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Evaluation of Mediterranean Diet adherence scores: a systematic review

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ABSTRACT

Objective/ The aim of this review was to evaluate the conceptual suitability, applicability, and psychometric properties of scores used internationally to measure adherence to the Mediterranean Diet.

Design: This was a systematic review to identify original articles that examined some aspects of the conceptual suitability, applicability or psychometric properties of the MD adherence score. Electronic searches were carried out in the international databases MEDLINE, SCOPUS, WEB OF SCIENCE, and EMBASE until 31 December 2015.

Setting: Relevant articles were identified by searching MEDLINE, SCOPUS, WEB OF SCIENCE and EMBASE. Three authors independently extracted information from eligible studies.

Participants: original articles that examined some aspects of the conceptual suitability, applicability or psychometric properties of the Mediterranean Diet adherence score. The studies where MD adherence scores were administered but did not bring forward any evidence about their performance related to conceptual suitability, applicability or psychometric properties were excluded.

Primary and secondary outcome measures: Information relating to the scales was extracted in accordance with the quality criteria defined by the Scientific Advisory Committee of the Medical Outcomes Trust for measurement of health results and the quality criteria recommended by Terwee: 1) conceptual; 2) applicability; and c) psychometric properties.

Results: Twenty-seven studies were identified as meeting the inclusion criteria, yielding 28 Mediterranean Diet adherence scores. The results showed that evidence is scarce and that very few scores fulfilled the applicability parameters and psychometric quality. The scores developed by Panagiotakis et al., Buckland et al., and Sotos-Prieto et al. showed the largest levels of evidence.

Conclusions: Scores measuring adherence to the Mediterranean Diet are useful tools for identifying the dietary patterns of a given population. However, further information is required regarding existing scores. In addition, new instruments with greater conceptual and methodological rigor should be developed and evaluated for their psychometric properties.

Key words: Mediterranean diet, scores, validity, review

Strengths and limitations to this study

- This systematic review and meta-analysis represents, to our knowledge, the most comprehensive examination of the evidence on the conceptual suitability, applicability, and psychometric properties of scores used internationally to measure adherence to the Mediterranean Diet.
- Twenty-seven studies were identified as meeting the inclusion criteria, yielding 28 Mediterranean Diet adherence scores. The results showed that evidence is scarce and that very few scores fulfilled the applicability parameters and psychometric quality.
- This review only took account of studies wherein the main objective was to develop or examine data about the applicability or psychometric properties of an MD adherence score. It could produce an underestimation of the predictive and/or concurrent validity, which are the most frequent analysis in longitudinal studies with this MD adherence scores.

- Future research should focus on improving the psychometric properties of the MD adherence scores, and analyzing the concordance between these instruments in compliance to normative quality criteria.

INTRODUCTION

Several epidemiological studies have evaluated the relationship between health and food intake[1-6]. Specifically, various population surveys and clinical trials provide evidence that diets that are high in fruits, vegetables, legumes, whole grains, fish, and moderate in dairy intake are associated with a lower incidence of chronic disease[4 7 8-10].

The Mediterranean Diet (MD) is characterized by a high intake of plant-based foods (vegetables, legumes, fruits, nuts, cereals [mainly whole grain]), olive oil as the main source of fat, moderate amounts of dairy (yogurt and cheese), low or moderate consumption of fish and meat, moderate consumption of wine consumed with meals, and an active lifestyle[11-14]. Although the various geographical regions of the Mediterranean have different diets, influenced by socio-cultural, religious, or economic factors, among others, it can be assumed that these diets are variations of the same MD diet[15-16].

Various longitudinal studies have analyzed the benefits of the MD in comparison with other types of diet[17-23]. These studies have shown that people with good adherence to the MD have a better quality of life and greater life expectancy, along with a decreased prevalence of chronic diseases such as certain types of cancer, type 2 diabetes, and cardiovascular or neurodegenerative disease[1 5 10 24-27]. Specifically, the protective role of the MD has been attributed to the high intake of plant-based foods along with a moderate consumption of wine, fish, and dairy, and a high intake of monounsaturated fatty acids in lieu of saturated and trans fatty acids, which is linked with an elevated antioxidant capacity[8 10]. Therefore, it is important to ascertain the degree of adherence to the MD through accurate measurement tools such as dietary scores based on the frequency of pattern-consistent and –inconsistent food consumption, as well as compliance with recommended intake[28].

Evidence shows that dietary scores are useful tools to evaluate the degree of adherence to the MD and its benefits in regards to health. Scores are composite constructs based on

dietary components, combining foods and nutrients to obtain valid operational variables that analyze the association between the quality of diet and its health effects[29]. Several scores are used to measure the degree of agreement with the MD. The first and most widely used score was created by Trichopoulou et al. in 1995[30]. This score evaluates concordance with the dietary pattern, by assigning one point when the intake of protective foods is higher than median, in the study/sample population or when the consumption of non-protective foods is lower than median, and zero in the opposite situations. Other scores based on the MD have been created for use in different geographical populations, for populations with different underlying physiological states, and so that alternate foods can be incorporated into and/or accounted for within the canonical pattern[11 31 34].

The characteristics of MD scores have been reviewed in different studies[15 35]. However, the quality of these instruments, which is fundamental to ensuring their valid and reliable application, has not been analyzed. The heterogeneity of MD adherence scores raises the potential for disparity in analyses as well as confusion as to which specific score to choose. Therefore, to be able to select a good instrument, one must first know the quality criteria it offers. Knowledge of such criteria is imperative for the accurate use of the instrument[36-39]. According to the Scientific Advisor Committee of the Medical Outcomes Trust (SAC), 8 quality criteria must be established, corresponding to 3 groups of information: conceptual suitability (conceptual and measurement model, cultural and linguistic adaptation); applicability (demands of the administrator and respondent, alternative forms, interpretability); and psychometric properties (reliability, validity, and responsiveness)[39].

For this reason, the aim of this review was to evaluate the conceptual suitability, applicability, and psychometric properties of MD adherence scores used internationally.

METHODOLOGY

Search strategy

To obtain original documents, electronic searches were carried out using the following international databases: MEDLINE, SCOPUS, WEB OF SCIENCE, and EMBASE. The search strategy was designed to obtain original studies about the development or validation of scores measuring adherence to the MD, published until 31 December 2015 (since the inception of the database). This strategy focused on combining the following keywords: Mediterranean diet, score, adherence, and terms associated with the psychometric properties of instruments (validity, quality, and reproducibility). In order to increase the sensibility of the search strategy, searches were conducted using the thesaurus of each of the databases selected and keywords – in the title and abstract – associated with the search terms (Figure 1). The electronic searches were complemented by manual searches[40] in international journals with regard to their relevance and frequency in the publication, by new searches in PubMed under the names of the identified MD score and under the names of the authors who had created or adapted them, and by the references of the articles which complied with the inclusion criteria. Abstracts from congresses and grey literature were excluded.

1. (mediterranean diet[Title/Abstract]) OR mediterranean diet[MeSH Terms]
2. (adherence [Title/Abstract])
3. (score [Title/Abstract]) OR (index [Title/Abstract])
4. ((quality) [Title/Abstract]) OR (validity[Title/Abstract])) OR reproducibility of results [MeSH Terms] OR reproducibility of results [Title/Abstract] OR psychometrics [MeSH Terms] OR psychometrics Title/Abstract]
5. 1 AND 2 AND 3 AND 4

Figure 1. Search strategy using MEDLINE for studies on the evaluation of Mediterranean diet adherence scores. Search was conducted for Medline with the appropriate search terms utilized for the other databases

Inclusion criteria

All original articles which objects were examined some aspects of the conceptual suitability, applicability or psychometric properties of the MD adherence score in English or Spanish were included.

Exclusion criteria

The studies where MD adherence scores were administered but did not bring forward any evidence about their performance related to conceptual suitability, applicability or psychometric properties were excluded.

Selection of studies

Three reviewers (MJCM, RFC and AZM) assessed the titles and abstracts to determine their inclusion or exclusion from the review. The reviewers worked independently, and if they were in disagreement, a third reviewer would resolve the disagreement or recommend reading the whole article.

Data extraction

Information was extracted by the same researchers (MJCM, RFC and AZM), who had independently carried out the selection of original articles, resolving disagreements through consensus with a third person. The information extracted was divided into two sections: information about the characteristics of the study and the sample, and information about the measurement scales. The first section included the characteristics of the study and the sample (inclusion criteria, sample size, and origin of the population).

Information relating to the scales was extracted in accordance with the quality criteria defined by the Scientific Advisory Committee of the Medical Outcomes Trust (SAC) for measurement of health results and the quality criteria recommended by Terwee[36-39]. In order

to facilitate understanding, the 8 attributes of the SAC were included in 3 groups of information:[41] 1) conceptual suitability (conceptual and measurement model, cultural and linguistic adaptation); 2) applicability (demands of the administrator/respondent alternative forms, and interpretability); and c) psychometric properties (reliability and validity and responsiveness). Table 1 sets out the quality criteria used and their measurement values.

Table 1: Attributes and criteria for reviewing instruments [a]

Group	Attributes	Criteria for review
Conceptual suitability	- Conceptual and measurement model used	- Concept to be measured (content validity) - Conceptual and empirical basis for item content and combinations - Information on dimensionality and distinctiveness of scales (floor and ceiling effects)
	- Cultural and language adaptations or translations: equivalence	- Conceptual and linguistic assessment - Evaluation of measurement properties
Applicability	- Information about respondent and administrative burden	- Information on: (a) time need to complete the instrument, (b) reading and comprehension level, (c) any special requirements or requests made of respondent
	- Special requirements regarding application, alternative forms	- Evidence on reliability, validity, responsiveness, interpretability, and burden for each mode of administration - Information on the comparability of alternative modes
	- The interpretability of the scores	- Rationale for selection of external criteria of populations for purposes of comparison and interpretability of data - Information regarding the ways in which data from the instrument should be reported and presented - Meaningful 'benchmarks' to facilitate interpretation of the scores
Psychometric properties		
	- Reliability:	
	o Internal consistency	- Homogeneity (intercorrelations) of the scale's items at one point in time: Cronbach's alpha coefficients and item-test correlations
	o Test-retest reliability (intra-rater)	- Stability of an instrument over time (test–retest): Person/Spearman coefficient values, as well as interclass correlation coefficients (ICC) and Kappa Coefficients were collected.
	o Equivalence (inter-rater)	- Inter-rater agreement at one point in time: Person/Spearman coefficient values, as well as interclass correlation coefficients (ICC) and Kappa Coefficients
	- Validity	
	o Content validity	- Evidence that the domain of an instrument is appropriate relative to its intended use. It is a theoretical validity that is included in conceptual suitability.
	o Criterion validity (concurrent and predictive)	- Evidence that shows the extent to which scores of the instrument are related to a criterion measure (gold standard): values of specificity and sensitivity, or statistics of correlation
	o Construct validity	- Evidence that supports a proposed interpretation of scores based on theoretical implications associated with the constructs being measured: factorial structure of the instrument, convergent or divergent evidence and discriminatory capacity of the instrument.
	- Responsiveness	- Effect size statistics and correlation measurements of change between predictors and clinical criteria

[a] Table elaborated by the authors[37-39]

Finally, a summary table (table 7) was created providing evidence from all the scales, with a view to synthesizing information on the basis of the criteria developed by McDowell [42]. The following assessment criteria were established: 1. Process of cross-transcultural adaptation (?: not reported; + translation only; ++: translation-back translation; +++ translation-back translation and pilot test); 2. Applicability (?: not reported; + data about the process of administration and interviewing; ++ visual material about foods and training of interviewers, +++: normative data); 3. Reliability (?: not reported or weak associations of some aspect of internal consistency reported; + alpha coefficient of internal consistency or intra-rater or inter-rater reliability reported; ++ alpha coefficient or interclass correlation coefficients (ICC) or correlated coefficient >0.70; 4. Validity (?: not reported, +: evidence from criterion or construct validity, ++: evidence from criterion and construct validity.

RESULTS

Search results

A total of 56 articles met the inclusion criteria, which were reduced to 52 once the duplicates had been removed (Figure 2). In addition, 19 of these articles were excluded after reviewing the title and the abstract because they did not meet the inclusion criteria. Finally a further 6 articles were excluded because they did not use specific MD adherence scores in their methodology. Therefore, 27 articles were included in the review, from which 28 MD adherence scores were used.

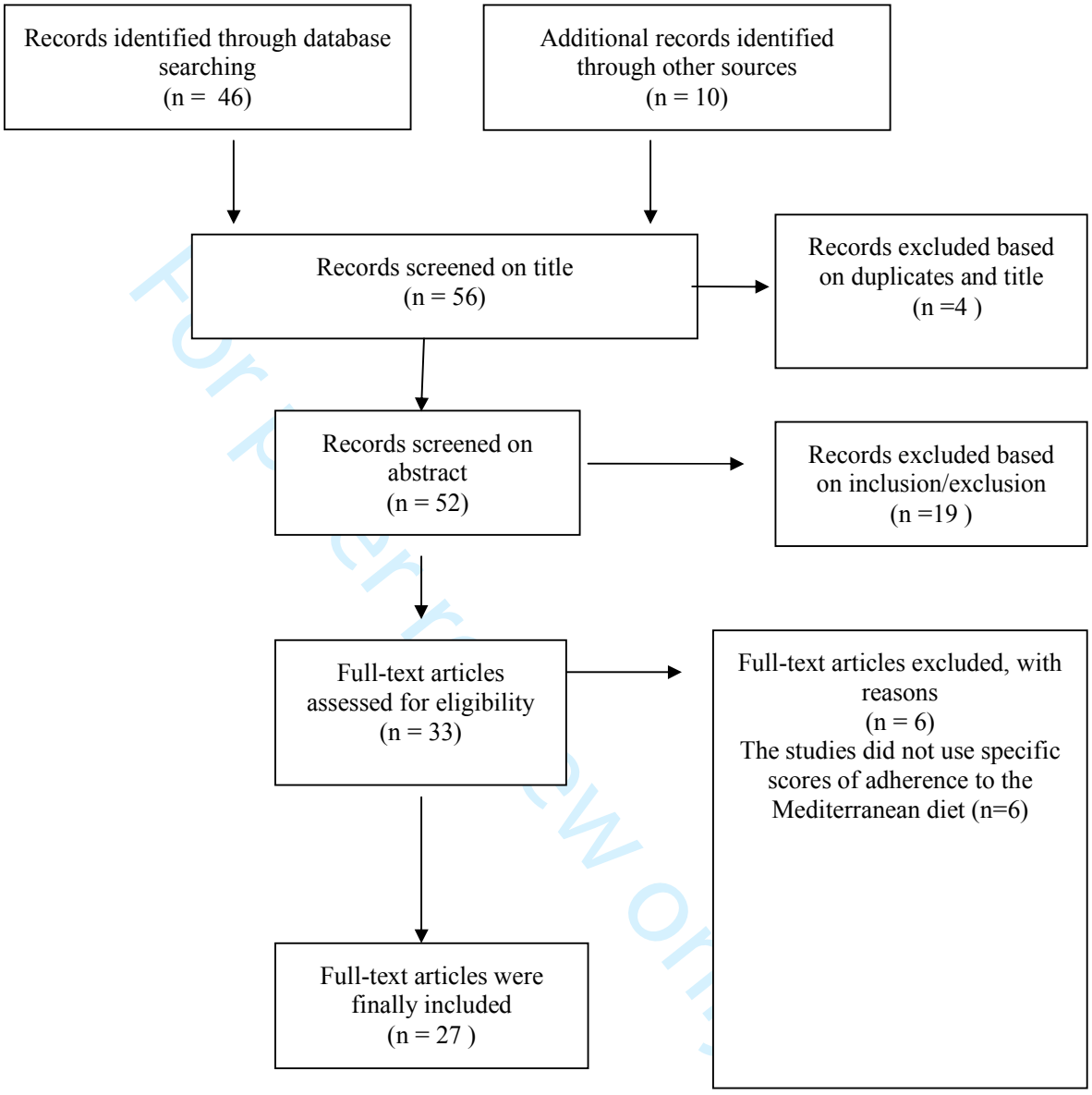

Figure 2. Search and inclusion process flowchart of studies to include in systematic review of the evaluation of Mediterranean diet adherence scores: identification, screening, eligibility and included.

Characteristics of included studies

The designs of the studies included were principally observational (12 cohort studies[14 16 26 28-31 43 45 46 54,55], 1 case and control study[34], 14 descriptive studies[6 11 12 29 32 33 44 47-49 51-53 56], and 1 intervention study[50]). A total of 18 studies focused on the general population[6 14 26 29 31-34 44 47 48 50-56], 3 on the elderly[30 43 46], 2 on children[11 12], 1 on university students[6], and 1 on pregnant women[31]. Finally, 3 of them did not indicate the target population of the scores. With respect to sample size, the scores created by Trichopoulou et al.[14 43] were developed using large samples: 22,043 and 74,607 people, respectively. There were 3 studies with a sample size of <150 people[29 49 50].

Conceptual suitability

Tables 2 and 3 summarize key data regarding the conceptual suitability of the different scores: the context in which they were applied, content validity, and cross-cultural adaptation process. The scores were listed according to their conceptual model and measurement. The majority of the scores (n = 19)[2 6 11 14 16 26 29-34 43-49] were based on positive and negative components of the MD. Five of them were based on the structure of the MD food pyramid[28 50-53], 3 on the general characteristics of the MD[54-56], and 1 on the diet quality index[12]. As a fundamental model, the scores created by Trichopoulou et al.[14 30 43] have been the most widely utilized, with 6 scores being created on the basis of their components[16 26 29 31 46 48].

Although there is no consensus on the meaning of the ratings, as a general rule, interpretation of these scales is positive for healthy items and negative for unhealthy items, with high scores indicating good adherence to the MD and low scores, poor adherence. Only the scores created by Scali et al.[44] and Gerber[47] provide inverted scores, where high scores indicate low adherence and low scores indicate good adherence (table 2).

