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Original article

Adaptation and predictive utility of a Mediterranean diet screener score

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SUMMARY

Background & aims: There is a substantial body of evidence supporting the health benefits of the Mediterranean diet, which has differing variations across the Mediterranean region. Abbreviated dietary screeners can be adapted and used to assess adherence to the local Mediterranean diet variant. We aimed to describe the process of adapting the Spanish Mediterranean Diet Adherence Screener (MEDAS) for use in Israel, and to test the predictive utility of the adapted score for mortality.

Methods: A professional committee of nutritional policy makers, dieticians and researchers adapted MEDAS to create an Israeli Mediterranean diet screener (I-MEDAS) that reflected the local Mediterranean diet and national dietary recommendations. The Hadera District Study (HDS) was a population-based, prospective cohort study of adults in Israel. Food frequency questionnaire (FFQ) data from the HDS was used to calculate Mediterranean diet adherence according to the I-MEDAS score criteria and evaluate the score's predictive utility. Mortality status was obtained from the national population registry. Cox proportional hazards regression models were used to test the predictive utility of the I-MEDAS score for all-cause mortality.

Results: The 14-item MEDAS was adapted to create a 17-item I-MEDAS. According to FFQ data from the HDS cohort (n = 1092 adults; median [IQR] follow-up time = 14 [12–15] years, 179 deaths), the median (IQR) I-MEDAS score was 8 (7–9). In multivariable analysis, every 1-point increase in the I-MEDAS score reduced the hazard of death by 12% (adjusted HR: 0.88; 95% CI: 0.80–0.97). The original MEDAS score was less strongly associated with mortality, and lost significance after adjustment for potential confounders.

Conclusions: I-MEDAS reflects the local Mediterranean diet and national dietary recommendations in Israel. The I-MEDAS score, calculated from FFQ data, demonstrated predictive utility for mortality in a population-based cohort of adults.

1. Introduction

The Mediterranean diet (MedDiet) is generally characterized by a high intake of plant foods (e.g., vegetables, fruits, legumes, nuts, preferably whole-grain cereals); use of olive oil as the main dietary fat; a moderate intake of dairy products; a low or moderate intake of meat and fish; and a moderate consumption of wine with meals

Abbreviations: 24HR, 24-h recall; CVD, Cardiovascular disease; FFQ, Food frequency questionnaire; HDS, Hadera District Study; I-MEDAS, Israel-Mediterranean Diet Adherence Screener; MEDAS, Mediterranean Diet Adherence Screener; MedDiet, Mediterranean diet; MOH, Ministry of Health; SES, Socio-economic status.

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[1,2]. This core diet has many local variations/adaptations across the Mediterranean region [2].

Scientific evidence supports the benefits of the MedDiet in reducing the risk of all-cause and cause-specific mortality [2–5]. It is also associated with reduced risk of developing numerous chronic and degenerative diseases (e.g., various types of cancers, type 2 diabetes, cardiovascular disease) [2,6,7]. Furthermore, the MedDiet may support healthy aging by delaying cognitive decline [2] and preserving physical function [8–10]. Given this evidence, the promotion of a MedDiet pattern can be an important strategy for improving population health [2].

Dietary scores can be useful tools for evaluating adherence to the MedDiet [2,11]. The first and most widely used score was developed by Trichopoulou et al. [12] and evaluated concordance with the MedDiet according to whether an individual's intakes of protective and non-protective foods/nutrients were higher or lower, respectively, than the sex-specific median intake in the study population. The score was calculated based on data from a full dietary assessment (either a food frequency questionnaire [FFQ] or several days'-collection of 24-h recall [24HR] questionnaires or food logs to establish habitual dietary intake). Such assessments are costly to administer and have a high respondent burden, which can create a barrier to the timely collection and evaluation of MedDiet adherence at the population level [11,13]. As a consequence, several short screeners have been validated as tools for rapid assessment of MedDiet adherence that may be useful for population surveillance and risk assessment in epidemiological research, and public health and clinical practice [2,11,13].

While many MedDiet scores/screeners have been described in the literature [2], there is a lack of in-depth, replicable descriptions of developing/adopting Mediterranean diet scores and/or screeners to local populations in order to maximize their content validity, applicability and predictive utility. In this paper, we provide a detailed description of the adaptation of a short, MedDiet screener to reflect the healthful characteristics of the traditional local Mediterranean diet in Israel; report intakes of foods included in the screener in a population-based cohort of Israeli adults; and, test the predictive utility of the adapted MedDiet screener score, and its individual components, for associations with mortality.

