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Design and development of an instrument to measure overall lifestyle habits for epidemiological research: the Mediterranean Lifestyle (MEDLIFE) index

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Abstract

Objective: To design and develop a questionnaire that can account for an individual's adherence to a Mediterranean lifestyle including the assessment of diet and physical activity patterns, as well as social interaction.

Design: The Mediterranean Lifestyle (MEDLIFE) index was created based on the current Spanish Mediterranean food guide pyramid. MEDLIFE is a twenty-eight-item derived index consisting of questions about food consumption (fifteen items), traditional Mediterranean dietary habits (seven items) and physical activity, rest and social interaction habits (six items). Linear regression models and Spearman rank correlation were fitted to assess content validity and internal consistency.

Setting: A subset of participants in the Aragon Workers' Health Study cohort (Zaragoza, Spain) provided the data for development of MEDLIFE.

Subjects: Participants (*n* 988) of the Aragon Workers' Health Study cohort in Spain.

Results: Mean MEDLIFE score was 11·3 (SD 2·6; range: 0–28), and the quintile distribution of MEDLIFE score showed a significant association with each of the individual items as well as with specific nutrients and lifestyle indicators (intra-validity). We also quantified MEDLIFE correspondence with previously reported diet quality indices and found significant correlations (ρ range: 0·44–0·53; $P < 0·001$) for the Alternate Healthy Eating Index, the Alternate Mediterranean Diet Index and Mediterranean Diet Adherence Screener.

Conclusions: MEDLIFE is the first index to include an overall assessment of lifestyle habits. It is expected to be a more holistic tool to measure adherence to the Mediterranean lifestyle in epidemiological studies.

Keywords
Diet quality
Mediterranean diet
Diet index
Lifestyle

The Mediterranean diet has repeatedly been associated with reduced cardiovascular outcomes[1–4]. How to measure an individual's or a population's adherence to a specific healthy diet has been always a challenge, and several indices have been proposed to assess the overall quality of diet. The Alternate Healthy Eating Index (AHEI)[3] was developed based on dietary guidelines and the food guide pyramid proposed by the US Department of Agriculture[5] and emphasizes the consumption of plant foods and unsaturated oils. The Alternate Mediterranean Diet Index (aMED)[1] was adapted from the original Greek Mediterranean Diet Scale[6] for the US population, by introducing some modifications such as eliminating the dairy group, separating nuts and fruits into two groups, and assigning a score to a moderate alcohol intake. These modifications were derived from results from observational studies showing associations between certain dietary patterns and lower rates of cardiovascular risk. More recently, a 14-point Mediterranean Diet Adherence Screener (MEDAS)[7] questionnaire was validated and developed within the PREDIMED study[2] and included two additional questions on dietary habits considered characteristic of the Mediterranean diet (choice of olive oil as the main fat for cooking and choice of white over red meat) in addition to assessing consumption of specific food groups.

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Diet is a major component of an individual's lifestyle. Single nutrients, food groups or even dietary patterns (e.g. AHEI, aMED and other dietary indices) can be used as an indicator of overall lifestyle, but it now seems obvious that we will miss fundamental information if no other behaviours are taken into account. Associations between diet and different cardiovascular outcomes could be strengthened by accounting for an in-depth understanding of lifestyle covariates[8,9]. Diet patterns are closely related to eating habits, and also with cultural and psychological aspects of lifestyle that must be addressed. Psychosocial factors such as job strain, stress, anxiety, resting patterns, and family and community support are directly linked with lifestyle and greatly influence cardiovascular health. Bhupathiraju *et al.*[9] evaluated the American Heart Association diet approach and other lifestyle recommendations (BMI and physical activity) in relation to CVD risk factors in a sample of Boston Puerto Ricans. However, no other components have been considered in the lifestyle index and so far existing indices do not account for other components beyond diet. Evidence from a number of studies demonstrates that, as part of the physical lifestyle environment, physical activity, sociability and adequate rest seem to be related with CVD development[10–13]. The assessment of these factors and conditions is challenging, but fortunately the Mediterranean lifestyle includes a series of very well-characterized behaviours (physical activity, sociability, siesta, etc.) that can serve as a proxy for an overall assessment of lifestyle beyond diet[14].

In fact, the new Mediterranean Diet Pyramid recently developed in Spain by the Mediterranean Diet Foundation includes guidelines for cultural, social and gastronomic characteristics that define a Mediterranean lifestyle[14]. This Mediterranean pyramid is supported by a number of international institutions and societies, and experts from various disciplines, and has been translated into multiple languages[14,15]. Therefore, based on these principles and in view of the lack of lifestyle indices, our objective was to describe the design and development of a Mediterranean Lifestyle (MEDLIFE) index based on the Mediterranean Diet Pyramid to quantify the adherence to a healthy (Mediterranean) lifestyle that includes, besides food consumption, other behavioural components such as physical activity, rest and social interactions. A secondary objective was to conduct a preliminary internal validation.

