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COMPONENTS OF THE MEDITERRANEAN DIETARY PATTERN AND COVID-19 SYMPTOMS

A.O.
ARTIGO ORIGINAL

COMPONENTES DA DIETA MEDITERRÂNICA E SINTOMAS COVID-19

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ABSTRACT

INTRODUCTION: Coronavirus disease (COVID-19) has affected millions of lives globally. Despite the favourable impact of Mediterranean Dietary Pattern on cardiometabolic disorders that predispose themselves to COVID-19 infection, it is important to know the dietary components with potential to improve disease-related outcomes.

OBJECTIVES: To investigate the association of the Mediterranean Dietary Pattern and its components with the severity of COVID-19 symptoms.

METHODOLOGY: Cross-sectional study with a sample of adults recovered from COVID-19 infection, residents of Funchal and unvaccinated. Data on sociodemographic variables, lifestyle, presence of chronic diseases, and intake of supplements food, self-perceived health status, COVID-19 symptoms and dietary consumption was collected using the Computer Assisted Telephone Interview method. Mediterranean Dietary Pattern adherence was obtained from the MEDAS (Mediterranean Diet Adherence Score) questionnaire. Simple and multiple logistic regression models were used to analyse the severity of COVID-19 symptoms and different metrics.

RESULTS: A total of 541 adults were included in the study, 60.0% were female and 53.9% were 40-59 years old. Data show that 15.7% of the participants were asymptomatic for COVID-19 infection and 26.9% had severe symptoms. A strong adherence to Mediterranean Dietary Pattern was found in 14.8% of the participants, and it was significantly higher among the asymptomatic participants than those who reported mild or severe symptoms. A low ingestion of red/ processed meats, fats (butter/cream/margarine), commercial pastry and carbonated/ sugar-sweetened drinks, as well as consumption of poultry more than red meat, was associated with less severe COVID-19 symptoms, after adjustment for sex, age and education level. Participants who reported an adequate consumption of olive oil (OR=0.47; 95% CI: 0.25-0.88) and vegetables (OR=0.57; 95% CI: 0.35-0.94) were less likely to experience any symptoms of disease. Nevertheless, results were not consistent when several items, associated in bivariate analysis and in unadjusted logistic regression models, were taken into consideration.

CONCLUSIONS: Adherence to Mediterranean Dietary Pattern, in particular adequate consumption of olive oil and vegetables, and limited ingestion of commercial pastry, red/ processed meat, fats and carbonated/ sugar-sweetened drinks, was associated with less severe symptoms of COVID-19 infection.

KEYWORDS

Covid-19, Mediterranean dietary pattern, Severity, Symptoms

RESUMO

INTRODUÇÃO: A doença de coronavírus 19 (COVID-19) afetou milhões de vidas em todo o mundo. Apesar do impacto favorável do Padrão Alimentar Mediterrânico nos distúrbios cardiometabólicos, que predispõem à infeção por COVID-19, é importante conhecer os componentes alimentares com potencial para melhorar os resultados relacionados com a doença.

OBJETIVOS: Investigar a associação entre o Padrão Alimentar Mediterrânico e seus componentes com a gravidade dos sintomas COVID-19.

METODOLOGIA: Estudo transversal em uma amostra de adultos recuperados da infeção por COVID-19, residentes no Funchal e não vacinados. Dados sobre variáveis sociodemográficos, estilo de vida, presença de doenças crónicas, ingestão de suplementos alimentares, estado de saúde percecionado, sintomas de COVID-19 e consumo alimentar foram recolhidos usando o método *Computer Assisted Telephone Interview*. A adesão ao Padrão Alimentar Mediterrânico foi obtida a partir do questionário MEDAS (*Mediterranean Diet Adherence Score*). Modelos de regressão logística simples e múltipla foram usados para analisar a gravidade dos sintomas da COVID-19 e diferentes métricas.

RESULTADOS: Um total de 542 adultos foram incluídos no estudo, 60,0% do sexo feminino e 53,9% com idade entre 40 e 59 anos. Os dados mostram que 15,7% dos participantes eram assintomáticos para infeção por COVID-19 e 26,9% apresentavam sintomas graves. Uma forte adesão ao Padrão Alimentar Mediterrânico foi encontrada em 14,8% dos participantes, sendo significativamente maior entre os assintomáticos do que naqueles que relataram sintomas leves ou graves. Baixa ingestão de carnes vermelhas/ processadas, gorduras (manteiga/creme ou margarina), pastelaria e refrigerantes/ bebidas açucaradas, assim como o consumo mais frequente de carne de aves do que carne vermelha, foi associada a uma menor gravidade dos sintomas, após ajustado para sexo, idade e escolaridade. Os participantes que relataram consumo adequado de azeite (OR=0,47; IC 95%: 0,25-0,88) e hortícolas (OR=0,57; IC 95%: 0,35-0,94) apresentaram menor probabilidade de ter algum sintoma da doença. Contudo, os resultados não

foram consistentes, quando considerados vários itens, associados na análise bivariada e em modelos de regressão logística não ajustados.
CONCLUSÕES: A adesão ao Padrão Alimentar Mediterrânico, em particular o consumo adequado de azeite e vegetais, a ingestão limitada de pastelaria, carnes vermelhas/processadas, gorduras e refrigerantes/ bebidas açucaradas, foi associada a menor severidade de sintomas da infeção por COVID-19.

