

# The Association between Obesity and Symptoms of Psychopathology and its Relationship with Sedentary Behavior and Mediterranean Diet

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## ABSTRACT

**Background:** Recent research indicates an association between obesity and symptoms of psychopathology, the nature of which remains obscure. This study examined the confounding role of behavioral factors on this association.

**Method:** One hundred and forty-two overweight/obese subjects who sought treatment for obesity, of both genders (51 males and 91 females), 18 to 64 years old and 139 normal-weight controls of both genders (41 males and 98 females), 18 to 63 years old, were enrolled in this study. We measured psychopathology features, using the Symptom Checklist 90-Revised (SCL-90-R), dietary habits, using the MedDietScore (MDS) questionnaire, and physical activity, using the International Physical Activity Questionnaire (IPAQ). A series of regression models were used to estimate the mediation of dietary patterns and physical activity on the obesity-psychopathology association.

**Results:** The associations between obesity and depression ( $\beta=0.32/\beta=0.15$ ), obsession-compulsion ( $\beta=0.03/\beta=-0.13$ ), anxiety ( $\beta=-0.25/\beta=-0.12$ ), interpersonal sensitivity ( $\beta=0.08/\beta=-0.04$ ) and psychoticism ( $\beta=-0.01/\beta=0.025$ ) are accounted for by sedentary behavior and Mediterranean diet.

**Conclusions:** Our data suggest that modifiable behavioral factors such as sedentary time and dietary patterns positively affect the association between obesity and symptoms of psychopathology.

## INTRODUCTION

Obesity is considered a top priority for public health due to its high worldwide prevalence (1, 2), and its well-known relation to higher medical mortality (2). Although the effects of obesity on physical health have been well documented (1, 2), the consequences for mental health are less certain. Previous evidence suggests a positive correlation between obesity and symptoms of psychopathology, such as depression (3, 4), anxiety (3, 4), somatization (5), hostility (6), impulsivity, interpersonal sensitivity and psychotic features (7). In particular, obese patients seeking weight loss show a high prevalence of psychiatric comorbidity (8, 9). However, other research shows no relationship between obesity and psychopathology (10, 11).

Existing literature has showed that primary obesity and symptoms of psychopathology share similar behavioral and lifestyle risk factors such as dietary habits, physical activity and sedentary time. On the one hand, physical

activity (12, 13) and specific dietary interventions (14-16), such as the Mediterranean Diet (MeDi) (17, 18), may reduce the risk of developing depression, as well as anxiety (15-17) and somatization (19). On the other hand, physical inactivity and unhealthy food habits are key determinants of obesity risk (2, 20). In fact, there is an inverse relation between adherence to a Mediterranean dietary pattern and prevalence of obesity (21). This association has been extensively investigated in the Greek population in the ATTICA study (21), a cross-sectional survey that randomly enrolled 1,514 men (18 to 87 years old) and 1,528 women (18 to 89 years old) with no history of cardiovascular disease.

The aforementioned similarities, related to common lifestyle risk factors of both obesity and psychopathology, suggest that specific behavioral factors linked to obesity, such as physical inactivity and nonadherence to the MeDi, may play a pathogenetic role in the comorbid psychopathology features. Existing findings show that behavioral patterns may interact with obesity and depression (22, 23), or anxiety (23), via pathways which include physical inactivity (1, 23) and dietary habits (1). In particular, it seems that obesity is associated with physical inactivity, unhealthy dietary behavior and health and appearance concerns that ultimately lead to depression and anxiety (1, 23). However, the existing data are not only limited but also contradictory. Previous findings lack consistency on whether physical activity attenuates the depressive symptoms associated with obesity (24), or not (25). Furthermore, it has been suggested that dietary patterns may improve psychological symptoms in obese persons (26, 27), although this may not always be the case (28, 29). In particular, although the MeDi is a key component of the dietary habits of Greek population, its mediating role regarding obese subjects showing symptoms of psychopathology has not been investigated yet.

Although existing findings deal with the influence of physical activity and diet on depression and anxiety, the impact of these factors on other symptoms of psychopathology prevalent in obese subjects, such as psychoticism, interpersonal sensitivity, somatization and hostility, has not been investigated.

