

Dieting, obsessive-compulsive thoughts, and orthorexia nervosa: Assessing the mediating role of worries about food through a structural equation model approach

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ABSTRACT

Background: Orthorexia Nervosa (ON) is a condition characterized by an obsessive focus on healthy eating, inflexible dietary rules, and persistent preoccupations with food. Despite it has been recently the subject of increasingly relevant studies, little is known about the mechanisms that might foster ON symptoms.

Objective: This study used a structural equation modeling approach to test the mediating effect of thoughts, worries, and preoccupations about food on the relationship that eating disorders (EDs) attitudes (e.g., dieting) and obsessive-compulsive thoughts and symptoms have with ON in a large community sample. It was hypothesized that the effect of dieting and obsessive-compulsive thoughts and symptoms on ON would be partially mediated by the presence of thoughts, worries, and preoccupations about food.

Methods: Data from a cross-sectional sample of 1328 participants (females = 976) recruited from the general population were asked to fill in an online survey comprising the Eating Attitude Test-26 (EAT-26), the Obsessive-compulsive subscale of the Symptom Checklist-90 Revised (SCL-90R-OC) and the Orthorexia Scale-15 (ORTO-15).

Results: Structural equation models indicated that both obsessive-compulsive thoughts and symptoms and dieting had a direct effect on ON and that food preoccupation partially mediated these relationships.

Conclusion: These findings provide novel insight into the nature of ON that could aid its conceptualization and treatment.

1. Introduction

1.1. Background

Orthorexia Nervosa (ON) is a condition characterized by an obsessive focus on healthy eating, inflexible dietary rules, and recurrent and persistent preoccupations related to food that significantly interferes with the functioning of the person in society (Donini et al., 2022).

Individuals with ON eliminate foods that are highly processed or

considered impure due to pesticides or artificial additives moved by the desire to overcome chronic diseases or improve general health, through a dietary regime that is not part of a medically prescribed diet (Plichta & Jezewska-Zychowicz, 2019; Senturk, Guler; Senturk, Erus, Genis, & Cosar, 2022). This generally results in severe food intake restriction and the exclusion of specific food groups - such as meat, dairy, grain, cooked food, and non-seasonal produce - leading to clinically significant malnutrition and excessive weight loss (Koven & Abry, 2015).

Persons presenting orthorexic behaviors are overly focused not only

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on the quality of food but also on the methods and materials used in its preparation. They read product labels carefully and commonly do healthy grocery shopping. To alleviate the numerous concerns related to food preparation and purchasing and to maximize the health benefits of eating, individuals with ON engage in specific behavioral patterns (e.g., not combining certain foods, eating selected foods only at specific times of the day/intervals, devoting much time to the research, analysis, and preparation of food - often more than 3 h per day, etc.) (Costa, Hardan-Khalil, & Gibbs, 2017; Dunn & Bratman, 2016) - and, non-adherence to self-imposed nutritional rules might trigger feelings of fear, guilt, shame, and further dietary restrictions (Scarff, 2017; Tabri, Yung, & Elliott, 2022).

ON has not yet been recognized as a distinct disorder by major classification systems, such as the Diagnostic and Statistical Manual of Mental Disorders or the International Classification of Diseases (Varga, Dukay-Szabo, Tury, & van Furth, 2013). For this reason, whether this form of pathologically healthy eating should be regarded as a behavioral/lifestyle phenomenon, a variety of well-known disorders, or a mental disorder per se has been the subject of increasingly relevant studies and clinical interest in recent years (Bartel, Sherry, Farthing, & Stewart, 2020; Cena et al., 2019; Costa et al., 2017; Haman, Barker-Ruchti, Patriksson, & Lindgren, 2015; McComb & Mills, 2019; Niedzielski & Kazmierczak-Wojtas, 2021; Ryman, Cesuroglu, Bood, & Syurina, 2019; Sanzari & Hormes, 2023; Tabri et al., 2022).

Specifically, the clinical characteristics of ON are similar to those of two psychopathological conditions: eating disorders (ED) and obsessive-compulsive disorder (OCD) (Atchison & Zickgraf, 2022; Bartel et al., 2020; Brytek-Matera, Fonte, Poggiogalle, Donini, & Cena, 2017; Pontillo et al., 2022).

As regards the association between ON and ED, it has been proposed that these conditions share abnormal eating attitudes with a prevalence of dieting behaviors (Dell'Osso et al., 2018), a lack of pleasure linked to food consumption, and the need to control food intake as a search for self-esteem and self-realization (Catalina Zamora, Bote Bonaechea, Garcia Sanchez, & Rios Rial, 2005; Segura-Garcia et al., 2015; Zickgraf, Ellis, & Essayli, 2019). Further, ON is likely to lead to many of the same medical complications triggered by restrictive eating caused in ED (e.g., gastrointestinal problems, anemia, abnormally slow heart rate hormonal imbalances, fatigue, and a weakened immune system) (Koven & Abry, 2015; Oberle, Klare, & Patyk, 2019). However, some researchers claim that - even if ON might resemble ED - individuals with ON are concerned with the quality of the food they eat, and weight loss is a common consequence of a highly restrictive diet to stay optimally healthy (Kummer, Dias, & Teixeira, 2008). Persons with ED, instead, are mainly worried about the quantity of food intake to maintain a very low body weight (Brytek-Matera et al., 2020; Heaner & Walsh, 2013; Segura-Garcia et al., 2015).

Nevertheless, a fixation on the quality and type of food has also been observed in those suffering from anorexia nervosa (AN) and bulimia nervosa (BN) as manifested by following strict dietary rules (Gramaglia, Brytek-Matera, Rogoza, & Zeppegno, 2017; Parra-Fernandez et al., 2018). Therefore, the focus on food quality might not be peculiar to ON. Also, recent studies show a correlation between ON and striving for a lowered body weight (Barnes & Caltabiano, 2017; Bona, Erdesz, & Tury, 2021; Brytek-Matera, Donini, Krupa, Poggiogalle, & Hay, 2015) characteristic of patients with ED. Taken together, these findings suggest the relationships between ON and ED may be particularly complex.

