International Journal of Food Sciences and Nutrition

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/iijf20

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To cite this article: Stefano Quarta, Luisa Siculella, Annalisa Levante, Maria Annunziata Carluccio, Nadia Calabriso, Egeria Scoditti, Fabrizio Damiano, Flavia Lecciso, Paula Pinto, María-Teresa García-Conesa, Fabio Pollice & Marika Massaro (2023) Association between Mediterranean lifestyle and perception of well-being and distress in a sample population of university Italian students, International Journal of Food Sciences and Nutrition, 74:4, 556-567, DOI: 10.1080/09637486.2023.2232129

To link to this article: https://doi.org/10.1080/09637486.2023.2232129

INTERNATIONAL JOURNAL OF FOOD SCIENCES AND NUTRITION
2023, VOL. 74, NO. 4, 556–567
https://doi.org/10.1080/09637486.2023.2232129

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STUDIES IN HUMANS

Association between Mediterranean lifestyle and perception of well-being and distress in a sample population of university Italian students

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ABSTRACT

We investigated the extent to which adherence to the Mediterranean diet (MD) in combination with Mediterranean lifestyle factors influenced students' perceptions of subjective well-being (SWB) and distress. 939 undergraduates completed a survey to assess sociodemographic and lifestyle characteristics, including adherence to the MD, depression, anxiety, stress, and SWB. Data were analysed with correlation, logistic, and multiple linear regression models. Higher adherence to MD correlated with better SWB. Fruit, red meat, sweet and caffeinated beverages contributed significantly. However, it was the combination of adherence to MD with other factors, including quality of social relationships, income, smoking, sleep, and physical activity that better predicted SWB. Our results confirm the positive influence of MD on SWB. However, they also suggest the need to consider perceptions of well-being by a more holistic approach that considers physical and social factors simultaneously to improve the development of more effective educational and motivational programmes.

ARTICLE HISTORY
Received 28 March 2023
Revised 21 June 2023
Accepted 27 June 2023

KEYWORDS
Subjective wellbeing (SWB); distress; Mediterranean diet and lifestyle factors; university students; lifestyle factors

Introduction

Historically medical research areas, including general medicine, neuroscience, and psychology, have traditionally focused on recognising and interpreting symptoms of disease, health deficits, and physical dysfunction. This approach, although critical to understand major diseases status, has developed a limited conception of "health status" as the mere absence of malaise and/or infirmity (Boruchovitch and Mednick 2002). In recent years, the concept of health has been broadened to encompass not only the maintenance of physical health, but the improvement of a broader well-being state that includes the promotion of positive mental states, life satisfaction and self-esteem (Boruchovitch and Mednick 2002) as well as the realisation of our full potentialities valuing our own virtues and strengths (Hasselberger 2022). This broader concept of health is supported by the clinical evidence of the many benefits that accrue, from high levels of well-being which have been shown to be associated with lower blood pressure (Ostir et al. 2006), increased immune functioning (Costanzo et al. 2004), enhanced longevity (Diener and Chan 2011) and reduced mortality (Chida and Steptoe 2008). Well-being can be evaluated by objective indicators (i.e. education, job availability, income, etc.) but also by subjective experiences of well-being (World Health Organization. Regional Office for Europe 2018). A recent revision on the SWB assessment indices highlights two main important areas to consider: the hedonic and the eudaimonic domains (Vik and Carlquist 2018). The hedonic well-being assesses the perception of life satisfaction, the presence of positive mood, and the absence of negative mood (Diener 2000), whereas the eudaimonic well-being refers to life meaning and

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/09637486.2023.2232129.

purpose (Waterman et al. 2003). Recently, we successfully developed a 9-item questionnaire composed of both hedonic and eudaimonic issues (Andrade et al. 2022) and further validated it against validated specific psychometric tools such as the DASS-21 and the World Health Organisation Quality of Life (WHOQoL) (Quarta et al. 2022). In addition to its positive effect on physical health, SWB has also been shown to be related to educational and career success. Enjoying intrinsic happiness feelings correlates with more successful employment conditions (Lyubomirsky et al. 2005) and academic success (Uusitalo-Malmivaara 2012), and a higher well-being seems to precede better career performance (Walsh et al. 2018). On the other hand, academic students and early career professionals are frequently exposed to situations of stress and anxiety, exacerbated by excessive focus on measuring performance and uncertainty about the future (Woolston 2019). In particular, the first years at the university represent a time frame of high emotional fragility in which the prevalence of depression and anxiety increases (Tran et al. 2017). Since the years at the university are recognised as a favourable intervention period for health promotion by working on modifiable factors and prevention (Dietz et al. 2020), it is highly advisable to continuously monitor students well-being and explore potential strategies and factors that could help to curb negative emotions and promote positive feelings as well as the overall well-being. Embrace a Mediterranean lifestyle, including higher adherence to a Mediterranean diet (MD), practicing a regular physical activity, and taking care of social relationships, play a critical role in maintaining psychological well-being (Muros and Knox 2020). Specifically for younger subjects, Khanna et al. (Khanna et al. 2019) found an inverse association between several typical MD foods and the risk of depression in adolescents, and Lo Moro et al. (Lo Moro et al. 2021) reported a positive association between general well-being and MD in a group of university students. In the present study we wanted to enhance our understanding of how and which dietary preferences in conjunction to other typical Mediterranean lifestyle factors (including physical activity, and quality of social relationship) may influence the perception of well-being in university students.