The majority of the scores were developed in Mediterranean countries: Spain (n = 14)[11 12 16 26 29 31-34 48 49 52 53], Greece (n = 3)[6 14 30], Italy (n = 2)[54 55], and France (n = 2)[44 47]. The remainder were developed in Canada (n = 1)[50], other European countries (n = 3)[43 45 46], Japan[51 56], and the United States (n = 2)[28 56] (see table 2).

Regarding the context of application (table 3), 12 of the 28 scores analyzed were applied to the general population[16 26 46-51 53-55], 7 in primary care[6 29 32 43 44 56], 3 in hospital care[31 33 34], 6 in the community[11 14 16 28 30 56], and 1 in sports clubs[16]. The scores developed by Panagiotakos et al.[6] and Woo et al.[56] are used in the context of primary care and also in the community.

None of the MD adherence scores details the process of cross-transcultural adaptation. The majority of the scores come from the one food frequency questionnaire (FFQ) previously validated for the population studied, however in the original studies of these instruments (FFQ), the process of cross-cultural adaptation has not been detailed.

Aplicability

Related to the applicability of the MD adherence scores, with the exception of the score created by Woo et al.[56], which does not specify the method of administration, all diet questionnaire were administered by trained interviewers. Regarding the source of information, all of scores were answered by the patients/participants (not by a proxy), except for the scores created by Serra-Majem et al.[11] and Woo et al.[56]. The participants, completed the diet questionnaires, and the researches calculated the MD score. The time taken to administer and complete the items was not reported for any of the scales analyzed. The only information provided was the existence of trained staff to administer the questionnaires. Regarding the completion of questionnaires about food intake, only 5 of the scores[6 14 25 44 56] indicate having

used a portion size booklets in order to help participants estimate their food intake more accurately. None of the studies provided normative data about the scores.

Table 2. Conceptual and measurement model of the MD adherence scores

Instrument	Country	n	Age	Dietary Data	Conceptual model	measurement model
MD Indices based on positive or negative components						
Trichopoulou and collegues						
• 1995[30]	Greece	182	>70y	FFQ	(+) 1.High ratio of MUFA/SFA; 2.Moderate alcohol consumption; 3.High consumption of legumes; 4.High consumption of cereals (bread and potatoes); 5.High consumption of Fruit; 6.High consumption of Vegetables. (-) 7.Low consumption of meat and derivatives, 8.Low consumption of milk and dairy	8-components (g/d) Score ≥4 = High adherence Food (+): 1pt consumption > average and 0pt consumption < average Food (-): 1pt consumption < average and 0pt consumption > average.
• 2003[14]	Greece	22.043	20-86y	FFQ	The same components as the previous version but with the addition of one more, fish.	The score ranges from 0 (minimum adherence to MD) to 9 (maximu adherence to MD).
• 2005[43]	Denmark, France, Germany, UK, Spain, The Netherlans, Norway, Sweden	74.607	>60y	FFQ,14D DR	Same components as the 2003 version, but the lipid profile is modified. Monounsaturated fats and polyunsaturated fats are included in the numerator	Scores range from 0 (minimum adherence to MD) to 9 (maximum adherence to MD).
Scali and colleagues[44] (2001)	France	964	20-76y	FFQ	(+) 1.Olive oil; 2.Fish: white and oily; 3.Cereals: bread (B and Wh); pasta (B and Wh); rice (B and Wh) and breakfast cereals; 4.Fruit + Vegetables. (-) 5.Fresh and processed meat, 6.Saturated fats, and 7.Cholesterol	7 components. Each component is divided into three scores according to consumption Good MDQI: score of 5-7 Medium-to-Good MDQI: score of 8-10 Medium-to-Poor MDQI: score of 11-13 Poor MDQI: score >13
Sánchez-Villegas and colleagues (2002)[16]	Spain	3847	N.R	FFQ	(+) 1. High ratio of MUFA/SFA fats; 2. Moderate consumption of alcohol (30g/d M y 20g/d W); 3. High consumption of legumes; 4. High consumption of cereals (bread and potatoes); 5. High consumption of Fruits; 6. High consumption of Vegetables. (-) 7. Low consumption of meat and derivatives; 8. Low consumption of milk and derivatives.	8 components (g/d) The intake of each of the groups was standardised with the z value (observed mean/standard deviation). The MPD was turned into a percentage, where 100% was maximum adherence and 0% was minimum adherence.
Martinez-González and colleagues						
• 2002[34]	Spain	342	<80y	FFQ	MPD: Includes an 'a priori' and a 'post hoc' score • 'a priori': combination of 8 components (+) 1.olive oil, 2.fibre, 3.Fruit, 4.Vegetable, 5.fish and 6.alcohol, (-) 7.meat and 8. Sum total of bread, pasta, rice. • 'post hoc': Each component is dichotomised into 2 categories.	Scores range from 5-40pt. Scores range from 0-8pt. Consumption of Vegetable, Fruit, olive oil, fibre, fish, and alcohol> average =1. Consumption of meat and cereals < average =1. The consumption of each of the elements was divided into 2 categories, with the same cut-off points as above. Score range 0-9.
2004[33]	Spain	342	<80y	FFQ	Fibre is substituted by the item: high consumption of Fruit and Vegetable. Legumes were added.	

(continued on next table)

Table 2. Conceptual model of the MD adherence scores: items *(continued)*

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
Serra-Majem and colleagues (2004)[11]	Spain	3850	2-24y	N.R[m]	(+) 1.Fruit or Fruit juices Fruit/d; 2.Two pieces of Fruit/d; 3.Raw or cooked Vegetable once/d; 4.Raw or cooked Vegetable > once/d; 5.Fish 2-3times/w; 6.Legumes> Once/w; 7.Pasta, rice ≥5 times/w; 8.Cereals or grains for breakfast; 9. Nuts 2-3times/w; 10.Olive oil at home; 11.Milk or derivatives for breakfast; 12.2 yoghurts and/or cheese (40g)/day. (-)13.Skipping breakfast; 14.Mass produced pastries for breakfast; 15. Sweets or candy every day; 16. Mass produced sweets for breakfast.	16 components Scored between 0 and 12p:The sum total of the scores is classified into: * >8pt =Optimum MD * 4-7pt =need improvement in the MD pattern * ≤ 3pt = very low quality MD.
Panagiotakos and colleagues (2006)[6]	Greece	3042	>18y	FFQ	(+) 1. Unrefined cereals (wholemeal bread, pasta, rice, other grains, biscuits); 2.Fruit; 3.Vegetables; 4. Legumes; 5.Potatoes; 6.Fish; 7.Alcohol intake (<300ml/d); 8.Olive oil. (-)9.Meat and meat products; 10.Chicken; 11.Full-fat dairy products.	11 components: Score: 0 and 55. Score 0-5 for food. Scores high = good adherence to MD. (+) 5 when consumed and 0 when not consumed daily. (-) Inverted score
Trichopoulos and colleagues (2004)[45]	Italy, Spain, Grece	N.R.	N.R.	FBSs[n]	(+) 1.Vegetable (including legumes); 2.Fruit; 3.Cereals; 4.Ratio of fats; 5.Alcoholic drinks (-) 6.Meat ; 7.Dairy products	7 variables: 1pt=consumption high above average in food (+) and consumption low below average in food (-)
Knoops and colleagues (2004)[46]	Spain, Grece, Switzerland, Italy. Belgium, Denmark, France, Portugal, Hungary, The Netherlands	2339	70-90y	DH[o]	1.Ratio MUFA/SFA; 2. Legumes, nuts, and seeds; 3.Grains; 4.Fruit; 5.Vegetable and potatoes; 6.Meat and derivatives; 7.Dairy products; and 8.Fish. Adjusted consumption according to calorie intake: M-2500Kcal, W-2000Kcal	8 variables: Score 0= low quality of diet Score 8= high quality of diet
Gerber (2006)[47] Med-DQI	France	964	30-77y	FFQ	(+) 1.Olive oil; 2.Fish; 3.Cereal; 4.Vegeables + Fruit. (-) 5. Meat; 6. Saturated fat (% energy); 7.Cholesterol	7 items. The score ranges from 0-14. Score 0: > consumption of food (+) and < consumption of food (-). Score 2: inverse case Good adherence: 1-4, Medium-good adherence: 5-7, Medium-poor: 8-10, Poor: 11-14
Buckland and colleagues (2009)[26]	Spain	41078	29-69y	FFQ, DH	(+) 1.Vegetable (excluding potatoes); 2.F (including dried fruits but excluding juices); 3.Legumes; 4.Fresh fish; 5.Cereals; 6.Olive oil; 7.Alcohol. (-)8.Meat; 9.Dairy products.	9 variables: Score 0-6= High low Score 7-10= medium adherence, Score 11-18: High adherence
Mariscal-Arcas and colleagues 2009[31]	Spain	318	18-46y	FFQ	8 Components typical of the MD + 3 micronutrients specific to pregnancy: 1.Iron, 2. calcium and 3. folic acid. Alcohol consumption was not taken into account.	The score ranges from 0-11 pt. Scoring 1pt≥ two thirds of recommended levels or if the W took nutritional supplements Scoring 0pt< the cut-off point

(continued on next table)

Table 2. Conceptual model of the MD adherence scores: items *(continued)*

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
Schröder and colleagues.						
• 2004[48]	Spain	2871	25-74y	FFQ, 24hr DR	(+) 1.Cereals; 2.Vegetables; 3.Fruit; 4.Legumes; 5. Fish; 6. Nuts and 7.Alcohol (0g and >20= 1, 0.1-20g= 3). (-) 8. Meat and 9. Dairy.	9 components. The score ranges from 9-27 pt. (+) The lowest tertile = 1, medium= 2 and high =3 (-) Inverted score.
• 2011[32]	Spain	7146	55-80y	FFQ, MEDAS[p]	Score 1: 1.Olive oil as main fat; 2.Preference for white meat; 3.Tablespoons of olive oil ≥4times/d; 4.Vegetable 2portions/d; 5.Pieces of Fruit ≥3/d; 6.Red meat or sausages <once/d; 7. Animal fat<1portion/d; 8. Sugary drinks < one glass (100ml/d); 9.Red wine≥5 servings/week; 10.Legumes ≥3 portions/week; 11. Portions of fish≥3times/week; 12.Mass produced desserts and pastries<2v/s; 13.Nuts ≥3times/week; 14.Dishes cooked with tomato sauce, garlic; onion, leeks, sautéed with olive oil ≥2times/w. Score 0: For inverse cases	14 items. Each item was allocated a score of 1 or 0 depending on consumption. High scores = better adherence
• 2012[49]	Spain	102	3-80y	24hr DR	(+)1.Legumes 2.Green leafy and other Vegetable; 3.Fish; 4. Citrus and other Fruits; 5. Whole foods; 6.Olive oil; 7.Dried fruits and nuts and 8. Red wine (S3=1-2 glasses/d). (-) 9.Red meat, sausages; 10.Dairy products.	10 variables. Score 10= very low adherence and Score 30=optimum adherence (+) Tertile 1=low, Tertile 2=medium, Tertile 3=high (-) Tertile high=1, Tertile 2=medium, Tertile 2= low.
Benítez-Arciniega and colleagues (2011)[29]						
• mMDS	Spain	107	58y	FFQ, DR 24hr	(+) 1.Cereals; 2.Fruit; 3.Vegetable; 4.legumes; 5.fish; 6.olive oil; 7.nuts; 8.moderate consumption of wine (=20g). (-) 9.Meat (including chicken and sausages) and 10. Dairy.	10 components. The score ranges between 10-30pt. (+) Codified tertile: 1 (low) to 3 (high). (-)The score was inverted
• MLDS	Spain	107	58y	FFQ, DR 24hr	Adds 3 components to the mMDS[q]: 11. Sugary drinks; 12. Sweets and pastries; and 13. Fast food. The score was inverted	The resulting score ranges between 13-39pt.
MD score based on the diet quality index (DQI)						
Mariscal-Arcas and colleagues (2007)[12]	Spain	288	6-18y	FFQ, 24hr DR	Modifies the classification criterion for "empty-calorie food". 4 components, 1.Variety of diet (0-20pt), 2.Suitability (0-40pt), 3.Moderation (0-30pt) and 4.General balance (0-10pt).	The score ranges between 0-100.
MD score based on the MD pyramid						
Goulet and colleagues (2003)[50]	Canada	73	30-65y	FFQ	11components (frequency: size or times/d or w) Pyramid base: 1.grains; 2.Fruit; 3.Vegetable; 4.legumes; dried fruits; nuts and seeds; 5.olive oil and 6.fish. Middle level: 7.dairy (2-3 portions/d) and 8.chicken (3 portions/w). Apex of the pyramid: 9. red and processed meat,;10. sweets and pastries and 11.eggs.	The total score ranges between 0-44pt. High scores = good adherence to MD.

(continued on next table)

Table 2. ***Conceptual model of the MD adherence scores: items (continued)***

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
Rumawas and colleagues (2009)[28]	USA	3021	N.R.	FFQ	Whole grain cereals; 2.Fruit; 3.Vegetable; 4.Dairy; 5.Red wine (M and W); 6.Fish and seafood; 7.Olives; legumes, nuts; 8.Potatoes and other root vegetables; 9.Eggs; 10.Chicken; 11.Sweets and pastries; 12.Meat; 13.Olive oil 10p= consumption, 5p= olive oil + vegetable oils, and 0pt= not consumed).	13 variables. With the exception of olive oil, each component was calculated between 0-10pt. Overconsumption deducted 1p proportionally for intake in excess of recommended amounts for each food group
Kanauchi and colleagues (2015)[51]	Japan	433	>30y	BDHQ, HDI	1Vegetable; 2.Fruit; 3.Grains; 4.Legumes; 5.Fish; 6.Red and processed meat; 7.Dairy; 8.Eggs; 9.Chicken; 10.Alcohol; 11.Ratio of MUFA/SAF fat.	11 variables. Values of 0 and 1 for each component. Alcohol, value 1 = consumption between 10-30g/d for M and MUFA/SFA= ratio out of 1.5. Score <5 = low adherence to MD
Monteagudo and colleagues (2015)[52]	Spain	1155	12-83y	FFQ	Foods consumed at each main meal (3pt): 1.Fruit; 2.Vegetable; 3.Cereals; 4. Olive oil. Foods consumed daily (2pt): 5. Nuts 6.Dairy. Foods consumed weekly (1pt): 7.Legumes; 8.Potatoes; 9.Eggs; 10.Fish; 11.White meat; 12.Red meat; 13.Sweets and pastries; 14.Fermented drinks.	14 variables. Total score: 0-24 for adults and the elderly 0-23 for adolescents (due to the exclusion of alcohol) 0: when the number of portions per meal, day, or week was high or low than recommended amounts.
Sotos-Prieto and colleagues (2014)[53]	Spain	988	40-55y	FFQ	Block 1: Consumption of foods. 1.Sweets and pastries; 2.Red Meat; 3.Processed Meat; 4.Egg; 5.Legumes; 6.White meat; 7.Fish and seafood; 8.Potatoes; 9.Low-fat dairy; 10.Nuts and olives; 11.Herbs, spices; 12.Fruit; 13.Vegetable; 14.Olive oil; 15.Cereals. Block 2: Dietary habits. 16.Water and herbal teas; 17.Wine; 18.Limiting salt in meals; 19.Preference for whole grain cereals; 20.Snacks; 21.Limiting snacking between meals; 22.Limiting sugar and sugary drinks. Block 3: Physical activity, social habits and daily living. 23.Physical activity; 24.Siesta; 25.Hours of sleep; 26.Watching TV; 27.Meeting up with friends; 28.Collective sports.	28 variables Score between 0 (bad Mediterranean style) and 28 (good Mediterranean style). If recommendations are observed = 1pt, if not observed =0pt.
MD score based on the characteristic components of the MD						
Alberti-Fidanza and colleagues • 1999[54]	Italy	N.R	40-59y	DH	MAI is computed using the % of energy intake of 4 food groups: 1. Carbohydrate group: bread, cereals, dried legumes, potatoes. 2. Protective food group: Vegetables, fresh legumes, F, fish, red wine, and vegetable oils. 3. Land animal food group: milk, cheese, meat, eggs, animal fats, and margarines. 4. Sweet food group: sugary drinks, cakes, pastries, biscuits, and sugars.	The MAI is obtained by dividing the sum total of groups 1 and 2 by the sum total of groups 3 and 4.

(continued on next table)

Table 2. Conceptual model of the MD adherence scores: items *(continued)*

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
• 2004[55]	Italy	N.R	45-65Y	DH	MED: bread, cereals, potatoes, legumes, V, F, fish, red wine, and vegetable oils. NOT MED: milk, cheese, meat, eggs, animal fats and margarines, sugary drinks, cakes, pastries, biscuits and sugar	The MAI divides the sum total of % of energy taken from foods typical of the MD by the sum total of the % of foods that are not typical in the MD.
Woo and colleagues (2001)[56]	China, Australia USA	1010	24-74Y	FFQ	1.Ratio of MUFA/SFA fats; 2. Moderate alcohol consumption (H<10g/d); 3.high consumption of legumes; 4.high consumption of cereals; 5.high consumption of Fruit; 6.high consumption of Vegetable; 7.low consumption of meat and derivatives; 8.low consumption of dairy and derivatives	8 variables The score is obtained by adjusting according to calorie intake: M-2500Kcal and W-2000Kcal. M: Score ≥ 4: High adherence and W: Score ≥ 3: High adherence

MD, Mediterranean diet; FFQ, food frequency questionnaire; MUFA/SFA, Monounsaturated Fatty Acids/ Saturated Fatty Acids; g/d, grams/day; pt, point; DR,14-day diet record; B, Brown or Whole wheat; Wh, White; MDQI, Mediterranean diet quality index; M, men; W, woman; MEP, Mediterranean Diet Pattern; N.R, Not reported; FBSs, Food availability dara record in the balance sheet; DH, dietary history; MEDAS, Mediterranean diet adherence screener; mMDS; Modified Mediterranean Diet Score; MLDS, Mediterranean-Like Diet Score; BDHQ, Brief self-administered diet history questionnaire; HDI, Healthy diet indicator; MAI, The Mediterranean Adequacy Index; MED, The Mediterranean-Style Diet.