2. Materials and methods

2.1. Adaptation of a MedDiet screener

Our search of the literature produced a number of short, food-based MedDiet adherence screeners that do not require completion of a full dietary assessment [11,12,14], which were discussed by the consultation committee (authors KA, OKL, RG, TS, LN, DS, LKB, RE). The committee deemed the MEDAS tool [11] to be the most appropriate screener for adaptation, due to its brevity and inclusion of both beneficial and detrimental foods, most of which were aligned with Israeli dietary recommendations [15]. The 14-item MEDAS was designed for use in the PREDIMED trial to assess the long-term effects of the MedDiet on incident cardiovascular disease (CVD) with participants randomly assigned to an olive oil- or nut-supplemented MedDiet, or a low-fat control diet [16,17]. MEDAS was used to assess the study participants' adherence to a MedDiet pattern at baseline and to the assigned dietary intervention during the trial [11]. Local adaptations were made to MEDAS based on national dietary recommendations and dietary intake data for the Israeli population.

2.2. Sample and study procedures

Data from the prospective Hadera District Study (HDS) cohort were used to evaluate the content validity and predictive utility of the adapted Israeli MEDAS (I-MEDAS) score. The study sample and interviewing procedures have been described in detail elsewhere [18–20]. Briefly, a randomly-selected sample of the urban population in the Hadera District in Israel was drawn from the population registry, stratified equally by gender, ethnicity (Arab or Jewish) and 10-year age groups (range: 25–74). The Hadera District population is predominantly urban (91.2%), similar to the total population in Israel (91.2%) [21]. The demographic and socio-economic characteristics of the Hadera District Jewish and Arab populations are similar to those of the national Jewish and Arab populations (e.g., median age, educational level, employment rate) [21]. The total HDS sample included 1318 individuals, of whom 1104 consented to participate in the study (84% response rate).

The original study questionnaire in Hebrew was translated into Arabic and Russian, and home interviews were conducted in the participant's native language by trained interviewers from 2002 to 2007. Data on socio-demographic characteristics, body weight and height, diet, physical activity, smoking, and chronic disease prevalence were collected [18,22]. The study was approved by the institutional ethics committee (Helsinki Committee) of Sheba Medical Center. All participants provided written informed consent.

2.3. Dietary assessment

Information on habitual dietary intake was collected using a quantified 240-item FFQ developed for the multi-ethnic Israeli Jewish and indigenous Arab populations, which has been used in numerous observational studies in Israel [13,22–24]. Participants were asked for detailed information about their intake of each item in the FFQ food list over the past year, including frequency of consumption, number of portions consumed, and portion size using pictorial aids. Participants could also add items that were not present in the food list. Participants reporting implausible energy intake (<500 kcal/d or >6000 kcal/d [22], n = 9) were excluded from the analysis.

2.4. Nutrient database

The database used to calculate nutrient values was based primarily on the UK food composition database [25], supplemented with data from international [26,27], Israeli [28] and Palestinian Arab [29] food composition tables, local manufacturers, and representative local recipes.

2.5. Socio-economic and health-behavior covariates/variables

Participants' years of education were evaluated as a continuous variable. Household occupational level was determined according to the 10-group ordinal scale of the Israel Bureau of Statistics occupational classification [30], with the score representing the highest occupational status level of the participant or his/her spouse. Due to the high correlation between the educational and occupational status variables (Pearson's $r \geq 0.70$), principal component analysis was used to reduce these variables to a single socio-economic status (SES) factor that explained 82.8% of the SES variance in the sample. Smoking status was dichotomized as never or ever smoked. The physical activity score (h/w) was calculated as the sum of hours per week of moderate/vigorous leisure and non-leisure physical activity and half of the hours per week of light physical activity. Measured weight and height (without shoes, in lightweight clothing) were obtained and used to calculate body mass index (BMI, kg/m^2). Baseline co-morbidities were ascertained from multiple sources, including participant-reported physician diagnosis or medication use, blood tests and electronic medical record diagnoses/lab tests. A modified Charlson comorbidity score [31] was calculated, with the addition of hypertension (with a weight of 1 point) for our analyses, since hypertension was associated both with baseline dietary behaviors and with mortality.

Mortality status was ascertained from the mortality data in the Interior Ministry population registry, updated to 10 April 2018, which were individually-linked to HDS participants via their unique Israeli identification numbers.

