Modified Mediterranean diet score adapted to a southern Mediterranean population and its relation to overweight and obesity risk

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Abstract

Objectives: The current study aimed to develop a modified Mediterranean diet
(MMD) score adjusted to the southern Mediterranean countries' cultural specific-
ities and to evaluate associations between adherence to this modified score and
overweight/obesity risk in Moroccan adults.
Design: Population-based cross-sectional study.
Setting: Rural and urban areas of the five greatest provinces of Morocco.
Participants: In total, 1516 participants were recruited between September 2009
and February 2017. Dietary assessment was obtained using a validated
Moroccan FFQ. We constructed a MMD score focusing on twelve components.
The MMD score ranged from 0 (no adherence to the traditional southern
Mediterranean diet (MD)) to 12 (maximal adherence) and was categorised as
low (scores 0–4), moderate (scores 5–7) and high (scores 8–12).
Results: Among the whole population, 754 (50·5 %) were women and 738 (49·5 %)
were men, and the mean age was about 55·60 ± 13·70. In total, 58 % of participants
were moderately active. Regarding educational level, 50·7 % were illiterate. The
prevalence of overweight and obesity was 43·3 and 8·6 %, respectively. In multi-
variate analyses, close adherence to MMD (scores 8–12) was associated with
reduced overweight/obesity risk (OR 0·61, 95 % CI 0·44, 0·84).
Conclusion: The prevalence of overweight and obesity was very high among
Moroccan adults. Adherence to the traditional southern MD may help prevent
overweight and obesity.

The Mediterranean diet (MD) refers to the traditional
dietary habits of people from countries around the
Mediterranean basin. It consists of[1,2] high intake of vege-
tables, legumes, whole grains, nuts, fruits and olive oil (as
the main source of added lipids), moderate intake of dairy
products, poultry, eggs and wine with meals and low intake
of red meat, all these combined with regular physical
activity[3,4]. Several studies have reported a protective
effect of MD against many conditions including diabetes,
obesity, cardiovascular, neurodegenerative and non-
communicable diseases[1,2,5–10].

There is much variation between different countries
surrounding the Mediterranean basin, and general patterns
in north and south Mediterranean countries can be identi-
fied. Globally, these two regions are affected by the gastro-
nomic preferences, socio-cultural and religious factors of
each country. Scores assessing adherence to the traditional
MD have been developed in northern Mediterranean
countries[1,3]. Nevertheless, few studies are available
regarding dietary patterns in south Mediterranean

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countries[11,12] and their specific aspects. For example, wine[13], which is a component of the MD, is not consumed in several south Mediterranean countries for religious reasons[14]. Except for Israel where a new MD score was adopted to reflect the local dietary habits[15], there is a lack of descriptions of the southern MD population.

Morocco is a middle-income country in North Africa with a population of nearly 34 million[16]. This country has been undergoing several transitions[17] which are displayed in different forms. Moroccan population is becoming increasingly urban with nearly 63 % of the population living in urban areas[18]. Social development has been heavily influenced by the change in Moroccan society structure, which has experienced remarkable socio-economic disparities and stable economic growth during the last decade[19,20]. The gross domestic product per capita is still moderate compared with developed countries[21]. In addition, the Moroccan lifestyle has changed considerably and that is expressed by the growing adoption of a western dietary pattern with high intake of animal products and sugar and sedentary behaviour[17,22]. Thus, nowadays, the traditional diet[23] is far from being the representative dietary pattern of the Moroccan population[22].

To the best of our knowledge, no studies have attempted to develop a dietary score fitted specifically to southern Mediterranean populations. The aim of the current study was to create a modified Mediterranean dietary (MMD) score adapted to south Mediterranean populations taking into consideration their geographical, socio-cultural and religious differences and to investigate its correlation with overweight and obesity risk in Morocco, a south Mediterranean country.

Subjects and methods

Study sample

The current study was nested in a large Moroccan case–control study, details of which have been published elsewhere[24]. To develop the MMD score, only data of the 1516 controls were used in the current study. These participants were recruited between September 2009 and February 2017 from rural and urban areas in the five greatest Moroccan regions, in an effort to approximate a nationally representative sample. Participants were healthy men and women, 18 years old or older, not on a diet, without any psychiatric problems, able to communicate and carry out the interview and capable of providing signed informed consent.

