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Revisión

# Description of indexes based on the adherence to the Mediterranean Dietary Pattern: a review

Angela Hernández Ruiz[1,2], Belén García-Villanova[1], Eduardo J. Guerra Hernández[1], Pilar Amiano[3,4], Mikel Azpiri[3] and Esther Molina Montes[4,5]

*[1]Departamento de Nutrición y Bromatología. Facultad de Farmacia. Universidad de Granada. [2]Programa de Doctorado en Nutrición y Ciencia de los Alimentos. Universidad de Granada. [3]Public Health Division of Gipuzkoa, Biodonostia Research Institute, Health Department, San Sebastian. [4]CIBER Epidemiología y Salud Pública, CIBERESP, Madrid. [5]Escuela Andaluza de Salud Pública. Instituto de Investigación Biosanitaria ibs.GRANADA. Hospitales Universitarios de Granada/Universidad de Granada (Granada), España.*

**Abstract**

***Introduction:*** **diet quality indexes are tools are aimed at quantifying the compliance to a defined dietary pattern. These indexes are a combined measure of dietary factors (food groups, foods, nutrients and ratios) and/or lifestyles factors. The Mediterranean Diet (MD) is a dietary pattern characterized by their positive effects against chronic diseases. There have been many indexes proposed for the assessment of this dietary pattern. An evaluation of their composition and health benefits is therefore convenient.**

***Objective:*** **the objective is to evaluate indexes of adherence to the MD with regard to their definition, methodological issues and validation as reported in epidemiological studies.**

***Methods:*** **we searched in PubMed for studies that developed MD Indexes up to October 2014.**

***Results:*** **a total number of 22 indexes were identified, with differences regarding the number of components (7-28), scoring (0, 1, 2, 3, 4, 5, 8 or 10, in case of compliance), range (0-100) and type of components (which could be food groups/foods or their combination, with nutrients). Among the positive components, fruits and vegetables were the most common and meats, among the negative components. There were also differences with regard to their composition and evaluation (e.g. criteria of moderate alcohol consumption), as well as with the scoring system (in medians, terciles or established servings).**

**DESCRIPCIÓN DE ÍNDICES BASADOS EN LA ADHESIÓN AL PATRÓN DIETÉTICO MEDITERRÁNEO: UNA REVISIÓN**

**Resumen**

***Introducción:*** **los índices de calidad la de dieta son herramientas que sirven para cuantificar el cumplimiento de un patrón dietético definido. Estos índices son una medida combinada de factores dietéticos (grupos alimenticios, alimentos, nutrientes y ratios) y/o estilos de vida. La dieta mediterránea (DM) es un patrón dietético que se caracteriza por sus efectos positivos contra ciertas enfermedades crónicas. Existen numerosos índices propuestos para la valoración de este patrón dietético. Es por lo tanto conveniente una evaluación de su composición y sus efectos sobre la salud.**

***Objetivo:*** **el objetivo es evaluar los índices de adhesión al patrón dietético mediterráneo en cuanto a su definición, aspectos metodológicos y validación en estudios epidemiológicos.**

***Métodos:*** **se buscaron en PubMed estudios que desarrollaron índices de DM hasta octubre de 2014.**

***Resultados:*** **se identificaron un total de 22 índices, con diferencias en cuanto al número de componentes (7-28), puntuación (0, 1, 2, 3, 4, 5, 8 o 10, en el caso de cumplimiento), rango (0-100) y tipo de componentes (grupos de alimentos/alimentos o su combinación con nutrientes). Entre los componentes positivos, los más comunes fueron frutas y verduras, y carnes entre los negativos. También hubo diferencias con respecto a su composición y evaluación (p. ej. criterios de consumo moderado de alcohol), así como con el sistema de puntuación (en medianas, terciles o raciones establecidas).**

**Correspondence:** Belén García-Villanova.
Departamento de Nutrición y Bromatología. Facultad de Farmacia, Campus Universitario de Cartuja, 18012 (Granada), España.
E-mail:belenv@ugr.es.

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***Conclusions:*** **this review suggests that since there is great heterogeneity in the definition of MD. It would be therefore convenient to establish more clearly the components to be included and to establish commonly defined criteria to quantify this dietary pattern.**

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Key words: *Mediterranean diet. Food habits. Nutrition assessment. Dietary pattern. Diet index.*

***Conclusiones:*** **esta revisión sugiere que existe una gran heterogeneidad en la definición de DM. Sería por tanto apropiado establecer con mayor claridad los componentes que deben incluirse, así como definir criterios comunes para cuantificar este patrón dietético.**

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Palabras clave: *Dieta mediterránea. Hábitos alimentarios. Evaluación nutricional. Patrón dietético. Índice de dieta.*

## Abbreviations

aMED: Alternate Mediterranean Diet Index.
Cardio: Cardioprotective Mediterranean Diet Index.
ITALIAN-MED: Italian Mediterranean Index.
L-based to the MD: Literature-based adherence score to the Mediterranean Diet.
MAI: Mediterranean Adequacy Index.
MeDite-PREDIMED/MEDAS: Mediterranean food pattern PREDIMED study.
MEDLIFE index: Mediterranean Lifestyle Index.
MD: Mediterranen Diet .
MDP: Mediterranean Dietary Pattern .
MDQI: Mediterranean Diet Quality Index.
MDS : Mediterranean Diet Scale.
MMD: Modified Mediterranean Diet .
mMDS: Modified Mediterranean Diet Score .
MD Score: Mediterranean Diet Score.
MSDPS: Mediterranean-Style Dietary Pattern Score.
MUFA: Monounsaturated fatty acids.
PUFA: Polyunsaturated fatty acids.
rMED: Relative Mediterranean Diet Score.
RR: relative risk.
SFA: Saturated fatty acids.