2.6. Statistical analyses

Descriptive statistics (chi-square or Fisher's exact tests for categorical variables and the Wilcoxon test for continuous variables) were used to characterize participant socio-demographic characteristics, non-dietary health behaviors and baseline co-morbidity, and to test for associations with mortality. Baseline intakes of the original MEDAS and the adapted I-MEDAS components were represented by nonparametric descriptors (median, interquartile range), due to their non-normal distribution. Associations between all-cause mortality and compliance with 1) the individual components of I-MEDAS, 2) the total I-MEDAS score, and 3) the original MEDAS score were evaluated in multivariable Cox proportional hazards regression models controlling for age, sex, the baseline co-morbidity score, and other possible confounders. Co-variates associated with mortality at a level of $P < 0.20$ in univariate analysis were entered into a backward elimination procedure. The least significant variables were eliminated from the model sequentially until all remaining variables were significant at a level of $P < 0.05$. Multivariable analyses did not control for total energy because the screener does not measure total energy intake. The proportional hazards assumption was tested using a Kolmogorov-type supremum test based on a sample of 1000 simulated residual patterns. To evaluate the fit of the multivariable models for predicting mortality, we calculated the area under the ROC curve (c-index). All analyses were performed using SAS (version 9.4, SAS Institute Inc., Cary, NC).

3. Results

The analysis included 1092 respondents, and the median (IQR) follow-up time was 14 (12–15) years, during which there were 179 deaths from all causes. Table 1 presents selected baseline socio-demographic and health characteristics by mortality status. Survivors were significantly younger and better educated than those who died. They had a higher socio-economic profile, better health behaviors, and less chronic morbidity. The all-cause mortality rate was higher among Arabs (14.7 per 1000 person-years) than Jews (10.6 per 1000 person-years).

Dietary screener adaptations: Table 2 presents the original 14-item MEDAS scoring components, and a summary of and rationale for the adaptations made to the items for I-MEDAS. The 14-item MEDAS was designed to test adherence to the PREDIMED intervention, which in one arm entailed the consumption of 4 tbsp olive oil/day. Since this represented a much higher consumption level than that found in our population (even among those producing their own olive oil), this item was dropped, while the item of using olive oil as the main culinary fat source was retained. There was debate about keeping tomato sauce (local counterpart of *sofrito*) as a separate item, rather than including it with other vegetables. Since it was not found to be associated with mortality in further analyses, it was combined with non-starchy vegetables. In addition, we made adaptations appropriate for the traditional diet of the southeastern Mediterranean area (e.g., the inclusion of commonly consumed forms of legumes such as hummus [chickpea] salad, tahini [sesame seed paste]). The ‘commercial cakes’ item was included in MEDAS because of its contribution to trans fat intake, while homemade cakes were more likely to be made with olive oil in Spain (Personal communication with Bes-Rastrollo M.). Since in Israel, both commercial and homemade cakes/cookies are generally made with trans or saturated fat, we modified this item to include both types. We also created an item for savory pastries (e.g., puff pastries), which are a major contributor to trans fat intake in Israel. Wine and alcohol consumption is very low in Israel, and since there is literature suggesting that moderate alcohol intake (regardless of type) may be beneficial [32,33], we used total alcohol intake in the adapted score. At the same time, there are indications that heavy alcohol intake might be increasing in younger age strata, so it is important to track, despite the low consumption among middle-aged and older adults. Finally, we adapted or added other items to more fully align the screener with national dietary recommendations. Fruit juice was excluded from the fruit item, due to the loss of nutritional value when whole fruit is processed into juice. An item about the intake of whole grains was added, given its centrality to the traditional local MedDiet [34], and the interest in

Table 1
Selected baseline HDS participant characteristics by mortality status.

	Death		P
	No (n = 913)	Yes (n = 179)	
Baseline age *median (IQR)*	47.7 (37.1–59.1)	64.9 (56.7–71.9)	<.0001
Sex: Women *N(%)*	476 (52.1)	72 (40.4)	0.0036
Ethnicity: Arab *N(%)*	441 (48.3)	103 (57.5)	0.0238
Education- years *median (IQR)*	12 (8–14)	8 (1–12)	<.0001
Highest profession score[a] *median (IQR)*	4.0 (1.0–8.0)	6.0 (1.0–8.0)	0.0002
Baseline BMI *median (IQR)*	28.0 (25.0–31.6)	28.8 (26.1–33.0)	0.0287
Baseline ever smoked *N(%)*	389 (42.6)	96 (53.6)	0.0066
Baseline physical activity score[b] (hr/wk) *median (IQR)*	24.5 (15.4–35.0)	10.5 (3.5–23.1)	<.0001
Leisure physical activity≥2.5 h/wk N*(%)*	284 (31.1)	43 (24.0)	0.0585
Baseline diabetes[c] *N(%)*	149 (16.4)	79 (44.4)	<.0001
Baseline hypertension[c] *N(%)*	265 (29.1)	116 (65.2)	<.0001
Baseline dyslipidemia[c] *N(%)*	397 (43.6)	115 (67.3)	<.0001
Baseline chronic morbidity score[d] *median (IQR)*	0.0 (0.0–1.0)	2.0 (1.0–4.0)	<.0001