Overall, it seems that subjects with obesity show high rates of symptoms of psychopathology. These symptoms could be partly explained by an unhealthy and inactive lifestyle which is common among subjects with obesity and subjects with depression, anxiety and/or other psychopathology features. Understanding the nature of the relationship between obesity and psychopathology

features is necessary since it will facilitate treatment options and will encourage requisite lifestyle interventions. Investigating potential moderators could help identify those individuals with higher BMI who are more likely to experience symptoms of psychopathology. Taking into consideration that existing data on the obesity-psychopathology mediation are inconclusive and limited to depression and anxiety, despite the fact that subjects with obesity show a broad range of psychopathology features (3-9), the aim of the present study was to investigate the association between obesity and psychopathology and to examine whether physical activity and dietary habits influence this association.

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## SUBJECT METHODS

### SAMPLING DESIGN

This was a case-control study conducted in a specialized obesity treatment unit (composed of a specialized team of physicians, including a psychiatrist) at a General Hospital in Athens, from January 2014 to September 2014. One hundred and forty-two overweight [body mass index (BMI) 25-29.9 kg/m<sup>2</sup>] and obese (BMI 30 kg/m<sup>2</sup>) subjects, of both genders (51 males and 91 females), 18 to 64 years old (35.88±10.42), presented willingly at the obesity treatment unit and were consecutively enrolled to exclude selection bias, and 139 normal-weight subjects (control group – BMI 18.5-24.9 kg/m<sup>2</sup>) of Greek ethnicity, of both genders (41 males and 98 females), 18 to 63 years old (34.05±8.96), were randomly selected from the community. Obesity was determined on the basis of height and weight (measured by the physicians of the study).

### PROCEDURES

Participants were classified as either overweight/obese (BMI ≥25) or normal weight (BMI 18.5–24.9). Participants from both study groups were interviewed about their weight history, personal and family medical and mental history, and were also asked to complete self-administered questionnaires. Exclusion criteria were the presence of a serious mental or physical illness (such as diabetes and thyroid disease, which have been shown to be associated with mental disorders) (30-32), the use of medication such as corticosteroid treatment, the psychiatric complications which are not rare (33), the non-completion of two or more questions in each questionnaire's subscale, and pregnant or lactating women.

Informed consent was obtained from all individual participants included in the study and patient anonymity

was preserved. This work was approved by the hospital's ethics committee and was carried out in accordance with the provisions of the Declaration of Helsinki.

### PSYCHOPATHOLOGY MEASURES

Participants were asked to complete the self-administered, 90-item, symptom check-list (SCL-90-R) revised questionnaire (34, 35). This questionnaire is developed and designed primarily to reflect the symptoms of psychopathology in a broad spectrum of individuals, ranging from non-patient "normal" correspondents, through medical patients of various types, to subjects with psychiatric disorders. In our study, the use of a multi-dimensional measure of psychopathology, such as the SCL-90R, permitted a simultaneous evaluation of prevalent psychopathology features.

Each item is rated on a 5-point scale of distress (0-4), ranging from "not at all" at one pole to "extremely" at the other. The 90 items are scored and interpreted in terms of nine primary symptom dimensions and three global indices of distress. These are labeled as following: Somatization, Obsession-Compulsion, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, Psychoticism, and Global Severity Index (GSI), Positive Symptom Distress Index (PSDI), Positive Symptom Total (PST). The Greek version of this questionnaire has been standardized and validated in a case-control study. Participants were comprised of 65 subjects with no mental or physical illness, randomly selected from the community, and 250 consecutive patients from a psychiatric hospital unit (36). The Cronbach's alpha indexes for the original questionnaire (and for the current study) are shown in Table 1.

### BEHAVIORAL MEASURES

Dietary habits were evaluated through the MedDietScore (MDS) questionnaire (37) and a special diet score that incorporates the inherent characteristics of this dietary pattern. The MeDi is a diet high in plant foods (such as vegetables, fruits, and cereals), fish and olive oil, and low-to-moderate intake of wine, as well as low intake of red meat and poultry (38). The validity of this questionnaire has previously been tested (37). The influence of the MeDi on subjects with obesity has been extensively investigated in the Greek population (21) and this justifies our choice of the MDS as a tool to test the dietary habits in our study. The Cronbach's alpha indexes for the original questionnaire (and for the current study) are shown in Table 1.