Table 3. Summary of key data about the conceptual suitability and content validity of adherence scores to the MD[a]

Instrument	Context	Content validity	Adaptation process
MD Indices based on positive or negative components			
Trichopoulou and colleagues.			
• 1995[30]	Community	Based on the recommendations of Davidson and Passmore (1979)[57] regarding dividing the score, but they combined cereals and starchy foods and did not take account of sugars and syrups.	FFQ validated for the Greek population.
• 2003[14]	Community	Based on the 1995 version, but with the inclusion of fish.	FFQ validated for the Greek population.
• 2005[43]	Primary Care	The versions of Trichopoulou and colleagues (1995)[30] and (2003)[14], were modified, substituting the item MUFA for the sum of MUFA + PUFA	FFQ validated for the European population.
Scali and colleagues (2001)[44]	Primary Care	Based on the DQI created by Patterson and colleagues (1994)[58] with an estimation of diet based on the quantitative consumption of different food groups according to recommendations to prevent diet-related diseases.	FFQ validated for the French population.
Sánchez-Villegas and colleagues (2002)[16]	General Population	The composition of the score is based on the version of Trichopoulou and colleagues (1995)[13] and the recommendations of Kouris-Blazos and colleagues (1999)[59] and Lasheras and colleagues (2000)[60]. The MDP was defined 'a priori' by adding together the standardised residuals of nutrients and foods after adjusting a regression model using total energy intake as the independent variable.	FFQ validated for the Spanish population.
Martínez-González and colleagues			
• 2002[34]	Hospital care	Based on the MD pattern, considering olive oil, fibre, Fruit, Vegetable, fish and alcohol as protective food items, and the consumption of meat and derivatives, and foods with a high glycemic index as risk elements.	FFQ validated for the Spanish population. O.V.[g]
• 2004[33]	Hospital care	This modifies the version developed by Martínez-González and colleagues (2002)[34], replacing the item fibre with high consumption of Fruit + Vegetable and including an item to cover legumes.	FFQ validated for the Spanish population. O.V
Serra-Majem and colleagues (2004)[11]	Community	The inclusion of variables is based on the MD pattern.	O.V.
Panagiotakis and colleagues (2005)[6]	Community & Primary Care	The inclusion of variables is based on the MD pyramid proposed by the Greek Ministry of Health and Welfare (1999)[61], including the consumption of unrefined foods, Fruit, Vegetable, legumes, potatoes, fish, meat and derivatives, chicken, full fat dairy, olive oil, and alcohol intake.	FFQ validated for the Greek population.
Knoops and colleagues (2004)[46]	General Population	The composition of the score is based on the version of Trichipoulou and colleagues (2003)[14], including Vegetabe + potatoes in the same item, and legumes + nuts + seeds in another item,	N.R
Gerber (2006)[47]	General Population	Based on the DQI created by Patterson and colleagues (1994)[58], but with the addition of olive oil (giving a higher score when consumption is low) and replacing the item of proteins with meat because fish was added with an opposing n gradient.	FFQ validated for the French population.
Buckland and colleagues 2009[26]	General Population	The composition of the score is based on the versions of Trichipoulou and colleagues (1995)[30] and (2003)[14], based on nine key components of the MD.	FFQ validated for the Spanish population. O.V
Mariscal-Arcas and colleagues (2009)[31]	Hospital care	Based on the version of Trichopoulou and colleagues (2003)[14] including specific requirements for pregnancy, Laraia ad colleagues (2004)[62].	N.R.

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Table 3. Summary of key data about the conceptual suitability and content validity of adherence scores to the MD *(continued)*

Instrument	Context	Content validity	Adaptation process
Schröder and colleagues			
• 2004[48]	General Population	The score is based on the version of Trichopoulou and colleagues (1995)[30] making reference to the consumption of cereals, Vegetable, Fruit, legumes, nuts, fish, full fat dairy, meat, and red wine.	FFQ validated for the Spanish population. O.V.
• 2011[32]	Primary Care	Based on the version of Martínez-Gonzales and colleagues (2004)[33], including 5 more variables; 2 of the items pertaining to the regular intake of typical MD foods and three items pertaining to the frequency of food consumption.	FFQ validated for the Spanish population
• 2011[49]	General Population	Includes items characteristic of the MD together with foods with antioxidant capacity.	N.R.
Benítez-Arciniega and colleagues (2011)[29]			
• mMDS[j]	Primary Care	Modified version of MDS by Trichopoulou and colleagues (1995)[30]. Calculated according to the distribution tertile of consumption with the exception of red wine.	FFQ validated for the Spanish population.
• MLDS[k]	Primary Care	Modified version of mMDS, with the addition of three new groups: sugary carbonated drinks, sweets and pastries, and fast food.	FFQ validated for the Spanish population.
MD score based on the diet quality index (DQI)			
Mariscal-Arcas and colleagues (2007)[12]	Young sports players/athletes	Based on the DQI-I by Tur and colleagues (2005)[63]. modified by Kim and colleagues (2005)[64]establishing fat intake at ≤30% of total energy, including Spanish recommended consumption levels, and changing the classificatory criterion 'empty-calorie food'.	FFQ validated for the Brazilian and Vietnamese populations.
MD Score based on the MD pyramid			
Goulet and collegues (2003)[50]	General Population	The score is based on the components of the MD pyramid, version Oldways Preservation and Exchange Trust, 2000 (grains, Fruit, Vegetable, legumes, olive oil, fish, nuts and seeds, dairy, fish, chicken, eggs, sweets and pastries, and red/processed meat).	Non-validated FFQ (based on typical foods in the region of Quebec).
Rumawas and colleagues (2009)[28]	Community	Based on the components of the MD pyramid[65], Contains 13 components corresponding to the 13 food groups in the Mediterranean diet pyramid.	FFQ validated for healthy working women. OV.
Kanauchi and colleagues (2015)[51]	General Population	The score is based on the latest updated version of the MD pyramid, according to Bach-Faig and colleagues (2011)[66], based on 11 components of the MD	FFQ validated for the Spanish population. O.V.
Monteagudo and colleagues 2015 [53]	General Population	The score is based on the latest updated version of the MD pyramid, according to Bach-Faig and colleagues (2011)[66], using the consumption recommendations for different foods and food groups.	Validated diet history questionnaire (BDHQ)
Sotos-Prieto and colleagues (2014)[53]	General Population	The score is based on the latest updated version of the MD pyramid, according to Bach-Faig and colleagues (2011)[66]. 28 items divided into three blocks (1-contains the frequency with which foods are consumed, 2- dietary habits of the MD, 3-physical activity, social life and habits).	FFQ validated for the Spanish population. O.V.

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Table 3. Summary of key data about the conceptual suitability and content validity of adherence scores to the MD (*continued)*

Instrument	Context	Content validity	Adaptation process
MD score based on characteristic components of the MD			
Alberti-Fidanza and colleagues			
• 1999[54]	General Population	Based on references of Mediterranean Dietary Pattern. The score is computed with the % of total calorie intake provided by typical MD foods.	Diet register validated by Alberti-Fidanza colleagues (1995)[67]
• 2004[55]	General Population	The score is based on typical MD dividing the sum of the total % of intake provided by typical MD food groups foods (bread, cereals, legumes, potatoes, vegetables, fruit, fish, red wine, vegetable oil) by the total sum of the % of energy provided by non typical MD foods (milk, cheese, meat, eggs, animal fats and margarines, sweet beverages, cakes, pies and cookies, sugar).	N.R.
Woo and colleagues 2001[56]	Community & Primary Care	The score is based on the reference Groot and colleagues (1996)[68] and on the consumption of 8 food categories.	FFQ Validated for the Chinese population.

MD, Mediterranean Diet; FFQ, Food Frequency Questionnaire; MUFA, Monounsaturated Fatty Acids; PUFA, Polyunsaturated Fatty Acid; DQI, Diet Quality Index- International; MDP, Mediterranean Diet Pattern; O.V., Original Version; N.R., Not Reported; MDS, Mediterranean Diet Score; mMDS, Modified Mediterranean Diet Score; MLDS, Mediterranean-Like Diet Score; DQI-I, Diet Quality Index-Intenational.

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Psychometric properties

With regard to internal consistency (table 4), only the score created by Sotos-Prieto et al.[53] provided a Cronbach alpha coefficient of 0.75. Given that the authors do not report item-test correlation coefficients, the degree of association between the items and the overall score was taken into account. The association between high global scores and the consumption of fruits, vegetables, nuts, and olive oil[6 14 28 31 44 47 48 52] was reported in 8 of the scores. With respect to equivalence, only the two scores created by Benítez-Arciniega et al.[29] provided data on equivalence (*inter-rater*) (ICC modified Mediterranean diet score (mMDS) = 0.48 and ICC Mediterranean-Like diet score (MLDS) = 0.62). None of the scores reported on test-retest reliability (intra-rater).

Related to criterion validity, predictive and concurrent validity were evaluated (table 5a and 5b). Predictive validity was reported in 5 of the 28 scores, using mortality rate or cardiovascular events as the predictive criterion. High MD adherence scores were associated with a significant reduction in the risk of mortality[14 26 30 43 46]. In only 1 study was the MD adherence score associated with cardiovascular events[26]. Concurrent validity was reported in 10 of the 28 scores; adherence to the Mediterranean diet was associated with clinical and biological markers of cardiovascular disease risk[6 28 31-34 48 50-52]. Finally, for the analysis of construct validity, the authors linked scores with other variables and scales (table 6). All measurement scores, with the exception of those developed by Trichopoulos et al.[14 30 43] and Alberti-Fidanza et al.[54], displayed a relationship with other health and dietary behavior variables. As for the relationship with other scales, only the scores created by Knoops et al.[46], Buckland et al.[26], Mariscal-Arcas et al.[31], and Monteagudo et al.[52] indicate comparison with the MD adherence score created by Trichopoulos et al.[30], obtaining high levels of agreement (70%).

Table 4. Summary of key reliability data for the different versions of MD adherence scores

Instrument	Internal Consistency
MD Indices based on positive and negative components	
Trichopoulou and colleagues	
• 2003[14]	High Score= high consumption of Vegetables (low score 18% vs. 80% high score), legumes (low score 23% vs. 76% high), Fruit and nuts (low score 23% vs. 76% high), cereals (low score 36% vs. 63% high), fish (low score 20% vs. 78% high), olive oil (low score 23% vs. 77% high) and low consumption of dairy (low score 69% vs. 32% high) and meat (low score 56% vs. 42% high).
Scali and colleagues (2001)[44]	High Score= high intake of Vegetables + Fruit (low score 188.7g vs. 1023.7g high), cereals (low score 15.7g vs. 158.9g high), fish (low score 15.7g vs. 66.9g high), olive oil (low score 1.1g vs. 31.9g high) and ⇓ intake of cholesterol (low score 460.5g vs. 222.9g high), SFA (low score 15.4g vs. 9.4g high) and meat (low score 168.4g vs. 19.6g high).
Panagiotakos and colleagues (2006)[6]	High Score= high intake of Vegetable (p=0.01), Fruit (p=0.03), legumes (p=0.001), potatoes (p=0.04), whole grain cereals (p=0.02), fish (p=0.01) and olive oil (p=0.01) and low red meat (p=0.03), chicken (p=0.03) and full fat dairy (p=0.04).
Gerber (2006)[47]	Score= high intake Vegetable + Fruit (low score 290g vs. 800g high), cereals (low score 129g vs. 180g high), fish (low score 19g vs. 58g high), olive oil (low score 0.3g vs. 20g high) and low intake of cholesterol (low score 430g vs. 220g high), SFA (low score 17g vs. 9g high), red meat (low score 130g vs. 130g high) and animal-based foods (low score 434g vs. 208g high).
Mariscal-Arcas and colleagues (2009)[31]	High Score= high intake of Vegetable (low tertile 1% vs. 36.2% high), fruit and nuts (low tertile 0% vs. 29% high), cereals (low tertile 0% vs. 39% high), fish (low tertile 1.8% vs. 28.8% high), MUFA (low tertile 0.0% vs. 36.8% high), legumes (low tertile 0.0% vs. 34.7% high) and low intake meat (low tertile 0.0% vs. 37% high) and dairy (low tertile 0.0% vs. 35.6% high).
Schroder and colleagues	
• 2004[48]	High Score= high intake of Fruit ($p<0.001$), Vegetable ($p<0.001$), nuts ($p<0.001$), fish ($p<0.001$), legumes and cereals $p<0.05$ in men. Low intake meat ($p<0.001$) and sweets and pastries $p<0.05$.
MD indices based on the MD pyramid	
Rumawas and colleagues (2009)[28]	Positive and significant correlation between the score and its items between a range of 0.11 meat and 0.50 vegetables.
Sotos-Prieto and colleagues (2014)[53]	Cronbach's α =0.75.
Monteagudo and colleagues (2015)[52]	High Score= low intake of Vegetable, Fruit, olive oil, fish, legumes ($P<0.05$) and low intake meat (low tertile 0.0% vs. 37% high) and sweets and pastries and fermented beverages ($p<0.05$).

MD= Mediterranean Diet; Instrument, The results that don't reported for the score component means there are no significant; g, grams; SFA, Saturated Fatty Acids; MUFA, Monounsaturated Fatty Acids.

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Table 5a Summary of key predictive utility data from the different versions of the MD adherence questionnaire

Instrument	Predictive		
	Markers	MD Adherence	Score items
MD Indices based on positive or negative components			
Trichopoulou and colleagues			
• 1995[30]	Mortality	High scores= decrease in mortality, OR = 0.83 (IC 95%, 0.69-0.99)	N.R
• 2003[14]	Mortality	Increase of 2p on the questionnaire score = decrease 25% global mortality (p<0.001). OR = 0.75 (IC 95%, 0.64-0.87).	Fruit and nuts OR = 0.82 (IC95%, 0.70-0.96) MUFA/SFA, OR = 0.5 (IC95%, 0.76-0.98)
• 2005[43]	Mortality	Increase in the score = reduction in total mortality,	N.R.
Knoops and colleagues (2004)[46]	Mortality	Decrease in mortality through all causes: Adherence to the MD (OR=O.77, IC 95%; 0.67-0.89)	Physical activity (OR=O.65, IC 95%; 0.56-0.76) Moderate alcohol consumption (OR=O.83, IC 95%; 0.71-0.91) Not smoking (OR=O.67, IC 95%; 0.570.78)
Buckland and colleagues (2009)[26]	Coronary disease	Increase adherence = 40% lower cardiovascular risk (p<0.001).	Consumption of olive oil, Vegetable, and alcohol associated significantly with a decrease in cardiovascular risk. Consumption of dairy associated inversely.

MD, Mediterranean diet; Instrument, The results that don't reported for the score component means there are no significant; OR, odds ratio; N.R., Not reported; MUFA/SFA, monounsaturated fatty acids/saturated fatty acids.

Table 5b Summary of key concurrent data from the different versions of the MD adherence questionnaire

Instrument	Concurrent		
	Markers	**MD Adherence**	**Score components**
MD Indices based on positive or negative components			
Martínez-Gonzalez and colleagues			
• 2002[34]	CHD: with biological markers of myocardial risk	Scores ≥20: OR = 0.17 (IC° of 95%, 0.06-0.51).	**Reduction in risk associated with consumption:** Olive oil, OR = 0.43 (IC of 95%, 0.19-0.99) Fibre OR = 0.36 (IC of 95%, 0.14-0.91) Fruit OR = 0.37 (IC of 95%, 0.14-0.96) Vegetable OR = 0.46 (IC of 95%, 0.21-1.04) Fish OR = 0.36 (IC of 95%, 0.15-0.87) Alcohol OR = 0.54 (IC of 95%, 0.24-1.22). **Increase the risk associated with consumption:** Meat and derivatives OR = 1.28 (IC of 95%, 0.61-2.70) Food with increase glycemic index OR = 1.11 (IC of 95%, 0.50-2.44
• 2004[33]	CHD: with biological markers of myocardial risk	Scores >6 on the questionnaire yield OR = 0.18 (IC of 95%, 0.03-0.97).	N.R.
Panagiotakis and colleagues (2006)[6]	Blood pressure (mmhg), C reactive protein, Fibrinogen, total cholesterol (mg/dl), BMI (Kg/m^2), coronary disease	Score inversely associated with: BP: (β-coefficient -5.1, P= <0.001) C reactive: (β-coefficient: -0.27, P= <0.001), Fibrinogen: (β-coefficient -13.5, P= <0.020) Cholesterol: (β-coefficient: -1.2, P= <0.001) BMI: (β-coefficient: -4.1, P= <0.001) Coronary disease OR: 0.46 (IC of 95%, 0.35-0.58)	N.R.
Mariscal-Arcas and colleagues (2009)[31]	BMI (Kg/m^2), weight (Kg)	Decrease score associated with increase BMI of the mother at the start of labour (p=0.045) and increase score was associated with lower weight at the end of the pregnancy (p=0.049).	N.R.
Schroder and colleagues			
• **2004[48]**	BMI (Kg/m^2),	An increase of 5U on the score was associated with a decrease in BMI 0.42 (p= 0.030, R^2: 0.082) and 0.68 (p= 0.007, R^2: 0.171) among M and W, respectively. Adjusting for confounding factors, the subjects with increase adherence displayed a 39 decrease in obesity for M and W.	N.R.
• **(2011)[32]**	BMI Changes, CHD, Waist/hip change (cm)	The MEDAS was associated with lower BMI (coefficient β: -0.146, p<0.001) Waist/hip ratio (coefficient β: -0.562, p<0.001) Cardiovascular risk (coefficient β: -0.001, p<0.001) Opposite association for the HDL-C (coefficient β:0.010, p<0.001)	N.R.
MD Indices based on the MD pyramid			
Goulet and colleagues (2003)[50]	LDL(mg/dl), apolipoprotein B, BMI(Kg/m^2),	The MD diet score was associated with lower LDL (r=-0.22, p=0.070), Apolipoprotein B (r=-0.21, p=0.070) BMI (r=-0.20, p=0.100)	N.R.