HDS Hadera District Study, BMI body mass index.
[a] Household occupational status level was determined according to the 10-group ordinal scale of the Israel Bureau of Statistics occupational classification [30], in which a lower score represents higher occupational status. In this analysis, the score represents the highest occupational status level of the participant or his/her spouse.
[b] Physical activity score: Sum of hours per day of leisure and non-leisure physical activity where an hour of moderate/vigorous activity is counted as 1 h, and an hour of light activity is counted as 30 min.
[c] Ascertained from baseline study participant-reported physician diagnosis, medication use, and/or blood tests; and/or electronic medical record diagnoses/lab tests.
[d] Modified Charlson comorbidity score [31], with the addition hypertension (with a weight of 1 point).

Table 2
Original MEDAS and revised I-MEDAS screener items and score criteria.

Screener item	Criterion for positive score	Serving size/Criterion definition		Operationalization for utility study	Comment
		MEDAS[a]	I-MEDAS		
Olive oil	4 + servings/d	1 tbsp/(13.5 g)	–	≥54 g	Tested adherence to the PREDIMED intervention diet, in which 1 arm was instructed to consume 4 tbsp/d; <2% of HDS participants met this criterion.
Preference for olive oil	Yes	Yes	Yes	g olive oil/d > g other oils	
Non-starchy Vegetables	2 + servings/d	200 g	200 g	≥400 g	Since we decided not to use servings of tomato sauce as a separate item, we included this with vegetables, where 1 serving of tomato sauce was considered equivalent to 0.5 servings of vegetables.
Fruit (including juice)	3 + servings/d	ND	–	–	
Fruit (without juice)	3 + servings/d	–	125 g	≥375 g	For health promotion purposes in Israel, fruit juice not included.
Red/Processed meat	<1 serving/d	<100–150 g	125 g of red meat or 60 g processed meat	<1 serving/d	In the typical consumption patterns in Israel, the weight of a red meat serving differs from that of a processed meat serving.
Poultry more than Red/Processed meat	Yes	Yes	Yes	g poultry > g red + processed meat	
Butter/Margarine	<1 serving/d	<12 g	<12 g	<12 g	
Sweet soft drinks	<1 serving/d	ND	<1	<200 g	
Wine	7 + glasses/wk	ND	–	–	Wine/alcohol consumption very low in Israel; <2% of HDS participants met this criterion.
Alcohol	7 + servings/wk	–	14 g pure alcohol	≥98 g pure alcohol/wk	For health promotion purposes in Israel, want to track alcohol consumption; included all types of alcohol and defined serving as amount containing 14 g pure alcohol.
Legumes	3 + servings/wk	150 g	150 g	≥450 g/wk	Hummus salad, which is consumed differently from cooked legumes, was not included in this category.
Fish (fresh & preserved)	3 + servings/wk	100–150 g of fish, 4–5 pieces or 200 g of seafood	125 g of fresh fish or 60 g of preserved fish	≥3 servings/wk	Seafood is rarely consumed in Israel; preserved fish is more commonly consumed and the weight of a typical serving of fresh fish differs from that of a serving of preserved fish.
Desserts	<3 servings/wk	ND	45 g for cakes 30 g for cookies	<3 servings/wk	All baked sweets in Israel were included, even if homemade, as they are likely to be made with butter/margarine rather than olive oil. The weight of typical servings of cake and cookies differs.
Nuts	3 + servings/wk	30 g	30 g	≥90 g/wk	
Sofrito/tomato sauce	≥2 times/wk	ND	–	1 serving = 0.5 servings of NS vegetables	After finding no association with mortality, this was combined with NS vegetables.
Salty snacks	≤3 servings/wk	–	25 g	≤75 g/wk	Highly processed, high sodium food.
Savory pastries	≤2 servings/wk	–	100 g	≤200 g/wk	Important source of trans fatty acid intake in Israel.
Whole grains	3 + servings/d	–	30 g for bread; 50 g for cooked grains	≥3 servings/d	Part of traditional local Mediterranean diet, and MOH dietary guidelines. The weight of typical servings of bread and cooked grains differs.
Non-sweetened dairy products	2 + servings/d	–	Amount containing 150 mg calcium	≥300 mg calcium	Highly consumed in Israeli society; important source of calcium, potassium and magnesium.
Hummus/tahini salad	3 + servings/wk	–	30 g hummus or 20 g tahini	≥3 servings/wk	Hummus is most commonly consumed legume; by MOH regulation contains ≥16% tahini; in HDS sample was the source of over half of the tahini intake. Tahini salad has many healthy properties, MOH interested in promoting its consumption. The weight of typical servings of hummus salad and tahini salad differs.