Methods

Study participants

The Aragon Workers' Health Study (AWHS) is a cohort study based on the annual health examinations of the workers of the General Motors Spain automobile assembly plant located in Figueruelas (Zaragoza, Spain). The overall aim of the study was to characterize the factors associated with metabolic abnormalities and subclinical atherosclerosis in a middle-aged (40–55 years old) population (n 3109) free of clinical CVD, whose methodology has been previously described[16]. Baseline measurements included evaluation of subclinical atherosclerosis by imaging techniques and additional questionnaires on cardiovascular and lifestyle factors[16]. Our investigation was conducted in the first 1100 participants who completed the questionnaire on food consumption frequency (FFQ). From this sample of participants, we excluded those who did not respond to the FFQ or who reported an implausible dietary intake (<3347 kJ (<800 kcal) or >17 573 kJ (4200 kcal)). The original data collection instrument is included as supplementary material. The final sample consisted of 988 individuals. The AWHS was approved by the Central Institutional Review Board of Aragón (CEICA). All study participants provided written informed consent.

Dietary assessment and calculation of diet quality indices

Dietary intake and habits were assessed using a semi-quantitative FFQ previously validated for the Spanish population[17], capturing long-term intake during the preceding year, taking into account seasonal variations and differences between weekday and weekend patterns. The questionnaire is based on 136 food items, including specific questions about consumption of supplements and information on adherence to restrictive diets. For each food included in the questionnaire, serving size was specified with the choice between nine frequencies of consumption from 'never or almost never' to 'more than six times a day'.

Diet quality indices (AHEI, aMED and the 14-point MEDAS) were calculated by using the information derived from the FFQ described above. In the absence of exact information on specific items, modifications from the published criteria were introduced (see online supplementary material). The AHEI, adapted from the original HEI[5], provides quantitative scoring for nine components[3]. Its scoring criteria are described in Supplemental Table 1. All items, except multivitamin use, of the AHEI each contribute 0–10 points to the total score. The total AHEI ranges from 2·5 (worst) to 87·5 (best). The aMED[1] was adapted from the former Mediterranean Diet Scale by Trichopoulou and co-workers[6]. Evaluated items include nine components. Median intakes for each item are considered as cut-offs for assigning 1 point (intake greater than the median) or 0 points (intake less than the median), with the exception of red and processed meat consumption and alcohol intake (Supplemental Table 2), with final score ranging from 0 (worst) to 9 (best). The MEDAS (a self-questionnaire used in the PREDIMED study) consists of twelve questions on the frequency of consumption of specific foods and two additional questions on dietary habits considered characteristic of a Mediterranean diet. Each question is scored 0 or 1 (Supplemental Table 3). The final MEDAS ranges from 0 (worst) to 14 (best).

Assessment of non-dietary variables

Physical activity was assessed using the Spanish validated version[18] of the Nurses' Health Study (NHS) and Health Professionals Follow-up Study (HPFS) physical activity questionnaires[19,20]. The questionnaire also includes questions about habits and lifestyle such as time spent sitting (h/d), watching television or video (h/d), in front of a computer (h/d), sleeping (h/d) or socializing with friends (h/d), differentiating between a typical weekday and a typical day weekend. Participants also completed an additional questionnaire on sociodemographic characteristics including education level, years of employment at the factory, shift and type of work performed, marital status, number of children and number of people who form their family unit.

Development of the Mediterranean Lifestyle (MEDLIFE) index

The MEDLIFE index was created based on following the principles of the Mediterranean Diet Pyramid[14,15] recently proposed by the Spanish Mediterranean Diet Foundation. A total of twenty-eight items were derived interpreting the pyramid and divided into three blocks. The first block contained items gathering food consumption frequency (fifteen items). The second block included items on Mediterranean dietary habits (seven items) and the third block, physical activity, rest, social habits and conviviality (six items). Each item scored 0 or 1. For each of the twenty-eight items, 1 point was given if the answer met the following conditions: (i) pastries, ≤2 servings/week; (ii) red meat, <2 servings/week; (iii) processed meat, ≤1 servings/week; (iv) eggs, 2–4 servings/week; (v) legumes, ≥2 servings/week; (vi) white meat, 2 servings/week; (vii) fish or seafood, ≥2 servings/week; (viii) potatoes, ≤3 servings/week; (ix) low-fat dairy products, 2 servings/d; (x) nuts including olives, 1–2 servings/d; (xi) herbs, spices and garnish (including onion, garlic or other herbs such as parsley, oregano), ≥1 serving/d; (xii) fruit including fresh juice, 3–6 servings/d; (xiii) vegetables (except potatoes), ≥2 servings/d; (xiv) olive oil consumption, ≥3 tbsp/d (1 tbsp = 13·5 g); (xv) cereals, 3–6 servings/d; (xvi) 6–8 glasses of water/d or ≥3 servings of infusions/week; (xvii) wine (red or white), 1–2 servings/d; (xviii) preference for whole grain products (or >25 g fibre/d); (xix) snacks, ≤2 servings/week. Three additional questions queried traditional Mediterranean habits: (xx) 'Do you limit salt addition during meals?'; (xxi) 'Do you limit nibbling between meals?'; (xxii) 'Do you limit sugar addition in beverages (including sugar-sweetened beverages)?' And six additional questions asked about physical activity, rest, social habits and conviviality: (xxiii) physical activity (moderate physical activity ≥150 min/week, 500–1000 MET/min per week or 30 min brisk walking, where MET = metabolic equivalent of task)[21,22]; (xxiv) nap during weekend; (xxv) 6–8 h sleep/d during weekdays[12,13,23]; (xxvi) watching television for <1 h/d during weekdays; (xxvii) ≥2 h during weekend dedicated to going out with friends; (xxviii) doing collective sports (cycling, jogging, soccer, etc.) for ≥2 h/week. The final MEDLIFE index ranged from 0 (worst) to 28 (best; Table 1).