PALAVRAS-CHAVE
COVID-19, Padrão alimentar mediterrânico, Severidade, Sintomas

INTRODUCTION

In 2019, a severe acute respiratory syndrome coronavírus, the SARS-CoV-2, was discovered and lead to a pandemic disease (COVID-19) that has affected millions of lives globally (1-3).The main measures taken worldwide to prevent and mitigate COVID-19 included home containment, social distancing, and travel restriction. These measures of containment had a remarkable influence on the health status of individuals and communities. On one hand, the lockdown and social distancing measures appear to reduce physical activity and increase unhealthy lifestyles, thus increasing Non-Communicable Diseases (NCD) risk factors (4, 5). Patients with NCDs, as metabolic and cardiovascular diseases, are more likely to have more severe clinical symptoms of COVID-19 (6). On the other hand, the SARS-CoV-2 infection also affects the progression of pre-existing clinical conditions which may increase the severity of COVID-19 and mortality risk (4). In Europe, an excess mortality rate was observed during the COVID-19 pandemic, particularly affecting elderly individuals and to a lesser extent young and older adults (7). Some determinants of NCDs were found to be also risk factors for COVID-19 infection, such as advanced age, male sex, obesity, smoking, low physical activity levels and poverty (5, 8). A balanced and healthy diet is a key component for the adequacy of the immune response, including the anti-inflammatory effects to reduce the risk of infection or the development of symptoms (9-11).

The Mediterranean Diet (MD) is considered as a sustainable and healthy dietary pattern, which has been consistently associated with lower risk of cardiovascular and metabolic diseases (12-14). A review conducted to define this pattern by food groups and nutrients, concluded that it is characterized by a high consumption of vegetables, fruits, and legumes/ pulses, and a moderate intake of nuts, fish, poultry and dairy products (12, 15). The Mediterranean Dietary Pattern (MDP) also recommends limited amounts of red, processed meat and sweets and the use of olive oil as the principal source of fat, for cooking and dressings. A moderate intake of red wine is also comprises in this food pattern. On average, and despite methodological differences among studies, the MDP provides 43% of energy from carbohydrates, 37% from total fat of energy (19% from monounsaturated and 5% from polyunsaturated fatty acids) and 15% from proteins. For a healthy lifestyle in young adults, the MDP provides the required daily amount of vitamins (D, E, C, A, B12, and folate), minerals (selenium, zinc, iron and manganese) and polyphenols needed to maintain an appropriate immune response (16). In COVID-19 disease, adequate protein and carbohydrate content, short-chain fatty acid and omega-3 fatty acid amounts, and high-dose of fiber, vitamin C, vitamin D and minerals, appears to be beneficial in setting an active immune response to fight against SARS-CoV-2 infection and reduce the inflammation that may lead to a severe clinical condition and poor outcomes (8). Therefore, it is with no surprise that, since the beginning of COVID-19 pandemic, there have been several papers describing the potential benefit of foods and nutrients from the MDP in the therapeutic approach of SARS-CoV-2 infection and in the improvement of symptoms of COVID-19 (16-20). Despite the few studies that have investigated the adherence of MDP and symptoms of disease, data shows that a higher Mediterranean Diet score is associated with a reduced severity of symptoms of COVID-19 (21, 22). However, it is important to address the dietary components of the MDP that have potential in improving disease-related outcomes and/or preventing COVID-19 infection.

OBJECTIVES

To investigate the association of MDP components and the severity of COVID-19 symptoms (asymptomatic, mild or severe).

METHODOLOGY

The present investigation received the approval of the Ethical Committee for Health (No.16/2021) of the Health Service of the Autonomous Region of Madeira (SESARAM, EPERAM). Data refers to adults (18-64 years old), residents in Funchal, recovered from COVID-19 infection and unvaccinated. The study methodology has been previously described elsewhere (22). Briefly, this is an observational, cross-sectional study, retrospective with self-reported primary data collection, by CATI (Computer Assisted Telephone Interviewing) system. Data was collected by trained nutritionists and included information on sociodemographic variables (gender, age group, education, marital status, and professional status), lifestyle (physical activity and regular smokers), presence of chronic diseases, intake of supplements food, self-perceived health status (health status in overall and body weight) and COVID-19 symptoms.

For statistical analyses BMI was categorized into classes - underweight/ eutrophic (<24.9 kg/m^2), pre-obesity (25.0–29.9kg/m^2), obesity (≥30kg/m^2) - and as a dummy variable (overweight if ≥25.0 kg/m^2) (23).

To assess dietary habits, the authors used the validated telephone administered version of the 14-item Mediterranean Diet Adherence Screener (MEDAS) questionnaire (24). A guide for applying the questionnaire was previously developed, by the nutritionists involved in the study, with types of food and portions, for each question, in order to reduce interpretation errors. The results were categorized to estimate the adherence to the MDP as follows: weak adherence, ≤5; moderate adherence, 6–9; strong adherence ≥10.

Covid-19 severity level was categorized according to reported symptoms: “Asymptomatic” if no symptoms; “severe” if trouble breathing, persistent pain or pressure in the chest, inability to speak or move or hospitalization; and “mild” if not included in the previous categories (ex: fever or chills; cough; fatigue; muscle or body aches; headache; anosmia; ageusia; sore throat; congestion or runny nose; nausea or vomiting; diarrhea) (25, 26). In the present study two dependent variables were created: one that included experiencing any COVID-19 symptoms (mild or severe) versus asymptomatic; and another that included having severe symptoms versus none or mild COVID-19 symptoms.