**Table 1.** Cronbach's alpha statistics for the original questionnaires and the current study

Subscale	Cronbach's alpha - Original questionnaire	Cronbach's alpha - Current study
SCL-90R		
Somatization	0.80	0.87
Obsession-compulsion	0.79	0.84
Interpersonal sensitivity	0.86	0.83
Depression	0.89	0.90
Anxiety	0.85	0.88
Hostility	0.86	0.83
Phobic anxiety	0.81	0.76
Paranoid ideation	0.83	0.81
Psychoticism	0.79	0.76
Total	0.94	0.97
MDS		
Total	0.90	0.95
IPAQ		
Total	0.96	0.93
Sedentary	0.89	0.84

SCL-90R=Symptom Checklist-90 Revised; MDS=MedDietScore; IPAQ=International Physical Activity Questionnaire.

Physical activity was evaluated on the basis of the International Physical Activity Questionnaire (IPAQ) (39). This is an instrument designed primarily for the surveillance of physical activity among adults. The short IPAQ form that was used in the present study was developed to measure four specific types of activity, namely walking, moderate-intensity, vigorous-intensity, sedentary (defined as IPAQsedentary or IPAQSED), and three levels of physical activity proposed to classify populations: low, moderate and high. A total physical activity score (IPAQTOTAL) is computed by summing up walking, moderate-intensity and vigorous-intensity activity. The validity and the reliability of this questionnaire have previously been tested in 12 countries, including Greece (39). The Cronbach's alpha indexes for the original questionnaire (and for the current study) are shown in Table 1.

### STATISTICAL ANALYSIS

Statistical analysis was performed using the STATISTICA software (version 10). All data were expressed as mean and standard deviation. Differences between variables in overweight/obese and normal-weight groups were tested with the standard MANOVA paradigm (40, 41). The two study groups were designated on the basis of weight and height and the calculation of BMI (kg/m<sup>2</sup>).

In order to test the interactions between behavioral

patterns, obesity and symptoms of psychopathology, four sets of linear regression models were specified based on procedures outlined by Baron and Kenny (42). More specifically: The first equation regressed the confounders (behavioral parameters) on the dependent variable (obesity); the second equation regressed the independent variables (symptoms of psychopathology) on the dependent variable (obesity); the third and fourth equations regressed the independent variables (symptoms of psychopathology) on the dependent variable (obesity) with the inclusion of the confounders (behavioral parameters). A similar analysis has been used in previous studies to test interactions (28, 43). According to Baron and Kenny (42), the independent variable must be significantly related to both the confounder and the dependent variable, the confounder must be significantly related to the dependent variable, and the association between the independent and dependent variables must be attenuated when the confounder is included in the regression model.

In our regression models residuals were symmetrically distributed. All significance tests were evaluated at the 0.05 level. No adjustment was considered necessary since the groups were matched for all relevant parameters (e.g., age, sex ratio) and subjects with a serious mental or physical illness were excluded from the study.

## RESULTS

### SAMPLE CHARACTERISTICS

Cases have been matched with controls by age and gender. The sex distribution was 41 male and 98 female participants in the control group, and 51 male and 91 female participants in the obese group ( $P > 0.05$ ). The overweight/obese distribution in the obese sample was 10 overweight (11.33%), 36 obese (24%), 62 morbid obese (43%), and 34 super-morbid obese (22.67%). The scales of obesity according to BMI are defined as follows: overweight-BMI 25-29.9 kg/m<sup>2</sup>, obese-BMI 30-39.9 kg/m<sup>2</sup>, morbid obese-BMI 40-49.9 kg/m<sup>2</sup>, super-morbid obese-BMI  $\geq 50$  kg/m<sup>2</sup>. Table 2 shows the distribution of SCL-90-R subscales for each study group. It also shows the distribution of age, BMI and behavioral patterns by study group.

### Interactions between dietary patterns, physical activity, obesity and psychopathology

Depression, interpersonal sensitivity, psychoticism, obsession-compulsion and anxiety were significantly ( $p < 0.05$ ) associated to MDSTOTAL and IPAQSED. Figure 1a and Figure 1b present the results of regression models