Apart from ED, research shows that ON exhibits some overlap with OCD (Brytek-Matera et al., 2022; Hallit, Azzi, Malaeb, & Obeid, 2022), mainly the presence of obsessive food-related thoughts, and the ritualistic processes of food preparation and consumption generating significant wasted time, severe distress or impaired social functioning (Brytek-Matera et al., 2021; Novara, Pardini, Maggio, Mattioli, & Piasentin, 2021; Vaccari et al., 2021). But, while in OCD the content of the obsession is perceived as ego-dystonic, the symptoms of ON - as in ED - are ego-syntonic (compatible with or acceptable to the ego) as eating

habits and ideas about eating become central in people's lives, forming part of their sense of identity (Mathieu, 2005).

Still, ED and OCD are often comorbid (Altman & Shankman, 2009; Halmi et al., 2005): individuals with an ED have statistically higher rates of OCD (11%–69%), and vice versa (10%–17%), and approximately 41% of those with a primary ED diagnosis also report having OCD (Godart, Flament, Lecrubier, & Jeammet, 2000; Kaye, Bulik, Thornton, Barbarich, & Masters, 2004; Mandelli, Draghetti, Albert, De Ronchi, & Atti, 2020). Further, both ED and OCD typically stem from intrusive obsessive thoughts and preoccupation (Garcia-Soriano, Roncero, Perpina, & Belloch, 2014) that can only be reduced by repetitive behaviors that in turn significantly impact the individual's daily functioning.

Recurrent and unwanted (as in OCD) food-related (as in ED) intrusive thoughts and preoccupation might therefore represent potential mechanisms underlying the association between ED attitudes (e.g. dieting) and OCD thoughts and symptoms that could aid ON conceptualization and treatment.

1.2. Aims and hypothesis

According to the dietary restraint model, individuals experience greater food preoccupation when they engage in dieting behaviors or have limited access to foods (Tan, Ruhl, Chow, & Ellis, 2016). Based on this theory it seems likely that food restriction would relate to excessive thoughts about food/eating and/or weight/shape - known as food preoccupation (Timmerman & Gregg, 2003). This, in turn, may relate to emotional eating and the onset of dysfunctional eating patterns (Carei, Fyfe-Johnson, Breuner, & Brown, 2010). This study is the first to explore the role of food preoccupation in models designed to advance current understanding of the long-term effects of dieting on orthorexic symptoms.

The purpose of the present study was to examine the mediating effect of preoccupations about food on the relationship that ED attitudes – such as dieting behaviors – and obsessive-compulsive symptoms have with orthorexic behaviors in a community sample.

Based on the above-mentioned scientific literature, it was expected that individuals who recall more ED attitudes and greater OCD symptomatology would report higher preoccupation with food, which, in turn, would relate to greater ON.

More in detail, food preoccupation would mediate the relationships that both restrictive ED attitudes (such as dieting) and OCD symptoms and thoughts have with ON. Explicit hypotheses about each path (relationship) between variables were formulated:

- H1.** Restrictive ED attitudes, food preoccupation, obsessive-compulsive thoughts and symptoms, and orthorexia nervosa are positively associated with each other;
- H2.** Restrictive ED attitudes predict orthorexia nervosa via food preoccupation;
- H3.** Obsessive-compulsive thoughts and symptoms predict orthorexia nervosa via food preoccupation;
- H4.** Restrictive ED attitudes and obsessive-compulsive thoughts and symptoms directly predict orthorexia nervosa;

In other words, it was hypothesized that the positive associations between ED attitudes and obsessive-compulsive symptoms on orthorexic behaviors would be partially mediated by the presence of preoccupations about food.

2. Material and methods

2.1. Procedure

Data collection was performed online survey via Qualtrics software (see supplementary material: Checklist for Reporting Results of Internet E-Surveys). First, the survey was administered to 10 participants who

were not included in the final sample to provide reliable estimates of the time needed to complete the questionnaire (7–20') and identify potentially untrustworthy responses (*i.e.*, too fast or too slow) (Rossi, Panzeri, Taccini, Parola, & Mannarini, 2022).

Participants were then recruited voluntarily through advertisements placed on social media platforms (*i.e.*, Facebook, Twitter) using a snowball sampling method (Fricker, 2008). The recruitment materials included details about the study aim and procedure, and the length of time of the survey (7–20 min); together with the weblink to access the survey once signed the online informed consent to participate. Respondents were informed of their right to decline to participate and to withdraw from the research once participation has begun; and whom to contact for questions about the research or in case of any discomfort in answering the questions. Confidentiality was also granted by assigning an anonymous code for each participant, as well as by storing and disposing data of securely.

Inclusion criteria for the participants in the study were: (A) being aged over 18 years, (B) being a native Italian speaker. Exclusion criteria were: (C) complete the assessment procedure (*i.e.*, providing missing answers) and (D) provision of online informed consent to participate in the study. The study protocol was approved by the Ethical Committee of the IRCCS Istituto Auxologico Italiano (protocol N° 020_02_18_04).

2.2. Sample size calculation

The sample size was calculated *a priori* according to the “*n:q* criterion” (Kline, 2016) – namely, the ratio between the number of participants (*n*) and the number of free model parameters to be estimated (*q*). In detail, considering the main analyses of the study (see the dedicated section), the number of parameters was equal to 51 (Hoyle, 2012; Kline, 2016). Moreover, according to the guidelines, a minimum of 10 subjects per parameter should guarantee adequate power for the hypothesized model. Consequently, a minimum of ten subjects per parameter (*i.e.*, 10×51) was ensured – thus, $N_{\text{minimum}} = 510$ participants (Hoyle, 2012; Kline, 2016).

2.3. Participants

The sample comprised 1328 participants [352 males (26.5%) and 976 females (73.5%), $age_{\text{mean}} = 28.70$; $age_{\text{SD}} = 5.843$], and with a BMI ranging from 14.88 kg/m² to 41.04 kg/m² [$mean = 22.97$ kg/m²; $SD = 3.89$; $median = 22.41$; $skewness = 1.01$; $kurtosis = 1.30$]. The descriptive statistics of the sample are reported in Table 1.