Statistical Analysis

Simple and multiple logistic regressions were conducted to examine the determinants of having severe COVID-19 symptoms, and of experiencing any COVID-19 symptoms versus none. For each dependent variable three models were estimated: not adjusted (Model 1); adjusted for sex, age and education level (Model 2); and adjusted for sex, age, education level, smoking status, physical exercise, chronic disease, weight perception, MDP adherence and the Mediterranean Diet items that were statistically significant in bivariate analysis and in unadjusted logistic regression models (Model 3).

Results were presented as odds ratio (OR) with 95% confidence interval (CI) and respective p-values. The level of significance was set at $p<0.05$. Statistical analysis was performed using SPSS software version 25.

RESULTS

Characteristics of the Study Population

The overall characteristics of the study population sample are summarized in Table 1, including their bivariate association with levels of COVID-19 symptoms. A total of 541 adults were included in the study, the majority of which were female (60.0%), aged 40-59 years old (53.9%), married/ civil union (62.9%) and employed (78.8%). The results showed that 1 in 6 participants, during COVID-19 disease, were asymptomatic, while 84.3% experienced any type of symptoms. Severe symptoms were reported for 26.9% of the respondents. Approximately 50.7% of adults who experienced severe symptoms perceived themselves as overweight, while among asymptomatic 60.0% evaluated themselves as being of normal weight ($p<0.05$). In reality, 42.9% of asymptomatic respondents were normal or underweight and 61.6% of adults who had severe symptoms were overweight. However, in this study, differences in BMI classes between COVID-19 symptoms were not statistically significant.

Analysis of the data showed that 61.6% of the participants reported a moderate adherence to the MDP, while 14.8% revealed a strong adherence (Table 1). The prevalence of a good MDP adherence were higher among those who experienced no symptoms (22.4%), compared to those who had severe clinical outcomes (11.6%). The higher percentage of consumption inadequacy (less than the recommendations) was found for the following dietary items: olive oil (87.5%); legumes (70.5%); tree nuts (69.2%); vegetables (64.8%); and fruits (60.7%). Differences between severity degrees of symptoms were statistically significant for wine glasses, commercial (not homemade) pastry and eating poultry more than red meats.

Determinants of having Severe COVID-19 Symptoms (*vs.* mild/ asymptomatic)

Table 2 showed the crude and adjusted OR of experiencing severe symptoms (vs mild/ asymptomatic). Compared with a low MDP adherence degree, and after adjusted for sex, age and education level, a moderate and a strong adherence decreased the odds of having severe symptoms of COVID-19 by 48 and 62%, respectively. A low ingestion of red/ processed meats (as well as the substitution of red meat by poultry), fats (butter/ cream/ margarine) and commercial pastry was associated with less severe COVID-19 symptoms, in the crude model and after adjustment for sex, age and education level. However, in model 3 the association was lost, after adjustments. Results also show that, participants who consumed poultry more often than red meat were less likely to experience severe symptoms of COVID-19, after being adjusted for sex, age and education level (OR=0.51; 95% CI: 0.33-0.77) but not after adjustment for other variables in model 3.

Participants who reported a low consumption of carbonated/ sugar-sweetened beverages were less likely to have more severe symptoms in model 2 (OR=0.56; 95% CI: 0.35-0.87) but no association was found in model 3. Weight perception, either underweight or overweight perception, was the only independent variable associated with more severe experiencing of COVID-19 symptoms, in model 3.

Determinants of having any COVID-19 Symptoms (*vs.* none)

Table 3 showed the results of the logistic regression to identify the determinants of COVID-19 symptoms versus none. A strong MDP adherence score were negatively associated with experiencing COVID-19 symptoms, in both crude (OR=0.39; 95% CI: 0.19-0.84) and adjusted for sex, age and educational level models (OR=0.30; 95% CI: 0.13-0.68). A moderate consumption of wine and a low ingestion of commercial pastry showed a protective effect against COVID-19 symptoms, but only in the crude model. After being adjusted for sex, age and education, a daily consumption of adequate amounts of olive oil (OR=0.47; 95% CI: 0.25-0.88) and vegetables (OR=0.57; 95% CI: 0.35-0.94) remained associated with having any symptoms of disease. After adjustments, in model 3, the associations found in bivariate and model 1 analysis were not confirmed except for education level.

DISCUSSION OF RESULTS

Higher adherence to the MDP was associated with the experiencing of less severe symptoms of COVID-19 disease or even the absence of symptoms. A food pattern characterized by a low consumption of commercial pastry was found to be the consistently dietary item associated with having less severe or any symptoms of this infection disease. Data from the present study showed that a high consumption of olive oil and vegetables, a moderate wine ingestion and a low consumption of red/ processed meat, fats (butter/cream or margarine) and carbonated/ sugar-sweetened drinks were also associated with a reduction of the severity of COVID-19 symptoms experienced.

In this study, the percentage of asymptomatic SARS-CoV-2 infection among the confirmed population was lower, compared to the 40.5% found in a systematic review and meta-analysis, conducted in 2021 in several countries (27). This can be explained by the selection criteria used to define asymptomatic cases. In our retrospective, cross-sectional study, participants were considered asymptomatic if they did not have symptoms at the screening point neither developed symptoms later, while in the meta-analysis asymptomatic infections were defined as those who did not present any symptoms at the time of the diagnosis.