Materials and methods

Study design and ethics

We conducted a cross-sectional web-based study using a descriptive-correlational research methodology. More detailed information about the study design, participants, and method of data collection has been previously published (Quarta et al. 2022).

Adherence to Mediterranean diet and complementary food preferences

Compliance with MD was assessed using the 14-MEDAS questionnaire previously validated in the Italian sample population (Quarta et al. 2021). We also explored preferences for other foods and beverages not included in the 14-MEDAS score, but also of interest in terms of young students' dietary habits: (i) foods: milk and dairy products, whole grains, pasta and pizza) and (ii) beverages: coffee, herbal tea, water, beer, and spirits. We also asked them about their general preference for omnivorous or vegetarian/vegan diets, as well as their social eating habits (number of meals per day, with whom you share meals with).

Assessment of the perception of distress and SWB

Stress, anxiety, and depression levels were assessed using the self-report questionnaire Depression Anxiety Stress Scales Short Version (DASS-21) as previously described (Quarta et al. 2022). Scores for the DASS-21 depression, anxiety, and stress subdomains were categorised as "normal", "mild", "moderate", "severe", and "extremely severe" (Bottesi et al. 2015). SWB and related C1 (positive) and C2 (negative) subdomains were assessed using the 9-item SWB index as previously described (Quarta et al. 2022).

Statistical methods

Descriptors of the sample population are presented as percentage (%) values of the total sample for ordinal or nominal variables and as median and inter-quartile range (IQR) for scale variables. Sex, age range, marital status, family income, number of household members, smoking, sport practising, disease status, social relationship quality (WHOQoL), night sleeping time were used as covariates. To examine differences between categories, we applied the Mann–Whitney U and Kruskal–Wallis tests for scale variables and Chi-square test for ordinal and nominal variables (significant p values <0.05). Univariate correlation analysis were performed to preliminary assess the potential relationship between variables (significant p values <0.05). Then, correlational analyses were per-formed applying Spearman non-parametric partial correlation and were controlled for factors reaching significance at

univariate analysis. For multiple linear regression modelling, we used the factors previously identified as statistically correlated with the SWB score ($p < 0.05$ at univariate analysis). A binary logistic regression model was used to assess the association between preference in food choices and levels of anxiety, depression, and stress. A more extensive description of methods is reported in supplementary material. Statistical analyses were all performed using the Statistical Package for the Social Sciences (SPSS) statistical package for Windows (SPSS, Inc, Chicago, IL, USA).

Results

Sample population description

A total of 939 respondents completed a valid questionnaire. Sociodemographic and lifestyle characteristics are all reported in the Supplementary Table 1.

Assessment of dietary habits: MD adherence and food preference

The majority of the respondents (91.4%) reported consuming both animal and plant foods, while only 8.6% of respondents ate a purely plant-based diet, of which 5.3% additionally consumed fish. Overall, adherence to the MD was moderate with a median score of 6 (IQR 3) (6.47 ± 1.75) with 66.6% and 29.4% falling into the "moderate" and "low" categories, respectively (Supplementary Table 2). On the basis of the 14-MEDAS ratings, participants were classified as low adherent (score <5), moderately adherent (score 6–9), and highly adherent (score >10) to the MD, and the proportion of respondents scoring 1 on each question was reported for each adherence class (Table 1). As expected, significant differences in the intake of typical Mediterranean foods were found among the three classes of MD adherence. In particular, the lowest class had the lowest intake of fish, fruit, wine, nuts, legumes, and vegetables. Only 0.4, 0.7, 1.1, 3.3, 4.3, and 13% of respondents adhered to the recommendations (light green), respectively. These percentages increase significantly for respondents in the high MEDAS class (darker green), indicating the types of foods whose consumption should be increased to move up to the higher MEDAS class of compliance. With regards to other foods and drinks (Supplementary Table 3), globally, the students indicated a preference for low-fat milk and derived products, which they consumed normally once a day, regardless of 14-MEDAS class they belonged to. A 64.5% of the respondents also indicated a preference for eating whole grains products, with a significantly higher percentage of consumers falling into the medium and high classes of the 14-MEDAS adherence. The consumption of pasta dishes (typical of Italy's culinary tradition) did not differ significantly among the different MEDAS classes, while the consumption of pizza was significantly higher among members of the lower the 14-MEDAS classes. Finally, consumption of coffee, herbal tea, water, and, beer was higher in the moderate and high 14-MEDAS classes, whereas spirits consumption, although inherently low, did not differentiate between the 14-MEDAS classes.

