Mg: Magnesium; STROBE: Strengthening the Reporting of Observational Studies in Epidemiology [22]/CONSORT: Consolidated Standards of Reporting Trial [2].

and physical activity, a higher DASH level was associated to lower measurements of body composition for both sexes. The DASH score was negatively associated with BMI (girls: $\beta = 0.07$, CI95% −0.10, −0.04; boys: $\beta = -0.05$, CI95% −0.08, −0.02), waist height ratio (girls: $\beta = -0.001$, CI95% −0.002, −0.001; boys: $\beta = -0.001$, CI95% −0.002, −0.0004), waist hip ratio (girls: $\beta = -0.001$, CI95% − 0.002, − 0.001; boys: $\beta = -0.001$, CI95%, −0.001, −0.00004), waist circumference (girls: $\beta = -0.24$, CI95%, −0.31, −0.16; boys: $\beta = -0.15$, CI95% − 0.24, −0.07), and hip circumference (girls: $\beta = -0.15$, CI95% −0.23, −0.07; boys: $\beta = -0.12$, CI95% −0.19, −0.04). A higher DASH score was associated with lower chances of overweight in girls (OR = 0.70, CI95% 0.56, 0.87) and boys (OR = 0.76, CI95% 0.62, 0.93) (Table 2).

In the study by Cohen et al. [25], the DASH score was based on nine categories of nutrients: total fat, saturated fat, protein, cholesterol, fiber, calcium, magnesium, potassium, and sodium. The research [25] has observed no significant associations between DASH scores and body weight and waist circumference in any of the age categories. DASH score was inversely associated with SBP in 14–18-year-old adolescents ($\beta = -0.46$; IC 95% −0.83 to −0.09). A 1-point increase in DASH score was associated with BP; however, no differences were observed among the other age categories. No significant differences in diastolic BP were found (11–13 years old, $\beta = -0.09$; IC 95% −0.60 to −0.79; 14–18 years old, $\beta = -0.10$; IC 95% −0.36 to −0.55). While analyzing the participants with a second 24-h dietary recall, an inverse association between DASH score and SBP for 11–13–year-old individuals was observed ($\beta = -0.57$; IC 95% −1.02 to −0.12). Such study, which examined a nationally representative sample of adolescents from the USA, has still discovered that the American population does not follow a similar dietary pattern to DASH (Table 2).

The DASH score used in the study of Golpour-Hamedani et al. [26] was build up by focusing on eight food components: high ingestion of fruits, vegetables, nuts and legumes, whole grains and low-fat dairy products, low calcium ingestion, red and meat, and sugary drinks. This score was adapted from Fung et al. [29], who evaluated the adhesion to the DASH diet in the Nurses Healthy Study cohort, including adult females from eight to forty years old. The research [26] has verified that the DASH diet was associated with obesity in the crude model (CI 95%: 1.28–8.75). However, when models were adjusted to confounding variables, there was no evidence of statistically significant associations (IC 95%: 0.35–31.21). Adhesion to DASH diet was significantly associated with higher levels of fruits, vegetables, low-fat dairy products, whole grains, nuts, and legumes (all $p < 0.001$). Individuals from the third tercile of DASH score presented significantly lower ingestion of sugary drinks, red meat ($p < 0.001$), and refined grains ($p < 0.001$) in comparison to those in the first tercile (Table 2).

3.5. Randomized clinical trials

Adolescents evaluated in a randomized cross-over clinical trial [13] received a menu sample (DASH group). Adhesion to the DASH diet was assessed by quantifying the plasma concentrations of Vitamin C, Ca, K, and Mg contents in the DASH diet, which were higher to those recommended during the intervention with Usual Dietary Advice (UDA). Groups that received both DASH and UDA recommendations were monthly accompanied by 30–45-min orientation sections. The UDA group received general information on healthy food choices. In the trial [13], serum levels of Vitamin C tended to be higher during DASH phase in relation to UDA ($p = 0.06$). Alterations in weight, WC, and BMI were the same for both intervention phases ($p = 0.13$). DASH recommendations have played a more significant role in the prevention of high DBP in relation to UDA ($p = 0.01$). In addition, DASH group presented a reduction in the prevalence of metabolic syndromes and high blood pressures, as well as an improvement in diet quality (Table 2).

The parallel-randomized clinical trial [24] evaluated a 3-month behavioral nutritional intervention with an emphasis on DASH diet versus Routine Care (RC) at the nutrition clinic, in adolescents with high BP. DASH intervention consisted of a 60-min counseling session with a nutritionist. Eight phone calls and two weekly e-mails were sent to participants, who were encouraged to fulfill their diet goals. Individuals from the control group received nutritional RC with a single 60-min counseling session containing general recommendation for hypertense individuals. Diet adhesion was evaluated based on the DASH pattern. The authors defined the DASH pattern as eight daily portions of fruits and vegetables, three daily portions of low-fat dairy products, and <30% of calories from lipids. The study [24] has verified that DASH group versus RC had a reduction in the z-scores from baseline to follow-up ($p < 0.01$), with a tendency of lower z-scores for systolic and DBP from the basal period until monitoring ($p = 0.07$). In terms of RC, the DASH group has presented an increase in fruit intake ($p < 0.001$), K and Mg ($p < 0.01$), as well as a decrease of total fat ($p < 0.05$). DASH intervention proved to be more efficient when it comes to improving the SBP and diet quality of adolescents with high BP (Table 2).