## Introduction

Nutritional epidemiology aims to determine the impact of diet and associated factors on health. Considering single dietary factors (food, nutrients,…) is a too simple view, since the main role is played overall by diet and both positive (synergism) and negative interactions (antagonism) between its various components[1]. These interactions are very difficult to interpret, as well as their relationship with risk of diseases or health determinants[2].

Diet quality indexes are tools to measure and quantify adherence to dietary patterns (food groups, foods and nutrients), quality indicators and /or lifestyle factors. The compliance to a defined dietary pattern or the adherence to it might be related to the risk of disease or their determinants[3].

The Mediterranean Diet (MD) is a nutritional model that is confined to the countries around the Mediterranean Sea[4,5,6]. This diet is based on high consumption of vegetables, fresh fruits, nuts, legumes, whole grains mainly and fish, fewer consumption of eggs and dairy products and an even lower consumption of meat, consumed especially pork, sheep and poultry. One of its main characteristic is the use of olive oil as a cooking fat and consumption of red wine in moderation during meals. This type of dietary pattern based on a high consumption of plant–based foods, which provide antioxidant nutrients and hundreds of non-nutritive constituents, such as phytochemicals, with important biological activities and a significant role in health preservation[7]. Numerous epidemiological studies have shown that the Mediterranean countries have a lower morbidity and mortality from non-communicable chronic diseases than other countries[8-13]. Trichopoulou et al. (1995) were the first defining an index of adherence to the MD, to assess the association between the adherence to it and mortality risk in an elderly population[14]. This index consisted of eight components: seven food groups/ foods (vegetables, fruits and nuts, legumes, grains, meat and meat products, milk and dairy products and wine red intake) and one ratio to account for the quality of fat (monounsaturated fatty and saturated fatty acids ratio; MUFA/SFA). This score was further modified by the same authors including fish intake and a higher adherence to this index was also associated with a lower mortality risk[8]. Interestingly, when the associations were assessed separately for each component, no statistically significant risks of mortality were found. This finding supported that diet as a whole may provide a more comprehensive approach to analyze the role of diet in disease prevention.

Since then, various indexes have been published to assess adherence to the MD. Some of them are based on slight modifications of the initially proposed score by Trichopolou et al. (1995)[14], while others do not share important aspects of its definition. Some of these indexes have been developed to adapt the MD to different populations, countries and age groups. The differences are mostly related to the components and the scoring system, giving rise to a great diversity or indexes regarding the number and types of components (food, food groups, nutrients, and/or lifestyle factors), scoring criteria and cut points used for scoring (mainly medians or tertiles).

The evaluation of indexes of adherence to the MD is of great interest to establish their predictive capacity of disease risk as there are numerous studies that have addressed the MD-disease relationship using different indexes of this dietary pattern[15]. The reliability of 10 indexes of adherence to the MD was analyzed within a healthy population in the study by Milá-Villaroel et al. (2011)[16]. Since a moderate correlation was found between several indexes, the authors concluded that a consensus on the components included in the MD indexes should be reached. However, a critical evaluation of the components included in these indexes was not carried out.

Our aim is to evaluate and compare indexes of adherence to this dietary pattern published in the literature with regard to the definition of the MD, considering their components, differences and similarities as well as their scoring shemes.

## Methods

We searched in Pubmed database for studies that developed and used Mediterranean Dietary Indexes in adults and elderly population up to October 2014. The following MeSH terms related with mediterranean dietary quality indexes were used for this purpose: Food Habit, Diet Mediterranean, Health Food, Nutrition Policy, Diet Therapy, Nutrition Therapy and Health. Moreover, we combined in this research strategy the following key words: Diet quality, Healthy diet, Diet index, Diet quality index, Dietary pattern, A priori diet, Dietary habit, Diet score, Healthy. In addition, references from selected articles were reviewed to find additional studies that were not retrieved through the initial search.

## Results

The search strategy retrieved twenty two indexes of adherence to the Mediterranean diet: Mediterranean Diet Scale (MDS, in different versions, 1995[14], 2003[8] and 2013[17]), Modified Mediterranean Diet[18] (MMD), Mediterranean Dietary Pattern (MDP, in different versions, 2002[19], 2003[20] and 2006[21]), Mediterranean-Style Dietary Pattern Score[22] (MSDPS), Mediterranean Diet Quality Index[23] (MDQI), Mediterranean Adequacy Index[24] (MAI), Alternate Mediterranean Diet Index[25] (aMED), Italian Mediterranean Index[26] (ITALIAN-MED), Relative Mediterranean Diet Score[27] (rMED), Mediterranean Diet Score (MD Score, in 2001[28], 2004[29], 2005[30] and 2007[31]), Modified Mediterranean Diet Score[32] (mMDS), Cardioprotective Mediterranean Diet Index[33] (Cardio), Mediterranean food pattern PREDIMED study[34] (MeDite-PREDIMED/MEDAS), Literature-based adherence score to the Mediterranean Diet[35](L-based to the MD) and Mediterranean Lifestyle Index[36] (MEDLIFE index).