**Table 2.** Descriptive statistics for the control and obese groups

	Control group (n=139) Mean (S.D.)	Obese group (n=142) Mean (S.D.)	p
Age (years) 18-64	34.05 (8.96)	35.88 (10.42)	ns
BMI (kg/m <sup>2</sup> )	21.83 (2.40)	41.97 (11.21)	$\leq 0.001$
Somatization	8.09 (7.81)	11.09 (8.29)	$\leq 0.001$
Depression	9.60 (8.77)	15.53 (10.63)	$\leq 0.01$
Phobic Anxiety	2.07 (3.65)	2.83 (3.59)	$\leq 0.001$
Obsession-Compulsion	8.61 (6.65)	10.70 (7.80)	$\leq 0.05$
Hostility	3.60 (3.82)	5.02 (4.99)	$\leq 0.05$
Anxiety	6.12 (6.09)	7.56 (7.84)	$\leq 0.01$
Paranoid Ideation	4.97 (4.12)	7.00 (4.44)	ns
Interpersonal Sensitivity	6.65 (5.20)	11.13 (7.20)	$\leq 0.001$
Psychoticism	4.44 (4.54)	8.19 (6.03)	$\leq 0.001$
MDSTOTAL	35.24 (5.49)	24.73 (4.49)	$\leq 0.001$
TOTALIPAQ	1697.99 (1235.37)	761.149 (853.95)	$\leq 0.001$
IPAQSED	145.73 (98.98)	432.89 (170.51)	$\leq 0.001$

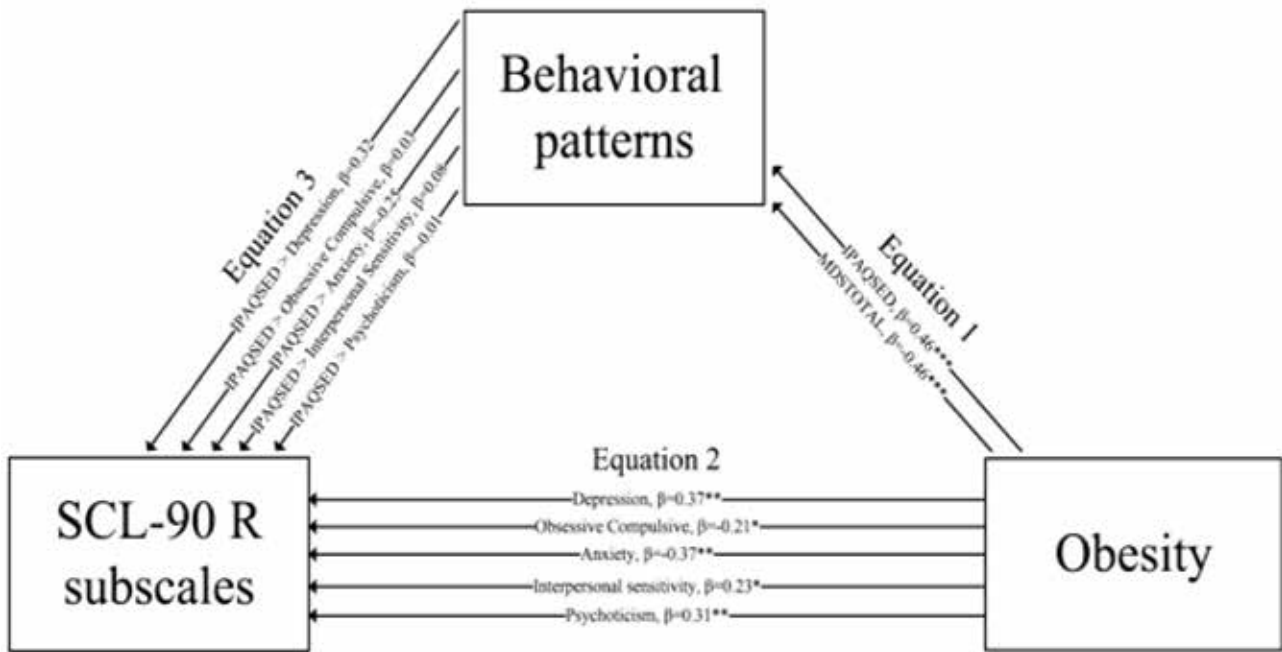
Wilks  $\Lambda = 0.23$ ,  $F_{14,251} = 14.09$ ,  $p < 0.001$

SD=standard deviation; ns=non significant; BMI=body mass index; MDS=MedDietScore; IPAQ=International Physical Activity Questionnaire; SED=sedentary.

examining the association between obesity, and SCL-90-R subscales and behavioral patterns. Since the aim of the study was to compare two groups, normal weight (BMI  $< 25$  kg/m<sup>2</sup>) and overweight/obese (BMI  $\geq 25$  kg/m<sup>2</sup>) subjects, no specific level of obesity was analyzed separately for the obese group. We found that obesity was positively related to depression, interpersonal sensitivity and psychoticism scales and negatively related to obsession compulsion and anxiety scales (Equation 2). In addition, obesity was negatively related to MDSTOTAL and positively related to IPAQSED at an equal degree (Equation 1).