In 2020, 26% of the Portuguese population above 16 years old presented a strong adherence to the MDP, a growth of 15% compared with 2016 (28). This result is higher than reported in the present study. However, if we consider only the adult population, the 14.8% of strong adherence prevalence found in our study is similar to the 15.7% showed in the National Food, Nutrition and Physical Activity Survey, 2015-2016 (Portuguese acronym: IAN-AF) (29).

Regarding food groups, findings revealed the same dietary items (legumes, vegetables, fruits and oleaginous nuts) with a higher percentage of consumption inadequacy, except for olive oil, of which the consumption was found to be lower than the recommendation in the population from Madeira, but not for all the country. In 2012-2015, the adult population of the RAM had already shown an inadequate consumption for almost all food groups, consuming more meat, fish and eggs, but less vegetables, cereals and fruits than the recommendations (30). Already after the beginning of the pandemic and the imposed measures of social containment, it was found that in the Madeira population there was a favorable trend in the consumption of fruit among the youngest, and a slight increase in vegetables ingestion between adults and elderly (31).

In unadjusted models, a low consumption of commercial pastry and a strong adherence to a MDP were associated with a reduction in the odds of having any degree of symptoms, including severe ones. However, these variables did not remain true after adjustment for all the other variables associated in the bi- and multivariate analysis of the present study.

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Table 1

Characteristics of the study population, in the total and by degree of COVID-19 symptoms

	TOTAL (%/N) (N=542)	COVID-19 SYMPTOMS			*p*
		ASYMPTOMATIC (%/N) (N=85)	MILD (%/N) (N=311)	SEVERE (%/N) (N=146)	
SOCIODEMOGRAPHIC VARIABLES					
Sex					
Male	217 (40.0%)	40 (47.1%)	128 (41.2%)	49 (33.6%)	0.108
Female	325 (60.0%)	45 (52.9%)	183 (58.8%)	97 (66.4%)	
Age (years old)					
18-29	83 (15.3%)	10 (11.8%)	51 (16.4%)	22 (15.1)	0.408
30-39	108 (19.9%)	19 (22.4%)	64 (20.6%)	25 (17.1%)	
40-49	137 (25.3%)	19 (22.4%)	75 (24.1%)	43 (29.5%)	
50-59	155 (28.6%)	22 (25.9%)	89 (28.6%)	44 (30.1%)	
60-64	59 (10.9%)	15 (17.6%)	32 (10.3%)	12 (8.2%)	
Education level					
0-9th	205 (37.8%)	**46 (54.1%)**	**108 (34.7%)**	**51 (34.9%)**	**0.005**
10th-12th	134 (24.7%)	**12 (14.1%)**	**89 (28.6%)**	**33 (22.6%)**	
> 12th	203 (37.5%)	**27 (31.8%)**	**114 (36.7%)**	**62 (42.5%)**	
Marital status (married/ civil union)	341 (62.9%)	56 (65.9%)	188 (60.5%)	97 (66.4%)	0.385
Working status (Active)	427 (78.8%)	68 (80.0%)	243 (78.1%)	116 (79.5%)	0.908
LIFESTYLE VARIABLES					
Smoke status					
Non-smoker	408 (75.3%)	59 (69.4%)	243 (78.1%)	106 (72.6%)	0.202
Ex-smoker	62 (11.4%)	9 (10.6%)	32 (10.3%)	21 (14.4%)	
Current smoker	72 (13.3%)	17 (20.0%)	36 (11.6%)	19 (13.0%)	
Physical exercise (≥150 minutes/ wk)	148 (27.3%)	22 (25.9%)	92 (29.6%)	34 (23.3%)	0.352
Dietarysupplements (yes)	117 (21.6%)	15 (17.6%)	68 (21.9%)	34 (23.3%)	0.594
HEALTH STATUS VARIABLES					
Chronic disease (yes)	219 (40.4%)	34 (40.0%)	119 (38.3%)	66 (45.2%)	0.369
Weight perception					
Normal	**287 (53.0%)**	**51 (60.0%)**	**175 (56.3%)**	**61 (41.8%)**	**0.019**
Under normal	**28 (5.2%)**	**5 (5.9%)**	**12 (3.9%)**	**11 (7.5%)**	
Excessive	**227 (41.9%)**	**29 (34.1%)**	**124 (39.9%)**	**74 (50.7%)**	
BMI classes					
Underweight/Eutrophic	216 (40.3%)	36 (42.9%)	124 (40.5%)	56 (38.4%)	0.968
Pre-obesity	187 (34.9%)	29 (34.5%)	106 (34.6%)	52 (35.6%)	
Obesity	133 (24.8%)	19 (22.6%)	76 (24.8%)	38 (26.0%)	
Overweight (yes)	320 (59.7%)	48 (57.1%)	182 (59.5%)	90 (61.6%)	0.793
MDP ITENS					
1.Olive oil as main culinary lipid	490 (90.4%)	80 (94.1%)	280 (90.0%)	130 (89.0%)	0.424
2.Olive oil ≥ 4 tablespoons/ d	68 (12.5%)	17 (20.0%)	33 (10.6%)	18 (12.3%)	0.068
3.Vegetables ≥ 2 servings/ d	191 (35.2%)	36 (42.4%)	110 (35.4%)	45 (30.8%)	0.209
4.Fruits ≥ 3 servings/ d	213 (39.3%)	39 (45.9%)	117 (37.6%)	57 (39.0%)	0.384
5.Red/processed meats ≤ 6/ wk	423 (78.0%)	71 (83.5%)	248 (79.7%)	104 (71.2%)	0.051
6. Butter/cream/margarine < 1/ d	372 (68.6%)	64 (75.3%)	218 (70.1%)	90 (61.6%)	0.068
7.Carbonated/sugar-sweetened drinks < 1/d	410 (77.6%)	66 (77.6%)	242 (77.8%)	102 (69.9%)	0.163
8.Wine glasses > 7and < 14/ wk	51 (9.4%)	**14 (16.5%)**	**24 (7.7%)**	**13 (8.9%)**	**0.048**
9.Legumes ≥ 3/ wk	160 (29.5%)	27 (31.8%)	88 (28.3%)	45 (30.8%)	0.760
10.Fish/seafood ≥ 3/ wk	265 (48.9%)	44 (51.8%)	152 (48.9%)	69 (47.3%)	0.804
11.Commercial pastry ≤2/wk	359 (66.2%)	**66 (77.6%)**	**206 (66.2%)**	**87 (59.6%)**	**0.020**
12.Tree nuts ≥ 3/ wk	167 (30.8%)	26 (30.6%)	90 (28.9%)	51 (31.9%)	0.433
13.Poultry more than red meats	390 (72.0%)	**62 (72.9%)**	**236 (75.9%)**	**92 (63.0%)**	**0.017**
14.Use of sofrito sauce ≥ 2/ wk	340 (62.7%)	49 (57.6%)	195 (62.7%)	96 (65.8%)	0.470
MDP ADHERENCE DEGREES					
Weak	128 (23.6%)	**14 (16.5%)**	**68 (21.9%)**	**46 (31.5%)**	**0.024**
Moderate	334 (61.6%)	**52 (61.2%)**	**199 (64.0%)**	**83 (56.8%)**	
Strong	80 (14.8%)	**19 (22.4%)**	**44 (14.1%)**	**17 (11.6%)**	