*Components and scoring schemes of the indexes of adherence to the MD.*

A description of the components of the indexes of adherence to the MD is shown in table **I.** The number of components of the indexes varied greatly. For instance, there were indexes with seven components (one index)[23], eight components (three indexes)[14,19,28], nine components (seven indexes)[8,18,25,27,29,33,35], ten components (three indexes)[17,21,32], eleven components (three indexes)[26,30,31], thirteen components (one index)[22], fourteen components (one index)[34], sixteen components (one index)[24], eighteen components (one index)[20] and twenty eight components (one index)[36]. Differences were also observed by types of components included in the indexes. The majority of these components were food groups / foods combined with nutrients (in eight indexes)[17-21,23,25,27] or only food groups / foods (in eight indexes)[22,24,26,29-31,33,34] without nutrients, food groups / foods combined with ratios (in two indexes)[14,17] or groups / foods combined with both nutrients and ratios (in two indexes)[8,28], as well as indexes that included lifestyle factors with food groups / foods (in one index)[32] or with groups of foods / foods combined with nutrients (one index)[36]. Other differences were noted regarding the scoring scheme applied to each index, which was mostly based on assigning equal weights to all the components. This scoring scheme of the components ranged between 0 to 1 (in eleven index es)[8,14,17,18,20,25,26,28,33,34,36], 0 to 2 (in three indexes)[23,27,35], 1 to 3 (in two indexes)[21,29], 0 to 5 (in three indexes)[19,30,31] or 0 to 10 (in one index)[22]. The mMDS was the only index using three different scoring weights (0 to 2, 0 to 4 and 0 to 8)[32].

The total range of the scores, as a result of the components´ scoring, was also different, ranging from 0 to 8 (in two indexes)[14,28], 0 to 9 (in four indexes)[8,18,25,33], 0 to 10 (in one index)[17], 0 to 11 (in one index)[26], 0 to 14 (in three indexes)[20,23,34], 0 to 18 (in two indexes)[27,35], 9 to 27 (in one index)[29], 0 to 28 (in one index)[36], 10 to 30 (in one index)[21], 5 to 40 (in one index)[19], 0 to 42 (in one index)[32], 0 to 55 (in two indexes)[30,31], and 0 to 100 (in two indexes)[22,24].

Table II shows dietary components included in each index of adherence to the MD. The components most commonly present in the indexes were vegetables (in twenty two indexes)[8,14,17-36], and fruits (in twenty two indexes)[8,14,17-36], followed by cereals (in twenty one indexes)[8,14,17-33,35,36], fish (in twenty indexes)[8,17-27,29-36], meat (in twenty indexes)[8,14,18-31,33-36], legumes (in eighteen indexes)[8,14,17,18,21,22,24-31,33-36], olive oil (in sixteen indexes)[19-24,26,27,29-36], milk and dairy products (in fifteen indexes)[8,14,17,18,20,22,24,27-31,35,36,] alcoholic beverages (in twelve indexes)[14,20-22,24,29-34,36], nuts (in eleven indexes)[8,14,17,18,21,22,25,27,29,34,36], alcohol (in ten indexes)[8,17-20,25-29,35], sweets and sweetened beverages (in six indexes)[22,24,26,32,34,36,] other fat (in four indexes)[20,24,26,34], eggs (in four indexes)[20,22,24,36,] MUFA / SFA ratio (in four indexes)[8,14,25,28], fiber (in two in-

**Table I**
*Description of the components of the indexes of adherence to the MD*

| *Reference* | *Index* | *Components* | *Scoring* | *Range* |
|---|---|---|---|---|
| Trichopoulou et al., 1995[14] | Mediterranean Diet Scale 1995 (MDS 95) | 8 components (7 foods groups/foods, 1 ratio) | 0-1 | 0-8 |
| Trichopoulou et al., 2003[8] | Mediterranean Diet Scale 2003 (MDS 03) | 9 components (7 foods groups/foods, 1 nutrient, 1 ratio) | 0-1 | 0-9 |
| Asghari et al., 2013[17] | Mediterranean Diet Scale 2013 (MDS 13) | 10 components (8 foods groups/foods, 2 ratios) | 0-1 | 0-10 |
| Trichopoulou et al., 2005[18] | Modified Mediterranean Diet (MMD) | 9 components (8 foods groups/foods, 1 nutrient) | 0-1 | 0-9 |
| Martinez-Gónzalez et al. , 2002[19] | Mediterranean Dietary Pattern 2002 (MDP 02) | 8 components (6 foods groups/foods, 2 nutrients) | 0-5 | 5-40 |
| Ciccarone et al., 2003[20] | Mediterranean Dietary Pattern 2003 (MDP 03) | 18 components (17 foods groups/foods, 1 nutrient) | 0-1 | 0-14 |
| Sánchez-Villegas et al. , 2006[21] | Mediterranean Dietary Pattern 2006 (MDP 06) | 10 components (9 foods groups/foods, 1 nutrient) | 1-3 | 10-30 |
| Rumawas et al., 2009[22] | Mediterranean-Style Dietary Pattern Score(MSDPS) | 13 components (13 foods groups/foods) | 0-10 | 0-100 |
| Scali et al., 2000[23] | Mediterranean Diet Quality Index (MDQI) | 7 components (5 foods groups/foods, 2 nutrients) | 2-0 | 14-0 |
| Alberti et al., 2009[24] | Mediterranean Adequacy Index (MAI) | 16 components (16 foods groups/foods) | - | 0-100 |
| Fung et al., 2005[25] | Alternate Mediterranean Diet Index (aMED) | 9 components (8 foods groups/foods, 1 nutrient) | 0-1 | 0-9 |
| Agnoli et al., 2005[26] | Italian Mediterranean Index (ITALIAN-MED) | 11 components (11 foods groups/foods) | 0-1 | 0-11 |
| Buckland et al., 2009[27] | Relative Mediterranean Diet Score (rMED) | 9 components (8 foods groups/foods, 1 nutrient) | 0-2 | 0-18 |
| Woo et al., 2001[28] | Mediterranean Diet Score 2001 (MD Score 01) | 8 components (6 foods groups/foods, 1 nutrient, 1 ratio) | 0-1 | 0-8 |
| Schroder et al., 2004[29] | Mediterranean Diet Score 2004 (MD Score 04) | 9 components (9 foods groups/foods) | 1-3 | 9-27 |
| Pitsavos et al., 2005[30] | Mediterranean Diet Score 2005 (MD Score 05) | 11 components (11 foods groups/foods) | 0-5 | 0-55 |
| Panagiotakos et al., 2007[31] | Mediterranean Diet Score 2007 (MD Score 07) | 11 components (11 foods groups/foods) | 0-5 | 0-55 |
| Yang et al., 2014[32] | Modified Mediterranean Diet Score (mMDS) | 10 components (8 foods groups/foods, 2 lifestyle factors) | 0-2<br>0-4<br>0-8 | 0-42 |
| Martinez-Gónzalez et al., 2004[33] | Cardioprotective Mediterranean Diet Index (Cardio) | 9 components (9 foods groups/foods) | 0-1 | 0-9 |
| Martínez-González et al., 2012[34] | Mediterranean food pattern PREDIMED Study (MeDiet-PREDIMED/ MEDAS) | 14 components (14 foods groups/foods) | 0-1 | 0-14 |
| Sofi et al., 2013[35] | Literature-based adherence score to the Mediterranean diet (L-based to the MD) | 9 components (8 foods groups/foods, 1 nutrient) | 0-2 | 0-18 |
| Sotos-Prieto et al., 2014[36] | Mediterranean Lifestyle (MEDLIFE index) | 28 components (21 foods groups/foods, 1 nutrient, 6 lifestyle factors) | 0-1 | 0-28 |