By design (following the principles of the Mediterranean Diet Pyramid: a lifestyle for today) and considering the main goal of utility of the index (being used as an independent short screener tool in epidemiological and clinical studies), each question is weighted equally and the scale of scoring this index is categorical. This will simplify the administration of the screener in future studies.

Statistical analysis/data analysis

We calculated Spearman rank correlation coefficients between the calculated diet quality indices (AHEI, aMED and MEDAS) and the MEDLIFE index. The κ statistic was used to evaluate the agreement between quintile distributions of the different indices. To assess content validity and internal consistency, linear regression models were fitted to determine β coefficients for quantifying the association between each MEDLIFE item and nutrient intakes (as continuous variables) derived from the FFQ. The regression models were adjusted for age (continuous), gender (male or female) and total energy intake (continuous). Adjusted means of each MEDLIFE item as well as other nutrient intakes according to quintile distribution of the MEDLIFE index were calculated. When the dependent variable was categorical, logistic regression was used. The P trend was tested across quintiles of MEDLIFE index distribution. Further statistical analyses conducted to evaluate internal consistency included Spearman rank correlations to examine associations between individual component scores and the total MEDLIFE index and Cronbach's α as a further estimate of internal consistency and reliability. $P < 0{\cdot}05$ was considered as statistically significant and all tests were two-tailed. Statistical analyses were conducted using the statistical software package STATA version 12·0.

Results and discussion

The overall MEDLIFE index development

The MEDLIFE index includes twenty-eight items divided into three different blocks, i.e. food consumption, dietary patterns and physical activity, rest, social habits and conviviality. Table 1 shows a description of each of the items and the scoring criteria. For each item we present the percentage of participants receiving the maximum score (1 point). In the food consumption block, only 6·1 % met 1-point criteria for processed meat (≤1 serving/week) and white meat (2 servings/week). Less than 50 % scored 1 point for fruit (18·0 %, 3–6 servings/d), nuts (19·7 %, 1–2 servings/d), olive oil (28·1 %, ≥3 servings/d) and legumes (31·1 %, ≥2 servings/week) consumption. However, 90·2 % and 80·0 % consumed fish/seafood and vegetables in ≥2 servings/week, respectively. As for food habits, only 15·7 % consumed 1–2 servings of wine daily and 69·1 %

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Table 1 Description of the Mediterranean Lifestyle (MEDLIFE) index, score distributions and correlations among a subset of participants (*n* 988) in the Aragon Workers' Health Study (AWHS) cohort (Zaragoza, Spain)