2.4. Measures

2.4.1. Demographics, medical, and clinical information

Participants were asked to self-report their age, gender, education, civil and work status, and existing diagnosis for ED. Weight (in kg), and height (in cm) were also self-reported and used to calculate the individuals' body mass index (BMI).

2.4.1.1. The Eating Attitude Test-26 (EAT-26). The EAT-26 (Dotti & Lazzari, 1998; Garner, Olmsted, Bohr, & Garfinkel, 1982) is a 26-item self-report questionnaire widely used to determine the presence of symptoms and concerns of ED in clinical and non-clinical samples. Respondents are asked to indicate how often they engage in specific behaviors on a 6-point Likert scale. The EAT-26 comprises three factors. The first one is (1) ‘Diet’ (Diet) which evaluates the respondent's engagement in dieting behaviors. Examples of items are: “I eat diet foods”, “I avoid foods with sugar in them”, and “Engage in dieting behavior”. The second factor is (2) ‘Bulimia/preoccupation with food’ (Bulimia) which evaluates the respondent's bulimic thoughts and worries and preoccupations about food. Examples of items are: “I find myself preoccupied with food” and “I feel that food controls my life”. The

Table 1

Sample descriptive statistics: demographic and actual medical variables.

Variables	Descriptive statistics	
Age (M, SD)	28.70	5.843
BMI (M, SD)	22.973	3.896
Gender (n, %)		
Male	352	26.5%
Female	976	73.5%
Civil Status (n, %)		
Single	390	29.4%
In a relationship	700	52.7%
Married	194	14.6%
Separated/divorced	44	3.3%
Education (n, %)		
Middle school degree	120	9.0%
High school degree	576	43.4%
Bachelor degree	535	40.3%
Master/Ph.D.	97	7.3%
Work Status (n, %)		
Student	296	22.3%
Worker	716	53.9%
Student and worker	162	12.2%
Unemployed	154	11.6%
BMI Class (n, %)		
Severely underweight (<16)	5	0.4%
Underweight (16–18.49)	110	8.3%
Normal weight (18.5–24.99)	881	66.3%
Overweight (25–29.44)	253	19.1%
Class I obesity (30–34.99)	67	5.0%
Class II obesity (35–39.99)	11	0.8%
Class III obesity (>40)	1	0.1%
ED Diagnosis (n, %)		
No ED	1189	89.5%
Anorexia Nervosa	44	3.3%
Bulimia Nervosa	25	1.9%
Binge Eating Disorder	35	2.6%
ED No Otherwise Specified	35	2.6%

Note: M = mean, SD = Standard deviation, n = number of individuals, % = percentage.

third factor is (3) ‘Oral control’ which evaluates the respondent's engagement in anorexic restrictive eating behaviors. Examples of items are: “I Cut my food into small pieces” and “I take longer than others to eat meals”. Given the semantic content of the items of this subscale are closely related to anorexic behaviors it was not included in the statistical analyses. For each factor, higher values indicate greater disordered eating behaviors. In this study, the total score as well as the three subscales of the EAT-26 showed high internal consistency: Total Score--Cronbach's alpha = .872; Diet-Cronbach's alpha = .862; and Bulimia-Cronbach's alpha = .804.

2.4.1.2. Symptom Checklist-90Revised - Obsessive-compulsive subscale (SCL-90R-OC). The SCL-90R-OC subscale (Derogatis & Unger, 2010; Prunas, Sarno, Preti, Madeddu, & Perugini, 2012) evaluates the severity of psychological and cognitive manifestations of obsessive-compulsive behavioral symptoms and thoughts through 10 items as part of the SCL-90R – a widely-used questionnaire for self-report of psychological distress and multiple aspects of psychopathology. Examples of items are: “Unwanted thoughts, words, or ideas that won't leave your mind”, “Unpleasant thoughts that repeat themselves”, and “Concerns about your negligence or carelessness”. Respondents are asked to rate how much were they bothered by their symptoms on a 5-point Likert scale, with higher values indicating greater obsessive-compulsive symptomatology. In this study, the SCL-90R-OC subscale showed a high internal consistency: Cronbach's alpha = .909.

2.4.1.3. The Orthorexia Scale-15 (ORTO-15). The ORTO-15 (Donini, Marsili, Graziani, Imbriale, & Cannella, 2005) is a 15-item self-report tool assessing the presence of orthorexic symptoms in the general

population. Examples of items are: “Are your food choices influenced by concerns about your health?”, “Does the thought of healthy food worry you for more than 3 h a day?”, or “Do you think that consuming healthy foods can improve your physical appearance?”. For each item, respondents are asked to rate the frequency of their orthorexic-type behaviors on a 4-point Likert scale, with lower values indicating greater orthorexic tendencies. To facilitate the interpretation of the results items were coded so that higher sum scores represent stronger orthorexic tendencies (Meule et al., 2020). In this study, the ORTO-15 showed a good internal consistency: Cronbach’s alpha = .779.

2.5. Statistical analyses

Statistical analyses were performed using the software R with the following packages: ‘graphViz’ in ‘Diagrammer’ (Iannone, 2018), ‘psych’ (Revelle, 2018), ‘lavaan’ (Rossee et al., 2015), semTools (semTools Contributors, 2016).

In accordance with the inclusion/exclusion criteria, none of the observations had missing data. In line with previous studies, before running the structural equation model (SEM), the following steps were performed (MacKinnon, Kisbu-Sakarya, & Gottschall, 2013; McDonald & Ho, 2002; Rucker, Preacher, Tormala, & Petty, 2011). Lastly, since SEM should be considered as linear model, its assumptions were tested and no violations were detected (see Supplementary material).

2.5.1. Preliminary analysis

Pearson correlation coefficient (r) was computed to assess the strength of the association between psychological variables to check for excessively strong linear relationships (*i.e.*, $r > |0.80|$) that may suggest multicollinearity - further deepened in the preliminary analyses, reported in the supplementary materials (Hayes, 2022; Tabachnick & Fidell, 2014).