Table 1. Distribution (%) of participants who scored 1 (within recommendation) on the 14-MEDAS questions across the three classes of MD adherence (low, medium, and high).

	Adherence to MD			
14-MEDAS question (% Score 1)	Low	Moderate	High	*p*-Value[a]
1. Olive oil as main culinary fat (yes)	85.9	96.8	100.0	0.000
6. Butter or cream (<1 portion/day)	83.3	97.9	100.0	0.000
7. Sweet drinks (<1 drink/day)	48.9	86.6	100.0	0.000
11. Desserts (<3 portions/week)	53.3	81.4	92.1	0.000
13. White meat preference (yes)	45.3	80.0	97.4	0.000
5. Red meat (<1 portion/week)	33.7	75.0	89.5	0.000
14. "Sofrito" (≥2 meals/week)	55.1	66.1	76.3	0.002
3. Vegetables (≥2 portions/day)	13.0	56.6	97.4	0.000
2. Olive oil (≥4 tbsp/day)	9.8	17.3	52.6	0.000
9. Legumes (≥3 portions/week)	4.3	16.2	60.5	0.000
12. Nuts (≥3 portions/week)	3.3	15.0	50.0	0.000
10. Fish/seafood (≥3 portions/week)	0.4	12.6	63.2	0.000
4. Fruits (≥3 portions/day)	0.7	12.2	34.2	0.000
8. Wine (7–14 glasses/week)	1.1	2.6	2.6	0.360
Legend to colour (score 1 %)				
0–25	26–50	51–75	76–100	

[a]Chi-squared tests were used to assess differences between groups of adherence to MD. Significance of colors are indicated in the last row of the table (legend to colour).

Associations between MD adherence and distress and well-being perception

We first estimated the 9-item SWB and the DASS-21 scores for the students in each of the three MD adherence categories (Table 2). The results show that participants with moderate or high adherence to the MD had slightly higher scores for the 9-item SWB and positive subdomain C1 and slightly lower scores for the negative C2 and DASS-21 subscales. To further support the observed association, we additionally performed non-parametric partial correlation analyses between these variables (Table 3). We confirmed that a higher adherence to the MD correlated significantly with better 9-item SWB and C1 subdomain scores. However, we did not find a significant association between adherence to MD and the negative C2 subdomain or the DASS-21 subscales.

Table 2. Distribution of mental health scores relative to MD adherence.

	Adherence to MD					
	Low	Moderate	High	*p* Value[a]	*p* Value[b]	*p* Value[c]
			9-Item SWB index			
Median (IQR)	5.44 (2.00)	5.78 (2.11)	5.83 (2.75)	**0.003**	**0.026**	0.305
Mean ± SD	5.43 ± 1.49	5.76 ± 1.54	6.03 ± 1.79			
C1 (positive)						
Median (IQR)	6.40 (1.95)	6.80 (2.00)	6.90 (2.45)	**0.001**	**0.030**	0.356
Mean ± SD	6.20 ± 1.54	6.56 ± 1.47	6.79 ± 1.66			
C2 (negative)						
Median (IQR)	6.75 (2.75)	6.50 (3.13)	5.65 (4.13)	0.054	0.086	0.369
Mean ± SD	6.52 ± 1.97	6.24 ± 2.09	5.92 ± 2.41			
Stress						
Median (IQR)	1.14 (1.00)	1.00 (1.00)	1.00 (0.86)	**0.032**	0.206	0.736
Mean ± SD	1.25 ± 0.70	1.15 ± 0.70	1.10 ± 0.67			
Anxiety						
Median (IQR)	0.42 (0.71)	0.28 (0.57)	0.28 (0.43)	**0.011**	**0.046**	0.375
Mean ± SD	0.58 ± 0.53	0.51 ± 0.55	0.41 ± 0.43			
Depression						
Median (IQR)	0.85 (1.00)	0.71 (1.14)	0.71 (1.18)	**0.024**	0.177	0.599
Mean ± SD	1.00 ± 0.70	0.90 ± 0.74	0.84 ± 0.72			

N: sample size; %: percentage of the sample population; IQR: interquartile range; SD: standard deviation. Mann–Whitney *U* tests were used to assess differences between groups. [a]Low adherence vs. moderate adherence. [b]Low adherence vs. high adherence. [c]Moderate adherence vs. high adherence (significant differences in bold when *p*-values <0.05).

Table 3. Correlations between adherence to MD and the 9-item SWB and DASS-21 scores.

Parameters	Adherence to MD (Spearman ρ)	*p* Values
SWB		
9-Item SWB index	**0.067**	**0.042**
C1	**0.075**	**0.023**
C2	−0.041	0.206
DASS-21 index		
Stress	−0.051	0.122
Anxiety	−0.056	0.086
Depression	−0.041	0.208

Correlations were controlled for: sex, pathology, marital status, family income, WHO social relationship score, smoking habits, sleep habits, sport practice. Significant differences are shown in bold when *p*-values <0.05.