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Table 5b Summary of key concurrent data from the different versions of the MD adherence questionnaire *(continued)*

Instrument	Concurrent		
	Markers	**MD Adherence**	**Score components**
Kanauchi and colleagues 2015[51]	HBP (mmHg)	No relationship between adherence to MED score and HBP (SBP =150,3mmHg, DBP=96,4mmHg). OR= 0.97, IC 95%: 0.57-1.66, p<0.922	N.R.
Rumawas (2009)[28]	BMI (Kg/m^2),, wait-his ratio (cm)	The MSDPS was associated with: <BMI (p=0.020), <waist-hip ratio (p<0.001),	N.R.
Monteagudo (2015)[52]	BMI (Kg/m^2)	Increase score with age adherence to MDSS = decrease BMI (p<0.050).	N.R.

MD, Mediterranean diet; Instrument, The results that don't reported for the score component means there are no significant; CHD, Coronary heart disease; OR, Odds ratio; IC, Confidence interval; BMI, Body mass index; BP, Blood pressure; N.R., Not reported; M, Men; W, Woman; MEDAS, Mediterranean diet adherence screener; HDL-C, High-density lipoprotein; LDL, Low-density lipoprotein; HBP, High blood pressure; MED, Mediterranean diet index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MSDPS, Mediterranean-style dietary pattern score; MDSS, The Mediterranean dietary serving score.

Table 6 Summary of key construct validity data and relationships with other variables from the different assessments of MD adherence scores

Instrument	Relationships with other variables	Relationships with other scales
MD Indices based on positive or negative components		
Scali and colleagues (2001)[44]	The MDQI score is related with: socio-demographic variables (p=0.021), level of education (p=0.006) and the use of tobacco (p=0.001).	N.R.
Sánchez-Villegas and colleagues (2002)[16]	Age and time spent engaged in physical activity associated with increase adherence to MDP The habit of taking an afternoon nap or siesta is associated with adherence to the MDP among M, (β= 1.4, IC 95%; 0-2.7). No association between the habit of smoking and adherence to MDP.	N.R.
Serra-Majem and colleagues (2004)[11]	Relationship with socio-economic variables (favourable index for low social class 42.8% vs. 54.9% high), level of education (favourable index for low levels of education 42.3% vs. 53.5% high) and population size (favourable index for small populations 44.3% vs. 52,8% large).	N.R.
Panagiotakis and colleagues (2006)[6]	Score inversely associated with: total antioxidants (β-coefficient 1.55, p= <0.001), Energy intake (β-coefficient -76.8, p= 0.003) The score was positively associated with: MUFA *vs*. SFA (β-coefficient: 0.16, P= 0.020). The score increase with the consumption of fruit (p0.03), Vegetable (p=0.010), potatoes (p=0.040), unrefined cereals (p=0.020), fish (p=0.010), legumes (0.001) and olive oil (p=0.010), whereas the consumption of red meat (p=0.030), poultry (p=0.030), full fat dairy (p=0.040) gave a decrease score.	N.R.
Knoops and colleagues (2004)[46]	Score average: North Europe=3 and South Europe=5. Alcohol intake: North Europe=17.5g ^{i}/d ^{j} among M and 5.5g/d W, and South=31g/d among M and 6g/d W	Compares the rMED with the MDS (Trichopoulou et al., 2003). The original score had a 14% decrease in mortality and the proposed score a 23% decrease.
Gerber (2006)[47]	The Med-DQI was associated with age, residence in rural areas, moderate-high alcohol consumption among M (inverse case for W). W with increase level of education = better quality of diet, inverse case for M. Obesity associated with decrease quality of diet among W, and with medium-low quality among M. Carotene (r=-0.12, p=0.016), vitamin E (r=-0.20, p<0.050), EPA (r=-0.-30, p<0.001) and DHA (r=-0-28, p<0.001) were increase with the quality of diet.	N.R.
Buckland and colleagues (2009)[26]	N.R.	Compares the rMED with the MDS (Trichopoulou et al., 2003). The same results are obtained.
Mariscal-Arcas and colleagues (2009)[31]	N.R.	Compares the MDS *(*Trichopoulou et al., 2003*)*. MDS= 4.31 (SD=1.32) ranking from 1 to 7 and MDS-P=7.53 (SD=1.44) ranking from 4 to 11.
Schroder and collleagues		
• 2004[48]	Among M, consumption of Fruit (p<0.001), Vegetable (p<0.001), fish (p<0.001), legumes (p<0.010, among M and among W *ns*), nuts (<0.001) and olive oil (p<0.001), carbohydrates (p<0.001), and proteins (p<0.001) ↑ significantly with a increase adherence to the MD in both sexes. M and W with increase adherence are more active (p<0.001), less smokers (p<0.050) and less drinkers of alcohol (p<0.001).	N.R.
• 2011[32]	Moderate correlation (r= 0.52) between the MEDAS score and the score calculated by means of FFQ.	N.R.
• 2012[49]	R= 0.40 between the 24 hour reminder and the mMDS. Association between dietary fibre, vitamin C, vitamin E, magnesium and potassium.	N.R.

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Table 6 Summary of key construct validity data and relationships with other variables from the different assessments of MD adherence *(continued)*

Instrument	Relationships with other variables	Relationships with other scales
MD Indices based on the diet quality index (DQI)		
Mariscal-Arcas and colleagues (2007) [12]	DQI-I associated with: duration of breakfast (p=0.003), level of physical activity (p=0.036) and age (p=0.007).	N.R.
MD Indices based on the MD pyramid		
Rumawas (2009) [28]	The MSDPS and the individual components of the score were more and significant with a range from r=0.11 for meat to r=0.50 for Vegetables. The MSDPS was associated with: dietary fibre, alcohol, omega 3 fatty acids, EPA, DHA, β- carotenes, lycopene, folic acid, vitamin C and E, calcium, magnesium, potassium and energy intake, (p<0.001). The MSDPS was associated with: age (p<0.001), <use of tobacco (p<0.001) and >consumption of multivitamins (p<0.001).	N.R.
Monteagudo (2015) [52]	Increase score with age ($0R^{u}$= 7.68; IC 3.66-16.13) Increase score with age adherence to MDSS = decrease snacking habits (p<0.050). Consumption of Vegetable, Fruit, olive oil, legumes and fish associated significantly with the 3rd tertile, Consumption of meat (white and red), sweets and pastries and fermented drinks associated with the 1st tertile (p<0.001)	Compares the MDSS with MDS (Trichopoulou et al., 1995). The MDSS displays a discrimination capacity compared with the MDS of 81%= 0.81, IC 95%: 0.736-0.890). Sensitivity=74% (IC 95%: 72-75%), specificity= 48% (IC 95%: 47-50%)
Sotos-Prieto (2014) [53]	The MEDLIFE score associated inversely with the consumption of sweets and pastries (β= -0.29, p=0.019), red meat (β= -0.14, p<0.001) and processed meat (β= -0.11, p=0.001). Inversely associated with number of hours spent watching TV (β= -0.10, p<0.001). The consumption of vegetable, fish, herbal teas, preference for whole grain cereals, limiting salt and limiting added sugar intake, and hours of physical activity correlated with the MEDLIFE, with β coefficients > 0.20. Nutrients, consumption of MUFA and PUFA, (omega 3) were associated with increase in the MEDLIFE. Similar results for vitamin C, Ca and Fe (p<0.001). Inverse association for trans fatty acids, saturated fatty acids, sugar, and levels of glucose (p<0.001).	The MEDLIFE was significantly associated with the AHEI, aMED and MEDAS (range ρ: 0.44-0.53; p<0,001)
MD Index based on characteristic components of the MD		
Alberti-Fidanza and colleagues • 2004[55]	Increase of 2.8 points on the MAI after monitoring the population over the years.	N.R.
Woo et al and colleagues (2001) [56]	Variations in the dietary pattern detected according to gender (p<0.001), geographical area (p<0.001) and age (p<0.001)	N.R.

MD, Mediterranean diet; Instrument, The results that don't reported for the score component means there are no significant; MDQI, Mediterranean diet quality index; N.R., not reported; MPD, Mediterranean pattern diet; M, men; MUFA, monounsaturated fatty acids; SFA, saturated fatty acids; g, grams; d, day; W, women; rMED, relative Mediterranean diet; MDS, Mediterranean diet score; EPA, Eicosapentaenoic acid; DHA, Docosahexaenoic acid; FFQ, food frequency questionnaire; MEDAS, Mediterranean diet adherence screener; mMDS, a modified Mediterranean diet score; DQI-I, diet quality index-international; MSDPS, Mediterranean-style dietary pattern score; OR, Odds ratio; MDSS, the Mediterranean dietary serving score; MEDLIFE, the Mediterranean lifestyle; PUFA, Polyunsaturated fatty acids; AHEI, the alternative healthy eating index; aMED, the alternative Mediterranean diet index; Ca, calcium; Fe, iron; MAI, the Mediterranean adequacy index.

With regard to the measure of responsiveness, none of the scores provided an estimation of a statistic capable of measuring effect size. Only the score developed by Goulet et al[50] examined the effect of a nutritional intervention, in which MD adherence scores increased significantly from 21.1 ± 3.6 in week 0 to 28.6 ± 4.4, P <0.001 after 6 weeks of intervention.

Table 7 presents the MD summary scores. Only 4 scores did not provide any information about the cross-transcultural process[14 31 32 55]. The scores developed by Trichopoulou et al.[14], Scali et al.[44], Panagiotakis et al.[6], Gerber[47], and Woo et al.[56] obtained the best evaluations in terms of applicability. The score created by Sotos-Prieto et al.[53] was the instrument with the most and best evidence about reliability. Information about validity was provided for most of the scores, but concurrent and predictive validity were only reported for the scores created by Martinez-Gonzalez et al.[33 34], Panagiotakis et al.[6], Knoops et al.[46], and Schoder et al[32]. The results indicate that the scores with the best overall evaluation were those created by Panagiotakis et al[6], Buckland et al.[25], and Sotos-Prieto et al.[53]. However, only the study by Sotos-Prieto et al.[53] provided information about reliability.

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Table 7. Summary information data from the different versions of the MD adherence scores.

Instrument	Cross-Cultural adaptation	Applicability	Reliability	Validity
MD Indices based on positive or negative components				
Trichopoulou and colleagues				
• 1995[30]	+	+	?	+
• 2003[14]	+	++	?	+
• 2005[43]	+	+	?	+
Scali and colleagues (2001)[44]	+	++	?	+
Sánchez-Villegas and colleagues (2002)[16]	+	+	?	+
Martinez-Gonzalez and colleagues				
• 2002[34]	+	+	?	++
• 2004[33]	+	+	?	++
Serra-Majem and colleagues (2004)[11]	+	?	?	+
Panagiotakis and colleagues (2006)[6]	+	++	?	++
Trichopoulos and colleagues (2004)[45]	?	+	?	+
Knoops and colleagues (2004)[46]	+	+	?	++
Gerber (2006)[47]	+	+	?	+
Buckland and colleagues (2009)[26]	+	++	?	+
Mariscal-Arcas and colleagues (2009)[31]	?	+	?	+
Schroder and colleagues				
• 2004[48]	+	+	?	+
• 2011[32]	+	+	?	++
• 2011[49]	?	+	?	?

(Continued on next page)

Table 7. Summary information data from the different versions of the MD adherence scores. ***(continued)***

Instrument	Cross-Cultural adaptation	Applicability	Reliability	Validity
Benítez-Arciniega and colleagues (2011)[29]				
• **mMDS**	+	+	+	?
• **MLDS**	+	+	+	?
MD Indices based on the diet quality index (DQI)				
Mariscal-Arcas and colleagues (2007)[12]	+	+	?	+
MD Indices based on the MD pyramid				
Goulet and colleagues (2003)[50]	+	+	?	+
Rumawas and colleagues (2009)[28]	+	+	?	+
Kanauchi and colleagues (2015)[51]	+	+	?	++
Monteagudo and colleagues (2015)[52]	+	+	?	+
Sotos-Prieto and colleagues (2014)[53]	+	+	++	+
MD Index based on characteristic components of the MD				
Alberti-Fidanza and colleagues				
• 1999[54]	+	+	?	+
• 2004[55]	?	+	?	+
Woo and colleagues (2001)[56]	+	++	?	+

Process of cross-transcultural adaptation
?= not reported
+ = translation only
++= translation-back translation
+++ =translation-back translation and pilot test
Applicability
?= not reported
+= data about the process of administration and interviewing
++ =visual material about foods and training of interviewers
+++= normative data
Reliability
?= not reported or weak associations of some aspect of internal consistency reported
+= alpha coefficient of internal consistency or intra-rater or inter-rater reliability reported
++ =alpha coefficient or ICC or correlated coefficient >0.70;
Validity
?= not reported
+=: evidence from criterion or construct validity
++=evidence from criterion and construct validity
[e]MD= Mediterranean Diet
[f]mMDS= modified Mediterranean Diet Score
[g]MLDS= Mediterranean-like diet score
[h]DQI= diet quality index

DISCUSSION

The review conducted here included 27 references and identified 28 MD adherence scores used internationally. The evidence obtained from these studies has been evaluated based on conceptual suitability, applicability, and psychometric properties. The results reveal that evidence is scarce, and that very few scores fulfill psychometric properties and applicability parameters typically associated with scales/indices. The scores developed by Panagiotakis et al.[6], Buckland et al.[25], and Sotos-Prieto et al.[53] provide the most information. However, as with the other scores analyzed, none of them provide complete information about the process of transcultural adaptation used. The scores reviewed here only specify that a previously validated food frequency questionnaire (FFQ) for the original population has been used, but don't provide the transcultural adaptation of this dietary questionnaires (translation, back translation and pilot study). The Scientific Committee of the Medical Outcomes Trust[39] considers cultural and linguistic adaptation to be an especially important criterion in achieving linguistic and cultural equivalence with an original instrument.

Applicability is one of the sections that presents the most information gaps. None of the scores report on normative data, and only 5 of them[6 14 25 44 56] provide detailed information about the administration process using photographic and visual material to obtain information as close to reality as possible.

The data about reliability are the most deficient. To ascertain the degree to which all the items on a scale measure the same construct, internal consistency must be measured. In this case, the score created by Sotos-Prieto et al.[53] is the only one that provides information about this topic, through the Cronbach alpha value. The degree of association between the scores obtained and the items included on the instrument has been taken into account, but this information cannot be considered a quality item-test measure of reliability. Regarding

reliability data, only the two scores created by Benítez-Arciniega et al.[29] display test-retest reliability and equivalence reliability.

Validity was the most widely reported property. Only the scores created by Benítez-Arciniega et al. [29] did not include any information about validity. In the scientific literature, there are different gold standards to evaluate criterion validity, such as clinical and biological markers for concurrent validity, and adverse events for predictive validity. However, the best gold standard, "observation of food intake," has not been used in any of the studies. In some of the studies analyzed[26 31], the gold standard used is the score created by Trichopoulou et al.[30] obtaining agreement levels of close to 70% with the original, considered here to provide construct validity. This one was the first score used to measure levels of adherence to the MD, but it cannot be considered a gold standard, since there is new evidence indicating changes in food and diet patterns. It should also be pointed out that no confirmatory analysis was conducted in relation to the structure of the instruments.

It has been consistently demonstrated that the MD helps to protect against cardiovascular disease as well as numerous chronic-degenerative diseases[1 2 35 69], nevertheless the protective effect of the MD is very different across the studies[35 70]. Consequently, a large number of MD adherence scores are being created to ascertain the relationship between diet and health. However, recent publications indicate that some of these scores do not offer strong predictive capacity regarding mortality or disease, thus questioning the quality[13 70 71]. This observation is borne out by the findings of this study, which have shown that the majority of the scores analyzed are lacking in information about the quality attributes of the scales.

For all of the above reasons, greater attention must be paid to the way in which these scores have been created. Firstly, a common criterion should be established to identify the components that make up the Mediterranean Diet. Secondly, different elements need to be unified: the number of components (nutrients, foods, or food groups), classification categories

for each population, measurement scale, statistical parameters (mean, median, tertiles, etc.) and the contribution of each component (positive or negative) to the score total[15 35 72 73]. Finally, given the great heterogeneity of the MD in different countries, further confirmatory analyses are required using biomarkers with a view to validating said dietary pattern.

Strengths and Limitations

Although the data are conclusive regarding the lack of quality of MD adherence scores and the need to improve the measurement of MD adherence, it is important to take into consideration the limitations of this review, which are related to the process of bibliographic searches, derived from the electronic search and retrieval of documents. In order to control this limitation, multiple synonyms of the search terms were used, and complementary searches of prestigious journals and bibliographic references were also conducted. Furthermore, this review only took account of studies wherein the main objective was to develop or examine data about the applicability or psychometric properties of an MD adherence score. It could produce an underestimation of the predictive and/or concurrent validity, which are the most frequent analysis in longitudinal studies with this MD adherence scores.

In conclusion, the use of scores to measure adherence to the MD is a very useful tool for identifying the dietary patterns of the population. For all this reasons, further information is required about the scores that currently exist, and/or new instruments with better conceptual grounded must be developed. Future research should focus on improving the psychometric properties of the MD adherence scores, and analyzing the concordance between these instruments in compliance to normative quality criteria.