BMI: Body Mass Indexd: day
MDP: Mediterranean Dietary Pattern
p: p-value
wk: Week

Table 2

Determinants of severe COVID-19 symptoms (*vs*. mild/ asymptomatic)

	MODEL 1		MODEL 2		MODEL 3	
	OR (95% IC)	*p*	OR (95% IC)	*p*	OR (95% IC)	*p*
SOCIODEMOGRAPHIC VARIABLES						
Sex (Female *vs*. male)	1.46 (0.98-2.17)	0.062	1.46 (0.98-2.19)	0.062	1.69 (1.08-2.64)	0.023
Age (years old)						
18-29	Ref.		Ref.		Ref.	
30-39	0.84 (0.43-1.62)	0.594	0.83 (0.43-1.61)	0.577	0.90 (0.44-1.82)	0.762
40-49	1.27 (0.69-2.33)	0.442	1.31 (0.71-2.41)	0.393	1.44 (0.73-2.83)	0.290
50-59	1.10 (0.60-2.00)	0.757	1.19 (0.63-2.22)	0.596	1.34 (0.66-2.72)	0.425
60-64	0.71 (0.32-1.58)	0.397	0.78 (0.34-1.82)	0.571	0.85 (0.33-2.14)	0.723
Education level						
0-9th	Ref.		Ref.		Ref.	
10th-12th	0.99 (0.60-1.63)	0.958	0.96 (0.56-1.63)	0.866	1.10 (0.63-1.94)	0.737
> 12th	1.33 (0.86-2.05)	0.202	1.29 (0.80-2.08)	0.293	1.74 (1.03-2.96)	0.039
Marital status (Married/ civil union *vs*. other)	1.23 (0.83-1.84)	0.303	1.25 (0.82-1.92)	0.300		
Working status (Active *vs*. non active)	1.06 (0.66-1.69)	0.817	1.00 (0.60-1.65)	0.986		
LIFESTYLE VARIABLES	Lifestyle variables					
Smoke status						
Non-smoker	Ref.		Ref.		Ref.	
Ex-smoker	1.46 (0.83-2.58)	0.194	1.68 (0.93-3.03)	0.087	1.61 (0.87-2.99)	0.132
Current smoker	1.02 (0.58-1.80)	0.942	1.20 (0.67-2.17)	0.536	1.24 (0.66-2.31)	0.506
PE (≥150 minutes/ wk *vs*. <150)	0.75 (0.48-1.17)	0.203	0.75 (0.48-1.19)	0.219	0.93 (0.57-1.50)	0.755
Dietary supplements (Yes *vs*. No)	1.15 (0.73-1.80)	0.559	1.08 (0.68-1.71)	0.751		
HEALTH STATUS VARIABLES						
Chronic disease (Yes *vs*. No)	1.31 (0.89-1.92)	0.167	1.38 (0.92-2.07)	0.124	1.40 (0.92-2.15)	0.119
Weight perception						
Normal	Ref.		Ref.		Ref.	
Under normal	**2.40 (1.07-5.39)**	**0.034**	**2.38 (1.04-5.44)**	**0.040**	**2.38 (1.00-5.63)**	**0.050**
Excessive	**1.79 (1.21-2.66)**	**0.004**	**1.80 (1.19-2.71)**	**0.005**	**1.56 (1.01-2.41)**	**0.045**
BMI classes						
Underweight/ Eutrophic	Ref.		Ref.			
Pre-obesity	1.10 (0.71-1.71)	0.671	1.24 (0.78-1.99)	0.360		
Obesity	1.14 (0.70-1.85)	0.589	1.28 (0.75-2.16)	0.369		
Overweight (Yes *vs*. No)	1.12 (0.76-1.65)	0.575	1.26 (0.82-1.92)	0.293		
MDP ITEMS						
1.Olive oil as main culinary lipid	0.81 (0.44-1.51)	0.513	0.80 (0.42-1.51)	0.484		
2.Olive oil ≥ 4 tablespoons/ d	0.97 (0.55-1.73)	0.926	0.94 (0.53-1.68)	0.837	0.77 (0.40-1.47)	0.428
3.Vegetables ≥ 2 servings/ d	0.76 (0.51-1.15)	0.192	0.68 (0.45-1.04)	0.078		
4.Fruits ≥ 3 servings/ d	0.99 (0.67-1.45)	0.941	0.99 (0.66-1.47)	0.942		
5.Red/processed meats ≤ 6/ wk	**0.60 (0.39-0.93)**	**0.021**	**0.50 (0.32-0.80)**	**0.004**	0.86 (0.47-1.58)	0.625
6. Butter/cream/margarine < 1/ d	**0.65 (0.44-0.97)**	**0.034**	**0.60 (0.40-0.90)**	**0.013**	0.68 (0.44-1.06)	0.088
7. Carbonated/sugar-sweetened drinks < 1/d	0.66 (0.43-1.01)	0.058	0.56 (0.35-0.87)	0.010		
8.Wine glasses > 7and < 14/ wk	0.92 (0.48-1.78)	0.807	1.10 (0.55-2.20)	0.789	1.23 (0.58-2.61)	0.582
9.Legumes ≥ 3/ wk	1.09 (0.72-1.65)	0.687	1.12 (0.73-1.70)	0.610		
10.Fish/seafood ≥ 3/ wk	0.91 (0.63-1.34)	0.644	0.88 (0.59-1.30)	0.509		
11.Commercial pastry ≤2/wk	**0.67 (0.45-1.00)**	**0.048**	**0.64 (0.42-0.97)**	**0.036**	0.81 (0.51-1.29)	0.370
12.Tree nuts ≥ 3/ wk	1.30 (0.87-1.94)	0.208	1.21 (0.80-1.84)	0.375		
13.Poultry more than red meats	**0.56 (0.37-0.84)**	**0.005**	**0.51 (0.33-0.77)**	**0.002**	0.69 (0.40-1.21)	0.200
14.Use of sofrito sauce ≥ 2/ wk	1.20 (0.80-1.78)	0.377	1.22 (0.82-1.83)	0.325		
MDP ADHERENCE DEGREES						
Weak	Ref.				Ref.	
Moderate	**0.59 (0.38-0.91)**	**0.018**	**0.52 (0.33-0.82)**	**0.005**	0.77 (0.44-1.35)	0.363
Strong	**0.48 (0.25-0.92)**	**0.026**	**0.38 (0.20-0.76)**	**0.006**	0.76 (0.32-1.80)	0.532