Exploring the interaction between MD adherence, well-being and distress perception and sociodemographic and lifestyle factors

We next examined the association between the 14-MEDAS score and some of the sociodemo-graphic, disease status, and lifestyle factors examined here. The results of the nonparametric partial correlation analysis are shown in Supplementary Table 4. The 14-MEDAS score negatively correlated with the number of household members, and positively with the income, number of meals per day, and, with sport practice, which showed the strongest association. Next, we delved into the relationships between sociodemographic and lifestyle factors (including adherence to MD) and the scoring of mental health by performing a multiple linear regression analysis. The results of the regression model with the 9-item SWB indices as dependent variables and the sociodemographic and lifestyle factors are shown in Table 4. The model confirmed that several lifestyle characteristics act as positive predictors of the 9-item SWB score, including higher 14-MEDAS score, sleeping longer at night, better household budget, practicing more physical activity, and having good social relationships. Not smoking also acts as a positive predictor. Interestingly, being a woman correlates negatively with the 9-item SWB and the C1 subdomain, while it works as a positive predictor for the C2 subdomain. Looking at β values, which indicate the strength of the effect of each independent variable on the dependent variable, the factors with the greatest effect on 9-items SWB were sex, family income, social relationship quality and length of night's rest. It is noteworthy that for the 9-item SWB, the combination of these variables explains about 25% of the variance, while for C1 the variables combination explains about 27% of the variance. We obtained quite different results when stress, anxiety, and depression were used as dependent variables. Here, the predictive power was lost for adherence to MD and for practicing physical activity. Looking at the β values, the factors with the greatest influence on stress, anxiety, and depression were gender, quality of social relationships, and smoking. The combination of these variables explained about 23% of the variance for depression, 17% for stress, and 12% for anxiety (Supplementary Table 5).

Exploring the association between specific food preferences and well-being and distress perception

We next examined whether and how each of the individual items of the 14-MEDAS score as well as the most common additional dietary choices not included in the 14-MEDAS questionnaire correlated with the SWB indices. The results of the partial correlation

Table 4. Multiple linear regression model to assess the relationship between 9-item SWB scores, with Mediterranean diet adherence, sociodemographic and lifestyle factors.

	[a]9-Items SWB			[b]C1			[c]C2		
Variable	*T*	*SE*	*B*	*T*	*SE*	*β*	*T*	*SE*	*B*
Adherence to MD	**0.175***	0.086	0.060	**0.175***	0.083	0.060	−0.173	0.123	−0.043
Sex (ref = man)	**−0.581*****	0.103	−0.163	**−0.279****	0.099	−0.080	**0.959*****	0.147	0.200
Pathology (ref = no pathology)	−0.170	0.131	−0.037	−0.206	0.126	−0.046	0.125	0.187	0.020
Marital status (ref = single)	−0.143	0.100	−0.042	−0.165	0.097	−0.049	0.115	0.144	0.025
Family income	**0.113*****	0.032	0.100	**0.120*****	0.031	0.109	**−0.105***	0.046	−0.069
WHO social relationship	**0.779*****	0.054	0.422	**0.812*****	0.052	0.452	**−0.738*****	0.078	−0.300
Smoking (ref = no smoker)	**−0.330*****	0.105	−0.089	**−0.407*****	0.101	−0.112	0.234	0.151	0.047
Sleep per night	**0.202*****	0.053	0.109	**0.134****	0.051	0.074	**−0.286*****	0.075	−0.115
Sport practice	**0.108****	0.041	0.078	**0.136****	0.039	0.101	−0.072	0.058	−0.039

T: non-standardized coefficient; SE: standard error; β: regression coefficient. MD adherence was assessed by the 14-MEDAS. **p*-Value < 0.05; ***p*-value < 0.01; ****p*-value < 0.001. Bold indicates significativity, the numbers of asterisks indicates the *p* values as specified in the legend.

[a]Intercept (SE) = 3.490 (0.193). Anova *p*-value <0.000, R=0.513, R^2=0.263, R^2 adjusted = 0.257, SE of the estimate = 1.33. [b]Intercept (SE)=4.05 (0.185). Anova *p*-value <0.000, R=0.533, R^2=0.284, R^2 adjusted = 0.277, SE of the estimate = 1.28. [c]Intercept (SE)=8.2 (0.276). Anova *p*-value <0.000, R=0.401, R^2=0.161, R^2 adjusted = 0.153, SE of the estimate = 1.91.