Data collection

The socio-demographic questionnaire included information about age, sex, educational level, marital status, residency and monthly income. In addition, tobacco smoking status (current smokers, ex-smokers and never smokers) was estimated according to the International Union against Tuberculosis and Lung Diseases Guide[25]. The physical activity intensity was assessed using the Global Physical Activity Questionnaire[26], from which the metabolic equivalent was calculated and divided into three categories: high, moderate and low intensity.

To assess BMI, height and weight were measured using a calibrated equipment (stadiometer and weighing scale), and BMI was calculated using the formula, weight (kg) divided by height^2 (m^2). BMI standard cut-offs were used to define overweight (≥ 25 to $< 30 \, kg/m^2$) and obesity ($\geq 30 \, kg/m^2$)[27].

Dietary assessment

A validated FFQ[28] was used to capture habitual diet. The Moroccan FFQ included 255 foods that were distributed in thirty-two groups. To extend the identification of foods relevant to the Moroccan population, the nutritional research team in Fez included a list of traditional Moroccan dishes. The frequency of consumption was classified into eight categories: never, 1–3 times/month, once a week, 2–4 times/week, 5–6 times/week, once per day, 2–3 times daily and >4 times daily. Using the local household servings[29], the frequency of intake was converted to average daily intake for each food item. The energy and nutrient intakes were calculated based on the available Food Composition Tables from Morocco[29], the Tunisian food composition table[30], the food composition table for African countries (FAO)[31], the French food composition table[32] and the United States Department of Agriculture nutrient database[33].

Moroccan traditional dishes

Through history, Moroccan cooking is heavily influenced by long cultural interactions including a mixture of Romans, Berber, Arabic, Ottoman, Andalusian and French cuisines[34], which allows it to be as one of the most diversified cuisines in the world, because they have received the culinary traditions from all these kitchens[34]. The most famous Moroccan dishes are Tajine, Couscous, Khobz (bread) and Spices.

1. Tajine usually composed of a wide selection of vegetables or legumes and small portion of red meat (lamb or beef) or poultry.
2. Couscous is composed of semolina grains (granules of durum wheat), topped with vegetables and meat and consumed once per week (every Friday).
3. Bread is essentially made from durum wheat semolina, and it is consumed in every meal.
4. Spices are usually used in almost every tagine, soup and couscous such as cumin, dried ginger, salt, black pepper and turmeric.

All these specific dishes were included in the FFQ used in the current study.

Development of southern Mediterranean diet score

Due to the differences in dietary patterns in populations around the Mediterranean Sea and the lack of information about southern Mediterranean populations, an MMD score was developed with reference to the updated MD pyramid[4] and the Moroccan traditional dishes and dietary specificities, to take into account the nutritional available data. This MMD score contained twelve components as follows:

1. Cereals including assida, smida, dchicha, belboula, porridge (herbel), mflak, barley couscous, wheat couscous, rice (any type) and (whole meal, white and homemade) bread.
2. Vegetables (e.g., lettuce, spinach, Rejla, Bakkoula, Mloukhia, tomatoes, aubergine, courgette, peppers (red, raw, rellow), cucumber, carrots, parsnip, swede, artichoke, radish, beetroot, chilli peppers, asparagus, aromatic herbs, leeks, onions, garlic, cauliflower, red pumpkin, Brussels sprouts, green broccoli, cabbage (white, red, green) and vegetable pickles).
3. Legumes (beans (white, green, soya, broad), lentils, chickpeas and peas).
4. Fruits (e.g., apples, pears, bananas, peaches, avocado, cherries, lemon pickles, mulberries, blackcurrants, raspberries, watermelon, grapes, mangoes, apricots, nectarines, plums, pineapple, kiwi fruit, orange, mandarine, grapefruit, figs (raw, dried), raisins and dates).
5. Fish (fresh fat fish (e.g., salamon, tuna, truite, sardine, bouri), white fresh fish (e.g., sole, merlan), fresh fish/other sea foods (eggs of fish), seafood shrimp, squid and mussels).
6. Modern dairy products (any type of milk, any type of cheese, any type of yogurt) and traditional dairy products[35] (lben; raib, jben).
7. Potatoes (all types).
8. Eggs (farmer and industrial eggs).
9. Red meat and processed meat (modern red meat, including tajine, steamed, grilled and roasted beef, lamb, camel, goat, kabab, chawarma, ham, sausage, as well as traditional red meat[36], including Khliaa and quadid).
10. Poultry and turkey (tajine, steamed, grilled and roasted).
11. Sweets including Moroccan confectioneries (such as Chabbakia, Mkharrka, Sellou, Zammita, Cake with date, Basboussa, Maqrout), Western-type confectioneries, chocolates, candy and caramel.
12. The ratio of MUFA:SFA. It is well known that the main source of MUFA is predominated by olive oil used in Moroccan daily cooking. Other types of added fats were included to calculate the ratio MUFA:SFA mainly: argan oil, vegetable oils, butter, mayonnaise and creams.