Food group	Foods included	Criteria for 1 point*	*n*	%	Spearman rank ρ
Block 1: Mediterranean food consumption					
1. Sweets	Candy (1 serving = 1 unit or 50 g), chocolates (1 serving = 30 g), biscuits (1 serving = 4–6 units), turron (1 serving = 40 g)	≤2 servings/week	123	12·5	0·21
2. Red meat	Beef, pork, lamb (1 serving = 100–150 g)	<2 servings/week	244	24·7	0·20
3. Processed meat	Ham (1 serving = 1 slice or 30 g), sausage, soft spicy sausage, bacon (1 serving = 50 g), hamburger (1 serving = 1 unit), liver (1 serving = 100–150 g), pâté (1 serving = 25 g)	≤1 serving/week	60	6·1	0·18
4. Eggs	Eggs (1 egg)	2–4 servings/week	649	65·7	0·16
5. Legumes	Lentils, beans, peas, chickpeas (1 serving = 1 plate or 150 g)	≥2 servings/week	307	31·1	0·21
6. White meat	Poultry and rabbit (1 serving = 100–150 g)	2 servings/week	60	6·1	0·13
7. Fish/seafood	White/oily fish (1 serving = 100–150 g), canned fish (1 serving = 1 can or 50 g), seafood (1 serving = 200 g)	≥2 servings/week	891	90·2	0·22
8. Potatoes	Roast/boiled potatoes, French fries (1 serving = 150–200 g)	≤3 servings/week	231	23·4	0·10
9. Low-fat dairy products	Skimmed dairy milk (1 serving = 1 cup or 200 ml), soft cheese	2 servings/d	16	1·6	0·11
10. Nuts and olives	Walnuts, almonds, hazelnuts (1 serving = 1 handful or 30 g), olives (1 serving = 10 units)	1–2 servings/d	195	19·7	0·26
11. Herbs, spices and garnish	Onion, garlic, herbs (parsley, oregano)	≥1 serving/d	547	55·4	0·39
12. Fruit	All fruit and fresh fruit-based juices (1 serving = 150–200 g)	3–6 servings/d	178	18·0	0·32
13. Vegetables	All vegetables except potatoes (1 serving = 150–200 g)	≥2 servings/d	790	80·0	0·39
14. Olive oil	Olive oil, virgin olive oil (1 serving = 1 tbsp)	≥3 servings/d	278	28·1	0·24
15. Cereals	White and whole grain bread (1 serving = 40 g), cereals (1 serving = 1 plate) and derivatives	3–6 servings/d	291	29·5	0·17
Block 2: Mediterranean dietary habits					
16. Water or infusions	Water or infusions (1 serving = 1 glass)	6–8 servings/d or ≥3 servings/week	98	9·9	0·23
17. Wine	White/red wine (1 serving = 1 cup)	1–2 servings/d	155	15·7	0·23
18. Limit salt in meals		Yes	359	36·3	0·27
19. Preference for whole grain products		Yes/fibre > 25 g/d	502	50·8	0·45
20. Snacks	Potatoes chips, popcorn (1 serving = 1 bag or 50 g)	≤2 servings/week	973	98·5	0·10
21. Limit nibbling between meals	Nibbling outside five main meals	Yes	683	69·1	0·22
22. Limit sugar in beverages (including sugar-sweetened beverages)		Yes	245	24·8	0·27
Block 3: Physical activity, rest, social habits and conviviality					
23. Physical activity (>150 min/week or 30 min/d)	Jogging, walking quickly, dance, aerobics, gardening	Yes	774	21·7	0·20
24. Siesta/nap	During weekends	Yes	404	40·9	0·22
25. Hours of sleep	During weekdays	6–8 h/d	802	81·2	0·16
26. Watching television	During weekdays	< 1 h/d	551	55·8	0·23
27. Socializing with friends	During weekends	≥2 h/weekend	537	54·4	0·15
28. Collective sports	During week	≥2 h/week	255	25·8	0·23

*0 points if these criteria are not met.

Table 2 Baseline characteristics across quintiles of the Mediterranean Lifestyle (MEDLIFE) index among a subset of participants (*n* 988) in the Aragon Workers' Health Study (AWHS) cohort (Zaragoza, Spain)

	Q1		Q2		Q3		Q4		Q5		
Characteristic*	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*-trend
Age (years)	50·8	3·85	51·5	3·47	51·4	3·73	51·1	3·70	51·2	3·59	0·412
Male (%)	97·1		93·6		96·8		94·3		93·8		0·054
BMI (kg/m^2)	28·2	3·80	27·8	3·53	27·8	3·52	27·3	3·17	27·6	3·67	0·002
Normal (%)	19·0		22·7		20·3		23·6		23·5		0·186
Overweight (%)	52·5		51·0		58·4		58·2		55·8		0·052
Obese (%)	28·4		26·3		21·3		18·1		20·7		<0·001
Smoking habits (%)											
Never	32·4		31·6		31·3		38·0		33·9		0·179
Former	30·6		31·1		33·3		37·4		39·8		0·009
Current	37·0		37·3		35·4		24·6		26·3		<0·001
Number of cigarettes/d	4·95	8·15	4·70	7·80	4·47	10·60	2·46	5·70	2·52	5·35	<0·001
Physical activity (MET-h/week)	29·7	21·0	33·0	21·0	33·6	19·7	37·4	20·6	42·6	23·4	<0·001
Education (%)											
Low	53·3		50·2		49·8		46·4		47·7		0·028
Medium	42·4		44·7		42·4		44·4		44·5		0·734
High	3·6		4·0		7·8		7·7		7·8		0·001

MET, metabolic equivalent of task.
*Continuous variables are expressed as mean and standard deviation. Categorical variables are expressed as percentages.

reported not having the habit of nibbling. Concerning rest, social habits and conviviality, 40·9 % reported that they took naps, 81·2 % reported sleeping for 6–8 h/d and 54·5 % socialized with friends for ≥2 h/weekend.

Although MEDLIFE is similar to other dietary indices reported in the literature regarding food groups, there are some differences. MEDLIFE includes low-fat dairy products that were not chosen in AHEI, aMED or MEDAS, and red meat and processed meat are considered separately as two groups. Assessment of nutrients such as *trans*-fatty acids and *n*-6 PUFA are included in AHEI and aMED while in our index, as in MEDAS, these are evaluated using foods that are rich sources of these fatty acids as a proxy. Another difference is the assignment of points and cut-offs for food servings. We strictly followed the guidelines in the Spanish Mediterranean Diet Pyramid to assign the score criteria and the cut-offs[14]. Some aspects regarding serving recommendations differ from others described (see supplemental tables and Table 1). When no specific definition was available, decisions were based on a literature review of international guidelines[12,21–23]. Another difference is the final scoring system; MEDLIFE, as well as aMED and MEDAS, used dichotomous points while AHEI did not (range: 2·5–87·5). Finally, MEDLIFE includes both the assessment of food consumption directly related to the Mediterranean diet and information on behaviours associated with the Mediterranean lifestyle beyond dietary habits, to include physical activity, rest, social habits and conviviality. By definition, the Mediterranean lifestyle concept reflects the dietary and social habits patterns characteristic of the Mediterranean basin countries in the 1960s[24]. Therefore, including additional information beyond the typical Mediterranean diet is essential to define an overall Mediterranean lifestyle.