MEDAS Mediterranean Diet Adherence Screener, I-MEDAS Israel-Mediterranean Adherence Diet Screener, HDS Hadera District Study, MOH Ministry of Health, ND not defined.
[a] From Schröder et al. [11].

promoting and tracking whole grain consumption [35]. We added dairy products as a beneficial food, because they are traditionally an integral part of the local MedDiet [24,34], are widely consumed in Israel [36], and are an important source of beneficial nutrients such as calcium, potassium, magnesium, iodine, Vitamin A, Vitamin B12, and protein [37]. There was also an interest in tracking intakes of potentially detrimental foods such as salty snacks (e.g., potato and corn chips/puffs, pretzels). After these adaptations, I-MEDAS included 17 components. To calculate the score, servings were translated into grams using the same definitions as used in the MEDAS score, when available and appropriate. In some cases in the Israeli context, the weight of typical servings differed among individual food items within a score component (e.g., red meat and processed meat, fresh and preserved fish, cakes and cookies, hummus and tahini). In these cases, food item-specific weights comprising a serving were set, and the total number of servings was used as the scoring criteria (Table 2). Each component received a score of 1 if the criterion was met, and 0 if it was not, so the total I-MEDAS score ranged from 0 to 17 points.

Using FFQ data, we calculated a MEDAS score, based on the original score criteria [11], and an I-MEDAS score, based upon the modification of MEDAS for the Israeli context, for each HDS participant.

Supplemental Table 1 provides median (IQR) intakes of the original MEDAS and the modified I-MEDAS components in the HDS sample, stratified by ethnicity and sex. Table 3 presents the baseline percentage of the sample that met the criterion for each of the MEDAS and I-MEDAS components. Intakes of some components characteristic of the MedDiet in Spain were very low across the HDS sample (e.g., wine). Intakes of several components characteristic of the local Mediterranean diet were also suboptimal (e.g., legumes/hummus/tahini, whole grains, vegetables, fruits, unsweetened dairy products).

The I-MEDAS score, as a whole, had a significant protective association against death in a minimally-adjusted model controlling for age (HR: 0.85, 95% CI: 0.77–0.94; *c*-statistic: 0.79) (Table 4). Further adjustment for sex, baseline comorbidities, SES and weekly physical activity contributed to the explanatory power of the model without substantially altering the association between the I-MEDAS score and mortality (HR for a 1-point increment: 0.88, 95% CI: 0.80–0.97; *c*-statistic: 0.84). The proportional hazards assumption for I-MEDAS was met in all models.

We also tested the association between the original MEDAS score and all-cause mortality. While it was also protective, it was a weaker mortality predictor than the I-MEDAS score, and became non-significant in the fully adjusted model (HR: 0.91, 95% CI: 0.81–1.02; *c*-statistic: 0.83).

Figure 1 presents hazards ratios for the associations of the total I-MEDAS score and its individual components, as calculated from baseline FFQ data, with mortality in multivariable models adjusted for age, sex, baseline comorbidities, SES, and weekly physical activity. In general, the I-MEDAS components tended toward a protective effect; however, given the relatively small sample size for investigating individual dietary components, the associations (with the exception of sweetened soft drink <1 serving/day) did not reach statistical significance.

4. Discussion

I-MEDAS is an adaption of the 14-item MEDAS designed to measure adherence to the local version of the Mediterranean diet and national dietary recommendations in Israel. In a prospective multi-ethnic, population-based cohort of Israeli adults, the I-MEDAS score demonstrated predictive utility for all-cause mortality, with every 1-point increase in the score reducing the hazard of death by 12%. Our findings suggest that the adapted I-MEDAS score is a more sensitive measure than the original MEDAS score for exploring the diet-mortality association among adults in Israel.