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2,3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4,5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4,5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4,5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	4-7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5,6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	31
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7,8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8-28
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8-28
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	27,28
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8-28
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	29,30
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	31
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	31
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

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Evaluation of Mediterranean Diet adherence scores: a systematic review

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Title: Evaluation of Mediterranean Diet adherence scores: a systematic review

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ABSTRACT

Objective/ The aim of this review was to evaluate the conceptual suitability, applicability, and psychometric properties of scores used internationally to measure adherence to the Mediterranean Diet.

Design: This was a systematic review to identify original articles that examined some aspects of the conceptual suitability, applicability or psychometric properties of the MD adherence score. Electronic searches were carried out in the international databases MEDLINE, SCOPUS, WEB OF SCIENCE, and EMBASE (January 1980 to 31 December 2015).

Eligibility criteria for selecting studies: original articles that examined some aspects of the conceptual suitability, applicability or psychometric properties of the Mediterranean Diet adherence score. The studies where MD adherence scores were administered but did not bring forward any evidence about their performance related to conceptual suitability, applicability or psychometric properties were excluded.

Data extraction: Information relating to the scales was extracted in accordance with the quality criteria defined by the Scientific Advisory Committee of the Medical Outcomes Trust for measurement of health results and the quality criteria recommended by Terwee: 1) conceptual; 2) applicability; and c) psychometric properties. Three authors independently extracted information from eligible studies.

Results: Twenty-seven studies were identified as meeting the inclusion criteria, yielding 28 Mediterranean Diet adherence scores. The results showed that evidence is scarce and that very few scores fulfilled the applicability parameters and psychometric quality. The scores developed by Panagiotakos et al., Buckland et al., and Sotos-Prieto et al. showed the largest levels of evidence.

Conclusions: Scores measuring adherence to the Mediterranean Diet are useful tools for identifying the dietary patterns of a given population. However, further information is required regarding existing scores. In addition, new instruments with greater conceptual and methodological rigor should be developed and evaluated for their psychometric properties.

Key words: Mediterranean diet, scores, validity, review

Strengths and limitations to this study

- This systematic review and meta-analysis represents, to our knowledge, the most comprehensive examination of the evidence on the conceptual suitability, applicability, and psychometric properties of scores used internationally to measure adherence to the Mediterranean Diet.
- Twenty-seven studies were identified as meeting the inclusion criteria, yielding 28 Mediterranean Diet adherence scores. The results showed that evidence is scarce and that very few scores fulfilled the applicability parameters and psychometric quality.
- This review only took account of studies wherein the main objective was to develop or examine data about the applicability or psychometric properties of an MD adherence score. It could produce an underestimation of the predictive and/or concurrent validity, which are the most frequent analysis in longitudinal studies with this MD adherence scores.

- Future research should focus on improving the psychometric properties of the MD adherence scores, and analyzing the concordance between these instruments in compliance to normative quality criteria.

INTRODUCTION

Several epidemiological studies have evaluated the relationship between health and food intake[1-6]. Specifically, various population surveys and clinical trials provide evidence that diets that are high in fruits, vegetables, legumes, whole grains, fish, and moderate in dairy intake are associated with a lower incidence of chronic disease[4, 7-10].

The Mediterranean Diet (MD) is characterized by a high intake of plant-based foods (vegetables, legumes, fruits, nuts, cereals [mainly whole grain]), olive oil as the main source of fat, moderate amounts of dairy (yogurt and cheese), low or moderate consumption of fish and meat, moderate consumption of wine consumed with meals, and an active lifestyle[11-14]. Although the various geographical regions of the Mediterranean have different diets, influenced by socio-cultural, religious, or economic factors, among others, it can be assumed that these diets are variations of the same MD diet[15, 16].

Various longitudinal studies have analyzed the benefits of the MD in comparison with other types of diet[17-23]. These studies have shown that people with good adherence to the MD have a better quality of life and greater life expectancy, along with a decreased prevalence of chronic diseases such as certain types of cancer, type 2 diabetes, and cardiovascular or neurodegenerative disease[1, 5, 10, 24-27]. Specifically, the protective role of the MD has been attributed to the high intake of plant-based foods along with a moderate consumption of wine, fish, and dairy, and a high intake of monounsaturated fatty acids in lieu of saturated and trans fatty acids, which is linked with an elevated antioxidant capacity[8 10]. Therefore, it is important to ascertain the degree of adherence to the MD through accurate measurement tools such as dietary scores based on the frequency of pattern-consistent and –inconsistent food consumption, as well as compliance with recommended intake[28].

Evidence shows that dietary scores are useful tools to evaluate the degree of adherence to the MD and its benefits in regards to health. Scores are composite constructs based on

dietary components, combining foods and nutrients to obtain valid operational variables that analyze the association between the quality of diet and its health effects[29]. Several scores are used to measure the degree of agreement with the MD. The first and most widely used score was created by Trichopoulou et al. in 1995[30]. This score evaluates concordance with the dietary pattern, by assigning one point when the intake of protective foods is higher than median, in the study/sample population or when the consumption of non-protective foods is lower than median, and zero in the opposite situations. Other scores based on the MD have been created for use in different geographical populations, for populations with different underlying physiological states, and so that alternate foods can be incorporated into and/or accounted for within the canonical pattern[11, 31-34].

The characteristics of MD scores have been reviewed in different studies[15, 35]. However, the quality of these instruments, which is fundamental to ensuring their valid and reliable application, has not been analyzed. The heterogeneity of MD adherence scores raises the potential for disparity in analyses as well as confusion as to which specific score to choose. Therefore, to be able to select a good instrument, one must first know the quality criteria it offers. Knowledge of such criteria is imperative for the accurate use of the instrument[36-39]. According to the Scientific Advisor Committee of the Medical Outcomes Trust (SAC), 8 quality criteria must be established, corresponding to 3 groups of information: conceptual suitability (conceptual and measurement model, cultural and linguistic adaptation); applicability (demands of the administrator and respondent, alternative forms, interpretability); and psychometric properties (reliability, validity, and responsiveness)[39].

For this reason, the aim of this review was to evaluate the conceptual suitability, applicability, and psychometric properties of MD adherence scores used internationally.

METHODOLOGY

Search strategy

To obtain original documents, electronic searches were carried out using the following international databases: MEDLINE, SCOPUS, WEB OF SCIENCE, and EMBASE. The search strategy was designed to obtain original studies about the development or validation of scores measuring adherence to the MD, published until 31 December 2015 (January 1980 to 31 December 2015). This strategy focused on combining the following keywords: Mediterranean diet, score, adherence, and terms associated with the psychometric properties of instruments (validity, quality, and reproducibility). In order to increase the sensibility of the search strategy, searches were conducted using the thesaurus of each of the databases selected and keywords – in the title and abstract – associated with the search terms (Figure 1). The electronic searches were complemented by manual searches[40] in international journals with regard to their relevance and frequency in the publication, by new searches in PubMed under the names of the identified MD score and under the names of the authors who had created or adapted them, and by the references of the articles which complied with the inclusion criteria. Abstracts from congresses and grey literature were excluded.

Inclusion criteria

All original articles which objects were examined some aspects of the conceptual suitability (conceptual and measurement model, cultural and linguistic adaptation), applicability (demands of the administrator/respondent alternative forms, and interpretability) or psychometric properties (reliability and validity and responsiveness) of the MD adherence score in English or Spanish published until 31 December 2015 (January 1980 to 31 December 2015) were included.

Exclusion criteria

The studies where MD adherence scores were administered but did not bring forward any evidence about their performance related to conceptual suitability, applicability or psychometric properties were excluded.

Selection of studies

Two reviewers (RFC and AZM) assessed the titles and abstracts to determine their inclusion or exclusion from the review. The reviewers worked independently, and if they were in disagreement, a third reviewer (MJCM) would resolve the disagreement or recommend reading the whole article.

Data extraction

Information was extracted by the same researchers (MJCM, RFC and AZM), who had independently carried out the selection of original articles, resolving disagreements through consensus with a third person. The information extracted was divided into two sections: information about the characteristics of the study and the sample, and information about the measurement scales. The first section included the characteristics of the study and the sample (inclusion criteria, sample size, and origin of the population).

Information relating to the scales was extracted in accordance with the quality criteria defined by the Scientific Advisory Committee of the Medical Outcomes Trust (SAC) for measurement of health results and the quality criteria recommended by Terwee[36-39]. In order to facilitate understanding, the 8 attributes of the SAC were included in 3 groups of information:[41] 1) conceptual suitability (conceptual and measurement model, cultural and linguistic adaptation); 2) applicability (demands of the administrator/respondent alternative forms, and interpretability); and c) psychometric properties (reliability and validity and responsiveness). Supplementary table 1, sets out the quality criteria used and their

measurement values. Finally, a summary table was created providing evidence from all the scales, with a view to synthesizing information on the basis of the criteria developed by McDowell[42]. The following assessment criteria were established: 1. Process of cross-transcultural adaptation (?: not reported; + translation only; ++: translation-back translation; +++ translation-back translation and pilot test); 2. Applicability (?: not reported; + data about the process of administration and interviewing; ++ visual material about foods and training of interviewers, +++: normative data); 3. Reliability (?: not reported or weak associations of some aspect of internal consistency reported; + alpha coefficient of internal consistency or intra-rater or inter-rater reliability reported; ++ alpha coefficient or interclass correlation coefficients (ICC) or correlated coefficient >0.70; 4. Validity (?: not reported, +: evidence from criterion or construct validity, ++: evidence from criterion and construct validity.

RESULTS

Search results

A total of 56 articles met the inclusion criteria, which were reduced to 52 once the duplicates had been removed (Figure 2). In addition, 19 of these articles were excluded after reviewing the title and the abstract because they did not meet the inclusion criteria. Finally a further 6 articles were excluded because they did not use specific MD adherence scores in their methodology. Therefore, 27 articles were included in the review, from which 28 MD adherence scores were used.

Characteristics of included studies

The designs of the studies included were principally observational (12 cohort studies[14, 16, 26, 28-31, 43-47], 1 case and control study[34], 14 descriptive studies[6, 11, 12, 29, 32, 33, 48-55], and 1 intervention study[56]). A total of 17 studies focused on the general population[6, 14, 26, 29, 32-34, 46-50, 52-56], 3 on the elderly[30, 43, 45], 2 on children[11, 12], 1 on university students[16], and 1 on pregnant women[31]. Finally, 3 of them did not indicate the target population of the scores[16, 28 44]. With respect to sample size, the scores created by Trichopoulou et al[14, 43] were developed using large samples: 22,043 and 74,607 people, respectively. There were 3 studies with a sample size of <150 people[29, 51,56].

Conceptual suitability

Supplementary tables 2 and 3 summarize key data regarding the conceptual suitability of the different scores: the context in which they were applied, content validity, and cross-cultural adaptation process. The scores were listed according to their conceptual model and measurement. The majority of the scores (n = 18)[6, 11, 14, 16, 26, 29-34, 43-45, 48, 49, 51] were based on positive and negative components of the MD. Five of them were based on the structure of the MD food pyramid[28 52-54,56], 3 on the general characteristics of the MD[46, 47, 55] and 1 on the diet quality index[12]. As a fundamental model, the scores created by Trichopoulou et al[14, 30, 43] have been the most widely utilized, with 6 scores being created on the basis of their components[16, 26, 29, 31, 45, 50].

Although there is no consensus on the meaning of the ratings, as a general rule, interpretation of these scales is positive for healthy items and negative for unhealthy items, with high scores indicating good adherence to the MD and low scores, poor adherence. Only the scores created by Scali et al[48] and Gerber[49] provide inverted scores, where high scores indicate low adherence and low scores indicate good adherence (supplementary table 2).

The majority of the scores were developed in Mediterranean countries: Spain (n = 14)[11, 12, 16, 26, 29, 31-34, 47, 50, 53, 54], Greece (n = 3)[6, 14 , 30], Italy (n = 2)[46, 47], and France (n = 2)[48, 49]. The remainder were developed in Canada (n = 1)[56], other European countries (n = 3)[43-45], Japan[52, 55], and the United States (n = 2)[28, 55] (see supplementary table 2).

Regarding the context of application (supplementary table 3), 12 of the 28 scores analyzed were applied to the general population[16 26 45-47, 49-54, 56], 6 in primary care[6, 29, 32, 43, 48, 55], 3 in hospital care[31, 33, 34], 6 in the community[6, 11, 14, 28 30, 55], and 1 in sports clubs[12]. The scores developed by Panagiotakos et al[6] and Woo et al[55] are used in the context of primary care and also in the community.

None of the MD adherence scores details the process of cross-transcultural adaptation. The majority of the scores come from the one food frequency questionnaire (FFQ) previously validated for the population studied, however in the original studies of these instruments (FFQ), the process of cross-cultural adaptation has not been detailed.

Regard to content validity, the majority of scores based on negative and positive components[6, 14, 26, 29, 31, 43, 45, 50] are created in function of the scores developed by Trichopolou and colleagues (1995)[30]. Scores of MD pyramid are based on the pyramid elaborated by Bach-Faig and colleagues (2011)[57]. The rest of scores are founded in general references of Mediterranean Diet pattern.

Aplicability

Related to the applicability of the MD adherence scores, with the exception of the score created by Woo et al[55], which does not specify the method of administration, all diet questionnaire were administered by trained interviewers. Regarding the source of information, all of scores were answered by the patients/participants (not by a proxy), except for the scores created by Serra-Majem et al[11] and Woo et al[55]. The participants, completed the diet questionnaires, and the researches calculated the MD score. The time taken to administer and

complete the items was not reported for any of the scales analyzed. The only information provided was the existence of trained staff to administer the questionnaires. Regarding the completion of questionnaires about food intake, only 5 of the scores[6, 14, 26, 48, 55] indicate having used a portion size booklets in order to help participants estimate their food intake more accurately. None of the studies provided normative data about the scores.

Psychometric properties

With regard to internal consistency (supplementary table 4), only the score created by Sotos-Prieto et al[54] provided a Cronbach alpha coefficient of 0.75. Given that the authors do not report item-test correlation coefficients, the degree of association between the items and the overall score was taken into account. The association between high global scores and the consumption of fruits, vegetables, nuts, and olive oil[6, 14, 28, 31, 48-50, 53] was reported in 8 of the scores. With respect to equivalence, only the two scores created by Benítez-Arciniega et al[29] provided data on equivalence (*inter-rater*) (ICC modified Mediterranean diet score (mMDS) = 0.48 and ICC Mediterranean-Like diet score (MLDS) = 0.62). None of the scores reported on test-retest reliability (intra-rater).

Related to criterion validity, predictive and concurrent validity were evaluated (supplementary table 5a and 5b). Predictive validity was reported in 5 of the 28 scores, using mortality rate or cardiovascular events as the predictive criterion. High MD adherence scores were associated with a significant reduction in the risk of mortality OR (0,64-0,83)[14, 26, 30, 43 45]. In only 1 study was the MD adherence score associated with cardiovascular events (increase adherence = 40% lower cardiovascular risk ($p<0.001$)[26]. Concurrent validity was reported in 10 of the 28 scores; adherence to the Mediterranean diet was associated inversely with clinical and biological markers of cardiovascular disease risk[6, 33, 34, 52, 56], body mass index, Waist-hip and weight[28, 31, 32, 50, 53, 56] Finally, for the analysis of construct validity, the

authors linked scores with other variables and scales (supplementary table 6). All measurement scores, with the exception of those developed by Trichopoulos et al[14, 30, 43] and Alberti-Fidanza et al[46], displayed a relationship with other health and dietary behavior variables (socio-demographic variables, level education, physical activity, habit of smoking, alcohol consumption ,age, antioxidants, energy and food intake). As for the relationship with other scales, only the scores created by Buckland et al[26], Mariscal-Arcas et al[31], Knoops et al[45], and Monteagudo et al[53] indicate comparison with the MD adherence score created by Trichopoulos et al[30], obtaining high levels of agreement (70%).

With regard to the measure of responsiveness, none of the scores provided an estimation of a statistic capable of measuring effect size. Only the score developed by Goulet et al[56] examined the effect of a nutritional intervention, in which MD adherence scores increased significantly from 21.1 ± 3.6 in week 0 to 28.6 ± 4.4, P <0.001 after 6 weeks of intervention.

Supplementary table 7 presents the MD summary scores. Only 4 scores did not provide any information about the cross-transcultural process[14, 31, 32, 47]. The scores developed by Panagiotakos et al[6], Trichopoulou et al[14], Scali et al[48], Gerber[49], and Woo et al[55] obtained the best evaluations in terms of applicability. The score created by Sotos-Prieto et al[54] was the instrument with the most and best evidence about reliability. Information about validity was provided for most of the scores, but concurrent and predictive validity were only reported for the scores created by Panagiotakos et al[6], Schoder et al[32], Martinez-Gonzalez et al[33, 34] and Knoops et al[45]. The results indicate that the scores with the best overall evaluation were those created by Panagiotakos et al[6], Buckland et al[26], and Sotos-Prieto et al[54]. However, only the study by Sotos-Prieto et al[54] provided information about reliability.

DISCUSSION

The review conducted here included 27 references and identified 28 MD adherence scores used internationally. The evidence obtained from these studies has been evaluated based on conceptual suitability, applicability, and psychometric properties. The results reveal that evidence is scarce, and that very few scores fulfill psychometric properties and applicability parameters typically associated with scales/indices. The scores developed by Panagiotakos et al[6], Buckland et al[26], and Sotos-Prieto et al[54] provide the most information. However, as with the other scores analyzed, none of them provide complete information about the process of transcultural adaptation used. The scores reviewed here only specify that a previously validated food frequency questionnaire (FFQ) for the original population has been used, but don't provide the transcultural adaptation of this dietary questionnaires (translation, back translation and pilot study). The Scientific Committee of the Medical Outcomes Trust[39] considers cultural and linguistic adaptation to be an especially important criterion in achieving linguistic and cultural equivalence with an original instrument.