Calculation of the modified Mediterranean diet score

The MMD score was calculated on the basis of the consumption of twelve components. A value of 0 or 1 was assigned to each of these twelve components (cereals, vegetables, fruits, legumes, dairy products, potatoes, eggs, red and processed meat, fish, sweets, poultry and turkey and ratio of MUFA:SFA) using the sex-specific medians of the sample as cut-offs. For components which are not frequently consumed in the context of a traditional MMD (red and processed meat, modern and traditional dairy products, poultry and turkey, potatoes, eggs and sweets), we attributed, for each participant, a value of 0 if the consumption was equal or above the median and 1 if it was below the median. For components frequently consumed in the context of the traditional MMD (cereals, legumes, fruits, vegetables, MUFA:SFA ratio and fish), a value of 0 or 1 was assigned when the participant consumed quantities below or above/equal to the median per component, respectively.

To calculate the MMD, we summed the twelve components for each participant. The score ranged from 0 (no adherence) to 12 (high adherence). Adherence to the MMD was classified into three categories: low (scores 0–4), moderate (scores 5–7) and high (scores 8–12).

Statistical analyses

Differences between the median of MMD score (low and high adherence to MMD score) and general characteristics of the study sample were calculated using the Student's t test for continuous variables or the χ^2 test for categorical variables.

The normality distribution of food groups was evaluated by computing Kolmogorov–Smirnov test. Food data were not normally distributed, even after log transformation. Thus, the analyses were performed with non-log transformation.

Logistic regression was used to evaluate the adherence to the MMD; overweight/obesity was the dependent variable. Multivariable models were adjusted for age (continuous), marital status (single, married, divorced, widow), educational level (illiterate, primary, secondary, university), smoking status (never, past, current) and physical activity level (low, moderate, high). All statistical analyses were performed using the SPSS statistical version 20.0. P-values ≤ 0.05 were considered statistically significant.

Results

Participants with missing data from the FFQ were excluded (n 10). Furthermore, based on the method of the ratio of energy intakes:estimated requirements[37], subjects within 1·5 SD extremes were classified as outlier reporters (under- or over-reporters) (n 14, eleven men and three women). Eventually, 1492 participants were included in the analysis of the current study.

As presented in Table 1, a total of 1492 participants were included in the current study, of which, 754 (50·5 %) were

Table 1 Median modified Mediterranean score (MMD) by general characteristics of the study sample (*N* 1492)

		Total population		Low (0–6)		High (7–12)		
		n	%	*n*	%	*n*	%	*P*
Sex	Female	754	50·5	333	51·2	421	50·0	0·63
	Male	738	49·5	317	48·8	421	50·0	
Marital status	Single	144	9·7	50	7·7	94	11·2	0·08
	Married	1147	76·9	504	77·5	643	76·4	
	Divorced	59	4·0	26	4·0	33	3·9	
	Widow	142	9·5	70	10·8	72	8·5	
Residency	Urban	1126	75·5	486	74·8	640	76·0	0·58
	Rural	366	24·5	164	25·2	202	24·0	
Educational level	Illiterate	757	50·7	360	55·4	397	47·1	<0·01
	Primary	273	18·3	110	16·9	163	19·4	
	Secondary	271	18·2	112	17·2	159	18·9	
	Higher	191	12·8	68	10·5	123	14·6	
Monthly income (MAD)	<2000	1067	71·5	483	74·3	584	69·4	0·07
	2000–5000	300	20·1	114	17·5	186	22·0	
	>5000	125	8·4	53	8·2	72	8·6	
BMI	Underweight	39	2·6	11	1·7	28	3·3	0·03
	Normal	678	45·4	278	42·8	400	47·5	
	Overweight	646	43·3	304	46·8	342	40·6	
	Obese	129	8·6	57	8·8	72	8·6	
Smoking status	Never smokers	1252	83·9	549	84·5	703	83·5	0·02
	Ex-smokers	135	9·0	68	10·5	67	8·0	
	Smokers	105	7·0	33	5·0	72	8·5	
Physical activity intensity	Low	216	14·5	79	12·1	137	16·3	0·02
	Moderate	865	58·0	401	61·7	464	55·1	
	High	411	27·5	170	26·2	241	28·6	
Alcohol consumption	Yes	22	1·5	16	1·9	6	0·9	0·12
	No	1470	98·5	826	98·1	644	99·1	
		Mean	SD	Mean	SD	Mean	SD	*P*
Age (years)								0·05
Mean		55·6		54·99		56·38		
SD		13·7		13·78		13·57		
Energy intake (kJ/d)								0·43
Mean				13610·51		13468·67		
SD				3345·93		3679·38		