**Table II**
*Dietary components included in each index of adherence to the MD*

| *Components (p or g/d)* | *MDS 95*[14] | *MDS 03*[8] | *MDS 13*[17] | *MMD*[18] | *MDP 02*[19] | *MDP 03*[20] | *MDP 06*[21] | *MSDPS*[22] | *MDQI*[23] | *MAI*[24] | *aMED*[25] | *ITA-MED*[26] | *rMED*[27] | *MD Score01*[28] | *MD Score04*[29] | *MD Score05*[30] | *MD Score07*[31] | *mMDS*[32] | *Cardio*[33] | *PREDI-MED*[34] | *Lbased*[35] | *MED-LIFE*[36] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cereals | X[1] | X | X[3] | X | X[4] | X[5] | X | X[13],[14] | X | X[14] | X[13] | X[21] | X | X | X | X[13],[14] | X[13],[14] | X | X[23] | - | X | X[14] |
| Vegetables | X | X | X | X | X | X[6] | X | X | X[16] | X | X | X | X | X | X | X | X | X | X[24] | X | X | X |
| Fruits | X[2] | X[2] | X | X | X | X | X | X | X | X[17] | X[20] | X | X[2] | X | X | X | X | X | X | X[20] | X | X[20] |
| Legumes | X | X | X | X | - | - | X | X[15] | - | X | X | X | X | X | X | X | X | - | X | X | X | X |
| Nuts | X | X[2] | X | X[2] | - | - | X | X | - | - | X | - | X | - | X | - | - | - | - | X | - | X[25] |
| Olive oil | - | - | - | - | X | X | X | X | X | X | - | X | X | - | X | X | X | X | X | X | X | X |
| Other fats | - | - | - | - | - | X[7] | - | - | - | X[18] | - | X[22] | - | - | - | - | - | - | - | X | - | - |
| Milk, dairy products | X | X | X | X | - | X[8] | X[11] | X | - | X[8] | - | - | X | X | X[11] | X[11] | X[11] | - | - | - | X | X[26] |
| Fish | - | X | X | X | X | X | X | X | X | X | X | X | X | - | X | X | X | X | X | X | X | X |
| Eggs | - | - | - | - | - | X | - | X | - | X | - | - | - | - | - | - | - | - | - | - | - | X |
| Meat, meat products | X | X | - | X | X | X[9] | X | X[9] | X | X | X | X | X | X | X | X[9] | X[9] | - | X | X[9] | X | X[9] |
| Meat rate | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sweets, sweets beverages | - | - | - | - | - | - | - | X | - | X[19] | - | X | - | - | - | - | - | X | - | X | - | X |
| Fiber | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | X |
| SFA (% kcal) | - | - | - | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cholesterol (mg) | - | - | - | - | - | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MUFA/SFA | X | X | - | - | - | - | - | - | - | - | X | - | - | X | - | - | - | - | - | - | - | - |
| PUFA/SFA | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MFA+SFA/SFA | - | - | - | X | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Alcoholic beverages | X | - | - | - | - | X[10] | X[12] | X | - | X | - | - | - | - | X[12] | X | X | X[12] | X[12] | X[23] | - | X[12] |
| Alcohol | - | X | X | X | X | X | - | - | - | - | X | X | X | X | X | - | - | - | - | - | X | - |

[1]Including bread and potatoes. [2]Joint fruits and nuts. [3]Refined cereals consumption (negative) or whole grains (positive). [4]Cereals: the sum of white bread, rice and pasta. [5]Four components that are not scoring (pasta, white bread, wheat bread and milk). [6]Includes raw vegetables, cooked vegetables and carrots. [7]Includes like separate components: vegetable oils, butter, cream and margarine. [8]Separate the consumption of milk and cheese. [9]Separate into two components: meat or poultry and processed meat. [10]Alcohol intake: wine, beer and spirits. [11]Specifies fat dairy[12]Alcohol intake: wine or red wine. [13]Including only whole cereals. [14] Including like component the potatoes. [15]This component includes: olives, legumes and nuts. [16]Joint vegetables and fruits. [17]Including fruit fresh and dry. [18]Including animal fats and margarines. [19]Separate in different components: sweet beverages, cakes/pies and cookies. [20]Including juices. [21]Specifies the consumption the pasta and the potatoes. [22]Including only butter. [23]Specifies cereals as white bread and rice or whole bread. [24]Joint and separate components for vegetables and fruits. [25]Including nuts and olives. [26]Specifies low fat dairy.

dexes)[19,36], meat rate (in one index)[17], SFA (in one index)[23], cholesterol (in one index)[23], PUFA / SFA ratio (in one index)[17], and MUFA + PUFA / SFA ratio (in one index)[18].