Applicability is one of the sections that presents the most information gaps. None of the scores report on normative data, and only 5 of them[6, 14, 25, 48, 55] provide detailed information about the administration process using photographic and visual material to obtain information as close to reality as possible.

The data about reliability are the most deficient. To ascertain the degree to which all the items on a scale measure the same construct, internal consistency must be measured. In this case, the score created by Sotos-Prieto et al[54] is the only one that provides information about this topic, through the Cronbach alpha value. The degree of association between the scores obtained and the items included on the instrument has been taken into account, but this information cannot be considered a quality item-test measure of reliability. Regarding

reliability data, only the two scores created by Benítez-Arciniega et al[29] display test-retest reliability and equivalence reliability.

Validity was the most widely reported property. Only the scores created by Benítez-Arciniega et al [29] did not include any information about validity. In the scientific literature, there are different gold standards to evaluate criterion validity, such as clinical and biological markers for concurrent validity, and adverse events for predictive validity. However, the best gold standard, "observation of food intake," has not been used in any of the studies. In some of the studies analyzed[26, 31], the gold standard used is the score created by Trichopoulou et al[30] obtaining agreement levels of close to 70% with the original, considered here to provide construct validity. This one was the first score used to measure levels of adherence to the MD, but it cannot be considered a gold standard, since there is new evidence indicating changes in food and diet patterns. It should also be pointed out that no confirmatory analysis was conducted in relation to the structure of the instruments.

It has been consistently demonstrated that the MD helps to protect against cardiovascular disease, inflammatory and metabolic diseases as well as numerous chronic-degenerative diseases[1, 2, 35, 58-63], nevertheless the protective effect of the MD is very different across the studies[35, 64]. Consequently, a large number of MD adherence scores are being created to ascertain the relationship between diet and health. However, recent publications indicate that some of these scores do not offer strong predictive capacity regarding mortality or disease, thus questioning the quality[13, 64, 65]. This observation is borne out by the findings of this study, which have shown that the majority of the scores analyzed are lacking in information about the quality attributes of the scales.

For all of the above reasons, greater attention must be paid to the way in which these scores have been created. Firstly, a common criterion should be established to identify the components that make up the Mediterranean Diet. Secondly, different elements need to be

unified: the number of components (nutrients, foods, or food groups), classification categories for each population, measurement scale, statistical parameters (mean, median, tertiles, etc.) and the contribution of each component (positive or negative) to the score total[15, 35, 66, 67]. Finally, given the great heterogeneity of the MD in different countries, further confirmatory analyses are required using biomarkers with a view to validating said dietary pattern.

Strengths and Limitations

Although the data are conclusive regarding the lack of quality of MD adherence scores and the need to improve the measurement of MD adherence, it is important to take into consideration the limitations of this review, which are related to the process of bibliographic searches, derived from the electronic search and retrieval of documents. In order to control this limitation, multiple synonyms of the search terms were used, and complementary searches of prestigious journals and bibliographic references were also conducted. Furthermore, this review only took account of studies wherein the main objective was to develop or examine data about the applicability or psychometric properties of an MD adherence score. It could produce an underestimation of the predictive and/or concurrent validity, which are the most frequent analysis in longitudinal studies with this MD adherence scores.

In conclusion, the use of scores to measure adherence to the MD is a very useful tool for identifying the dietary patterns of the population. However, our results point out that fewer of the analysed scores suit the quality criteria. The developed scores by Panagiotakos et al[6], Buckland et al[26], and Sotos-Prieto et al[54] have obtained better evidence, although they have not been considered as gold standard, due to they don´t fit all of the quality criteria. As a consequence, it could be possible that the employed scores to evaluate the relationship between MD and health don´t present a good predictive ability, originating significant bias in

the obtained results. For all this reasons, further information is required about the scores that currently exist, and/or new instruments with better conceptual grounded must be developed. Future research should focus on improving the psychometric properties of the MD adherence scores, and analyzing the concordance between these instruments in compliance to normative quality criteria.

Figure legend

Figure 1. Search strategy using MEDLINE for studies on the evaluation of Mediterranean diet adherence scores. Search was conducted for Medline with the appropriate search terms utilized for the other databases

Figure 2. Search and inclusion process flowchart of studies to include in systematic review of the evaluation of Mediterranean diet adherence scores: identification, screening, eligibility and included.

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1.	(mediterranean diet[Title/Abstract]) OR mediterranean diet[MeSH Terms]
2.	(adherence [Title/Abstract])
3.	(score [Title/Abstract]) OR (index [Title/Abstract])
4.	((quality) [Title/Abstract]) OR (validity[Title/Abstract])) OR reproducibility of results [MeSH Terms] OR reproducibility of results [Title/Abstract] OR psychometrics [MeSH Terms] OR psychometrics Title/Abstract]
5.	1 AND 2 AND 3 AND 4

Figure 1. Search strategy using MEDLINE for studies on the evaluation of Mediterranean diet adherence scores. Search was conducted for Medline with the appropriate search terms utilized for the other databases

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322x450mm (300 x 300 DPI)

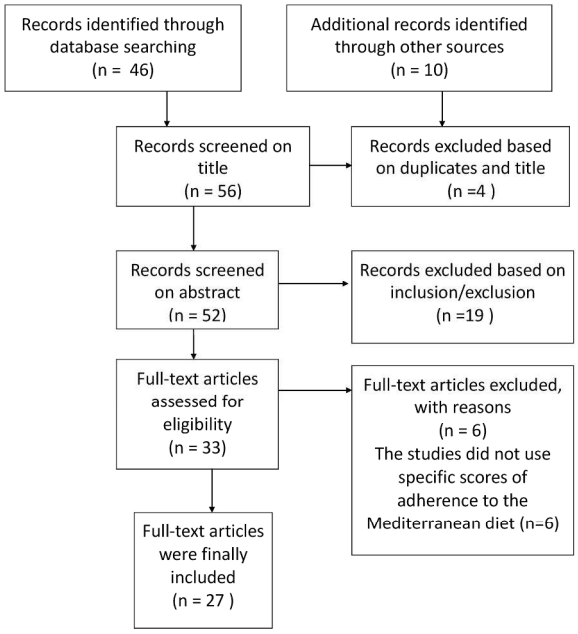

Figure 2. Search and inclusion process flowchart of studies to include in systematic review of the evaluation of Mediterranean diet adherence scores: identification, screening, eligibility and included.

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Table 1: Attributes and criteria for reviewing instruments[a]

Group	Attributes	Criteria for review
Conceptual suitability	- Conceptual and measurement model used	- Concept to be measured (content validity) - Conceptual and empirical basis for item content and combinations - Information on dimensionality and distinctiveness of scales (floor and ceiling effects)
	- Cultural and language adaptations or translations: equivalence	- Conceptual and linguistic assessment - Evaluation of measurement properties
Applicability	- Information about respondent and administrative burden	- Information on: (a) time need to complete the instrument, (b) reading and comprehension level, (c) any special requirements or requests made of respondent
	- Special requirements regarding application, alternative forms	- Evidence on reliability, validity, responsiveness, interpretability, and burden for each mode of administration - Information on the comparability of alternative modes
	- The interpretability of the scores	- Rationale for selection of external criteria of populations for purposes of comparison and interpretability of data - Information regarding the ways in which data from the instrument should be reported and presented - Meaningful 'benchmarks' to facilitate interpretation of the scores
Psychometric properties		
	- Reliability :	
	o Internal consistency	- Homogeneity (intercorrelations) of the scale's items at one point in time: Cronbach's alpha coefficients and item-test correlations
	o Test-retest reliability (intra-rater)	- Stability of an instrument over time (test–retest): Person/Spearman coefficient values, as well as interclass correlation coefficients (ICC) and Kappa Coefficients were collected.
	o Equivalence (inter-rater)	- Inter-rater agreement at one point in time: Person/Spearman coefficient values, as well as interclass correlation coefficients (ICC) and Kappa Coefficients
	- Validity	
	o Content validity	- Evidence that the domain of an instrument is appropriate relative to its intended use. It is a theoretical validity that is included in conceptual suitability.
	o Criterion validity (concurrent and predictive)	- Evidence that shows the extent to which scores of the instrument are related to a criterion measure (gold standard): values of specificity and sensitivity, or statistics of correlation
	o Construct validity	- Evidence that supports a proposed interpretation of scores based on theoretical implications associated with the constructs being measured: factorial structure of the instrument, convergent or divergent evidence and discriminatory capacity of the instrument.
	- Responsiveness	- Effect size statistics and correlation measurements of change between predictors and clinical criteria

[a] Table elaborated by the authors[37-39]

Table 2. Conceptual and measurement model of the MD adherence scores

Instrument	Country	n	Age	Dietary Data	Conceptual model	measurement model
MD Indices based on positive or negative components						
Trichopoulou and collegues						
• 1995[30]	Greece	182	>70y	FFQ	(+) 1.High ratio of MUFA/SFA; 2.Moderate alcohol consumption; 3.High consumption of legumes; 4.High consumption of cereals (bread and potatoes); 5.High consumption of Fruit; 6.High consumption of Vegetables. (-) 7.Low consumption of meat and derivatives, 8.Low consumption of milk and dairy	8-components (g/d) Score ≥4 = High adherence Food (+): 1pt consumption > average and 0pt consumption < average Food (-): 1pt consumption < average and 0pt consumption > average.
• 2003[14]	Greece	22.043	20-86y	FFQ	The same components as the previous version but with the addition of one more, fish.	The score ranges from 0 (minimum adherence to MD) to 9 (maximu adherence to MD).
• 2005[43]	Denmark, France, Germany, UK, Spain, The Netherlans, Norway, Sweden	74.607	>60y	FFQ,14D DR	Same components as the 2003 version, but the lipid profile is modified. Monounsaturated fats and polyunsaturated fats are included in the numerator	Scores range from 0 (minimum adherence to MD) to 9 (maximum adherence to MD).
Scali and colleagues[44] (2001)	France	964	20-76y	FFQ	(+) 1.Olive oil; 2.Fish: white and oily; 3.Cereals: bread (B and Wh); pasta (B and Wh); rice (B and Wh) and breakfast cereals; 4.Fruit + Vegetables. (-) 5.Fresh and processed meat, 6.Saturated fats, and 7.Cholesterol	7 components. Each component is divided into three scores according to consumption Good MDQI: score of 5-7 Medium-to-Good MDQI: score of 8-10 Medium-to-Poor MDQI: score of 11-13 Poor MDQI: score >13
Sánchez-Villegas and colleagues (2002)[16]	Spain	3847	N.R	FFQ	(+) 1. High ratio of MUFA/SFA fats; 2. Moderate consumption of alcohol (30g/d M y 20g/d W); 3. High consumption of legumes; 4. High consumption of cereals (bread and potatoes); 5. High consumption of Fruits; 6. High consumption of Vegetables. (-) 7. Low consumption of meat and derivatives; 8. Low consumption of milk and derivatives.	8 components (g/d) The intake of each of the groups was standardised with the z value (observed mean/standard deviation). The MPD was turned into a percentage, where 100% was maximum adherence and 0% was minimum adherence.
Martinez-González and colleagues	Spain	342	<80y	FFQ	MPD: Includes an 'a priori' and a 'post hoc' score • 'a priori': combination of 8 components (+) 1.olive oil, 2.fibre, 3.Fruit, 4.Vegetable, 5.fish and 6.alcohol, (-) 7.meat and 8. Sum total of bread, pasta, rice. • 'post hoc': Each component is dichotomised into 2 categories.	Scores range from 5-40pt. Scores range from 0-8pt. Consumption of Vegetable, Fruit, olive oil, fibre, fish, and alcohol> average =1. Consumption of meat and cereals < average =1.
• 2002[34]						
• 2004[33]	Spain	342	<80y	FFQ	Fibre is substituted by the item: high consumption of Fruit and Vegetable. Legumes were added.	The consumption of each of the elements was divided into 2 categories, with the same cut-off points as above. Score range 0-9.

(continued on next table)

Table 2. Conceptual model of the MD adherence scores: items *(continued)*

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
Serra-Majem and colleagues (2004)[11]	Spain	3850	2-24y	N.R[m]	(+) 1.Fruit or Fruit juices Fruit/d; 2.Two pieces of Fruit/d; 3.Raw or cooked Vegetable once/d; 4.Raw or cooked Vegetable > once/d; 5.Fish 2-3times/w; 6.Legumes> Once/w; 7.Pasta, rice ≥5 times/w; 8.Cereals or grains for breakfast; 9. Nuts 2-3times/w; 10.Olive oil at home; 11.Milk or derivatives for breakfast; 12.2 yoghurts and/or cheese (40g)/day. (-)13.Skipping breakfast; 14.Mass produced pastries for breakfast; 15. Sweets or candy every day; 16. Mass produced sweets for breakfast.	16 components Scored between 0 and 12p:The sum total of the scores is classified into: * >8pt =Optimum MD * 4-7pt =need improvement in the MD pattern * ≤ 3pt = very low quality MD.
Panagiotakos and colleagues (2006)[6]	Greece	3042	>18y	FFQ	(+) 1. Unrefined cereals (wholemeal bread, pasta, rice, other grains, biscuits); 2.Fruit; 3.Vegetables; 4. Legumes; 5.Potatoes; 6.Fish; 7.Alcohol intake (<300ml/d); 8.Olive oil. (-)9.Meat and meat products; 10.Chicken; 11.Full-fat dairy products.	11 components: Score: 0 and 55. Score 0-5 for food. Scores high = good adherence to MD. (+) 5 when consumed and 0 when not consumed daily. (-) Inverted score
Trichopoulos and colleagues (2004)[45]	Italy, Spain, Grece	N.R.	N.R.	FBSs[n]	(+) 1.Vegetable (including legumes); 2.Fruit; 3.Cereals; 4.Ratio of fats; 5.Alcoholic drinks (-) 6.Meat ; 7.Dairy products	7 variables: 1pt=consumption high above average in food (+) and consumption low below average in food (-)
Knoops and colleagues (2004)[46]	Spain, Grece, Switzerland, Italy. Belgium, Denmark, France, Portugal, Hungary, The Netherlands	2339	70-90y	DH[o]	1.Ratio MUFA/SFA; 2. Legumes, nuts, and seeds; 3.Grains; 4.Fruit; 5.Vegetable and potatoes; 6.Meat and derivatives; 7.Dairy products; and 8.Fish. Adjusted consumption according to calorie intake: M-2500Kcal, W-2000Kcal	8 variables: Score 0= low quality of diet Score 8= high quality of diet
Gerber (2006)[47] Med-DQI	France	964	30-77y	FFQ	(+) 1.Olive oil; 2.Fish; 3.Cereal; 4.Vegeables + Fruit. (-) 5. Meat; 6. Saturated fat (% energy); 7.Cholesterol	7 items. The score ranges from 0-14. Score 0: > consumption of food (+) and < consumption of food (-). Score 2: inverse case Good adherence: 1-4, Medium-good adherence: 5-7, Medium-poor: 8-10, Poor: 11-14
Buckland and colleagues (2009)[26]	Spain	41078	29-69y	FFQ, DH	(+) 1.Vegetable (excluding potatoes); 2.F (including dried fruits but excluding juices); 3.Legumes; 4.Fresh fish; 5.Cereals; 6.Olive oil; 7.Alcohol. (-)8.Meat; 9.Dairy products.	9 variables: Score 0-6= High low Score 7-10= medium adherence, Score 11-18: High adherence
Mariscal-Arcas and colleagues 2009[31]	Spain	318	18-46y	FFQ	8 Components typical of the MD + 3 micronutrients specific to pregnancy: 1.Iron, 2. calcium and 3. folic acid. Alcohol consumption was not taken into account.	The score ranges from 0-11 pt. Scoring 1pt≥ two thirds of recommended levels or if the W took nutritional supplements Scoring 0pt< the cut-off point

(continued on next table)

Table 2. Conceptual model of the MD adherence scores: items *(continued)*

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
Schröder and colleagues.						
• 2004[48]	Spain	2871	25-74y	FFQ, 24hr DR	(+) 1.Cereals; 2.Vegetables; 3.Fruit; 4.Legumes; 5. Fish; 6. Nuts and 7.Alcohol (0g and >20= 1, 0.1-20g= 3). (-) 8. Meat and 9. Dairy.	9 components. The score ranges from 9-27 pt. (+) The lowest tertile = 1, medium= 2 and high =3 (-) Inverted score.
• 2011[32]	Spain	7146	55-80y	FFQ, MEDAS[p]	Score 1: 1.Olive oil as main fat; 2.Preference for white meat; 3.Tablespoons of olive oil ≥4times/d; 4.Vegetable 2portions/d; 5.Pieces of Fruit ≥3/d; 6.Red meat or sausages <once/d; 7. Animal fat<1portion/d; 8. Sugary drinks < one glass (100ml/d); 9.Red wine≥5 servings/week; 10.Legumes ≥3 portions/week; 11. Portions of fish≥3times/week; 12.Mass produced desserts and pastries<2v/s; 13.Nuts ≥3times/week; 14.Dishes cooked with tomato sauce, garlic; onion, leeks, sautéed with olive oil ≥2times/w. Score 0: For inverse cases	14 items. Each item was allocated a score of 1 or 0 depending on consumption. High scores = better adherence
• 2012[49]	Spain	102	3-80y	24hr DR	(+)1.Legumes 2.Green leafy and other Vegetable; 3.Fish; 4. Citrus and other Fruits; 5. Whole foods; 6.Olive oil; 7.Dried fruits and nuts and 8. Red wine (S3=1-2 glasses/d). (-) 9.Red meat, sausages; 10.Dairy products.	10 variables. Score 10= very low adherence and Score 30=optimum adherence (+) Tertile 1=low, Tertile 2=medium, Tertile 3=high (-) Tertile high=1, Tertile 2=medium, Tertile 2= low.
Benítez-Arciniega and colleagues (2011)[29]						
• mMDS	Spain	107	58y	FFQ, DR 24hr	(+) 1.Cereals; 2.Fruit; 3.Vegetable; 4.legumes; 5.fish; 6.olive oil; 7.nuts; 8.moderate consumption of wine (=20g). (-) 9.Meat (including chicken and sausages) and 10. Dairy.	10 components. The score ranges between 10-30pt. (+) Codified tertile: 1 (low) to 3 (high). (-)The score was inverted
• MLDS	Spain	107	58y	FFQ, DR 24hr	Adds 3 components to the mMDS[q]: 11. Sugary drinks; 12. Sweets and pastries; and 13. Fast food. The score was inverted	The resulting score ranges between 13-39pt.
MD score based on the diet quality index (DQI)						
Mariscal-Arcas and colleagues (2007)[12]	Spain	288	6-18y	FFQ, 24hr DR	Modifies the classification criterion for "empty-calorie food". 4 components, 1.Variety of diet (0-20pt), 2.Suitability (0-40pt), 3.Moderation (0-30pt) and 4.General balance (0-10pt).	The score ranges between 0-100.
MD score based on the MD pyramid						
Goulet and colleagues (2003)[50]	Canada	73	30-65y	FFQ	11components (frequency: size or times/d or w) Pyramid base: 1.grains; 2.Fruit; 3.Vegetable; 4.legumes; dried fruits; nuts and seeds; 5.olive oil and 6.fish. Middle level: 7.dairy (2-3 portions/d) and 8.chicken (3 portions/w). Apex of the pyramid: 9. red and processed meat,;10. sweets and pastries and 11.eggs.	The total score ranges between 0-44pt. High scores = good adherence to MD.