MAD, Moroccan Dirham.
Student's *t* test for continuous variables; χ^2 test for categorical variables.

women and 738 (49·5 %) were men, and the mean age was about 55·6 ± 13·7. Regarding educational level, 50·7 % were illiterate. Of the participants, 71·5 % earned <2000 Moroccan dirham per month. The prevalence of overweight and obesity was 43·3 and 8·6 %, respectively. When we estimated the MMD median by baseline characteristics, those who adhered more closely to the high category of MMD score were more likely to be illiterate, with lower educational level and lower monthly income, and they were more likely to be never smokers, have a normal BMI and have moderate physical activity intensity (Table 1).

Table 2 shows the mean consumption of food groups at each of the MMD levels. Among all participants, 23 % showed close adherence to the MMD. As expected, high intake of cereals, vegetables, legumes and fruits, moderate intake of fish and low intake of potatoes, red and processed meat, poultry and turkey and sweets were associated with close adherence to the MMD. Mean energy intake is higher in the highest MMD score category, but the *P*-value is

non-significant and that could be explained by the high consumption of the beneficial components of MMD score such as cereals, especially bread consumed in every meal, and the great variability presented in our nutritional variables.

In multivariate analyses, adjusting also for confounding factors, high compared with low MMD score, was overall associated with significantly reduced overweight/obesity risk (OR 0·61, 95 % CI 0·44, 0·84). This inverse association in the overall sample was driven by the inverse association noted among women (OR 0·57, 95 % CI 0·36, 0·89). The association between MMD score and overweight/obesity risk was not statistically significant among men (Table 3).

Discussion

This is the first study to develop an MMD score adapted to the southern Mediterranean, Moroccan dietary habits and to evaluate its association with overweight/obesity risk. The prevalence of overweight and obesity combined

Table 2 Food group means by categories of modified Mediterranean score (MMD) score

Foods		MMD score (0–4) (n 317)		MMD score (5–7) (n 833)		MMD score (8–12) (n 342)		P
		Mean	SD	Mean	SD	Mean	SD	
Energy intake	(kJ/d)	13 282·31	3081·15	13 550·13	3676·18	13 769·56	3382·22	0·20
Cereals	(g/d)	342·08	143·98	374·07	158·33	434·47	145·23	<0·01
Vegetables	(g/d)	194·24	75·32	233·64	158·00	250·40	170·96	<0·01
Legumes	(g/d)	128·15	90·27	157·56	114·53	160·85	121·31	<0·01
Fruits	(g/d)	128·74	89·51	174·82	152·92	261·04	171·18	<0·01
Fish	(g/d)	22·60	23·11	29·60	27·65	34·43	25·00	<0·01
Ratio MUFA/SFA	(g/d)	1·26	0·31	1·50	0·59	1·52	0·52	<0·01
Dairy products	(g/d)	237·40	127·87	186·91	147·20	156·98	115·52	<0·01
Potatoes	(g/d)	58·71	30·61	46·20	35·44	29·20	19·06	<0·01
Eggs	(g/d)	24·22	17·03	20·49	20·33	14·58	15·98	<0·01
Red and processed meat	(g/d)	84·60	61·62	61·75	76·33	24·32	38·80	<0·01
Poultry and turkey	(g/d)	65·57	51·10	47·28	43·56	27·47	30·23	<0·01
Sweets	(g/d)	18·09	31·21	13·60	25·91	5·90	13·15	<0·01

Differences of food groups and the Mediterranean diet adherence categories were assessed one-way ANOVA.