d: Day
BMI: Body Mass Index
MDP: Mediterranean Dietary Pattern
p: p-value
PE: Physical Exercise
wk: Week
Model 1 – Unadjusted.
Model 2 – each independent variable was entered separately together with sex, age and education level.
Model 3 – the following variables entered in the model: sex; age; educational level; smoke status; physical exercise; chronic disease; weight perception; MDP items (Olive oil ≥ 4 tablespoons/d; Red/processed meats ≤6/wk; Butter/cream/ margarine <1/d; Wine glasses >7 and < 14/ wk; Commercial pastry ≤2/wk; Poultry more than red meats); and MDP adherence degrees).

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Table 3

Determinants of having any COVID-19 symptoms (*vs*. asymptomatic)

	MODEL 1		MODEL 2		MODEL 3	
	OR (95% IC)	*p*	OR (95% IC)	*p*	OR (95% IC)	*p*
SOCIODEMOGRAPHIC VARIABLES						
Sex (Female *vs*. male)	1.41 (0.88-2.24)	0.151	1.35 (0.84-2.17)	0.213	1.47 (0.86-2.51)	0.157
Age (years old)						
18-29	Ref.		Ref.		Ref.	
30-39	0.64 (0.28-1.47)	0.292	0.69 (0.30-1.60)	0.387	0.83 (0.34-1.99)	0.668
40-49	0.85 (0.38-1.93)	0.699	0.98 (0.42-2.24)	0.952	1.25 (0.51-3.07)	0.622
50-59	0.83 (0.37-1.84)	0.644	1.17 (0.51-2.73)	0.710	1.49 (0.59-3.72)	0.397
60-64	0.40 (0.17-0.97)	0.043	0.63 (0.25-1.62)	0.338	0.87 (0.31-2.48)	0.798
Education level						
0-9th	Ref.		Ref.		Ref.	
10th-12th	**2.94 (1.49-5.79)**	**0.002**	**2.90 (1.43-5.88)**	**0.003**	**2.83 (1.35-5.91)**	**0.006**
> 12th	**1.89 (1.12-3.18)**	**0.017**	**1.89 (1.06-3.35)**	**0.031**	**1.87 (1.00-3.51)**	**0.050**
Marital status (Married/civil union vs other)	0.86 (0.53-1.40)	0.538	0.90 (0.54-1.51)	0.694		
Working status (Active *vs*. non active)	0.92 (0.52-1.63)	0.765	0.84 (0.45-1.56)	0.586		
LIFESTYLE VARIABLES						
Smoke status						
Non-smoker	Ref.		Ref.		Ref.	
Ex-smoker	1.00 (0.47-2.13)	0.991	1.10 (0.50-2.42)	0.806	1.02 (0.45-2.30)	0.960
Current smoker	0.55 (0.30-1.01)	0.052	0.64 (0.34-1.22	0.178	0.69 (0.34-1.37)	0.286
PE (≥150 minutes/ wk *vs*. <150)	1.09 (0.64-1.85)	0.748	1.00 (0.58-1.73)	0.999	1.29 (0.71-2.32)	0.400
Dietary supplements (Yes *vs*. No)	1.34 (0.74-2.44)	0.338	1.25 (0.68-2.31)	0.476		
HEALTH STATUS VARIABLES						
Chronic disease (Yes *vs*. No)	1.02 (0.64-1.64)	0.934	1.20 (0.72-2.00)	0.479	1.08 (0.64-1.82)	0.786
Weight perception						
Normal	Ref.		Ref.		Ref.	
Under normal	0.99 (0.36-2.74)	0.991	0.91 (0.32-2.60)	0.864	0.76 (0.26-2.23)	0.610
Excessive	1.48 (0.90-2.42)	0.122	1.53 (0.91-2.56)	0.109	1.37 (0.80-2.37)	0.256
BMI classes						
Underweight/ Eutrophic	Ref.		Ref.			