*Description of the components of the MD indexes*

Food groups / foods

- Cereals. This food group was considered as positive on the indexes. Cereals consumption is valued (without specifying whether they are refined or whole). However, there were two indexes that penalized their consumption: the MDS 2013[17] index considers refined cereals as a negative component and whole cereals as a positive component and the Cardio index[33] considers white bread and white rice as a negative component and whole bread as a positive component.
- Vegetables. It is a component included in all indexes and its assessment was always positive. A particular index worthy of mentioning is the Cardio index[33], which had two components for assessment of vegetables: one accounting only for vegetables and another one combining intake of vegetables and fruits.
- Fruit. The assessment of this group was also always positive. Some indexes included in this group the intake of nuts as are this indexes [8,14,17,27] and there was one index specifying the inclusion of dried fruit[24].
- Legumes. Its assessment was always positive. All indexes included legumes as a whole, although there was one index that also included nuts and olives within this component[22].
- Nuts. This component was always valued positively. Some indexes considered nuts in combination with fruits[8,14]. Particularly, there was one index considering intake of nuts combined with that of olives[36].
- Fats: Olive oil and other fats. Assessing the form of dietary fat is one of the most differing characteristic of the indexes. Some indexes specified the consumption of olive oil as a positive component[19-24,26,27,29-36], whilst others took the presumed detrimental effect of fats into consideration, considering them as to be scored negatively. This was to the case of other vegetable oils, butter, cream and margarine[20], animal fat and margarine[24], and butter[26,34]. Besides, some indexes implemented ratios for assessment of dietary fat quality. The ratios considered were the MUFA/SFA, the MUFA + PUFA / SFA and the PUFA / SFA.
- Milk and dairy products. This component presented a high diversity in its assessment. On the one hand, most of the indexes valued this group as negatively in the diet, in particular, when they referred to fatty milk and dairy products[21,29,30,31]. On the other hand, they were positively valued if skimmed milk and dairy products were considered[36]. In general, all valued the consumption of milk and dairy products together[8,14,17,18,21,22,27-31,34], except few indexes that separated them into different components of the same group, e.g. cheese[20].
- Fish. Most indexes included this component[8,17-27,29-36]. It was always valued positively and any of the indexes distinguished between fatty and lean fish.
- Eggs. Few indexes considered eggs as a MD component[20,22,24,36]. A moderate or low consumption was considered adequate.
- Meats. The indexes differed greatly regarding the definition of this component, although the assessment was always considered to be negative. Some indexes accounted for meat consumption in general[8,14], few others only consider red meat and processed meat[20,21,25,35], and others distinguished between lean meat and fatty meat in two separate components with a different scoring weight[22,30,31,34,36]. There was only one index valuing this food group through a ratio as red-to-white meat[17].
- Sweets, confectionery and sweetened beverages. This component was always valued negatively. Only two indexes considered these foods, including sweetened beverages and different types of sweets[32,34].
- Alcoholic beverages. This component was assessed in many different ways depending on the index under consideration. Some indexes valued positively the consumption of alcohol when this was defined as moderate consumption of wine[14,21,22,29,31,33,34,36] and other indexes included all types of alcoholic beverages[20].

Nutrients

There were few indexes that included nutrients as components, namely fiber[19,36], SFA[23], cholesterol[23] and the most importance, alcohol intake. This component was overall common to all the indexes was the positive scoring of moderate alcohol consumption, which was defined as moderate levels (g/alcohol/day) by sex-specific consumption levels[8,17-20,25-29,35]. The definition of moderate alcohol consumption differed among the indexes as well: 10-20 g/day[21], or 5-25 g/day in women and 10-50 g/day in men[8,18,27] or 0 g/day in women and up to 10 g/day in men[28].

Lifestyle factors

There were only two indexes that included lifestyle factors[32,36]. The MMDS, considered drinking during

meals and eating fast food or out from home[32]. The recently published MEDLIFE index included a specific section accounting for six lifestyle factors: physical activity, nap, hours of sleep, watching television, socializing with friends and collective sports[36].

*Cut off values*

Among the indexes, the scoring criteria for each component varied greatly. These criteria are shown in table III.

Three types of cut offs were considered to account for dietary intake within each component (except that of alcohol intake): 1) based on the distribution of the dietary intake in the study population in grams/day[8,14,17,18,19,21,23,26,27,28,29]; 2) based on a fixed amount of dietary intake in servings/day or grams/day[20,22,25,30,31,33-36]; 3) or using arbitrary choices of cut points[22,24,32]. Regarding the first case, the cut off values to assign the scoring could be established as sex-specific medians of the intake distribution[8,14,17,18,19,25] as tertiles[21,23,26,27,29,30] or as quintiles[19].