analysis are shown in supplementary Table 6. Of the 23 independent variables included in the analysis, 5 yielded a significant correlation with the 9-item SWB, C1, and C2, including the amount of fruit consumed daily, which correlated positively with the 9-item SWB and C1, and the frequency of red meat consumption, which otherwise showed a negative correlation. Also noteworthy is the result for the consumption of bottled sweet drinks, the consumption of which correlates negatively with the 9-item SWB and, correspondingly, positively with the C2 subdomain. Finally, the consumption of caffeinated beverages (such as coffee and tea) correlates negatively with the 9-item SWB and correspondingly with the C2 subdomain. To examine the potential contribution of each item of the MEDAS score and the additional dietary choices in relation to perceptions of anxiety, depression, and stress, we performed binary logistic regression analysis splitting participants into two groups, normal and distressed, as allowed by DASS-21 scoring method (Bottesi et al. 2015). The results shown in Figure 1 are in line with the positive relationship observed for the 9-item SWB. The amount of fruit consumed daily significantly reduces the risk of anxiety and shows a negative trend for depression. Coffee consumption increases the risk of depression, while the amount of red meat consumed weekly increases the risk of higher stress. Finally, excessive consumption of saturated fats and bottled sweet drinks increase the risk of being more anxious and stressed.

Discussion

In an attempt to examine the extent to which adherence to the Mediterranean diet (MD) in combination with Mediterranean lifestyle factors may influence students' perceptions of subjective well-being (SWB), we confirmed that higher adherence to MD correlated with better SWB, but it was the combination of adherence to MD with other factors, including quality of social relationships, income, smoking, sleep, and physical activity, that better predicted SWB.

MD refers to the dietary habits that were common until the late 1950s in various regions of the Mediterranean basin, that although differed culturally shared the same dietary habits: daily consumption of abundant plant foods, use of olive oil as the main source of fat, frequent consumption of fish, small amounts of meat, small to moderate portions of dairy products, and moderate consumption of wine with meals (Willett et al. 1995). Interestingly, the UNESCO recently expanded the definition of MD by detaching the term from its purely dietary meaning and

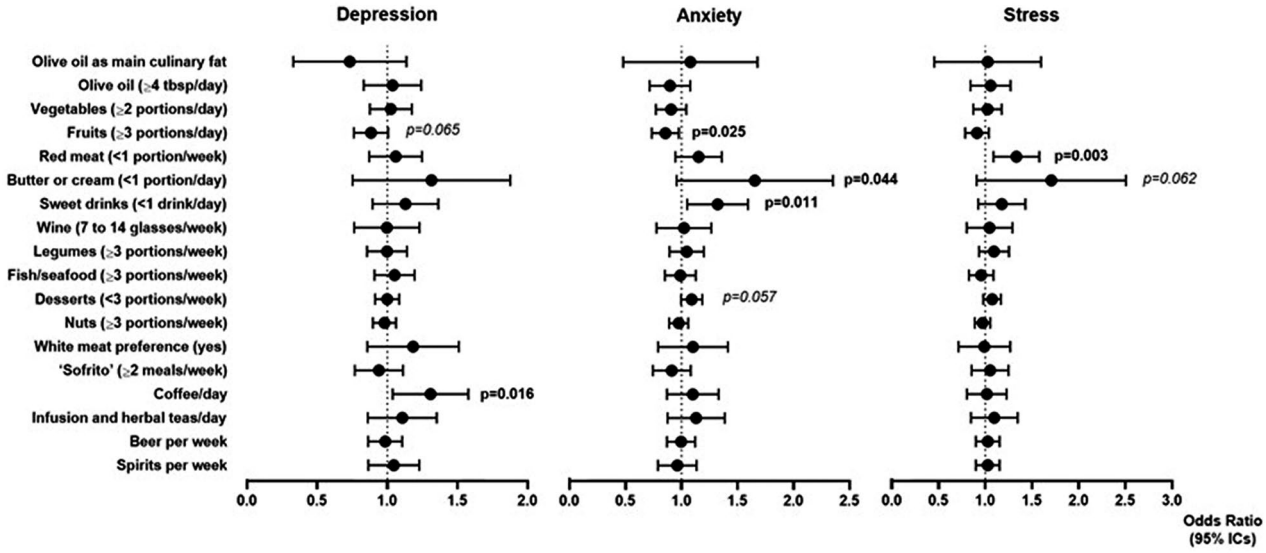

Figure 1. Plot of odds ratio (or) and 95% ICs of anxiety, depression and stress by MEDAS items and additional food choices in students. The binary logistic regression analysis was adjusted for sex, pathology, marital status, family income, WHO social relationship score, smoking habits, sleep habits, number of meals per day and sport practice.

expanding it to include several other lifestyle parameters, such as being physically active, spending time in nature, and maintaining high levels of social relationships and sociability (UNESCO. Intangible Heritage Lists. 2012. Available online: www.unesco.org). It has been speculated, therefore, that all of these factors in combination may be responsible for the health benefits associated with this broader Mediterranean lifestyle model (Gerber and Hoffman 2015).