Pre-obesity	1.09 (0.64-1.86)	0.753	1.30 (0.74-2.28)	0.368		
Obesity	1.20 (0.66-2.19)	0.554	1.66 (0.86-3.21)	0.134		
Overweight (Yes *vs*. No)	1.13 (0.71-1.82)	0.603	1.42 (0.85-2.38)	0.179		
MDP ITEMS						
1.Olive oil as main culinary lipid	0.55 (0.21-1.41)	0.212	0.58 (0.22-1.53)	0.270		
2.Olive oil ≥ 4 tablespoons/ d	**0.50 (0.27-0.92)**	**0.026**	**0.47 (0.25-0.88)**	**0.018**	0.51 (0.26-1.01)	0.054
3.Vegetables ≥ 2 servings/ d	0.70 (0.44-1.12)	0.136	**0.57 (0.35-0.94)**	**0.028**		
4.Fruits ≥ 3 servings/ d	0.73 (0.46-1.16)	0.177	0.67 (0.41-1.09)	0.103		
5.Red/processed meats ≤ 6/ wk	0.66 (0.36-1.22)	0.186	0.60 (0.32-1.14)	0.116	0.55 (0.24-1.27)	0.162
6. Butter/cream/margarine < 1/ d	0.68 (0.40-1.15)	0.151	0.62 (0.36-1.07)	0.083		
7.Carbonated/sugar-sweetened drinks < 1/d	0.88 (0.50-1.52)	0.640	0.67 (0.38-1.21)	0.188		
8.Wine glasses > 7and < 14/ wk	**0.45 (0.23-0.87)**	**0.017**	0.53 (0.26-1.07)	0.078	0.64 (0.30-1.36)	0.243
9.Legumes ≥ 3/ wk	0.88 (0.54-1.45)	0.621	0.85 (0.51-1.43)	0.542		
10.Fish/seafood ≥ 3/ wk	0.87 (0.55-1.39)	0.564	0.78 (0.48-1.27)	0.319		
11.Commercial pastry ≤2/wk	**0.51 (0.30-0.89)**	**0.017**	0.54 (0.30-0.95)	0.033	0.65 (0.35-1.22)	0.183
12.Tree nuts ≥ 3/ wk	1.01 (0.61-1.67)	0.961	0.88 (0.52-1.49)	0.640		
13.Poultry more than red meats	0.94 (0.56-1.59)	0.826	0.86 (0.50-1.47)	0.578	1.31(0.64-2.69)	0.465
14.Use of sofrito sauce ≥ 2/ wk	1.29 (0.80-2.06)	0.292	1.42 (0.87-2.31)	0.157		
MDP ADHERENCE DEGREES						
Weak	Ref.		Ref.		Ref.	
Moderate	0.67 (0.36-1.25)	0.205	0.56 (0.29-1.09)	0.090	0.76 (0.35-1.66)	0.490
Strong	**0.39 (0.19-0.84)**	**0.016**	**0.30 (0.13-0.68)**	**0.004**	0.47 (0.17-1.32)	0.152

d: Day
BMI: Body Mass Index
MDP: Mediterranean Dietary Pattern
p: p-value
PE: Physical Exercise
wk: Week
Model 1 – Unadjusted.
Model 2 – each independent variable was entered separately together with sex, age and education level.
Model 3 – the following variables entered in the model: sex; age; educational level; smoke status; physical exercise; chronic disease; weight perception; MDP items (Olive oil ≥ 4 tablespoons/d; Red/processed meats ≤6/wk; Wine glasses >7 and < 14/ wk; Commercial pastry ≤2/wk; Poultry more than red meats; and MDP adherence degrees).

The sample size and the absence of unmeasured confounding factors may explain the differences between models. Beside demographic characteristics (age and gender), other factors such as virulence of the SARS-CoV-2 variants and biological differences may be associated with COVID-19 symptoms and progression (32).