MEDLIFE intra-validity (content validity and internal consistency) and its correlation with other diet quality scores

The mean score of the MEDLIFE index for participants in our cohort was 11·3 (SD 2·6) out of a total possible of 28. No differences by gender and age were found ($P=0·326$, and $P=0·919$, respectively). Spearman rank correlation coefficients between MEDLIFE components and the total MEDLIFE index were all significant and ranged from 0·10 for potatoes and snacks to 0·45 for preference for whole grain products (Table 1). Adjustment for age and energy intake did not significantly change these correlations (data not shown). The MEDLIFE index also showed good internal consistency by Cronbach's α coefficient (0·75).

Participants' characteristics according to quintiles of MEDLIFE index score are presented in Table 2. Those in the highest quintile compared with the lowest were more likely to have lower BMI, smoke less, be physically active and have greater education.

The associations between each MEDLIFE component and other nutrient intakes derived from the FFQ and the quintile distribution of the overall MEDLIFE index are presented in Tables 3 and 4, respectively. The β coefficients represent the association of the single item or nutrient with the index. Furthermore, adjusted means are presented according to the distribution of the index. The MEDLIFE index was inversely associated with the intake of sweets ($\beta=-0·29$, $P=0·019$), red meat ($\beta=-0·14$, $P<0·001$) and processed meat ($\beta=-0·11$, $P=0·011$). It was also inversely associated with hours of television watched ($\beta=-0·10$, $P<0·001$). In contrast, fish/seafood, vegetables, infusions consumption, limited added salt and sugar, preference for whole grains, physical activity and time spent on collective sports were the items that

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Table 3 Sex-, age- and energy-adjusted mean intakes of overall components of the Mediterranean Lifestyle (MEDLIFE) index according to quintile distribution of the MEDLIFE index among a subset of participants (*n* 988) in the Aragon Workers' Health Study (AWHS) cohort (Zaragoza, Spain)