*Description of studies that have developed the Mediterranean diet indexes*

European countries

- Spain. Martinez-Gónzalez et al. developed the Mediterranean Dietary Pattern 2002 (MDP 02) in a study population comprised of 342 subjects aged <80 years[19]. Increments of one unit in the adherence to this score were associated with 8% (95 % CI: 0.86-0.98) reduction of the risk of myocardial infarction. This score was modified by Sánchez-Villegas et al. (2006) within 6319 subjects of the SUN cohort, in whom no significant association was observed between the adherence to this Mediterranean Dietary Pattern adherence index (MDP 06) and weight gain[21]. Buckland et al. in 2009, developed the Relative Mediterranean Diet Score within 41,078 participants of the EPIC-Spain cohort[27]. This score is based on the score developed previously by Trichopoulou et al.[8,14], although some modifications were adopted, such as that olive oil replaced the fat ratio and tertiles were used as cut points instead of sex-specific medians. The rMED has been associated with a significant reduction in CHD risk (RR for one unit increase in the adherence to rMED: 0.94, 95 % CI: 0.47- 0.76). In 2004, Schroder et al., reported that risk of obesity decreased with increasing adherence to the DM defined as the Mediterranean Diet Score 2004 (MD Score -04)[29] in 2930 adults and elderly subjects, as those in the highest group of adherence to the score were less likely to be obese with respect to those of the lowest group of adherence (OR=0.61; 95% CI: 0.40-0.92 in men and women). Martinez-Gónzalez et al. (2004), developed the Cardioprotective Mediterranean Diet Index (Cardio) in a study that included 342 subjects[33]. They found that an increment of one unit in the adherence to this score was associated with 18% reduction in the risk of myocardial infarction. In 2012 within the PREDIMED trial and 7,447 adults with cardiovascular risk factors, the Mediterranean food pattern PREDIMED was developed[34]. A high adherence to this score (≥ ten points) versus a low adherence (≤ seven points) was found to reduce the risk of obesity by 32% (95% CI: 0.57-0.80) in women and by 34% (95% CI: 0.44-0.80) in men. Recently, Sotos-Prieto et al., 2014 developed the Mediterranean Lifestyle Index (MEDLIFE index) in 988 participants of 40-55 years age belonging to the Aragon Workers Health Study cohort, which also incorporates lifestyles factors as components[36]. This index was positively correlated with other Mediterranean quality indexes, as aMED[25] and MeDiet-PREDIMED/MEDAS[34].
- Greece. The first score/index of adherence to the MD was developed by Trichopoulou et al., in 1995 among an elderly population (182 participants)[14]. In this study, a one unit increase in the score was associated with a 17% reduction of overall mortality (95 % IC: 0.69-0.99). The same authors modified this index in 2003 within the 22,043, participants of the EPIC-Greek Cohort. A higher adherence to this new index was associated with a reduction of mortality in adults and elderly people[8]. Moreover, two units increment in this score was inversely associated with mortality (RR=0.75, 95% CI: 0.74-0-87), as well as with cause-specific mortality of coronary heart disease (RR= 0.67: 95% CI: 0.47-0.94) and cancer (RR=0.66, 95% CI: 0.59-0.98).

  A new modification of MDS 2003 was carried out in 2005. This Modified Mediterranean Diet index (MMD) was also developed within the EPIC cohort[18]. An increase of two units in this score was associated with a 8% (95% IC: 0.88-0.97) lower overall mortality risk.

  Pitsavos et al., 2005 developed the Mediterranean Diet Score 2005[30]. They found that the participants (3,042 subjects of the ATTICA study) in the highest tertile of the adherence to the score had, on average, 11% higher Total Antioxidant Capacity levels than did the participants of the lowest tertile have. The score was modified in the study by Pangiotakos et al. 2007 by using different cutt off values[31]. There were found positive predictive values of the score regarding hypertension 45% (95% CI:

**Table III**
*Scoring system of each index of adherence to the Mediterranean Diet for the maximum scoring*

| *Components* | *MDP03*[20] | *MSDSP*[22] | *MDQI*[23] | *MD Score 01*[28] | *MD Score 05*[30] | *MD Score 07*[31] | *Cardio*[33] | *MeDi-PREDIMED*[34] | *L-based MD*[35] | *MEDLIFE index*[36] |
|---|---|---|---|---|---|---|---|---|---|---|
| Cereals | - | 8 s/d | > 300 g/d | > 248 g/d/W<br>> 291 g/d/M | > 18 s/m | > 22 s/w | <1 s/d or >5 s/w[2,3] | - | > 1.5 s/d | 3-6 s/d |
| Vegetables and fruits | ≥ 17 s/w | 6 s/d | > 700 g/d | > 248 g/d/W<br>> 303 g/d/M | > 18 s/m | >33 s/w | ≥ 1 s/d[4] | ≥ 2 s/d | > 2.5 s/d | ≥ 2 s/d |
| | > 1 s/d | 3 s/d | | > 216 g/d/W<br>> 249 g/d/M | > 18 s/m | >22 s/w | ≥ 1 s/d | ≥ 3 s/d | > 2 s/d | 3-6 s/d |
| Legumes | - | 4 s/w[1] | - | > 49 g/d/W<br>> 60 g/d/M | 0-18 s/m | > 6 s/w | ≥ 2 s/w | ≥ 3 s/w | > 2 s/d | ≥ 2 s/w |
| Olive oil | >1 s/d | Only use | > 15 g/d | - | 0-18 s/m | Daily | ≥ 1 sp/d | ≥4 sp/d | Regular use | ≥ 3 s/d |
| Nuts | - | 4 s/w[1] | - | - | - | - | - | ≥3 s/w | - | - |
| Other fats | - | - | - | - | - | - | - | <1 s/d | - | - |
| Milk, dairy products | - | 2 s/d | - | <194 g/d/W<br><201 g/d/M | Rare/<br>no consumption | ≤ 10 s/w | - | - | < 1 s/d | 2 s/d |
| Fish | ≥ 1s/w | 6 s/w | > 60 g/d | - | > 18 s/m | >6 s/w | ≥ 3 s/w | ≥3 s/w | > 2.5 s/d | ≥ 2 s/w |
| Meat, meat products | ≤2 s/w<br>0 s/w | 1 s/w | < 25 g/d | < 91 g/d/W<br><109 g/d/M | Rare/no consump-tion | ≤1 s/w | < 1 s/d | <1 s/d | > 1.5 s/d | <2 s/w<br>≤ 1 s/w |
| Sweets, sugared drinks | - | 3 s/w | - | - | - | - | - | <3 s/d<br><1 s/d | - | Limit |
| SFA (%kcal) | - | - | < 10 % kcal | - | - | - | - | - | - | - |
| Cholesterol (mg) | - | - | < 300 mg/d | - | - | - | - | - | - | - |
| MUFA/SFA | - | - | - | > 1.6 | - | - | - | - | - | - |
| Alcohol | ≤12-36 g/d | 1.5 s/d/W | - | < 10 g/d/M | < 3 gl/d | <300 ml/w | ≥ 1 gl/d | ≥7 gl/w | <1->2 AU/d[5] | 1-2 s/d |