A recent study, conducted by Perez-Araluce and colleagues in Spain, assessed the effect of the nine food groups of the MD, defined by Trichopoulou, on the risk of COVID-19 infection, symptomatic and severe disease (33). The authors only found one association, a harmful one, with the consumption of whole dairy products, a food group that is not typical of the MD. They concluded that a MDP as a whole is, probably, more important in preventing symptoms of COVID-19, than each component separately. Another study, that included the countries that had national dietary data from the Global Dietary Databases of the United Nations and coronavírus disease statistics from the World Health Organization (WHO), highlighted that diet alone is probably insufficient to enhance the immune system (34). They found that a higher intake of fruits was associated with an increased infection rate but not with the mortality rate by COVID-19. The study also showed that raising consumption of beans and legumes decreased the crude infection and mortality rates, while a higher sugar-sweetened beverages intake has a positive effect on mortality rates. In the last case, it could be explained, on the one hand by the substrates presented in plant protein of beans and legumes as factors that influence the response of the human immune system, and on the other by the role of sugar-sweetened beverages in weight gain. In this ecological study, the authors hypothesized that, despite fruits having an important role in enhancing the immune system responses, higher intake of these micronutrients makes a barrier in improving the human immune system or response to the pathogens due to the role of the fruits with a high glycemic index. Nevertheless, this ecological study did not investigate the symptoms of COVID-19 severity. A similar result was found in another study that intended to examine the association of specific dietary data and incidences of COVID-19 in the United Kingdom (35). Vegetables consumption, but not fruit consumption, was associated with COVID-19 risk. The authors highlighted that, despite fruits and vegetables sharing several health benefits, each food group has specific bioactive compounds. Additionally, fruits are also relatively higher in sugar (fructose) while vegetables contain more starch. While fruits and vegetables vary in their energy, nutrient, and dietary bioactive contents, they remain rich dietary sources of vitamins, minerals, dietary bioactive compounds and dietary fiber, which can exert antioxidant and anti-inflammatory properties (18, 36). Among the potential mechanisms by which fruit and vegetables influences the immune system are changes to the gut-associated lymphoid tissues arising from altered gut microflora, in response to dietary fiber, and a reduction in serum inflammatory factor levels likely due to the phenolic compounds. A very recent study, conducted among unvaccinated COVID-19 patients, aged 30 years old in Iranian hospitals, has shown that a more frequent adherence to the MD, scored by the MEDAS questionnaire, has a significant negative relationship with the symptoms of COVID-19 and serum inflammatory markers (37). Consistent with our results, the authors of the Iranian study found a lower incidence of COVID-19 symptoms among patients who adhere more to the MD. However, there are methodological differences, namely, asymptomatic patients were not included.

Our study also compiled other information that could be associated with COVID-19 symptoms. Participants with a perception of weight under or above the normal were more likely to present more severe symptoms. It is possible that those who had more severe symptoms increased awareness of weight perceived, especially because obesity is a known risk factor for adverse COVID-19 outcome (38). Also, those who have attained a higher educational level were more likely to present any COVID-19 symptoms (vs asymptomatic). One possible explanation may lie in the job characteristics of the participants during the pandemic and the exposure level to the virus. The type of work facilities and the interpersonal requirement of the occupation may influence the exposure to the virus and, consequently the viral load acquired. A high viral load of the SARS-CoV-2 appears to increase the transmission and influence negatively the course of the disease and the severity of the symptoms (39, 40).

This study has a few limitations. First, MDP data may not reflect current food patterns in the RAM. As the COVID-19 pandemic continues, these findings represent a snapshot in time of the pandemic. Second, recovery from COVID-19 did not capture the fatal cases, nor consider the sequels resulting from the disease. Additionally, self-reported data may have increased information and social desirability bias. Ultimately, the present study was cross-sectional and no causal inference can be made. Despite these limitations, and according to our knowledge, the present study represents the first paper work exploring the association between key components of MDP and COVID-19 symptoms among the Portuguese population. One of the strengths of this study is that the questionnaires were applied by trained health care professionals (nutritionists) and it may reduce information bias. Additionally, the MEDAS questionnaire is a validated tool to categorize MDP adherence in different populations and countries, using the same methodology and allowing comparisons between them (41). In the future, well-designed dietary clinical trials would be necessary to explore and confirm the effects of MDP components, in preventing or improving COVID-19 disease and related outcomes.

Even though vaccines and therapeutics are ongoing, there is no treatment so far that effectively cures or prevents COVID-19 infection. Hence, prevention is the key and the host preparation to combat the virus is a very important strategy to avoid COVID-19 severity. Healthy dietary habits are important not only to prevent but also for supporting the immune response during COVID-19, as well as in the post-acute phase, i.e., “long COVID”, that is sometimes characterized by the onset of various long lasting and disabling symptoms.

CONCLUSIONS

The findings of the present study highlight the potential protective role of the MDP in the development of severe COVID-19 symptoms. Medical community and public health agencies should promote adequate consumption of olive oil and vegetables, and a limited ingestion of commercial pastry, red and processed meat, fats (butter/cream/ margarine) and carbonated/ sugar-sweetened drinks.

CONFLICTS OF INTEREST

None of the authors reported a conflict of interest.

AUTHORS’ CONTRIBUTIONS

VC: Was the principal investigator; VC, LC and SA: Contributed to study design, data collection, analysis and interpretation of data; LC: Was involved in drafting the manuscript; MR: contributed to the statistical analysis and critical review. All authors read and approved the final version of the manuscript.

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