(continued on next table)

Table 2. ***Conceptual model of the MD adherence scores: items (continued)***

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
Rumawas and colleagues (2009)[28]	USA	3021	N.R.	FFQ	Whole grain cereals; 2.Fruit; 3.Vegetable; 4.Dairy; 5.Red wine (M and W); 6.Fish and seafood; 7.Olives; legumes, nuts; 8.Potatoes and other root vegetables; 9.Eggs; 10.Chicken; 11.Sweets and pastries; 12.Meat; 13.Olive oil 10p= consumption, 5p= olive oil + vegetable oils, and 0pt= not consumed).	13 variables. With the exception of olive oil, each component was calculated between 0-10pt. Overconsumption deducted 1p proportionally for intake in excess of recommended amounts for each food group
Kanauchi and colleagues (2015)[51]	Japan	433	>30y	BDHQ, HDI	1Vegetable; 2.Fruit; 3.Grains; 4.Legumes; 5.Fish; 6.Red and processed meat; 7.Dairy; 8.Eggs; 9.Chicken; 10.Alcohol; 11.Ratio of MUFA/SAF fat.	11 variables. Values of 0 and 1 for each component. Alcohol, value 1 = consumption between 10-30g/d for M and MUFA/SFA= ratio out of 1.5. Score <5 = low adherence to MD
Monteagudo and colleagues (2015)[52]	Spain	1155	12-83y	FFQ	Foods consumed at each main meal (3pt): 1.Fruit; 2.Vegetable; 3.Cereals; 4. Olive oil. Foods consumed daily (2pt): 5. Nuts 6.Dairy. Foods consumed weekly (1pt): 7.Legumes; 8.Potatoes; 9.Eggs; 10.Fish; 11.White meat; 12.Red meat; 13.Sweets and pastries; 14.Fermented drinks.	14 variables. Total score: 0-24 for adults and the elderly 0-23 for adolescents (due to the exclusion of alcohol) 0: when the number of portions per meal, day, or week was high or low than recommended amounts.
Sotos-Prieto and colleagues (2014)[53]	Spain	988	40-55y	FFQ	Block 1: Consumption of foods. 1.Sweets and pastries; 2.Red Meat; 3.Processed Meat; 4.Egg; 5.Legumes; 6.White meat; 7.Fish and seafood; 8.Potatoes; 9.Low-fat dairy; 10.Nuts and olives; 11.Herbs, spices; 12.Fruit; 13.Vegetable; 14.Olive oil; 15.Cereals. Block 2: Dietary habits. 16.Water and herbal teas; 17.Wine; 18.Limiting salt in meals; 19.Preference for whole grain cereals; 20.Snacks; 21.Limiting snacking between meals; 22.Limiting sugar and sugary drinks. Block 3: Physical activity, social habits and daily living. 23.Physical activity; 24.Siesta; 25.Hours of sleep; 26.Watching TV; 27.Meeting up with friends; 28.Collective sports.	28 variables Score between 0 (bad Mediterranean style) and 28 (good Mediterranean style). If recommendations are observed = 1pt, if not observed =0pt.
MD score based on the characteristic components of the MD						
Alberti-Fidanza and colleagues • 1999[54]	Italy	N.R	40-59y	DH	MAI is computed using the % of energy intake of 4 food groups: 1.Carbohydrate group: bread, cereals, dried legumes, potatoes. 2. Protective food group: Vegetables, fresh legumes, F, fish, red wine, and vegetable oils. 3. Land animal food group: milk, cheese, meat, eggs, animal fats, and margarines. 4. Sweet food group: sugary drinks, cakes, pastries, biscuits, and sugars.	The MAI is obtained by dividing the sum total of groups 1 and 2 by the sum total of groups 3 and 4.

(continued on next table)

Table 2. Conceptual model of the MD adherence scores: items *(continued)*

Instrument	Country	n	Age	Dietary Data	Conceptual model	Measurement model
• 2004[55]	Italy	N.R	45-65Y	DH	MED: bread, cereals, potatoes, legumes, V, F, fish, red wine, and vegetable oils. NOT MED: milk, cheese, meat, eggs, animal fats and margarines, sugary drinks, cakes, pastries, biscuits and sugar	The MAI divides the sum total of % of energy taken from foods typical of the MD by the sum total of the % of foods that are not typical in the MD.
Woo and colleagues (2001)[56]	China, Australia USA	1010	24-74Y	FFQ	1.Ratio of MUFA/SFA fats; 2. Moderate alcohol consumption (H<10g/d); 3.high consumption of legumes; 4.high consumption of cereals; 5.high consumption of Fruit; 6.high consumption of Vegetable; 7.low consumption of meat and derivatives; 8.low consumption of dairy and derivatives	8 variables The score is obtained by adjusting according to calorie intake: M-2500Kcal and W-2000Kcal. M: Score ≥ 4: High adherence and W: Score ≥ 3: High adherence

MD, Mediterranean diet; FFQ, food frequency questionnaire; MUFA/SFA, Monounsaturated Fatty Acids/ Saturated Fatty Acids; g/d, grams/day; pt, point; DR,14-day diet record; B, Brown or Whole wheat; Wh, White; MDQI, Mediterranean diet quality index; M, men; W, woman; MEP, Mediterranean Diet Pattern; N.R, Not reported; FBSs, Food availability dara record in the balance sheet; DH, dietary history; MEDAS, Mediterranean diet adherence screener; mMDS; Modified Mediterranean Diet Score; MLDS, Mediterranean-Like Diet Score; BDHQ, Brief self-administered diet history questionnaire; HDI, Healthy diet indicator; MAI, The Mediterranean Adequacy Index; MED, The Mediterranean-Style Diet.

Table 3. Summary of key data about the conceptual suitability and content validity of adherence scores to the MD[a]

Instrument	Context	Content validity	Adaptation process
MD Indices based on positive or negative components			
Trichopoulou and colleagues.			
• 1995[30]	Community	Based on the recommendations of Davidson and Passmore (1979)[57] regarding dividing the score, but they combined cereals and starchy foods and did not take account of sugars and syrups.	FFQ validated for the Greek population.
• 2003[14]	Community	Based on the 1995 version, but with the inclusion of fish.	FFQ validated for the Greek population.
• 2005[43]	Primary Care	The versions of Trichopoulou and colleagues (1995) [30] and (2003)[14], were modified, substituting the item MUFA for the sum of MUFA + PUFA	FFQ validated for the European population.
Scali and colleagues (2001)[44]	Primary Care	Based on the DQI created by Patterson and colleagues (1994)[58] with an estimation of diet based on the quantitative consumption of different food groups according to recommendations to prevent diet-related diseases.	FFQ validated for the French population.
Sánchez-Villegas and colleagues (2002) [16]	General Population	The composition of the score is based on the version of Trichopoulou and colleagues (1995)[13] and the recommendations of Kouris-Blazos and colleagues (1999)[59] and Lasheras and colleagues (2000) [60]. The MDP was defined 'a priori' by adding together the standardised residuals of nutrients and foods after adjusting a regression model using total energy intake as the independent variable.	FFQ validated for the Spanish population.
Martínez-González and colleagues	Hospital care	Based on the MD pattern, considering olive oil, fibre, Fruit, Vegetable, fish and alcohol as protective food items, and the consumption of meat and derivatives, and foods with a high glycemic index as risk elements.	FFQ validated for the Spanish population. O.V.[g]
• 2002[34]			
• 2004[33]	Hospital care	This modifies the version developed by Martínez-González and colleagues (2002)[34], replacing the item fibre with high consumption of Fruit + Vegetable and including an item to cover legumes.	FFQ validated for the Spanish population. O.V
Serra-Majem and colleagues (2004)[11]	Community	The inclusion of variables is based on the MD pattern.	O.V.
Panagiotakis and colleagues (2005)[6]	Community & Primary Care	The inclusion of variables is based on the MD pyramid proposed by the Greek Ministry of Health and Welfare (1999)[61], including the consumption of unrefined foods, Fruit, Vegetable, legumes, potatoes, fish, meat and derivatives, chicken, full fat dairy, olive oil, and alcohol intake.	FFQ validated for the Greek population.
Knoops and colleagues (2004)[46]	General Population	The composition of the score is based on the version of Trichipoulou and colleagues (2003)[14], including Vegetabe + potatoes in the same item, and legumes + nuts + seeds in another item,	N.R
Gerber (2006)[47]	General Population	Based on the DQI created by Patterson and colleagues (1994)[58], but with the addition of olive oil (giving a higher score when consumption is low) and replacing the item of proteins with meat because fish was added with an opposing n gradient.	FFQ validated for the French population.
Buckland and colleagues 2009[26]	General Population	The composition of the score is based on the versions of Trichipoulou and colleagues (1995)[30] and (2003) [14], based on nine key components of the MD.	FFQ validated for the Spanish population. O.V
Mariscal-Arcas and colleagues (2009)[31]	Hospital care	Based on the version of Trichopoulou and colleagues (2003)[14] including specific requirements for pregnancy, Laraia ad colleagues (2004)[62].	N.R.

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Table 3. Summary of key data about the conceptual suitability and content validity of adherence scores to the MD *(continued)*

Instrument	Context	Content validity	Adaptation process
Schröder and colleagues			
• 2004[48]	General Population	The score is based on the version of Trichopoulou and colleagues (1995)[30] making reference to the consumption of cereals, Vegetable, Fruit, legumes, nuts, fish, full fat dairy, meat, and red wine.	FFQ validated for the Spanish population. O.V.
• 2011[32]	Primary Care	Based on the version of Martínez-Gonzales and colleagues (2004)[33], including 5 more variables; 2 of the items pertaining to the regular intake of typical MD foods and three items pertaining to the frequency of food consumption.	FFQ validated for the Spanish population
• 2011[49]	General Population	Includes items characteristic of the MD together with foods with antioxidant capacity.	N.R.
Benítez-Arciniega and colleagues (2011)[29]			
• mMDS[j]	Primary Care	Modified version of MDS by Trichopoulou and colleagues (1995)[30]. Calculated according to the distribution tertile of consumption with the exception of red wine.	FFQ validated for the Spanish population.
• MLDS[k]	Primary Care	Modified version of mMDS, with the addition of three new groups: sugary carbonated drinks, sweets and pastries, and fast food.	FFQ validated for the Spanish population.
MD score based on the diet quality index (DQI)			
Mariscal-Arcas and colleagues (2007)[12]	Young sports players/athletes	Based on the DQI-I by Tur and colleagues (2005)[63]. modified by Kim and colleagues (2005)[64]establishing fat intake at ≤30% of total energy, including Spanish recommended consumption levels, and changing the classificatory criterion 'empty-calorie food'.	FFQ validated for the Brazilian and Vietnamese populations.
MD Score based on the MD pyramid			
Goulet and collegues (2003)[50]	General Population	The score is based on the components of the MD pyramid, version Oldways Preservation and Exchange Trust, 2000 (grains, Fruit, Vegetable, legumes, olive oil, fish, nuts and seeds, dairy, fish, chicken, eggs, sweets and pastries, and red/processed meat).	Non-validated FFQ (based on typical foods in the region of Quebec).
Rumawas and colleagues (2009)[28]	Community	Based on the components of the MD pyramid[65], Contains 13 components corresponding to the 13 food groups in the Mediterranean diet pyramid.	FFQ validated for healthy working women. OV.
Kanauchi and colleagues (2015)[51]	General Population	The score is based on the latest updated version of the MD pyramid, according to Bach-Faig and colleagues (2011)[66], based on 11 components of the MD	FFQ validated for the Spanish population. O.V.
Monteagudo and colleagues 2015 [52]	General Population	The score is based on the latest updated version of the MD pyramid, according to Bach-Faig and colleagues (2011)[66], using the consumption recommendations for different foods and food groups.	Validated diet history questionnaire (BDHQ)
Sotos-Prieto and colleagues (2014)[53]	General Population	The score is based on the latest updated version of the MD pyramid, according to Bach-Faig and colleagues (2011)[66]. 28 items divided into three blocks (1-contains the frequency with which foods are consumed, 2- dietary habits of the MD, 3-physical activity, social life and habits).	FFQ validated for the Spanish population. O.V.

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Table 3. Summary of key data about the conceptual suitability and content validity of adherence scores to the MD (*continued*)

Instrument	Context	Content validity	Adaptation process
MD score based on characteristic components of the MD			
Alberti-Fidanza and colleagues			
• 1999[54]	General Population	Based on references of Mediterranean Dietary Pattern. The score is computed with the % of total calorie intake provided by typical MD foods.	Diet register validated by Alberti-Fidanza colleagues (1995)[67]
• 2004[55]	General Population	The score is based on typical MD dividing the sum of the total % of intake provided by typical MD food groups foods (bread, cereals, legumes, potatoes, vegetables, fruit, fish, red wine, vegetable oil) by the total sum of the % of energy provided by non typical MD foods (milk, cheese, meat, eggs, animal fats and margarines, sweet beverages, cakes, pies and cookies, sugar).	N.R.
Woo and colleagues 2001[56]	Community & Primary Care	The score is based on the reference Groot and colleagues (1996)[68] and on the consumption of 8 food categories.	FFQ Validated for the Chinese population.

MD, Mediterranean Diet; FFQ, Food Frequency Questionnaire; MUFA, Monounsaturated Fatty Acids; PUFA, Polyunsaturated Fatty Acid; DQI, Diet Quality Index- International; MDP, Mediterranean Diet Pattern; O.V., Original Version; N.R., Not Reported; MDS, Mediterranean Diet Score; mMDS, Modified Mediterranean Diet Score; MLDS, Mediterranean-Like Diet Score; DQI-I, Diet Quality Index-Intenational.

Table 4. Summary of key reliability data for the different versions of MD adherence scores

Instrument	Internal Consistency
MD Indices based on positive and negative components	
Trichopoulou and colleagues	
• 2003[14]	High Score= high consumption of Vegetables (low score 18% vs. 80% high score), legumes (low score 23% vs. 76% high), Fruit and nuts (low score 23% vs. 76% high), cereals (low score 36% vs. 63% high), fish (low score 20% vs. 78% high), olive oil (low score 23% vs. 77% high) and low consumption of dairy (low score 69% vs. 32% high) and meat (low score 56% vs. 42% high).
Scali and colleagues (2001)[44]	High Score= high intake of Vegetables + Fruit (low score 188.7g vs. 1023.7g high), cereals (low score 15.7g vs. 158.9g high), fish (low score 15.7g vs. 66.9g high), olive oil (low score 1.1g vs. 31.9g high) and ⇓ intake of cholesterol (low score 460.5g vs. 222.9g high), SFA (low score 15.4g vs. 9.4g high) and meat (low score 168.4g vs. 19.6g high).
Panagiotakos and colleagues (2006)[6]	High Score= high intake of Vegetable (p=0.01), Fruit (p=0.03), legumes (p=0.001), potatoes (p=0.04), whole grain cereals (p=0.02), fish (p=0.01) and olive oil (p=0.01) and low red meat (p=0.03), chicken (p=0.03) and full fat dairy (p=0.04).
Gerber (2006)[47]	Score= high intake Vegetable + Fruit (low score 290g vs. 800g high), cereals (low score 129g vs. 180g high), fish (low score 19g vs. 58g high), olive oil (low score 0.3g vs. 20g high) and low intake of cholesterol (low score 430g vs. 220g high), SFA (low score 17g vs. 9g high), red meat (low score 130g vs. 130g high) and animal-based foods (low score 434g vs. 208g high).
Mariscal-Arcas and colleagues (2009)[31]	High Score= high intake of Vegetable (low tertile 1% vs. 36.2% high), fruit and nuts (low tertile 0% vs. 29% high), cereals (low tertile 0% vs. 39% high), fish (low tertile 1.8% vs. 28.8% high), MUFA (low tertile 0.0% vs. 36.8% high), legumes (low tertile 0.0% vs. 34.7% high) and low intake meat (low tertile 0.0% vs. 37% high) and dairy (low tertile 0.0% vs. 35.6% high).
Schroder and colleagues	
• 2004[48]	High Score= high intake of Fruit ($p<0.001$), Vegetable ($p<0.001$), nuts ($p<0.001$), fish ($p<0.001$), legumes and cereals $p<0.05$ in men. Low intake meat ($p<0.001$) and sweets and pastries $p<0.05$.
MD indices based on the MD pyramid	
Rumawas and colleagues (2009)[28]	Positive and significant correlation between the score and its items between a range of 0.11 meat and 0.50 vegetables.
Sotos-Prieto and colleagues (2014)[53]	Cronbach's α =0.75.
Monteagudo and colleagues (2015)[52]	High Score= low intake of Vegetable, Fruit, olive oil, fish, legumes ($P<0.05$) and low intake meat (low tertile 0.0% vs. 37% high) and sweets and pastries and fermented beverages ($p<0.05$).