2.5.2. Test of the measurement models

The measurement model (*i.e.*, factorial structure) of each scale used in the SEM was tested to confirm that the original scale model had a good fit to the data – essentially, that the scales used were consistent with the original validation studies and the data did not configure differently. The measurement model of each scale – EAT26 (‘Diet’ and ‘Bulimia’) SCL-90R-OC, and ORTO-15 – was separately assessed with confirmatory factor analysis (CFAs), using the diagonally weighted least square (DWLS) estimator (Brown, 2015; Kline, 2016). Model fit was assessed with the conventional goodness-of-fit indices and their recommended cutoff values (Hoyle, 2012; Hu & Bentler, 1999; Kline, 2016): (A) the Chi-square statistics (χ^2) that should preferably be non-statistically significant ($p > .05$); (B) the Root-Mean-Square Error of Approximation (RMSEA), with ‘RMSEA ≤ 0.08 ’ indicating ‘acceptable’ model fit; (C) the Comparative Fit Index (CFI), with ‘CFI ≥ 0.90 ’ indicating ‘acceptable’ model fit; and (D) the Standard Root Mean Square Residual (SRMR), with ‘SRMR ≤ 0.08 ’ indicating good model fit.

2.5.3. Test the ‘common method bias’

Harman’s ‘single-factor test’ was performed to test the absence of the ‘common method bias’ – namely, the presence of a single latent factor that explains the relationships among the latent constructs measured by the subscales better than multiple related factors (Harman, 1976; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). First, a four correlated factors model was specified according to the measurement model of each single scale. Then, a single-factor model was specified. All the items of the abovementioned scales were forced to load onto a general single latent factor. Then, models were compared using test differences of goodness-of-fit indices: $\Delta\chi^2$ ($p > .050$), ΔCFI (>0.010), and $\Delta RMSEA$ (>0.015) (van de Schoot, Lugtig, & Hox, 2012). Model comparisons were based on conventional interpretation guidelines (Millsap, 2012; Vandenberg & Lance, 2000). In case the first model showed better-fit values than the second, then this would suggest the absence of the

‘common method bias’.

2.5.4. Item parceling

Latent factors were defined using parcels (*i.e.*, the result of the sum/aggregation of several items) as indicators – as they demonstrate several psychometric advantages such as higher reliability (compared to single items) and lower probability of violation of assumptions (e.g., normality) (Little, Rhemtulla, Gibson, & Schoemann, 2013). A ‘partially disaggregated parcel’ approach was used (Bandalos & Finney, 2001; Coffman & MacCallum, 2005). Since all of the scales used in the present study were unidimensional (‘Diet’, ‘Bulimia’, ‘OC’, and ‘ORTO’), item parcels were created using the ‘item-to-construct balance strategy’ (Chongming, Nay, & Hoyle, 2010; Little, Cunningham, Shahar, & Widaman, 2002) by inspecting the absolute value of factor loadings ($|\lambda|$) resulting from each measurement model (Little et al., 2002; Little et al., 2013). For each scale, at least 3-item-parcel per latent variable was created – allowing each factor to be at least ‘just identified’ – with factor loadings on the related construct higher than $|0.50|$ (Kline, 2016; Little et al., 2013; MacKinnon, 2012). Once item parcels were created, descriptive statistics were examined: they should not show skewness (Sk) greater than $|3|$ and kurtosis (k) greater than $|10|$ (Kline, 2016).

2.5.5. Structural equation model

A SEM with latent variable was performed specifying two related separated predictors, one mediator, and an outcome (Frazier, Tix, & Barron, 2004; Iacobucci, 2008, 2009; MacKinnon, Fairchild, & Fritz, 2007; Wiedermann & von Eye, 2015). More in detail, bulimia/worries about food (X_1) and dieting (X_2) were regressed on orthorexic symptoms (Y) through obsessive-compulsive thoughts and symptoms (M_1) – Fig. 1. The maximum likelihood (ML) estimator was used. According to guidelines (e.g., Kline, 2016), considering that not all of the indicators (parcels) showed a perfectly normal distribution, a 10,000 non-parametric bootstrap resampling procedure (MacKinnon et al., 2007, 2013) was applied with the Bollen–Stine method (Bollen & Stine, 1993; Enders, 2005, 2010; Hancock & Liu, 2012; Kline, 2016). The model was evaluated using the ‘goodness-of-fit’ indices previously described (χ^2 , RMSEA, CFI, SRMR) and their cutoff values (Frazier et al., 2004; Hu and Bentler, 1999; Iacobucci, 2009). All regression coefficients (β) reported in the results section were unstandardized.

3. Results

3.1. Preliminary analysis

Correlation analyses (H1) showed small-to-large associations between the psychological variables involved in the mediation model. In addition, considering continuous external variables, the correlation matrix suggested negligible effects of both BMI¹ and age (Table 2).

3.2. Structural models

The EAT-26 (‘Dieting’ and ‘Bulimia’ subscales) showed adequate goodness-of-fit indices: $\chi^2(151) = 1323.239$; $p < .001$; RMSEA = 0.076; 90%CI 0.073–0.080; $p(\text{RMSEA} < 0.05) < 0.001$, CFI = 0.973, SRMR = 0.116 (see supplementary materials for more details). Also, the SCL-90R-OC scale showed adequate goodness-of-fit indices: $\chi^2(35) = 251.326$; $p < .001$; RMSEA = 0.068; 90%CI 0.060–0.076; $p(\text{RMSEA} < 0.05) < 0.001$, CFI = 0.995, SRMR = 0.042. Lastly, the ORTO-15 showed adequate fit indices: $\chi^2(90) = 787.708$; $p < .001$; RMSEA = 0.076; 90%CI 0.072–0.081; $p(\text{RMSEA} < 0.05) < 0.001$, CFI = 0.951, SRMR = 0.074. See the supplementary material for a more detailed

¹ Note: a SEM including the effect of BMI was also tested. Results suggested no statistically significant differences between this model and the reported one – neither in goodness of fit indices nor in model parameters.