With this in mind, we decided to comprehensively investigate whether adherence to MD, in combi-nation with other Mediterranean lifestyle factors, influenced the perceptions of SWB and of the levels of distress in a University community in southern Italy, a European region traditionally adherent to the typical MD lifestyle.

With a mean MEDAS score of 6.47 ± 1.75 (on a 14-point scale), our students are clearly moving away from the healthy MD dietary tradition. Our data are similar to those collected in other university cohorts, including a cohort in Cyprus (Hadjimbei et al. 2016), in Spain (Miguez Bernardez et al. 2013; Garcia-Meseguer et al. 2014), and recently in Italy (Caparello et al. 2020; Lo Moro et al. 2021). As expected, students who follow vegetarian or vegan diets had significantly higher 14-MEDAS scores (8.32 ± 1.31). In fact, the less popular foods in our cohort were those related to plant foods. These observations are consistent with those of Caparello (Caparello et al. 2020) Martínez Álvarez (Martínez Álvarez et al. 2015) and Garcia-Meseguer (Garcia-Meseguer et al. 2014) in Italy and Spain, respectively. Among other foods, fish and seafood consumption was also alarmingly low, a result that is among the lowest recorded to date (Martínez Álvarez et al. 2015; Hadjimbei et al. 2016; Caparello et al. 2020). Otherwise, surprisingly adherent to the MD tradition was the low consumption of red meat (76% of respondents reported consuming red meat less than once a week) and the preference for white meat (70.5% of respondents), which is consistent with Caparello's data (Caparello et al. 2020). Regarding consumption/use of fats the diffuse preference for olive oil use is consistent with the preference previously found in Cyprus (Hadjimbei et al. 2016) and Italy (Caparello et al. 2020). It is noteworthy that, in agreement with Moreno-Gómez (Moreno-Gómez et al. 2012), students who ate more meals per day had better dietary quality and achieved a significantly higher 14-MEDAS score. Apparently, snacks within the Mediterranean diet are an easy option/opportunity to consume fresh fruits, vegetables, or nuts, which contributes to in-creased MD adherence.

In addition to genetic susceptibility, in recent years researchers have increasingly focused on the role of environmental factors, including diet, in modulating/influencing different mental health traits (Parletta et al. 2013; Opie et al. 2015). Although considerable efforts have been made to investigate the role of specific nutrients and dietary patterns on mental illness in the general population (Shabbir et al. 2022), little attention has been paid to the mental health of university students, especially in terms of improving

positive psychology in its various constructs (Oades and Mossman 2017). Correlation analysis revealed a positive statistically significant relationship between adherence to MD and both the 9-item SWB and the positive C1 subdomain, which remained significant also after controlling for potential confounders, including sports practicing. This suggests a possible protective contribution of MD, per se, to individuals' psychological functioning, but not to the negative perceptions captured under the C2 subdomain or by distress constructs. In agreement with other authors who also studied college students and general population (Lesani et al. 2016; Moreno-Agostino et al. 2019; López-Olivares et al. 2020), we confirmed a positive role of fruit consumption in improving the 9-items SWB score, while consumption of red meat, sweet beverages and industrial sweets were confirmed as negative determinants of both the 9-items SWB and C1 scores, and as positive determinants of the C2 component. It is possible that the general beneficial properties attributed to fruits, including anti-inflammatory and antioxidant effects, as well as their ability to improve endothelial function and neuronal membrane composition may all contribute to the improvement of mental health (Parletta et al. 2013). Fruits are a rich source of vitamin C, an important co-factor in the production of dopamine (Girbe et al. 1994), a neurotransmitter that sustain life motivation, attraction to life and enjoyment (Kringelbach and Berridge 2009). Fruits also contains vitamins of the B group and complex carbohydrates, which also promote the synthesis of neurotransmitters involved in regulating mood, including serotonin and oxytocin in addition to dopamine (Rao et al. 2008). Eating carbohydrates increases tryptophan and tyrosine levels in the brain, which are important precursors for the synthesis of serotonin and dopamine (Rooney et al. 2013), while B vitamins also play a role in mitochondrial function, which may promote feelings of vitality and life engagement (Depeint et al. 2006). Another plausible biological pathway underling the potential role of fruit in psychological well-being is mediated by vitamin- and mineral-dependent increases in brain-derived neurotrophic factor (Molteni et al. 2002), an important protein required for several brain functions, including neuronal development and plasticity (Gomez-Pinilla and Nguyen 2012). Consistent with the observation of López-Olivares (López-Olivares et al. 2020) and Withe (White et al. 2013), the lack of effects of fruit consumption on modulation of negative emotions picked up under C2 domain remains an intriguing but still unresolved issue. Red meat is considered one of the most controversial foods in health/nutritional history, including mental health (Boada et al. 2016). While it contains abundant protein, minerals such as zinc and iron, and vitamins of group B that may contribute to the proper production and release of neurotransmitters (Mlyniec et al. 2014), it is also a major source of cholesterol, saturated fatty acids, and arachidonic acids, which may increase the risk for mental disorders by promoting inflammation (Melo et al. 2019). These adverse effects are thought to be caused by the pro-inflammatory effects of saturated fat on the nucleus accumbens in the brain (Abildgaard et al. 2011). In agreement with Moreno Agostino (Moreno-Agostino et al. 2019) and Cabiedes-Miragaya (Cabiedes-Miragaya et al. 2021), our data support a negative role of red meat in the perception of SWB and positive feelings while it increases the perception of negative feelings. The magnitude of the effect of red meat on the 9-item SWB score, and on the C1 and C2 components is undoubtedly small, but this evidence warrants further investigation into the role of red meat on psychological well-being.