Table 3 Multiple logistic regression-derived OR and 95 % CI for risk of obesity/overweight according to the level of modified Mediterranean score (MMD) score

Adherence to MMD score	Model 1	
	OR	95 % CI
Overall (N 1492)		
Low (0–4)	1	
Moderate (5–7)	0·67	0·51, 0·87
High (8–12)	0·61	0·44, 0·84
Men (n 738)		
Low (0–4)	1	
Moderate (5–7)	0·64	0·43, 0·95
High (8–12)	0·63	0·39, 1·02
Women (n 754)		
Low (0–4)	1	
Moderate (5–7)	0·66	0·45, 0·96
High (8–12)	0·57	0·36, 0·89

Logistic regression models adjusted for age, marital status, educational level, physical activity intensity and smoking status (for overall and for men).

exceeded 50 % among the Moroccan adult population we studied. The results of our study indicated that close adherence to MMD (scores 8–12) compared with low adherence (scores 0–4) coincides with the reduced overweight/obesity risk (OR 0·61, 95 % CI 0·44, 0·84).

The current MMD score was developed according to the updated MD pyramid recommendations[4]. In addition to internationally known food items, Moroccan traditional food and dietary culinary specificities were also included in this MMD score. Because of the very low (or absence) consumption of pork and alcohol beverages in Moroccan people, these items were not included in the created score. For all these reasons, we consider that the MMD developed score is closest to the actual nutritional habits of the Moroccan and the southern Mediterranean populations.

In this cross-sectional study, in a population sample which though not formally representative covers both rural and urban areas in the five greatest Moroccan regions, we found a high prevalence of overweight/obesity (nearly 52 %) among Moroccan adults. Consistent with our results, a literature review aimed to describe the prevalence of excess weight status in North African adults found that Moroccan women have the highest prevalence of overweight in this region with about 47·8 %[38]. These findings are coherent with evidence from a previous national survey[39].

Morocco passes through the third phase of its epidemiological transition in both urban and rural areas[17,39]. Our results of general characteristics show a great variability that can be expected in the questionnaire period of 9 years. Several characteristics of Morocco's socio-economic transition over the last decade could induce that variability, including monthly income, housing and educational level[19,40,41]. All of these factors make it easier to access work (especially for women) and increase urbanisation[39,42]. In addition, in that period, the Arab Spring lightly affected Morocco's economic status, although the economic growth has been stably increased despite the rioting[20].

Our nutritional variables present a large variability that may be due to a nutritional shift characterised by the adoption of western dietary habits in young people and the restoration of traditional diets in elderly people[17]. For instance, according to a new Moroccan study, the current daily fibre intake decreased and that of saturated fat increased in the current Moroccan diet compared with the traditional MD[17].

Overall, our participants who reported high adherence to the MMD score had a 39 % reduced risk for excess weight in comparison with participants in the lowest compliance category, this suggested association driven particularly by the results among women. Previous international research found convincing evidence that the MD pattern was inversely associated with lower levels of prevalent overweight and obesity[43–47]. An intervention trial aimed to

examine the weight change by diabetes status among participants receiving a Mediterranean-style diet concluded that adherence to MD provided weight loss after 24-month follow-up[48]. However, there are practically no published data on MD adherence among the Moroccan population. We could identify only one study published by El Rhazi et al.[22] that concluded that the MD score does not adequately address adherence to the traditional diet in the Moroccan population. The MD score developed in northern Mediterranean countries cannot accurately reflect compliance to the traditional Moroccan dietary habits, which include specificities driven by religion, mainly abstinence from alcohol.

Limitations and strengths should be noted in the current study. Regarding the results on the prevalence of obesity and overweight, the study sample was not formally representative; however, it covered both rural and urban areas in the five greatest Moroccan regions. In addition, the long period of the questionnaire is a real cause of the high variability presented in our results. This long period coincides with a slight socio-economic change and may have an impact on the general characteristics representativeness of our recruited population. Furthermore, the social class more presented in our study is the poor class, followed by the middle class (real classification). Concerning the association of MMD with overweight/obesity, our study is hindered by the limitations of all observational studies, in which residual confounding cannot be excluded. Diet was assessed only at recruitment, but dietary change was still an important confounder related to excess weight. On the other hand, dietary information was collected using a validated FFQ adapted to the Moroccan population, and when developing the MMD score, southern Mediterranean, and in particular Moroccan, diet specificities were taken into account.

Conclusion

Our results indicate that adherence to the traditional southern MD may be associated with the reduced risk of overweight and obesity in the Moroccan adult population. The results can have important public health implications, given the recent shift towards a western dietary pattern in this population.

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