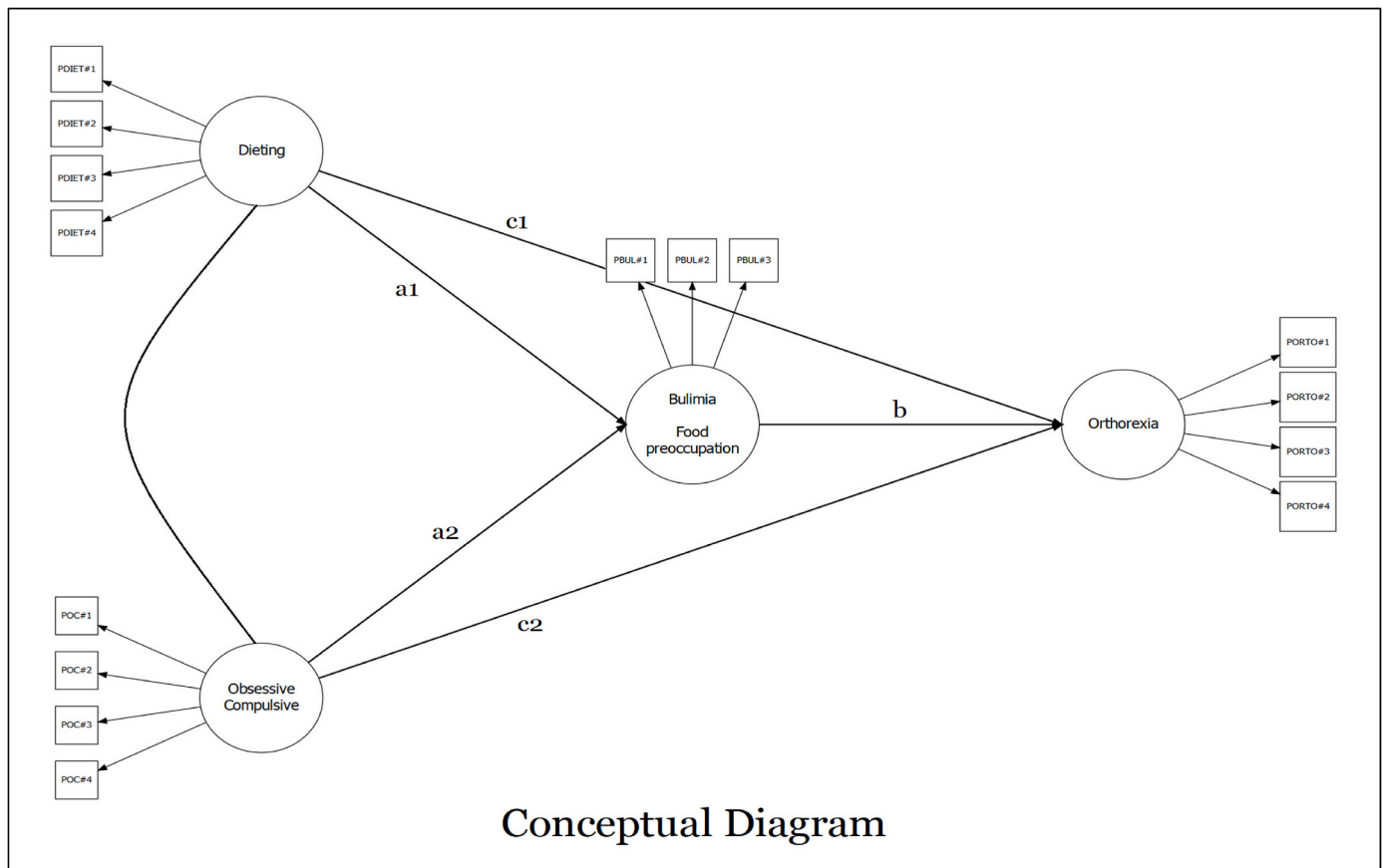


Fig. 1. Graphical representation of the mediation models tested.

Table 2
Scale descriptive statistics and correlation analysis.

	Descriptive statistics				Correlations						
	M	SD	SK	K	EAT-26 Total score	Dieting	Bulimia	SCL-90-R OCD	ORTO-15	BMI	Age
EAT-26 Total score	8.67	9.316	1.820	3.754	–						
Dieting	5.23	6.342	1.664	2.620	.927***	–					
Bulimia	1.46	2.746	2.441	6.148	.774***	.616***	–				
SCL-90-R OCD	1.56	0.855	0.522	0.195	.329***	.318***	.313***	–			
ORTO-15	34.89	6.396	0.489	0.492	.642***	.651***	.534***	.353***	–		
BMI	22.97	3.897	1.015	1.303	.098***	.163***	.145***	.249***	.119***	–	
Age	28.70	5.843	0.199	–1.010	–.052§	–.016§	–.077**	.259***	–.127***	.313***	–

Note: *** $p < .001$, ** $p < .010$, and § $p > .050$ ns. M = mean, SD = standard deviation, SK = skewness, K = kurtosis; Dieting = Dieting subscale of EAT-26; Bulimia = Bulimia subscale of EAT-26; SCL-90-R OCD = Obsessive-compulsive disorder subscale of the SCL-90-R; ORTO-15 = Total score of the Orthorexia Scale 15; BMI = Body Mass Index.

analysis.

3.3. Harman’s single-factor test

Harman’s single-factor test showed the absence of the ‘common method bias’. Indeed, the CFA with four correlated factors provided adequate fit indices: $\chi^2(896) = 8007.678$; $p < .001$; RMSEA = 0.077; 90%CI 0.076–0.079; $p(\text{RMSEA} < 0.05) < 0.001$, CFI = 0.956, SRMR = 0.092. Opposite, the single-factor CFA provided poor fit indices: $\chi^2(1224) = 28197.125$; $p < .001$; RMSEA = 0.129; 90%CI 0.128–0.130; $p(\text{RMSEA} < 0.05) < 0.001$, CFI = 0.841, SRMR = 0.146. The model comparison further suggested the absence of the ‘common method bias’: $\Delta\chi^2(328) = 20.189$, $p < .001$; $|\Delta\text{RMSEA}| = 0.052$, and $|\Delta\text{CFI}| = 0.115$.

3.4. Latent mediation model with parcels

All parcels are statistically significantly associated with the latent variable and exhibit factor loading higher than the recommended threshold of $|0.5|$; in fact, they range from a minimum of 0.652 to a maximum of 0.870 (Table 3). Once the adequacy of the indicators in representing the latent construct of interest was established, the SEM was examined.