		Q1		Q2		Q3		Q4		Q5		
MEDLIFE component	*β*	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P* trend
Sweets (servings/week)	−0·29	10·88	10·13, 9·66	10·15	9·66, 10·63	9·74	9·25, 10·22	9·32	8·72, 9·92	8·61	7·67, 9·55	0·019
Red meat (servings/week)	−0·14	4·31	4·10, 3·82	3·95	3·82, 4·09	3·76	3·62, 3·89	3·56	3·39, 3·72	3·22	2·96, 3·48	<0·001
Processed meat (servings/week)	−0·11	8·58	8·19, 8·05	8·30	8·05, 8·55	8·15	7·90, 8·40	8·00	7·69, 8·31	7·74	7·25, 8·22	0·011
Eggs (servings/week)	0·01	3·05	2·82, 2·93	3·08	2·93, 3·23	3·09	2·94, 3·24	3·11	2·92, 3·29	3·13	2·84, 3·42	0·872
Legumes (servings/week)	0·05	1·79	1·72, 1·88	1·92	1·88, 1·97	2·00	1·96, 2·04	2·08	2·02, 2·13	2·21	2·12, 2·29	<0·001
White meat (servings/week)	0·05	1·96	1·81, 2·00	2·10	2·00, 2·20	2·17	2·07, 2·27	2·25	2·12, 2·37	−0·10	2·18, 2·57	0·011
Fish/seafood (servings/week)	0·25	4·39	4·15, 4·86	5·01	4·86, 5·17	5·36	5·20, 5·52	5·71	5·51, 5·90	6·31	6·00, 6·61	<0·001
Potatoes (servings/week)	−0·05	4·13	3·94, 3·89	4·01	3·89, 4·13	3·95	3·83, 4·06	3·88	3·73, 4·03	3·77	3·54, 4·00	0·163
Dairy products (servings/d)	0·04	0·29	0·22, 0·34	0·39	0·34, 0·44	0·45	0·40, 0·49	0·50	0·44, 0·56	0·60	0·51, 0·69	<0·001
Nuts (servings/d)	0·04	0·52	0·46, 0·59	0·63	0·59, 0·67	0·69	0·65, 0·73	0·75	0·70, 0·80	0·85	0·78, 0·93	<0·001
Herbs (servings/d)	0·10	0·82	0·75, 1·03	1·08	1·03, 1·13	1·22	1·17, 1·27	1·36	1·30, 1·42	1·61	1·51, 1·70	<0·001
Fruit (servings/d)	0·14	1·67	1·55, 1·94	2·01	1·94, 2·08	2·20	2·13, 2·27	2·39	2·30, 2·48	2·72	2·58, 2·86	<0·001
Vegetables (servings/d)	0·22	2·36	2·24, 2·85	2·93	2·85, 3·00	3·24	3·16, 3·32	3·55	3·46, 3·65	4·10	3·95, 4·24	<0·001
Olive oil (servings/d)	0·11	2·58	2·46, 2·78	2·86	2·78, 2·94	3·02	2·94, 3·10	3·18	3·08, 3·27	3·45	3·29, 3·60	<0·001
Cereals (servings/d)	0·02	3·27	3·14, 3·23	3·31	3·23, 3·39	3·34	3·25, 3·42	3·36	3·26, 3·46	3·40	3·24, 3·56	0·348
Tea (servings/week)	0·23	0·00	−0·28, 0·41	0·59	0·41, 0·77	0·92	0·74, 1·10	1·25	1·03, 1·47	1·82	1·47, 2·17	<0·001
Limit salt*	0·24	20·80	15·10, 26·80	32·40	26·80, 38·00	37·90	30·20, 45·70	43·80	37·40, 50·10	65·20	56·80, 73·50	<0·001
Preference whole grains*	0·46	25·20	20·40, 41·70	46·50	41·70, 51·30	57·80	51·20, 64·50	67·10	51·20, 64·50	67·10	61·60, 72·60	<0·001
Wine (servings/d)	0·02	0·91	0·78, 0·88	0·96	0·88, 1·04	0·99	0·91, 1·07	1·01	0·91, 1·11	1·06	0·91, 1·22	0·507
Snacks (servings/week)	−0·01	0·14	0·11, 0·10	0·13	0·10, 0·15	0·12	0·09, 0·14	0·11	0·08, 0·14	0·09	0·05, 0·14	0·126
Limit nibbling*	0·18	42·30	36·80, 27·40	32·80	27·40, 38·20	29·10	21·50, 36·70	24·10	17·80, 30·30	15·10	6·90, 23·20	<0·001
Limit sugar*	0·34	88·40	83·50, 77·90	82·7	77·90, 87·40	75·50	68·80, 82·20	64·60	59·20, 70·00	46·30	39·10, 53·40	<0·001
Physical activity*	0·26	65·50	60·60, 70·00	74·80	70·00, 79·60	85·30	78·50, 92·00	86·40	80·90, 92·00	93·10	85·80, 100·00	<0·001
Nap*	0·17	29·70	23·80, 28·90	34·7	28·90, 40·50	45·10	37·00, 53·30	51·60	45·00, 58·30	55·10	46·40, 63·80	0·001
Hours of sleep/d	0·03	6·08	5·98, 6·10	6·17	6·10, 6·23	6·21	6·15, 6·28	6·26	6·18, 6·34	6·34	6·21, 6·47	0·001
Television hours/d	−0·10	1·85	1·75, 1·52	1·59	1·52, 1·65	1·44	1·38, 1·50	1·29	1·21, 1·37	1·04	0·92, 1·15	<0·001
Socialize (h/weekend)	0·14	1·51	1·31, 1·72	1·85	1·72, 1·98	2·04	1·91, 2·17	2·23	2·07, 2·39	2·56	2·31, 2·81	<0·001
Collective sports (h/week)	0·34	0·41	0·12, 1·08	2·00	1·08, 1·45	1·74	1·56, 1·93	2·22	1·99, 2·45	3·05	2·69, 3·40	<0·001

*Categorical variables are presented as the percentage of people who reach 1 point and 95 % confidence interval.

Table 4 Sex-, age- and energy-adjusted mean intakes of selected daily nutrients known to be related to food groups that constitute the Mediterranean Lifestyle (MEDLIFE) index according to quintile distribution of the MEDLIFE index among a subset of participants (*n* 988) in the Aragon Workers' Health Study (AWHS) cohort (Zaragoza, Spain)