3.6. Risk of bias and report quality evaluation

Figure 2 presents a summary of the evaluations of risk of bias by means of three tools adequate for each study design.

Cross-sectional studies [15,25,26] were categorized according to their low or unknown risk of bias for most of the questions, since they were not clear on whether they made use of inclusion/exclusion criteria equally to all groups, or if researchers eliminated any unintentional disclosure impacts, if friction was taken into consideration, and if missing data were treated adequately, in accordance with specific literature [19].

The cohort studies [14,23] relevant to this review presented low risk of bias for all fields, except for the outcomes assessment domain, which was classified as moderate risk, since, for both studies, outcomes assessment may be influenced by the knowledge on disclosure [20].

Regarding the evaluation of randomized clinical trials in terms of selection bias, the cross-section trial [13] presented low risk of bias, since it describes the fact that the researchers have digitally generated randomized number, whereas there was no information on this matter in the parallel trial [24].

Randomized clinical trials [13,24] did not bring to surface enough information on allocation concealment. In terms of performance bias, the cross-sectional trial [13] presented high risk, since their participants were not blind in relation to the treatment. The parallel trial [24], on the other hand, presented unknown risk of bias. In relation to detection bias, both researches presented unknown risk, for there were no sufficient information on whether the outcome evaluators had any knowledge on this matter.

In terms of friction bias, both studies present high risk, since both of them contain losses with incomplete outcomes. About the report risk of bias evaluation, all studies presented low risk, since their protocols were made available and all outcomes were reported [18].

For the sake of report quality evaluation, the authors made use of the STROBE [22] declaration and CONSORT [21] verification list, according to the study design in question. The complete items are presented in Table 2 and their data are described in details in Supplementary Table 2.

According to STROBE [22], one article [23] has fulfilled 79.5% of the requirements; two studies [14,15] have fulfilled 89.5%; and two articles have fulfilled 96.4% [25,26] of the applicable requirements. Whenever the CONSORT list was used, the cross-sectional randomized clinical trial [13] has met 74% of the requirement, whereas the parallel-randomized clinical trial [24] has met 77.5% of the applicable requirements.

4. Discussion

Up to this moment, this is the first systematic review to evaluate the effects of DASH on overweight, obesity, and BP in adolescents.

Some characteristics of the DASH pattern seem to support the loss of body weight when it comes to the individuals investigated in the aforementioned studies. The energy density of the DASH pattern is relatively low [32], in a way individuals can consume less energy without decreasing the number of foods ingest during the day. DASH guidelines encourage an increase in the consumption of fruits and vegetables and whole grains. Such foods are rich in fibers, water, and provide for a feeling of satiety [32].

Oilseeds and legumes can also increase satiety, since they are full of proteins and fibers [33]. Besides, avoiding candies and sugary drinks is a highly advocated matter when it comes to DASH [34]. Other DASH components, such as low-fat dairy products, may also play a crucial role in appetite reduction and body weight [35]. On the other hand, eating less fat products and red meat and more fish was also associated with body weight loss [36]. A systematic review [32] studied the effects of DASH diet on weight and body composition in adults. Its meta-analysis has revealed that DASH group lost more weight in relation to control groups. It has also shown that the low-energy DASH dietary pattern resulted in greater weight loss in comparison to other diets. Such effect was ever greater in overweight and obese participants [32].

DASH pattern has proven to be a healthy choice for adolescents, since they will be able to maintain body weight and still be provided with adequate nutrients that will aid in their growth and development [13]. In the Saneei et al. study [13], the recommendations to follow DASH have resulted in significant reductions in energy density, saturated fat consumption, and Na, as well as an increase in the intake of K, Ca, dietary fibers, fruits, vegetables, and vitamin C.

Such dietary pattern has proven to be a healthy choice for adolescents, since they are able to maintain body weight and still be provided with adequate nutrients that will aid in their growth and development.

DASH has been considered a healthy diet pattern. Research showed that DASH might help lower BP [9,37], improve lipid profile [38] control blood glucose [39] and prevent cardiovascular diseases [40]. In addition, DASH pattern provides for a food diet rich in minerals, such as Mg, Ca, K, with lower levels of Na, which are inversely associated with obesity [41].