The hypothesized model (Figs. 1 and 2) provided adequate goodness-of-fit indices: $\chi^2(84) = 672.851$; $p < .001$; RMSEA = 0.073; 90%CI 0.068–0.078; $p(\text{RMSEA} < 0.05) < 0.001$, CFI = 0.950, SRMR = 0.040. Results are reported in Fig. 2 and Table 4.

Dieting (X_1) and obsessive-compulsive thoughts and symptoms (X_2) were positively associated with each other: $\beta = 0.347$ (SE = 0.031) [95% CI: 0.286; 0.407], $z = 11.186$, $p < .001$.

Dieting (X_1) was positively associated with bulimia/worries about

Table 3
Item parcels' descriptive statistics and factor loadings (λ).

	Descriptive				Confirmatory factor analysis				
	M	SD	Sk	K	λ (se)	z-value	p-value	λ^*	R ²
Dieting (X₁)									
pDIET#1	.6320	0.675	1.028	.248	0.558(0.017)	32.024	<.001	0.827	0.684
pDIET#2	.4307	0.635	1.758	2.813	0.527(0.022)	24.451	<.001	0.829	0.688
pDIET#3	.2277	0.450	2.568	7.583	0.343(0.019)	18.267	<.001	0.762	0.580
pDIET#4	.2430	0.481	2.555	7.154	0.363(0.021)	17.706	<.001	0.756	0.571
Obsessive-compulsive (X₂)									
pOC#1	1.2046	0.889	.712	.490	0.754(0.022)	33.902	<.001	0.848	0.720
pOC#2	1.7663	0.955	.508	.086	0.831(0.023)	36.820	<.001	0.870	0.757
pOC#3	1.6803	1.006	.479	.027	0.847(0.023)	36.450	<.001	0.843	0.710
pOC#4	1.6491	1.021	.524	.055	0.860(0.024)	36.254	<.001	0.843	0.710
Bulimia/worries (M)									
pBUL#1	.2093	0.472	2.654	7.561	0.263(0.020)	12.857	<.001	0.791	0.626
pBUL#2	.3166	0.610	2.230	4.667	0.367(0.023)	15.672	<.001	0.855	0.730
pBUL#3	.2026	0.461	2.618	7.281	0.272(0.019)	14.148	<.001	0.840	0.706
Orthorexia (Y)									
pORTO#1	2.6227	0.567	.111	-.285	0.260(0.015)	17.840	<.001	0.761	0.579
pORTO#2	2.5486	0.486	.237	.135	0.216(0.013)	17.202	<.001	0.735	0.541
pORTO#3	2.1032	0.564	.738	.559	0.229(0.014)	16.700	<.001	0.672	0.452
pORTO#4	1.9312	0.535	.637	.495	0.210(0.013)	15.821	<.001	0.652	0.426

Note: M = mean, SD = standard deviation Sk = Skewness, K = Kurtosis; λ = unstandardized factor loading; se = standard error; λ^* = unstandardized factor loading; R² = explained variance; p(...) = item parcel; Dieting = Dieting subscale of EAT-26; Bulimia = Bulimia subscale of EAT-26; OC = Obsessive-compulsive disorder subscale of the SCL-90-R; ORTO = Orthorexia Scale 15.