Because MD reflects many influences of Mediterranean culture, including close social and environmental relationships (Bach-Faig et al. 2011), adherence to the MD may be predicted by several sociodemographic and lifestyle variables, including gender, income, number of cohabitants and quality of social and family relationships in addition to physical activity (Bach-Faig et al. 2011).

On this background, we further explored the interplay and the predictive contribution of all these factors in regulating the perceptions of SWB and of the levels of distress. Attempting to model the complex interactive contributions of several Mediterranean lifestyle factors to the perceptions of SWB and its subdomains C1 and C2, we confirmed a significant role for several lifestyle factors in modelling SWB and C1, including adherence to MD, family income, quality of social relationships, smoking habits, regular physical activity, and sleep quality. For C2, only family income, social relationships, and sleep duration significantly contributed to the modulation of negative perception. In contrast, MD and physical activity had no effect. We find closer agreement regarding the positive impact of MD on SWB as measured by Lo Moro's Warwick–Edimburgh Psychological Well-Being Scale (Lo Moro et al. 2021), and with the positive and negative components of emotional well-being assessed by López-Olivares, for which we find complete agreement in terms of the impact of MD on the positive component and the lack of influence on the negative

component (López-Olivares et al. 2020). Consistent with the hypothesis of a multifactorial contribution of the Mediterranean lifestyle to SWB, we confirm a significant role for several other factors, of which the quality of social relationships resulted to be the strongest one. It has long been known that social relationships influence psychological well-being through several mechanisms, including modelling health-related behaviours, participation in social activities, and sharing of social support and resources (Kawachi and Berkman 2001). Our data suggest that is the clustering of several Mediterranean healthier behavioural factors (diet, physical activity, and social contact) that contributes to substantial improvement in SWB and perception of positive feelings and consistent with those of Lo Moro (Lo Moro et al. 2021) and López-Olivares (López-Olivares et al. 2020). Since SWB is not the mere flipside of psychological distress, but both assessments are essential indicators of overall mental health (Ryff 2014), we also examined the role of the Mediterranean lifestyle on perceived distress in its three dimensions of anxiety, stress, and depression. Although subjects who were moderately adherent to the MD had significantly lower scores for anxiety, stress, and depression than those who were in the lowest range of adherence, our correlation analysis, conformingly to the lack of effect of MD on the C2 subdomain, we did not find any statistically significant relationships between adherence to MD and each distress dimensions. Rather, consistent with the results for the C2 subdomain, we confirmed a significant predictive role only for some sociodemographic factors, including family income, quality of social relationships, smoking, and sleep duration. MD adherence, again, showed no effect on the different measured dimensions of distress, whereas physical activity can lower only anxiety levels. Our results are in conflict with the protective role of the MD in preventing/limiting mental health traits related to depression, anxiety, and stress observed by Sánchez-Villegas in a Spanish student cohort (Sanchez-Villegas et al. 2009; Sánchez-Villegas et al. 2016; Hershey et al. 2022), by Hodge in a cohort of older Australians (Hodge et al. 2013) and by Sadeghi in a middle-aged Iranian cohort (Sadeghi et al. 2021). In contrast to these findings and consistent with our data, no significant association between dietary patterns similar to the Mediterranean pattern and depression has been found in some other studies, such as by Lai in a longitudinal observational study on Australian women (Lai et al. 2016) and by Crichton in a cohort of mixed Australian adults (Crichton et al. 2013). Such different findings may be explained by different methods of assessing dietary intake or psychological disorders. In most of the aforementioned studies, the assessment of psychological disorders was based on clinical diagnosis rather than on the severity of symptoms of mental disorders as self-reported by our participants and calculated using the DASS-21 score. Indeed, when psychological disorders were assessed using the DASS-21 score, as recently done by Dinu (Dinu et al. 2022) and Rostami (Rostami et al. 2022), the protective role of MD was less convincing, suggesting that further studies need to be designed using more robust methods, such as randomised clinical trials.