		Q1		Q2		Q3		Q4		Q5		
Nutrient	β	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P* trend
Energy (kJ/d)	49·52	11 737	11 408, 12 046	12 260	12 046, 12 475	12 551	12 338, 12 764	12 843	12 580, 13 106	13 348	12 938, 13 758	< 0·001
Energy (kcal/d)	49·52	2805·09	2726·46, 2878·98	2930·24	2878·98, 2981·50	2999·76	2948·84, 3050·68	3069·53	3006·67, 3132·39	3190·30	3092·31, 3288·29	< 0·001
Carbohydrates (%E)	– 0·16	46·01	45·37, 45·18	45·59	45·18, 46·01	45·36	44·95, 45·77	45·13	44·62, 45·64	44·73	43·94, 45·53	0·093
Proteins (%E)	0·10	14·77	14·55, 14·88	15·02	14·88, 15·16	15·16	15·02, 15·30	15·29	15·12, 15·47	15·53	15·26, 15·81	0·001
Total fat (%E)	0·04	34·47	33·95, 34·25	34·59	34·25, 34·92	34·65	34·31, 34·98	34·71	34·29, 35·13	34·82	34·17, 35·47	0·458
MUFA (%E)	0·06	15·83	15·54, 15·80	15·99	15·80, 16·19	16·08	15·89, 16·27	16·17	15·94, 16·41	16·33	15·96, 16·70	0·124
PUFA (%)	0·03	5·66	5·48, 5·62	5·73	5·62, 5·84	5·78	5·67, 5·89	5·82	5·68, 5·96	5·89	5·68, 5·68	0·078
n-3 different from fish (g/d)	0·05	1·45	1·39, 1·54	1·58	1·54, 1·62	1·65	1·61, 1·69	1·72	1·67, 1·77	1·84	1·77, 1·92	< 0·001
SFA (%E)	– 0·11	10·19	9·98, 9·76	9·90	9·76, 10·03	9·74	9·6, 9·87	9·58	9·41, 9·74	9·30	9·04, 9·56	< 0·001
Trans-fatty acids (%E)	– 0·01	0·28	0·27, 0·25	0·26	0·25, 0·27	0·25	0·24, 0·26	0·23	0·22, 0·24	0·21	0·20, 0·23	0·001
Alcohol (g/d)	0·03	20·50	18·61, 19·35	20·57	19·35, 21·79	20·61	19·40, 21·82	20·65	19·14, 22·15	20·71	18·35, 23·07	0·619
Cholesterol (mg/d)	– 0·90	164·80	160·30, 159·58	162·52	159·58, 159·58	161·25	158·33, 164·16	159·97	156·37, 163·57	157·77	152·16, 163·38	0·099
Vitamin C (mg/d)	9·85	148·19	141·94, 169·05	173·09	169·05, 177·13	186·92	182·91, 190·93	200·81	195·83, 205·78	224·84	217·04, 232·63	< 0·001
Ca (mg/d)	15·64	1005·02	973·81, 1024·34	1044·54	1024·34, 1064·74	1066·49	1046·42, 1086·55	1088·52	1063·64, 1113·39	1126·65	1087·68, 1165·62	< 0·001
Fe (mg/d)	0·33	17·83	17·61, 18·52	18·66	18·52, 18·81	19·13	18·98, 19·27	19·59	19·41, 19·77	20·39	20·12, 20·67	< 0·001
Glycaemic load	– 1·73	183·02	179·90, 176·62	178·64	176·62, 180·66	176·2	174·20, 178·21	173·76	171·27, 176·25	169·53	165·63, 173·43	< 0·001
Sugar (g/d)	– 2·08	30·59	28·62, 24·06	25·33	24·06, 26·61	22·41	21·14, 23·68	19·48	17·91, 21·05	14·40	11·94, 16·86	< 0·001
Na (mg/d)	4·00	3427·60	3362·84, 3395·79	3437·70	3395·79, 3479·61	3443·31	3401·68, 3484·94	3448·94	3397·33, 3500·56	3458·69	3377·83, 3539·55	0·443
Physical activity (MET-h/week)	2·40	27·02	25·01, 31·79	33·10	31·79, 34·40	36·47	35·18, 37·77	39·86	38·25, 41·47	45·72	43·21, 48·24	0·001

%E, percentage of energy intake; MET, metabolic equivalent of task.

contributed most to the MEDLIFE index, with β coefficients higher than 0·20. Herbs, spices and other garnish, fruit, olive oil, limited nibbling or snacking, napping habits and socialize hours showed moderate but significant direct associations with the MEDLIFE index (β range: 0·10–0·20; $P<0·001$). A smaller but significant contribution to MEDLIFE was found for legumes, white meat, dairy products, nuts and hours of sleep ($P<0·05$). All of these associations are also consistent according to quintiles of distribution (P trend $<0·05$). No statistically differences were found for eggs, potatoes, cereals, wine and snack consumption.

As for nutrient consumption, percentage of energy from MUFA and PUFA, specifically *n*-3 (different from fish), was associated with increasing MEDLIFE quintiles. Similar results were observed for vitamin C, Ca and Fe (P trend $<0·001$ for all). However, a significant and inverse association was found for percentage of energy from SFA and *trans*-fatty acids, sugar and glycaemic load (P trend $<0·001$ for all; Table 4). These results are consistent with those reported in other studies comparing dietary indices created from FFQ and nutrient adequacy (content validity and internal consistency)[7,25–27].

Concerning the other diet quality scores assessed, the mean values were as follows: aMED = 4·0 (SD 1·8), AHEI = 49·5 (SD 9·0) and MEDAS = 6·5 (SD 1·7). Similar mean values were found regarding aMED and AHEI in the NHS and HPFS[1,25]. MEDAS scoring was approximately 2 points lower in our population compared with other Spanish populations[28,29]. However, our population is younger and older populations seem to better preserve the Mediterranean habits.