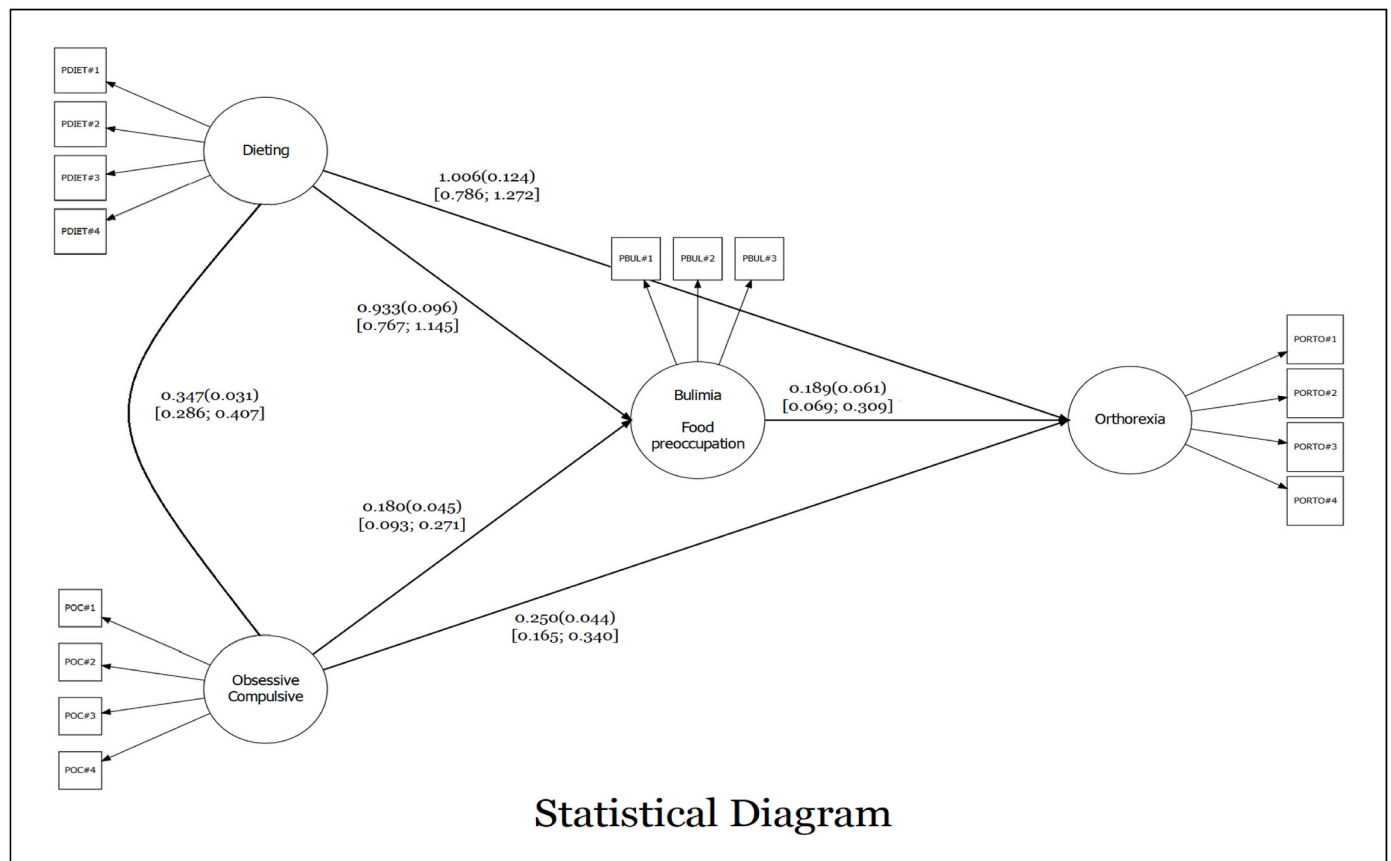


Fig. 2. Graphical representation of the mediation model with unstandardized regression coefficients, standard errors and confidence intervals (95%).

Table 4

Summary of standardized parameter estimates (beta) with 95% confidence intervals for key pathways tested (Fig. 2).

Path		β^*	β (SE)	95%CI [L - U]	<i>z</i> -value	<i>p</i> -value	<i>R</i> ²
Dieting (<i>X</i> ₁) → Bulimia/worries (M)	(a1)	0.657	0.933 (0.096)	[0.767; 1.145]	9.736	<i>p</i> < .001	
Obsessive-compulsive (<i>X</i> ₂) → Bulimia/worries (M)	(a2)	0.126	0.180 (0.045)	[0.093; 0.271]	3.999	<i>p</i> < .001	.505
Bulimia/worries (M) → Orthorexia (Y)	(b)	0.162	0.189 (0.061)	[0.069; 0.309]	3.085	<i>p</i> = .002	.636
Dieting (<i>X</i> ₁) → Orthorexia (Y)	(c1)	0.607	1.006 (0.124)	[0.786; 1.272]	8.131	<i>p</i> < .001	
Obsessive-compulsive (<i>X</i> ₂) → Orthorexia (Y)	(c2)	0.151	0.250 (0.044)	[0.165; 0.340]	5.634	<i>p</i> < .001	
Dieting (<i>X</i> ₁) ↔ Obsessive-compulsive (<i>X</i> ₂)		0.347	0.347 (0.031)	[0.286; 0.407]	11.186	<i>p</i> < .001	
Indirect effect of <i>X</i> ₁ on Y via M	(a1*b)	0.107	0.177 (0.056)	[0.067; 0.286]	3.170	<i>p</i> = .002	
Indirect effect of <i>X</i> ₂ on Y via M	(a2*b)	0.021	0.034 (0.015)	[0.009; 0.068]	2.273	<i>p</i> = .023	
Total effect <i>X</i> ₁ on Y		0.713	1.183 (0.100)	[1.004; 1.395]	11.771	<i>p</i> < .001	
Total effect <i>X</i> ₂ on Y		0.171	0.284 (0.045)	[0.197; 0.377]	6.261	<i>p</i> < .001	

Note: β^* = standardized beta; β = unstandardized beta; 95%CI = 95% confidence intervals for the unstandardized beta; *R*² = explained variance.

food (M), *path a1*: $\beta = 0.933$ (SE = 0.096) [95%CI: 0.767; 1.145], *z* = 9.736, *p* < .001. At the same time, obsessive-compulsive thoughts and symptoms (*X*₂) were positively associated with bulimia/worries about food (M), *path a2*: $\beta = 0.180$ (SE = 0.045) [95%CI: 0.093; 0.271], *z* = 3.999, *p* < .001. Also, (H2) bulimia/worries about food (M) predicted orthorexic symptoms (Y), *path b*: $\beta = 0.189$ (SE = 0.061) [95%CI: 0.069; 0.309], *z* = 3.085, *p* = .002.

Moreover, (H3) dieting (*X*₁) predicted orthorexic symptoms (Y), *path c1*: $\beta = 1.006$ (SE = 0.124) [95%CI: 0.786; 1.272], *z* = 8.131, *p* < .001. At the same time, (H4) obsessive-compulsive thoughts and symptoms (*X*₂) predicted orthorexic symptoms (Y), *path c2*: $\beta = 0.250$ (SE = 0.044) [95%CI: 0.165; 0.340], *z* = 5.634, *p* < .001.

Furthermore, an examination of the two indirect paths was performed. The *first* total indirect effect (controlling for *X*₂: Dieting → bulimia/worries about food → orthorexic symptoms) was statistically significant [$\beta = 0.177$ (SE = 0.056) [95%CI: 0.067; 0.286], *z* = 3.170, *p* = .002]. Also, the *second* total indirect effect (controlling for *X*₁: Obsessive-compulsive thoughts and symptoms → bulimia/worries about food → orthorexic symptoms) was statistically significant [$\beta = 0.034$ (SE = 0.015) [95%CI: 0.009; 0.068], *z* = 2.273, *p* = .023].

Hence, the two total model effects were examined. The first total model effect (controlling for *X*₂: dieting → bulimia/worries about food → orthorexic symptoms *plus* dieting → orthorexic symptoms) was statistically significant [$\beta = 1.183$ (SE = 0.100) [95%CI: 1.004; 1.395], *z* = 11.771, *p* < .001 – thus suggesting a partially mediated path. The second total model effect (controlling for *X*₁: obsessive-compulsive thoughts and symptoms → bulimia/worries about food → orthorexic symptoms *plus* obsessive-compulsive thoughts and symptoms → orthorexic symptoms) was statistically significant [$\beta = 0.284$ (SE = 0.045) [95%CI: 0.197; 0.377], *z* = 6.261, *p* < .001 – thus suggesting a partially mediated path. Results are reported in Table 4.