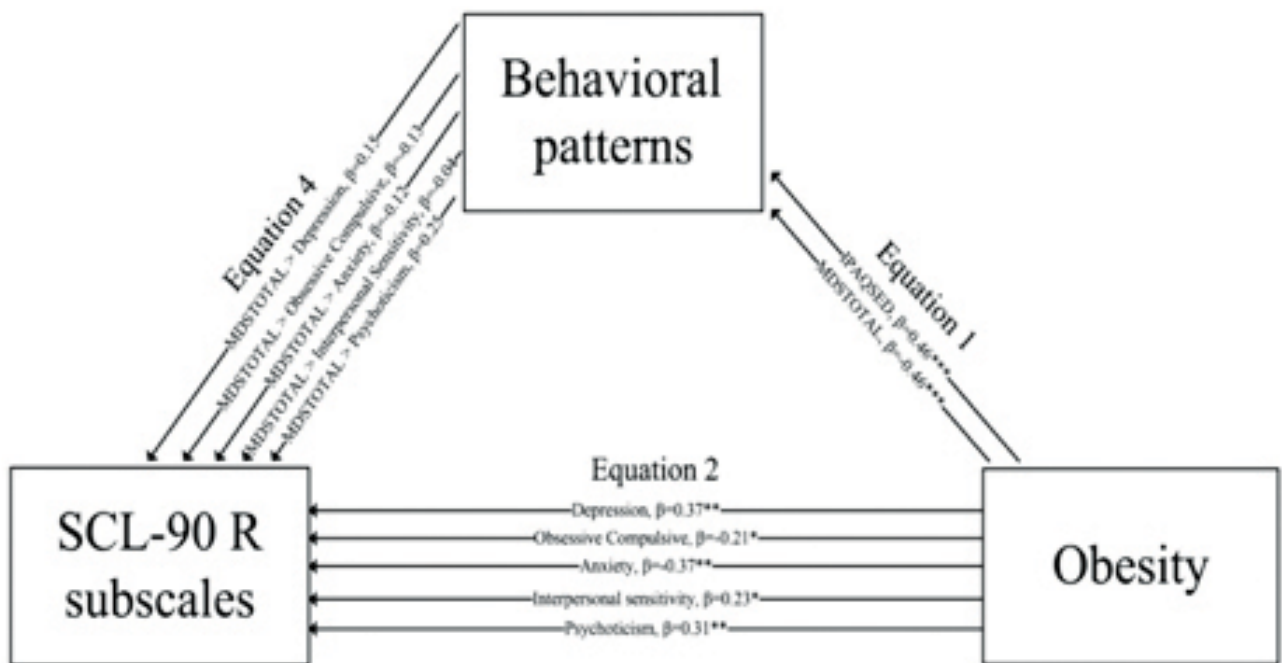
In order to examine whether symptoms of psychopathology were related to lifestyle characteristics, we examined the association between obesity and psychopathology features with the inclusion of IPAQSED (Figure 1a/Equation 3) and MDSTOTAL (Figure 1b/Equation 4). The comparison of Equation 2 with Equations 3 and 4 shows a decrease in the regression coefficients for obesity (i.e. betas), demonstrating that the observed relationships between obesity and symptoms of psychopathology (Equation 2) were attenuated after the inclusion of the behavioral factors into the model (Equations 3 and 4). In this sense, we were safe to assume that the differences

Figure 1a. Results of testing the behavioral patterns mediation model.



\* $P < .05$ , \*\* $P < .01$ , \*\*\* $P < .001$

Figure 1b. Results of testing the behavioral patterns mediation model.



\* $P < .05$ , \*\* $P < .01$ , \*\*\* $P < .001$

in psychopathology between normal weight subjects and subjects with obesity could be partially accounted for by sedentary time and dietary patterns.