To complete the analysis, we also assessed the potential contribution of each Mediterranean food item under investigation (regardless of MD class of adherence) to the risk of anxiety, depression, and stress. As already reviewed elsewhere, we confirmed a clear protective role for fruits, whose consumption was associated with a significantly reduced risk of depression (Saghafian et al. 2018) and stress (Mikolajczyk et al. 2009), and an adverse role for the consumption of butter, creams, and sweetened beverages and pastries, probably due to their high content of saturated fats and refined sugars (Knüppel et al. 2017; Melo et al. 2019; Lopes Cortes et al. 2021).

With regards to the association between other additional food preferences examined here, well-being and levels of perceived distress, we were particularly puzzled by the adverse effect of coffee consumption in terms of lowering 9-item SWB and increasing the perception of negative emotions, as well as its significant contribution to higher risk of anxiety, but not depression and stress. Coffee is among the most commonly consumed drinks worldwide (Lim et al. 2019). Benefits attributed to moderate caffeine consumption include increased alertness, wakefulness, and improved cognitive function, which is why its consumption has become very common among college students (Champlin et al. 2016). In general, however, college students appear to indulge in excessive coffee consumption, reporting significantly higher caffeine consumption than the rest of the population (McIlvain et al. 2011; Champlin et al. 2016). Although several epidemiological studies suggest that caffeine may prevent depressive symptoms (Garcia-Blanco et al. 2017), and one animal study suggests that caffeine may enhance the effects of antidepressants (Szopa et al. 2016), other studies have shown an association between caffeine consumption and exacerbation of levels of anxiety in patients with panic disorder (Santos et al. 2019) and in healthy subjects (Klevebrant and Frick 2022), including college students (Bertasi et al. 2021). Our data confirm Bertasi's findings

(Bertasi et al. 2021) regarding worsening anxiety symptoms and add new findings: in contrast to previous studies (Kawada 2021; Qureshi et al. 2022), which found no association between coffee and SWB, our data show significant worsening of 9-item SWB and C1 indices in college students.

Despite the contribution of the present study, which included an assessment of several dimensions of mental health, dietary habits, and various sociodemographic and lifestyle factors, our results and conclusions should be considered in light of several limitations. First, despite the large number of participants, our sample was limited to young students, mostly women, with high levels of education, and coming from a single urban area, so results should be generalised to the rest of the student population with caution. Second, our data were based on self-reports, which may be prone to error and bias. It is possible that different associations will result when the specific foods that make up these classes are assessed separately. Third, the cross-sectional design of the study does not al-low us to draw conclusions about the directionality of the relationship between MD and mental health; as well as it does not allow us to establish a causal relationship. Individuals at risk for mental illness or with previous psychiatric disorders may tend to consume unhealthy, high-energy, sweetened foods. These unhealthy foods may potentially exacerbate the symptoms of an existing or latent disorder; therefore, low SWB scores and high levels of anxiety or depression may be the cause rather than a consequence of unhealthy food intake. Further studies with prospective or interventional designs are warranted to confirm the direction of the association/interplay between Mediterranean dietary habits and mental illness.

In conclusion, we confirm a role for some previously recognised protective lifestyle factors, such as adherence to MD, physical activity, and maintenance of good, satisfying social activities, in improving well-being in university students. Although the role of these factors was already known, our data underscore the importance of a holistic approach in better understanding protective and harmful factors, rather than being limited to considering individual foods as preventive measures. These findings should be considered in addition and in conjunction with our previous findings that emphasise the existence of a close relationship between nature, socio-environmental factors, physical and mental health (Quarta et al. 2022). Overall, these findings should be carefully considered by policy makers to implement more effective educational policies and preventive screening pro-grams to ensure real improvement in mental and physical health, especially among more vulnerable, youngest people.

Ethical approval

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of University of Salento (No. 0056300, 24 March 2021). Informed consent was obtained from all subjects involved in the study.

Author contributions

Stefano Quarta and Marika Massaro conceptualized and designed the study; Stefano Quarta, Marika Massaro Annalisa Levante, Flavia Lecciso, Fabio Pollice, María-Teresa García-Conesa and Luisa Siculella designed research; Stefano Quarta, Marika Massaro, Maria Annunziata Carluccio, Nadia Calabriso and María-Teresa García-Conesa, coordinated data collection and transfer; Stefano Quarta analyzed data and performed statistical analysis; Marika Massaro María-Teresa García-Conesa, Nadia Calabriso, Egeria Scoditti, Luisa Siculella, Annalisa Levante, Flavia Lecciso, Fabrizio Damiano and Paula Pinto assisted with literature review and data analysis; Marika Massaro drafted the final manuscript; Stefano Quarta, Marika Massaro, Annalisa Levante, Flavia Lecciso, Fabrizio Damiano, Fabio Pollice, Paula Pinto, Maria Annunziata Carluccio, Luisa Siculella, and María-Teresa García-Conesa performed final review and editing; all authors read and approved the final manuscript. All authors report no conflicts of interest.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

Data availability statement

Results attained in this study are included in the manuscript. Individual data are not publicly available due to ethical restrictions.

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