Since MEDAS was modified from an existing 9-item MedDiet screener [38,39] specifically to test adherence to the PREDIMED trial dietary interventions in a Spanish population [16], its application in other settings/populations may require additional modifications. We found relatively few examples of the use of MEDAS outside of Spain in the published literature, all of which were in non-Mediterranean countries (e.g., UK, US, and Germany) [40–42]. In these studies, the 14-item MEDAS was used with no modifications, perhaps because these countries do not have local MedDiet variants. Nevertheless, the applicability of criteria such as ‘4 tablespoons of olive oil/d’ (which is quite a high amount, representing the PREDIMED trial's dietary target for the intervention arm that was provided with olive oil) would benefit from critical appraisal, since even in a representative sample of Spanish adults only 8% met this criterion [43].

We present a detailed, operationalized description of adapting MEDAS to fit the local version of the MedDiet and national dietary recommendations in Israel. The adaptations also reflected the results of our preliminary exploration of the predictive utility of the overall score and its individual components. Our findings were suggestive of protective associations between most of the I-MEDAS score's individual components and mortality, but most of these associations did not reach statistical significance. This is not an uncommon finding in MedDiet score studies in relation to mortality and other outcomes [3,12,38,44,45]. The effect of an overall dietary pattern is cumulative and therefore it is likely to be greater than the effect of its individual components separately [44]. Our findings support the predictive potential of some of the added components (e.g., non-sweetened dairy products, whole grains), and the merits of their inclusion in a MedDiet screener in this population. Other components may benefit from further refinement in identifying the thresholds that have greater predictive

Table 3
Percentage of HDS participants whose baseline dietary intake met the criteria for the MEDAS and I-MEDAS screener components.

Screener item	Criterion for positive score	% Achieving target	
		MEDAS	I-MEDAS
Olive oil	4 + servings/d	1.2	–
Preference for olive oil	Yes	39.9	39.9
Non-starchy vegetables	2 + servings/d	23.1	–
Sofrito/tomato sauce	2 + times/wk	26.3	–
Non-starchy vegetables incl. tomato sauce	2 + servings/d	–	26.2
Fruit (including juice)	3 + servings/d	20.1	–
Fruit (without juice)	3 + servings/d	–	17.6
Red/Processed meat	<1 serving/d	93.7	93.7
Poultry more than Red/Processed meat	Yes	84.5	84.5
Butter/Margarine	<1 serving/d	90.6	90.6
Sweet soft drinks	<1 serving/d	70.2	70.2
Wine	7 + glasses/wk	1.3	–
Alcohol (serving = 14 g pure alcohol)	7 + servings/wk	–	3.2
Legumes	3 + servings/wk	1.8	1.8
Fish (fresh & preserved)	3 + servings/wk	30.0	30.0
Desserts (cakes, cookies)	<3 servings/wk	45.2	45.2
Nuts	3 + servings/wk	47.5	47.5
Salty snacks	≤3 servings/wk	–	99.7
Savory pastries	≤2 servings/wk	–	85.9
Whole grains	3 + servings/d	–	5.3
Non-sweetened dairy	2 + servings/d	–	53.3
Hummus/tahini salad	3 + servings/wk	–	32.8

MEDAS Mediterranean Diet Adherence Screener, I-MEDAS Israel-Mediterranean Adherence Diet Screener, HDS Hadera District Study.

Table 4
Multivariable Cox proportional hazard models testing the association between I-MEDAS and all-cause mortality (n = 1092).

Parameter	Model 1			Model 2			Model 3			Model 4		
	HR	95% CI	p	HR	95% CI	p	HR	95% CI	p	HR	(95% CI)	p
I-MEDAS (per 1 pt increment)	0.85	(0.77–0.94)	0.001	0.85	(0.77–0.94)	0.001	0.88	(0.79–0.97)	0.008	0.88	(0.80–0.97)	0.013
Age (per 10y increment)	2.38	(2.35–2.42)	<0.001	1.92	(1.64–2.23)	<0.001	1.82	(1.55–2.13)	<0.001	1.77	(1.51–2.07)	<0.001
Sex: Female vs male (ref)				0.70	(0.51–0.95)	0.020	0.60	(0.44–0.83)	0.002	0.63	(0.46–0.86)	0.005
Co-morbidity score (per 1 pt increment)				1.42	(1.32–1.53)	<0.001	1.43	(1.32–1.54)	<0.001	1.39	(1.29–1.50)	<0.001
Ethnicity: Arab vs Jewish (ref)				1.39	(1.03–1.88)	0.029	0.95	(0.65–1.40)	0.799			
SES factor (per 1 pt increment)							0.73	(0.60–0.89)	0.002	0.79	(0.67–0.94)	0.007
Baseline physical activity score[a] (per 1 h/wk increment)										0.98	(0.97–1.00)	0.021
C-statistic	*0.793*	*(0.792-0.795)*		*0.833*	*(0.831-0.835)*		*0.838*	*(0.836-0.839)*		*0.838*	*(0.837-0.840)*	

Italics signify the concordance statistic (C-statistic), which is a measure of goodness of fit for binary outcomes in the proportional hazard regression model. The point estimate is the C-statistic for the model, rather than an HR.