With regard to the association between these diet quality indices and MEDLIFE, the MEDLIFE index was significantly associated with AHEI, aMED and MEDAS (ρ range: 0·44–0·53; $P<0·001$; Table 5). MEDLIFE correlated the most with MEDAS ($\rho = 0·53$) and AHEI ($\rho = 0·52$; $P<0·001$ for both) although the highest correlation was seen between AHEI and aMED because many of the items in each index are based on similar dietary recommendations; this is comparable to the results reported by Fung *et al.*[1]. Analysing MEDLIFE by blocks, the first two (food consumption and Mediterranean dietary habits) correlated strongly with MEDAS ($\rho = 0·557$ and 0·568, respectively; $P<0·001$ for both) probably because MEDAS also includes two questions about food intake habits and both have been developed based on the Mediterranean diet. In addition, to analyse the strength of correlation between indices, we also evaluated the agreement between indices. The results were along the same lines as the correlations ($P<0·001$), giving evidence that the MEDLIFE index successfully captures overall quality diet and the Mediterranean diet.

Strengths and limitations

The current paper presents the description and development of an index to measure adherence to a Mediterranean lifestyle. Compared with the other indices described, it is

Table 5 Spearman's correlation coefficients among diet quality scores from the FFQ completed by a subset of participants (*n* 988) in the Aragon Workers' Health Study (AWHS) cohort (Zaragoza, Spain)

	aMED	AHEI	MEDAS	MEDLIFE	MEDLIFE-FC	MEDLIFE-FC + DH
aMED	1·00					
AHEI	0·62	1·00				
MEDAS	0·50	0·56	1·00			
MEDLIFE	0·44	0·52	0·53	1·00		
MEDLIFE-FC	0·38	0·48	0·56	0·76	1·00	
MEDLIFE-FC + DH	0·47	0·54	0·57	0·89	0·86	1·00

aMED, Alternate Mediterranean Diet Score; AHEI, Alternate Healthy Eating Index; MEDAS, Mediterranean Diet Adherence Screener; MEDLIFE, Mediterranean Lifestyle index; MEDLIFE-FC, MEDLIFE food consumption; MEDLIFE-FC + DH, MEDLIFE food consumption + dietary habits.
All *P* values are <0·001.

the first overall quality index that aims to measure other variables beyond food consumption that are part of the Mediterranean lifestyle definition (physical activity, adequate rest, sociability and conviviality). Beneficial effects of the Mediterranean diet have been widely recognized internationally by the scientific community[30]. Therefore, the development of our index aims to be valid not only in Spain but also elsewhere. Its items can be easily defined by the FFQ used in epidemiological studies that can facilitate its internationality.

We have to note that because we assessed diet using a semi-quantitative FFQ, we have to assume some of the disadvantages related to this tool (by its nature, some misclassification can occur and it is less precise than other tools). However, the previous validation study of this FFQ[17] and other scientific literature supports that FFQ rank usual intakes well[31].

In addition, the fact that the MEDLIFE index was developed in a population including mostly men and belonging to a specific population (General Motors Spain automobile assembly plant) could be regarded as a limitation, but it should not affect the development of the index. Women tend to be more accurate in reporting dietary consumption and other studies have found that women seem to have better scores in dietary indices than men[9,32]. During the replication on an independent population, possible gender-based biases as well as other possible interactions will be evaluated. A further step conducting an external validation will help us to elucidate some of these issues.

Another limitation is that the scale of scoring this index is categorical. One of the major goals of this instrument is to use it as a short screener in epidemiological and clinical studies to assess potential health benefits associated with the Mediterranean lifestyle, so we considered that people in clinical practice could obtain easily a Mediterranean lifestyle score if we used a 0 or 1 point scoring system. However, this categorization may limit the range of possible scores and then have some limitations. One of the limitations might be that, when evaluating changes in the score over time, differences among groups are more difficult to detect. Therefore, we do not discard that a future scoring system considering both continuous and categorical scales may be developed to assess associations with health outcomes and evaluate changes over time in epidemiological studies. A continuous scale has the advantage of increasing the sensitivity and therefore the ability to detect changes over time. In addition, it does not assume a linear relationship when the aim is to study associations with health outcomes. Finally, as in previously developed indices, the development always implies some arbitrary decisions regarding those items that are not specifically named in the food pyramid as well as in the assignment of cut-off points that need to be considered when using the instrument.

Conclusions

MEDLIFE correlates well with other previously validated diet quality indices, validating its use. Previous indices analysed have been associated with favourable intermediate and final cardiovascular risk phenotypes and overall health effects[25,26,28,30,33]. Hence, considering that MEDLIFE implies a more comprehensive assessment of lifestyle, we expect it will help to refine the associations between the Mediterranean diet (lifestyle) and chronic disease. MEDLIFE is a short measuring instrument that could be used in future epidemiological and clinical studies as a valid instrument to measure adherence to the Mediterranean lifestyle.

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the manuscript. J.L.P. conceived and designed the study, obtained funding and helped to draft the manuscript: *Ethics of human subject participation:* The AWHS was approved by the Central Institutional Review Board of Aragón (CEICA), Spain.

Supplementary material

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