## DISCUSSION

The present study suggests that sedentary behavior and the MeDi interact with obesity and symptoms of psychopathology. All Baron and Kenny criteria (42) were met in our study in order to establish the aforementioned interactions.

### **The role of sedentary time in the association between obesity and symptoms of psychopathology**

Previous data suggest that subjects with obesity are engaged in sedentary behavior (44) which in turn is associated with increased risk of depression (45) and anxiety (46). However, existing data related to the impact of sedentary time on symptoms of psychosis are extremely limited and focus on the opposite direction, i.e., psychosis leading to sedentary behavior; these data show no association between sedentary behavior and symptoms of psychosis in overweight/obese subjects (47). Furthermore, to the best of our knowledge there are no findings related to the interactions between sedentary time and interpersonal sensitivity or obsession-compulsion in subjects with obesity.

Our results demonstrate that sedentary behavior of subjects with obesity may lead, at least partially, to prevalent symptoms of psychopathology. Sedentary acts, such as sitting time, screen time, reading, computer use, television viewing time, could potentially play a role in the development of symptoms of depression, psychosis, anxiety and traits of obsession-compulsion and interpersonal sensitivity. Hence, encouraging subjects with obesity to increase light intensity activity and thus decrease the volume of sedentary behavior may provide a feasible starting point for improving not only physical but also mental health. Previous studies have already suggested that even minor increases in physical activity of sedentary overweight or obese subjects might reduce symptoms of depression (25). However, at this stage it would be inappropriate to recommend specific prevention and treatment strategies. There is need for more research that would shed light on this issue before reaching definitive conclusions regarding the specific role of sedentary time on the obesity-psychopathology association.

It is important to note that in our study there was no difference between obese and normal weight subjects as to the total physical activity score (IPAQTOTAL).

However, this is of no importance since there is evidence showing that regular moderate-to-vigorous intensity physical activity does not undo the deleterious effects of sedentary behavior (48).

### **The role of MeDi, in the association between obesity and symptoms of psychopathology**

Existing findings have shown that the MeDi might reduce the risk of developing depression (17, 18) and anxiety (17), and that low-calorie diets, such as the MeDi, might improve psychological parameters such as psychoticism and interpersonal sensitivity (26). Hence, it is possible that the MeDi affects, at least partially, the obesity-psychopathology association. Previous data suggest that the intake of nutrients such as omega-3 fatty acids (49-51) and the consumption of foods such as olive oil, fish, fruits and vegetables (49, 50), all of which are the inherent dietary and nutritional characteristics of the MeDi, are inversely associated with depression (49, 50) and anxiety (51) risk. Hence, it is safe to suggest that nonadherence to the MeDi could have a negative impact on mental health in subjects with obesity. Therefore, it is possible that the Mediterranean type of food might contribute to a better psychological status and prevent, at least partially, prevalent psychopathology features. Our study supports the importance of dietary patterns as a means of potential control of psychopathology.

### **The interactions between sedentary time, obesity and symptoms of psychopathology: Possible pathways**

Up to now, the precise etiologies for psychopathology features such as depression, psychoticism and interpersonal sensitivity, as well as the possible pathways for associating these features to sedentary behavior, are not yet known.

It is well established that moderate-to-vigorous physical activity is effective in preventing vascular disease in carotid arteries (52) through several pathways, such as anti-inflammatory actions (53), effect on key biomarkers of atherosclerosis (54), and promotion of neovascularization and proper endothelial function (55). Hence, it would be proper to suggest that physical inactivity and sedentary time may increase the risk of cerebrovascular disease (CVD), which may ultimately lead not only to physical health morbidity, but also to mental health disturbances, such as symptoms of depression or psychosis, following left (56) or right (57) focal cerebral lesions, respectively. A similar pathway could possibly explain the mediating effect of sedentary time on the association between obesity, and interpersonal sensitivity and obsession-compulsion.

It is possible that psychopathology may not necessarily result from tissue damage (i.e., cerebral lesions). It might solely be the result of some biochemical imbalance, such as diminutions/deficits in neurotrophic factors (e.g., BDNF) and/or elevations/excesses in neurotoxic or neurodegenerative factors and related genes (58). It has been reported that depression may be an inflammatory disorder and elevated inflammation markers have been consistently reported in depression (59). It seems that sedentary behavior is associated with elevated inflammation markers (60), and this could possibly explain, at least partially, the observed negative relations of the sedentary time to depression.