[a] Physical activity score: Sum of hours per day of leisure and non-leisure physical activity where an hour of moderate/vigorous activity is counted as 1 hour, and an hour of light activity is counted as 30 min.

utility. For example, the MEDAS question about red/processed meat refers to daily intake and has a threshold of <1 serving/d, which does not distinguish between those consuming <1 serving/wk and those consuming 6 servings/wk. In the HDS cohort, 94% met this criterion, compared to 82% in a representative Spanish sample [43]; and thus it is not a very sensitive or informative threshold for the Israeli population. There is a need for combining and/or collecting additional dietary intake datasets to enhance the statistical power and identify a more sensitive threshold for this and other components of the score (e.g., alcohol, butter/margarine). Although the intakes of some components were very low (e.g., whole grains, legumes), they were retained in the screener because of the public health initiatives promoting their intake.

The protective association we found between the total I-MEDAS score and mortality is consistent with a large body of literature across and beyond the Mediterranean region [3–5,44–54]. The PREDIMED trial itself did not find an association between the MedDiet-promoting intervention arms (as compared to the low-fat control arm) and all-cause mortality [16]. However, since mortality was not a primary outcome, and the trial was stopped early due to clear evidence of a protective effect against CVD events (primary outcome) [16,17], the power of the PREDIMED study for evaluating the diet-mortality association was limited [55]. It is noteworthy that we found the adapted I-MEDAS score to have more robust predictive utility vis-à-vis all-cause mortality in our sample than the original MEDAS score. This suggests that it is important to use MedDiet scores that accurately reflect the regional/local variations in the Mediterranean diet, and are sensitive to adherence in specific Mediterranean populations. However, this must be counter-balanced by the need for comparability across populations. The