MD= Mediterranean Diet; Instrument, The results that don't reported for the score component means there are no significant; g, grams; SFA, Saturated Fatty Acids; MUFA, Monounsaturated Fatty Acids.

Table 5a Summary of key predictive utility data from the different versions of the MD adherence questionnaire

Instrument	Predictive		
	Markers	MD Adherence	Score items
MD Indices based on positive or negative components			
Trichopoulou and colleagues			
• 1995[30]	Mortality	High scores= decrease in mortality, OR = 0.83 (IC 95%, 0.69-0.99)	N.R
• 2003[14]	Mortality	Increase of 2p on the questionnaire score = decrease 25% global mortality (p<0.001). OR = 0.75 (IC 95%, 0.64-0.87).	Fruit and nuts OR = 0.82 (IC95%, 0.70-0.96) MUFA/SFA, OR = 0.5 (IC95%, 0.76-0.98)
• 2005[43]	Mortality	Increase in the score = reduction in total mortality,	N.R.
Knoops and colleagues (2004)[46]	Mortality	Decrease in mortality through all causes: Adherence to the MD (OR=O.77, IC 95%; 0.67-0.89)	Physical activity (OR=O.65, IC 95%; 0.56-0.76) Moderate alcohol consumption (OR=O.83, IC 95%; 0.71-0.91) Not smoking (OR=O.67, IC 95%; 0.570.78)
Buckland and colleagues (2009)[26]	Coronary disease	Increase adherence = 40% lower cardiovascular risk (p<0.001).	Consumption of olive oil, Vegetable, and alcohol associated significantly with a decrease in cardiovascular risk. Consumption of dairy associated inversely.

MD, Mediterranean diet; Instrument, The results that don't reported for the score component means there are no significant; OR, odds ratio; N.R., Not reported; MUFA/SFA, monounsaturated fatty acids/saturated fatty acids.

Table 5b Summary of key concurrent data from the different versions of the MD adherence questionnaire

Instrument	Concurrent		
	Markers	**MD Adherence**	**Score components**
MD Indices based on positive or negative components			
Martínez-Gonzalez and colleagues			
•2002[34]	CHD: with biological markers of myocardial risk	Scores ≥20: OR = 0.17 (IC° of 95%, 0.06-0.51).	**Reduction in risk associated with consumption:** Olive oil, OR = 0.43 (IC of 95%, 0.19-0.99) Fibre OR = 0.36 (IC of 95%, 0.14-0.91) Fruit OR = 0.37 (IC of 95%, 0.14-0.96) Vegetable OR = 0.46 (IC of 95%, 0.21-1.04) Fish OR = 0.36 (IC of 95%, 0.15-0.87) Alcohol OR = 0.54 (IC of 95%, 0.24-1.22). **Increase the risk associated with consumption:** Meat and derivatives OR = 1.28 (IC of 95%, 0.61-2.70) Food with increase glycemic index OR = 1.11 (IC of 95%, 0.50-2.44
• 2004[33]	CHD: with biological markers of myocardial risk	Scores >6 on the questionnaire yield OR = 0.18 (IC of 95%, 0.03-0.97).	N.R.
Panagiotakis and colleagues (2006)[6]	Blood pressure (mmhg), C reactive protein, Fibrinogen, total cholesterol (mg/dl), BMI (Kg/m^2), coronary disease	Score inversely associated with: BP: (β-coefficient -5.1, P= <0.001) C reactive: (β-coefficient: -0.27, P= <0.001), Fibrinogen: (β-coefficient -13.5, P= <0.020) Cholesterol: (β-coefficient: -1.2, P= <0.001) BMI: (β-coefficient: -4.1, P= <0.001) Coronary disease OR: 0.46 (IC of 95%, 0.35-0.58)	N.R.
Mariscal-Arcas and colleagues (2009)[31]	BMI (Kg/m^2), weight (Kg)	Decrease score associated with increase BMI of the mother at the start of labour (p=0.045) and increase score was associated with lower weight at the end of the pregnancy (p=0.049).	N.R.
Schroder and colleagues			
• **2004[48]**	BMI (Kg/m^2),	An increase of 5U on the score was associated with a decrease in BMI 0.42 (p= 0.030, R^2: 0.082) and 0.68 (p= 0.007, R^2: 0.171) among M and W, respectively. Adjusting for confounding factors, the subjects with increase adherence displayed a 39 decrease in obesity for M and W.	N.R.
• **(2011)[32]**	BMI Changes, CHD, Waist/hip change (cm)	The MEDAS was associated with lower BMI (coefficient β: -0.146, p<0.001) Waist/hip ratio (coefficient β: -0.562, p<0.001) Cardiovascular risk (coefficient β: -0.001, p<0.001) Opposite association for the HDL-C (coefficient β:0.010, p<0.001)	N.R.
MD Indices based on the MD pyramid			
Goulet and colleagues (2003)[50]	LDL(mg/dl), apolipoprotein B, BMI(Kg/m^2),	The MD diet score was associated with lower LDL (r=-0.22, p=0.070), Apolipoprotein B (r=-0.21, p=0.070) BMI (r=-0.20, p=0.100)	N.R.

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Table 5b Summary of key concurrent data from the different versions of the MD adherence questionnaire *(continued)*

Instrument	Concurrent		
	Markers	**MD Adherence**	**Score components**
Kanauchi and colleagues 2015[51]	HBP (mmHg)	No relationship between adherence to MED score and HBP (SBP =150,3mmHg, DBP =96,4mmHg). OR= 0.97, IC 95%: 0.57-1.66, p<0.922	N.R.
Rumawas (2009)[28]	BMI (Kg/m^2),, wait-his ratio (cm)	The MSDPS was associated with: <BMI (p=0.020), <waist-hip ratio (p<0.001),	N.R.
Monteagudo (2015)[52]	BMI (Kg/m^2)	Increase score with age adherence to MDSS = decrease BMI (p<0.050).	N.R.

MD, Mediterranean diet; Instrument, The results that don't reported for the score component means there are no significant; CHD, Coronary heart disease; OR, Odds ratio; IC, Confidence interval; BMI, Body mass index; BP, Blood pressure; N.R., Not reported; M, Men; W, Woman; MEDAS, Mediterranean diet adherence screener; HDL-C, High-density lipoprotein; LDL, Low-density lipoprotein; HBP, High blood pressure; MED, Mediterranean diet index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; MSDPS, Mediterranean-style dietary pattern score; MDSS, The Mediterranean dietary serving score.

Table 6 Summary of key construct validity data and relationships with other variables from the different assessments of MD adherence scores

Instrument	Relationships with other variables	Relationships with other scales
MD Indices based on positive or negative components		
Scali and colleagues (2001)[44]	The MDQI score is related with: socio-demographic variables (p=0.021), level of education (p=0.006) and the use of tobacco (p=0.001).	N.R.
Sánchez-Villegas and colleagues (2002)[16]	Age and time spent engaged in physical activity associated with increase adherence to MDP The habit of taking an afternoon nap or siesta is associated with adherence to the MDP among M, (β= 1.4, IC 95%; 0-2.7). No association between the habit of smoking and adherence to MDP.	N.R.
Serra-Majem and colleagues (2004)[11]	Relationship with socio-economic variables (favourable index for low social class 42.8% vs. 54.9% high), level of education (favourable index for low levels of education 42.3% vs. 53.5% high) and population size (favourable index for small populations 44.3% vs. 52,8% large).	N.R.
Panagiotakis and colleagues (2006)[6]	Score inversely associated with: total antioxidants (β-coefficient 1.55, p= <0.001), Energy intake (β-coefficient -76.8, p= 0.003) The score was positively associated with: MUFA *vs.* SFA (β-coefficient: 0.16, P= 0.020). The score increase with the consumption of fruit (p0.03), Vegetable (p=0.010), potatoes (p=0.040), unrefined cereals (p=0.020), fish (p=0.010), legumes (0.001) and olive oil (p=0.010), whereas the consumption of red meat (p=0.030), poultry (p=0.030), full fat dairy (p=0.040) gave a decrease score.	N.R.
Knoops and colleagues (2004)[46]	Score average: North Europe=3 and South Europe=5. Alcohol intake: North Europe=17.5g[i]/d[j] among M and 5.5g/d W, and South=31g/d among M and 6g/d W	Compares the rMED with the MDS (Trichopoulou et al., 2003). The original score had a 14% decrease in mortality and the proposed score a 23% decrease.
Gerber (2006)[47]	The Med-DQI was associated with age, residence in rural areas, moderate-high alcohol consumption among M (inverse case for W). W with increase level of education = better quality of diet, inverse case for M. Obesity associated with decrease quality of diet among W, and with medium-low quality among M. Carotene (r=-0.12, p=0.016), vitamin E (r=-0.20, p<0.050), EPA (r=-0.-30, p<0.001) and DHA (r=-0-28, p<0.001) were increase with the quality of diet.	N.R.
Buckland and colleagues (2009)[26]	N.R.	Compares the rMED with the MDS (Trichopoulou et al., 2003). The same results are obtained.
Mariscal-Arcas and colleagues (2009)[31]	N.R.	Compares the MDS *(*Trichopoulou et al., 2003*)*. MDS= 4.31 (SD=1.32) ranking from 1 to 7 and MDS-P=7.53 (SD=1.44) ranking from 4 to 11.
Schroder and collleagues		
• 2004[48]	Among M, consumption of Fruit (p<0.001), Vegetable (p<0.001), fish (p<0.001), legumes (p<0.010, among M and among W *ns*), nuts (<0.001) and olive oil (p<0.001), carbohydrates (p<0.001), and proteins (p<0.001) ↑ significantly with a increase adherence to the MD in both sexes. M and W with increase adherence are more active (p<0.001), less smokers (p<0.050) and less drinkers of alcohol (p<0.001).	N.R.
• 2011[32]	Moderate correlation (r= 0.52) between the MEDAS score and the score calculated by means of FFQ.	N.R.
• 2012[49]	R= 0.40 between the 24 hour reminder and the mMDS. Association between dietary fibre, vitamin C, vitamin E, magnesium and potassium.	N.R.

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Table 6 Summary of key construct validity data and relationships with other variables from the different assessments of MD adherence *(continued)*

Instrument	Relationships with other variables	Relationships with other scales
MD Indices based on the diet quality index (DQI)		
Mariscal-Arcas and colleagues (2007) [12]	DQI-I associated with: duration of breakfast (p=0.003), level of physical activity (p=0.036) and age (p=0.007).	N.R.
MD Indices based on the MD pyramid		
Rumawas (2009) [28]	The MSDPS and the individual components of the score were more and significant with a range from r=0.11 for meat to r=0.50 for Vegetables. The MSDPS was associated with: dietary fibre, alcohol, omega 3 fatty acids, EPA, DHA, β- carotenes, lycopene, folic acid, vitamin C and E, calcium, magnesium, potassium and energy intake, (p<0.001). The MSDPS was associated with: age (p<0.001), <use of tobacco (p<0.001) and >consumption of multivitamins (p<0.001).	N.R.
Monteagudo (2015) [52]	Increase score with age ($0R^{u}$= 7.68; IC 3.66-16.13) Increase score with age adherence to MDSS = decrease snacking habits (p<0.050). Consumption of Vegetable, Fruit, olive oil, legumes and fish associated significantly with the 3rd tertile, Consumption of meat (white and red), sweets and pastries and fermented drinks associated with the 1st tertile (p<0.001)	Compares the MDSS with MDS (Trichopoulou et al., 1995). The MDSS displays a discrimination capacity compared with the MDS of 81%= 0.81, IC 95%: 0.736-0.890). Sensitivity=74% (IC 95%: 72-75%), specificity= 48% (IC 95%: 47-50%)
Sotos-Prieto (2014) [53]	The MEDLIFE score associated inversely with the consumption of sweets and pastries (β= -0.29, p=0.019), red meat (β= -0.14, p<0.001) and processed meat (β= -0.11, p=0.001). Inversely associated with number of hours spent watching TV (β= -0.10, p<0.001). The consumption of vegetable, fish, herbal teas, preference for whole grain cereals, limiting salt and limiting added sugar intake, and hours of physical activity correlated with the MEDLIFE, with β coefficients > 0.20. Nutrients, consumption of MUFA and PUFA, (omega 3) were associated with increase in the MEDLIFE. Similar results for vitamin C, Ca and Fe (p<0.001). Inverse association for trans fatty acids, saturated fatty acids, sugar, and levels of glucose (p<0.001).	The MEDLIFE was significantly associated with the AHEI, aMED and MEDAS (range ρ: 0.44-0.53; p<0,001)
MD Index based on characteristic components of the MD		
Alberti-Fidanza and colleagues • 2004[55]	Increase of 2.8 points on the MAI after monitoring the population over the years.	N.R.
Woo et al and colleagues (2001) [56]	Variations in the dietary pattern detected according to gender (p<0.001), geographical area (p<0.001) and age (p<0.001)	N.R.

MD, Mediterranean diet; Instrument, The results that don't reported for the score component means there are no significant; MDQI, Mediterranean diet quality index; N.R., not reported; MPD, Mediterranean pattern diet; M, men; MUFA, monounsaturated fatty acids; SFA, saturated fatty acids; g, grams; d, day; W, women; rMED, relative Mediterranean diet; MDS, Mediterranean diet score; EPA, Eicosapentaenoic acid; DHA, Docosahexaenoic acid; FFQ, food frequency questionnaire; MEDAS, Mediterranean diet adherence screener; mMDS, a modified Mediterranean diet score; DQI-I, diet quality index-international; MSDPS, Mediterranean-style dietary pattern score; OR, Odds ratio; MDSS, the Mediterranean dietary serving score; MEDLIFE, the Mediterranean lifestyle; PUFA, Polyunsaturated fatty acids; AHEI, the alternative healthy eating index; aMED, the alternative Mediterranean diet index; Ca, calcium; Fe, iron; MAI, the Mediterranean adequacy index.

Table 7. Summary information data from the different versions of the MD adherence scores.

Instrument	Cross-Cultural adaptation	Applicability	Reliability	Validity
MD Indices based on positive or negative components				
Trichopoulou and colleagues				
• 1995[30]	+	+	?	+
• 2003[14]	+	++	?	+
• 2005[43]	+	+	?	+
Scali and colleagues (2001)[44]	+	++	?	+
Sánchez-Villegas and colleagues (2002)[16]	+	+	?	+
Martinez-Gonzalez and colleagues				
• 2002[34]	+	+	?	++
• 2004[33]	+	+	?	++
Serra-Majem and colleagues (2004)[11]	+	?	?	+
Panagiotakis and colleagues (2006)[6]	+	++	?	++
Trichopoulos and colleagues (2004)[45]	?	+	?	+
Knoops and colleagues (2004)[46]	+	+	?	++
Gerber (2006)[47]	+	+	?	+
Buckland and colleagues (2009)[26]	+	++	?	+
Mariscal-Arcas and colleagues (2009)[31]	?	+	?	+
Schroder and colleagues				
• 2004[48]	+	+	?	+
• 2011[32]	+	+	?	++
• 2011[49]	?	+	?	?

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Table 7. Summary information data from the different versions of the MD adherence scores. *(continued)*

Instrument	Cross-Cultural adaptation	Applicability	Reliability	Validity
Benítez-Arciniega and colleagues (2011)[29]				
• **mMDS**	+	+	+	?
• **MLDS**	+	+	+	?
MD Indices based on the diet quality index (DQI)				
Mariscal-Arcas and colleagues (2007)[12]	+	+	?	+
MD Indices based on the MD pyramid				
Goulet and colleagues (2003)[50]	+	+	?	+
Rumawas and colleagues (2009)[28]	+	+	?	+
Kanauchi and colleagues (2015)[51]	+	+	?	++
Monteagudo and colleagues (2015)[52]	+	+	?	+
Sotos-Prieto and colleagues (2014)[53]	+	+	++	+
MD Index based on characteristic components of the MD				
Alberti-Fidanza and colleagues				
• 1999[54]	+	+	?	+
• 2004[55]	?	+	?	+
Woo and colleagues (2001)[56]	+	++	?	+

Process of cross-transcultural adaptation
?= not reported
+ = translation only
++= translation-back translation
+++ =translation-back translation and pilot test
Applicability
?= not reported
+= data about the process of administration and interviewing
++ =visual material about foods and training of interviewers
+++= normative data
Reliability
?= not reported or weak associations of some aspect of internal consistency reported
+= alpha coefficient of internal consistency or intra-rater or inter-rater reliability reported
++ =alpha coefficient or ICC or correlated coefficient >0.70;
Validity
?= not reported
+=: evidence from criterion or construct validity
++=evidence from criterion and construct validity
[c]MD= Mediterranean Diet
[f]mMDS= modified Mediterranean Diet Score
[g]MLDS= Mediterranean-like diet score
[h]DQI= diet quality index

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2,3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4,5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4,5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4,5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	4-7
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5,6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	31
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7,8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8-28
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8-28
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	27,28
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8-28
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	29,30
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	31
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	31
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

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