s/w: servings/week; s/d: servings/day; g/d: grams/day; g/d/W: grams/day/women; g/d/M: grams/day/men; s/m: servings/month; gl/d: glasses/day; ml/w: ml/week; sp/d: spoon/day. AU/d : Alcohol Unit/ day.

Observations respect to the alcohol intake. MDS-95: moderate ethanol consumption (there were no men who drank more than 7 gl/d of wine and no women who drank more than 2 gl/d of wine). MDS 03, MMD5 and rMED: consumption specified by sex (5-25 g women and 10-50 g men). MDP 06: 10 g/d women and 20 g/d men. aMED: 5-15 g/d for both sexes. ITALIAN-MED: 12 g/d for both sexes. MD Score 04: 20 g/d.

[1]Includes legumes, nuts and olives. [2]White bread ( <1 s/d) or whole bread ( >5 s/w). [2]An point is added if the consumption of rice and white bread is low or when the consumption of whole bread is high. [3]A point is added when consumed ≥ 1 s/d of fruits and vegetables. [4]1 unit = 12 grams.

0.52-0.57), hypercholesterolemia 46% (95% CI: 0.51-0.56), diabetes 12% (95% CI: 0.86-0.89) and obesity 33% (95% CI: 0.65-0.70).

- Italy. Ciccarone et al., 2003 developed the Mediterranean Dietary Pattern 2003[20]. A higher adherence to this score was independently associated with a 56% reduction in PAD risk (95% CI: 0.64-0.83). Agnoli et al. 2011., developed the Italian Mediterranean Index in 40,681 adults of the EPIC Italy Cohort aged 35-74 years[26]. A high adherence to this index versus a low adherence was inversely associated with risk of all types of stroke and with risk of ischaemic stroke 63% (95% CI: 0.19-0.70).
- France. Scali et al. in 2000 developed the Mediterranean Diet Quality Index in 964 adults (aged 20-76 years)[23]. Only 9.5% of men and 9.0% of women were shown to have a healthy diet in terms of adherence to the MD.

Other countries

- United States. Rumawas et al. (2009), developed the Mediterranean-Style Dietary Pattern Score within 3,021 participants (mean age = 60 years) of the Framingham Offspring Cohort[22]. The participans with a higher adherence to MSDPS (vs lower adherence) had a lower BMI and waist circumference. Moreover, they observed a positive relationship with intakes of dietary fiber, omega-3, fatty acids, antioxidant vitamins, calcium, magnesium, and potassium, and inverse associations with added sugar, glycemic index, saturated fat, and trans-fat, and the (n-6): (n-3) fatty acid ratio. The Alternate Mediterranean Diet Index developed by Fund et al. (2005) in 1380 female nurses of the Nurses Health Study was associated with significantly lower concentrations of several biomarkers, specially with C reactive protein levels (24% lower in the top than in the bottom quintile of the score)[25]. A more recently published index is the Modified Mediterranean Diet Score by Yang et al. 2014[32]. A higher adherence to this score was also inversely related with obesity risk and with risk of weight gain over the past 5 years 43% (95% CI: 0.39-0.84), as well as with the presence of metabolic syndrome 35% (95% CI: 0.54-0.94).
- Iran. Asghari et al. in 2013 developed the Mediterranean Diet Scale 2013 in 451 participants of the Tehran Lipid and Glucose Study[17]. This score was found to be not associated with significative chances in the lipid profile.
- China. Woo et al. developed the Mediterranean Diet Score 2001[28]. In their study it was reported that those who were older had a higher adherence to the MD.

The Mediterranean Adequacy Index was developed by Alberti et al., (2009), based on the diets of population groups from Italy, Greece, U.S.A, Costa Rica, Chile, Spain and Germany[24]. This index was found to be inversely associated with mortality in elderly participants who were followed-up for 10 years.

Index based on a literature review

Literature based score to the adherence MD is an index based on the results of cohort prospective studies belonging to different countries (Greece, Australia, Spain, Belgium, Denmark, France, Hungary, Italy, The Netherlands, Portugal, Switzerland, Germany, Sweden, UK, USA, Norway)[35]. Two point increase in this index was reported to reduce by 8% of the risk of overall mortality (95% CI: 0.91-0.93), by 10% the risk of CVD (95% CI: 0.87-0.92) and by 4% the risk of cancer (95% CI: 0.95-0.97).