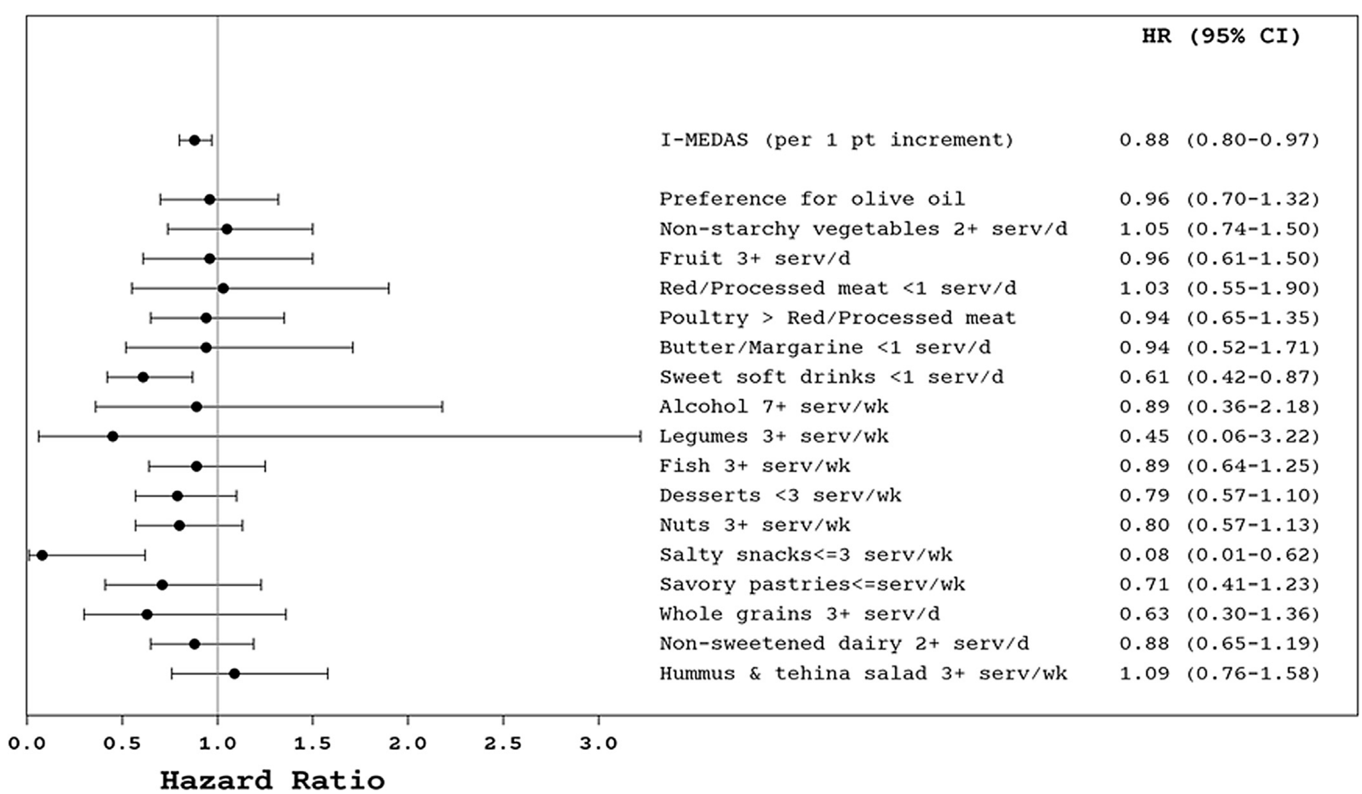

Fig. 1. Hazard Ratios (adjusted for age, sex, baseline chronic morbidity, SES and weekly physical activity) for the associations between the total I-MEDAS score and its individual components and mortality in the Hadera District Study Cohort.

original Mediterranean Diet Score developed by Trichopoulou [12], which was scored based on sex-specific median intakes in each population, created major challenges for comparability, particularly since differences in these median intakes, and thus the scale, were not always reported [4,47,48,56,57]. For scores such as MEDAS with absolute criteria, the profile for MedDiet adherence is explicit, and where local variants of the score clearly report adaptations and modified criteria, it is easier to identify the specific differences in the scores to assess comparability across scores/studies.

The median I-MEDAS score of 8 (out of a possible 17) in a multi-ethnic, population-based HDS cohort, as calculated from FFQ data, indicated suboptimal MedDiet adherence among adults in Israel. Since the baseline HDS dietary data was collected (2002–2007), there have been public health campaigns promoting the intake of specific dietary components (e.g., whole grains) or the Mediterranean diet as a whole [15,35]. More recently collected dietary intake data from this cohort and the second national dietary assessment survey [58,59] are currently being analyzed and will enable an updated evaluation of MedDiet adherence. Utilization of I-MEDAS as a rapid assessment and surveillance tool that can be administered at regular time intervals may facilitate more proximate tracking of trends and change in response to public health campaigns.

Our study has a number of strengths and limitations. The proposed locally-adapted I-MEDAS tool and score were based upon the deliberation of nutrition policy makers and epidemiological researchers, and the specific adaptations made to the original 14-item MEDAS are clearly described. Adherence to I-MEDAS and its individual components were evaluated in a multi-ethnic, population-based sample of adults with data from a comprehensive 240-item FFQ, which captures habitual diet and foods eaten on a weekly as well as a daily basis, and thus provides a better source than short-term dietary assessment data (e.g., 24HR, daily food logs) for evaluating the components that are scored according to weekly intakes. The predictive utility of the I-MEDAS score was evaluated with prospective cohort FFQ data. Nevertheless, the data are observational, and weaknesses of this study include those inherent to self-reported dietary data, which we minimized to the extent possible through an interviewer-administered, rather than self-administered, FFQ with an extensive food list. Although the analyses controlled for confounding by relevant demographic, socio-economic, health status and lifestyle parameters, we cannot exclude the possibility of confounding by unmeasured/untested factors. The sample size limited our ability to undertake subgroup analyses either in terms of population groups or food components (particularly where intake was very low). This study does not evaluate the performance of the screener itself, but rather the predictive utility of the screener components and scoring criteria as calculated using data from a full FFQ. Thus, our findings on the predictive utility of the I-MEDAS score are exploratory and should be confirmed in additional prospective cohort studies that directly test the performance of the screener as well.

5. Conclusions

We present a locally-adapted MedDiet screener that can be used to track adherence to the adoption of a MedDiet dietary pattern and additional healthy eating principles in Israel. Application of the I-MEDAS score in a population-based cohort of adults shows a need for improved MedDiet adherence, and provides evidence of the score's predictive utility for all-cause mortality.

Authors' contributions

All authors participated in the conception and design of the MEDAS adaptation process; critically reviewed the manuscript for important intellectual content; and gave final approval of the version to be submitted. O.K. conceived of and supervised the HDS cohort study. K.A., O.K. and A.Z. conducted the I-MEDAS score building and adherence analysis in the HDS cohort data, and all authors reviewed the results. K.A. prepared the manuscript draft.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.clnu.2018.12.034.

Conflict of interest

All authors declare no conflict of interest.

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