A systematic review verified a positive influence of DASH on BP in adults; however, it emphasizes the variation of answers given by different subgroups [37]. Another systematic review [42] showed that DASH was very effective in lowering BP, as well as the total cholesterol and LDL-cholesterol concentrations. Alterations in systolic and DBP were greater for the participants with higher basal blood pressures and BMI. Such changes provided for a reduction of approximately 13% in the Framingham risk score of ten years for cardiovascular diseases. DASH diet improved cardiovascular risk factors and demonstrated greater benefits for individuals with increased cardio metabolic risk [42]. The systematic review [43] which evaluated the most recent evidences on DASH diet adhesion has verified that relevant studies made use of urinary excretion, dietary ingestion evaluation, and DASH score measurements. This review has verified that there are no consensus in terms of the best approach to evaluate DASH adhesion. It has also pointed out the importance of investigating effective approaches to support DASH and isolated dietary counseling [43].

Regarding the dietary evaluation methods used, five out of seven studies included in this systematic review made use of a food intake record or 24-h hour dietary recall in order to assess food intake. Despite the fact they made use of a golden pattern method for dietary evaluation, adolescents may present difficulties when it comes to registering the right size of food portions and details related to the foods they had, such as the way they were prepared, for instance [43]. Even though dietary sub-reports may be a concern, it has been shown that the recording of food intake for the main meals is much more complete in relation to the snacks, even among overweight and obese people [43].

The articles selected in this study made use of objective and subjective methods to evaluate the adhesion to DASH diet, and it is known that such methods present both vantages and disadvantages [43].

The quantification of serum vitamin C used in the cross-sectional randomized clinical trial [13] is a biomarker for dietary intake of nutrients. It is an evaluation method, which does not rely on the memory of the participant and is relatively accessible. However, such evaluation, even when combined with 3-day food intake records, may not be sufficient to detect the adhesion to the DASH diet [13]. Therefore, investigating a more adequate adhesion biomarker related to DASH diet should be taken into consideration in future research.

Utilization of the DASH score is a subjective approach to evaluate the adhesion to such diet. This method makes use of self-recorded data related to dietary intake obtained by 3-day reminders, 24-h records and/or FFQ to compare with the recommendations. This helps obtaining information on the type and/or quantity of the food consumed, thus resulting in a quality score of the diet. This method is, however, subject to limitations inherent to all dietary evaluation methods, such as memory and answer bias [43]. It would be much more adequate if all studies made use of both methods as a complement to each other. Nevertheless, the choices related to the most adequate evaluation method depend on physical and financial resources available at the time of research. This review has detected different methods used for evaluation by the DASH score systems, which confirms that there is still no consensus when it comes to the use of score in adolescents. It also shows the importance of validating and standardize a specific instrument to be used in this specific age group. In addition, it demonstrated that adhesion to DASH is still very low in adolescents [14,15,25,26]. This aspect may have limited the capacity to verify associations in the studies by Cohen et al. [25] and Golpour-Hamedani et al. [26]. It is important to highlight that five out of seven studies discussed here were carried out in the United States and Canada, which are countries with high prevalence of overweight and obesity in children and adolescents [44,45], as well as red meat and fast-foods, especially in the USA.

In terms of risk of bias and report quality evaluation, some relevant information – especially concerning blinding related to outcome/treatment, randomization, and allocation concealment – were incomplete for some studies mentioned here. Other information on exclusion and inclusion criteria being applied evenly to all groups, as well as the domain of measurement of the outcomes, was not provided by some studies.

Still, even though the majority of the studies had their statistical analyzes adjusted for some important variables, some differences in the choice of the variables used has been verified. This may have occurred due to their different delimitations and outcome. Besides, such studies have provided different statistical analyzes, which depended on their study designs.

In order to provide for better quality studies, this systematic review managed to summarize a few aspects, which may be relevant for the methodological quality of future investigations.

Independently from their designs, all studies should be planned carefully and rely on validated methods for the population in question.

To make writing easier, manuscripts must be prepared in accordance with the guidelines for structuring projects. In the search results, it is highly suggested that the authors also present absolute data, both at baseline and after monitoring/intervention, mean and standard deviation of data related to body weight, BMI, BP – not only in figures, so that it can be possible to obtain evidences and to compare data in future meta-analyzes.

The main limitations of this systematic review relate to the small number of eligible studies due to the criteria established by the authors and the differences in study design. Studies found in literature presented important differences in their evaluation methods related to the adhesion to DASH diet. The lack of homogeneity among the studies made it difficult to perform a statistical comparison and meta-analysis. In conclusion, three out of seven articles evaluated only girls; therefore, their findings should interpreted wisely in order to avoid generalization.

5. Conclusion

This study collects important information related to the DASH dietary pattern and its positive effects on BP, overweight, and obesity in adolescents. However, adhesion to such food intake pattern seem to be low for this age group. Even though many propitious results related to DASH in adolescents have been found, future research remains indispensable in order to confirm such findings. It is hoped that, in the future, dietary interventions based on DASH may be a part of public policies to fight hypertension, overweight, and obesity, since it that can be adopted by all age groups of the population.

Conflict of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2018.09.003.

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