It has also been reported that depression is characterized by atrophies in brain areas such as prefrontal cortex and the hippocampus (61). Sedentary persons tend to have smaller total brain and gray matter volumes than persons who actively participate in physical activity (62), indicating possible structural brain changes that may explain, at least partially, the role of sedentary time on symptoms of depression.

#### **The interactions between MeDi, obesity and symptoms of psychopathology: Possible pathways**

Previous research in several countries, including Greece (63), has shown that adherence to the MeDi is associated with a reduced risk of carotid atherosclerotic plaques (64) and CVD (65); in addition, the consumption of specific elements of the MeDi, such as fiber (66), fish (67) and olive oil (68), may play a protective role in this direction. The effects of the MeDi on the development of atherosclerosis seem to be mediated by the decrease in plasma concentrations of markers of inflammation and endothelial dysfunction (69-71), such as CRP, IL-6, fibrinogen, and homocysteine, and by the decrease in metabolic syndrome features (71), suggesting a potential intermediate pathway between dietary patterns, carotid atherosclerosis, and, thus, CVD. C-IMT (72) and CVD (73) in turn are associated with an increased risk of symptoms of depression, indicating that the mediating effect of unhealthy dietary habits on the obesity-depression association may be explained through a pathway implicating cerebrovascular lesions. A similar pathway may explain the mediating effect of unhealthy diet on the association between obesity and symptoms of psychopathology such as interpersonal sensitivity, psychoticism and obsession-compulsion.

#### **The interactions between obesity and symptoms of psychopathology**

In our study, obesity was associated positively with depression, obsession-compulsion, anxiety, interpersonal sensitivity and psychoticism.

Despite obesity's medical impact, the negative outcomes that subjects with obesity experience as a result of discrimination are often ignored. Obese individuals are frequently stigmatized because of their weight in many domains of daily life such as school, employment, health care and the media. Weight stigmatization translates into victimization and bullying (74). Multiple psychopathological outcomes are associated with exposure to weight stigmatization and bullying, such as depression (74, 75) and anxiety (74, 76). Furthermore, subjects with obesity may have low self-esteem, which leads to disturbed interpersonal relationships and interpersonal sensitivity (74). Hence, the social component of obesity related to stigma and bullying should always be taken into consideration when subjects with obesity have depression, anxiety or other symptoms of psychopathology and seek psychiatric treatment.

This study has some limitations. First, subjects with obesity who seek weight loss may limit the generalizability of the findings, as they would probably have higher rates of psychopathology and be more likely to provide accurate information or endorse psychopathology symptoms than people with obesity who do not attend a specialized center or hospital. Nevertheless, the interactions between behavioral factors, obesity and psychopathology are consistent and highly significant. Second, the statistical models used in our study cannot suggest evidence for causality, in the sense that the results cannot demonstrate causal connections between the tested variables; in contrast, they show statistical associations. Furthermore, there are several alternative interactions between the variables of interest. The psychopathology features could lead to sedentary behavior, which in turn could enhance obesity, or a low adherence to the MeDi could lead to obesity, which in turn could result in symptoms of psychopathology. Furthermore, sedentary activity could be associated with unhealthy dietary behavior, causing augmentation of BMI, obesity and, ultimately, depression. However, this is a cross-sectional study and, unlike prospective studies, there are no well defined temporal relationships among predictor - confounder - outcome. Hence, no strong arguments regarding causality can be made based on the data of this study. Third, our study relied heavily on self-reporting for measuring psychopathology status, which may have under- or over-estimated its true incidence. It has been suggested that self-reported questionnaires, like SCL 90-R, are used as screening tools rather than substitutes for an in-depth interview. Moreover, the observed associations between psychopathology status and obesity were consistent.

## CONCLUSIONS

Our results highlight the role of behavioral factors in the association between obesity and symptoms of psychopathology. Subjects with obesity with an unhealthy and inactive lifestyle may have an increased risk of developing psychiatric symptoms. These findings may have clinical significance since prevention and intervention strategies including increased exercise and healthy dietary habits, may soothe, at least partially, the psychological burden of these subjects and reduce the risk of late-life symptoms of psychopathology. Further research is required to fully understand the molecular mechanisms that connect obesity with psychopathology and to investigate additional lifestyle parameters that might affect this relationship, in order to improve both physical and mental health of subjects with obesity.

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