*Indexes and their relationship to the diseases and mortality*

As outlined before, among the indexes published in the literature, most of them have been associated with health benefits and prevention of chronic diseases: the MDS 1995 in preventing obesity[37,38] and cancer[39]; MDS 2003 improving the cardiometabolic profile[40-42] hepatic and renal function[43], as well as cognitive function[44], MMD reducing risk of cardiovascular diasease[45,46], cancer[47,48], and hypertension[49], MDP 2006 preventing obesity[50], MDQI preventing cardiovascular disease[51] and diabetes[52], MAI reducing blood pressure[53], aMED reducing mortality[54,55], cancer[56,57], diabetes mellitus type II[58-60] and risk of hip fractures[61], ITALIAN-MED preventing colorectal cancer[62], rMED reducing overall mortality and cardiovascular disease mortality[63], as well as risk of cardiovascular disease[64], gastric cancer[65], obesity[66] and of diabetes mellitus[67], and MeDiet-PREDIMED regarding adequacy of intake of HCO[68] and some assessment parameters of body composition[69].

## Limitations, recommendations and future research

The principal usefulness of these indexes is their ability to assess the adherence to Mediterranean dietary pattern in diverse study populations (from childhood into adulthood or the elderly years) and to relate it to the risk of disease or mortality, or even health determinants, in both mediterranean and non-mediterranean countries. MD indexes published in the literature have been widely reviewed and validated regarding their preventative effects against obesity[37,38,66], mortality[54,55,63], cancer[39,47,48,56,57,62,65] and other chronic diseases[45,46,52,58-60]. However, they have received less

attention with regard to their implementations in terms of number and contents of components, cutpoints, and scoring sheme. The current review includes twenty two indexes of adherence to the MD. Although all these indexes valued the Mediterranean dietary pattern, they evaluated very differently the dietary characteristics of the MD. Differences encountered are based on the components used, as they can be adapted to the population´s dietary habits. For example, the use of olive oil in countries where consumption is frequent[19-24,26,27,29-36] or the use of a ratios to assess the quality of fat[8,14,17,18,25,28], if olive oil is not the main source of MUFA in the diet. The second differences underlie on the choice of the components and whether their consumption is valued positively or negatively. The scoring scheme to express the contribution of food (food frequency or established grams/food/nutrients, depending on the consumption of the population) is another issue that differs among the MD indexes. Finally, the number of qualifying divisions (cut offs) and the contribution of each component to the overall score is highly diverse. Moreover, the study population or country where the index was developed represents another source of variability between the indexes. The above mentioned variabilities in the development of the indexes hinder their comparability. However, all indexes measure the degree of adherence to the MD based on consumption of certain foods that are characteristic of the Mediterranean area. As such, the correlation between most indexes of adherence to the MD published in the literature is moderately strong[16].

It is currently difficult to decide about the components that should be included to develop a reliable index of adherence to the MD.. Some indexes include food groups, foods and nutrients according to the scientific evidence on their detrimental or beneficial effects on health, and within the context of what is considered to be a Mediterranean dietary pattern. Interestingly, there were only two indices that incorporated lifestyle factors into their definition of the MD index[32,36], which is a type of component frequently included in other indexes diet quality. Despite the fact that this component is not strictly a dietary factor, the current Mediterranean Diet Pyramid establishes physical activity, adequate rest and conviviality as other components of the MD.

It is also important to establish a propor number of divisions or cutpoints to categorize the population into high or low adherence categories. The inclusion of a high number of categories can complicate the use and interpretation of the index, whereas a small number of cutpoints may result in loss of information and low diagnostic capacity[70]. In the case of MD indexes, it seems most advisable to divide the population into tertiles, establishing three categories of adherence, as low, indermediate and high adherence to the MD. One of the limitations found is that in all indexes all the components contribute equally, i.e. with equal weights, to the total index score. By doing so, the index does not take into consideration whether a component is more beneficial towards health preservation or whether it defines more properly the MD pattern. For example, the component of fruits and vegetables in the index should be valued more positively than that of cereals, especially if whole cereals consumption is not specified.

There is great complexity in assessing the interactions between the components, especially when it comes to heterogeneous food groups. This problem arises when foods with very different nutritional characteristics are joined in the same food group. An example is the inclusion of nuts into the groups of fruits, as happenss in the MDS[8,14] indexes. Alternatively, in the component of cereals, some indexes include potatoes whilst others not, and few others distinguished the group of whole cereals. Meat also is another component showing a great heterogeneity, as some indexes included any meat, others included red and processed meat, whereas others consider different types of meat (e.g. fatty and lean meat). These differences in the computerization of the components of the indexes may explain the variable degree of adherence to them. For instance, it has been reported that fruits and vegetables are the components most correlated to indexes of adherence to the MD, while dairy products and meat are components with a low correlation to the indexes[16]. Therefore, although there are not any established criteria to select the optimal number of components of specific food groups, foods or nutrients, the choice of the number of components and their definition should be driven by their association with several chronic diseases, so as to improve the predictive capacity, and the purpose of the MD index in terms of defining appropriately the MD.

## Conclusion

Overall, the indexes herein revised appear to have limitations, especially regarding the interpretation and comparison of risks associated with chronic diseases or mortality. This is due to their great heterogeneity with regard to the definition of the MD, components included and scoring scheme. Thus, the evaluation of the adherence to this dietary pattern and interpretation of results should be always made with caution and paying close attention to the particular index that was used in the study. Due to this heterogeneity in the definition of the MD, more studies are needed to establish clearer interpretations about the index of adherence to the MD and its relation to disease risk and mortality. Furthermore, efforts should be made to better characterize the components to be included in the definition of a MD dietary pattern index, as well as with regard to the evaluation on how the scoring scheme should be established to categorize the population into levels of adherence to the MD. However, the utility for promoting the pattern of the traditional Mediterranean diet

and their health benefits, as shown overall by these indexes, is well-established.


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