4. Discussion

This study is the first designed to advance the current understanding of the effects of both OC thoughts and symptoms and disordered eating attitudes (e.g. dieting) on the development of orthorexic behaviors by investigating the conceptual scheme depicted in Figs. 1 and 2 in a large Italian community sample. Based on the dietary restraint model (Tan et al., 2016), it was explored how the relationship among (A) obsessive-compulsive thoughts and symptoms and (B) exerting control over food with (D) ON might be explained by (C) food preoccupations.

Principal findings of the present research showed that dieting was found to have a direct impact on ON but preoccupation and worries about food played an important mediating role in this relationship by explaining a sensible portion of variance for ON. Simultaneously, also

obsessive-compulsive thoughts directly influenced ON and this relationship was mediated by preoccupation and worries about food. This highlights the central role of preoccupation and worries about food in mediating the relationship of both restrictive dieting attitudes and obsessive-compulsive symptoms on ON tendencies. The mediating role of this variable suggests how orthorexic symptoms and behaviors can be triggered by thoughts, worries and preoccupations toward 'healthy' eating – which result in attitudes that may be dysfunctional (and/or alarming) for the individual's health (Donini et al., 2022; Dunn & Bratman, 2016). The central role of worries and preoccupations highlights the great importance of (dysfunctional) thoughts regarding food that are a key variable in some disordered eating behaviors and EDs (Rossi et al. 2023).

Moreover, it should be highlighted that the direct effects of the predictors (dieting and obsessive-compulsive thoughts) maintain their significance, even in presence of the mediating role of preoccupation and worries about food, meaning that they entail a specific association with ON. These findings align with current scientific literature (Donini et al., 2022; Zagaria, Vacca, Cerolini, Ballesio, & Lombardo, 2022). On one hand, they suggest that restrictive ED attitudes (dieting) may be related to ON through the primary goal to lose or maintain weight to be as healthy as possible (Donini et al., 2022). Thus, ON behaviors are strongly associated with dietary restrictions (e.g., the ability to follow the self-imposed restrictive dietary rules) in order to improve the health condition and/or avoiding future adverse negative health effects (Donini et al., 2022) – suggesting that weight and body shape concerns are only secondary to self-imposed healthy dietary rules. On the other hand, these findings suggest that obsessive-compulsive thoughts and symptoms may be related to ON through traits of perfectionism, cognitive inflexibility, obsessions, and prevalent and repetitive thoughts – despite markedly related to food and healthy eating attitudes (Donini et al., 2022). Thus, individuals with orthorexic symptoms may experience as ego-syntonic their thoughts about healthy food, suggesting how this may represent a maintaining factor of ON as well as a potential resistance factor in treatment or towards seeking professional help.

About the secondary findings of the present research, correlation analysis showed that restrictive ED attitudes such as control over food (namely, dieting) was highly associated with both food preoccupations and ON, as well as preoccupation with food which also resulted highly correlated with ON. Similarly, higher levels of dietary restrictive behaviors were related to the presence of preoccupation with food in a previous investigation (Timmerman & Gregg, 2003). Moreover, obsessive-compulsive symptoms and particularly BMI poorly correlated with any of the above-mentioned variables. This supports conclusions from previous studies in which BMI did not show significant associations with food preoccupation across ED diagnosis (Godefroy, Trinchera, &

Dorard, 2020; Oberle & Lipschuetz, 2018; Ramacciotti et al., 2011).

Overall, these findings add to our understanding of the construct of food preoccupation among individuals with core features of eating disorders and disordered eating behaviors (Rossi et al., 2023).

Moreover, these findings are in line with existing evidence for pre-occupations and worries about food contributing to and accounting for a significant amount of variance in EDs (Lydecker, Simpson, Smith, White, & Grilo, 2022; Tan et al., 2016; Thompson & Chad, 2000; Williams, Dev, Hankey, & Blitch, 2017). Specifically, greater levels of food preoccupation were found in women with BN and AN than in healthy controls in more than one study (Monteleone et al., 2020; Rasmus, Czubak-Paluch, & Brytek-Matera, 2023). However, no previous studies focused on the relationship between worries about food and ON and, while these results provide novel insights into the nature of orthorexic symptomatology by shedding light on the mechanisms underlying the relationships between ED attitudes and OC symptoms on pathological healthy eating. Due to the novelty of the study, the comparison of the study's findings with existing literature is limited and the research outcomes should be interpreted with caution and considering the following limitations.

4.1. Limitations and strengths

The present research is not free from limitations. First, its cross-sectional design does not allow for causal inferences. Forthcoming longitudinal and/or experimental studies should identify the directionality of the associations (Mignemi et al., 2023). Second, only online self-report measures were administered, which could be potentially biased (e.g., convenience sample, social desirability), therefore lowering the study ecological validity. Future studies replicating and extending the present findings should use also behavioral/objective measures. Third, a statistical limitation is the non-perfect fit of EAT-26 in the SRMR, probably due to the items' mandatory recoding procedure (Dotti & Lazzari, 1998, see Supplementary materials for a more detailed discussion). Additionally, despite the good fit-indices of the ORTO-15, two items did not show a statistically significant factor loading on the latent variable – however this is in line with several evidence from international literature (Donini et al., 2005; Meule et al., 2020). Future studies will replicate these findings using more accurate measurement scales. Fourth, while the sample was relatively large, participants from the general population were mostly healthy-weight females (73.5%) in their early 30s. While such sampling allows building on the knowledge of food preoccupation beyond the clinical context to help prevent its impact on physical and mental health, generalizability of research findings is partial. Future research should attempt replicating the current investigation with individuals meeting the ON diagnostic criteria and using gender balanced samples.

Despite these limitations, several strengths should be acknowledged, such as the large sample size and precise and sophisticated statistical analyses. Furthermore, these findings shed light on the understanding of an important and complex emergent topic – both in clinical and community samples. Another strength relies in the fact that this is the first study testing and confirming the relationships among ON-related variables hypothesized by previous literature (Donini et al., 2022), providing initial support towards the theoretical conceptualization of the ON emerging construct (Koven & Abry, 2015).

4.2. Clinical implications and future directions

This research adds to the literature in several ways. First, it helps explain the important role that worries and preoccupations about food might have in ON. Second, the current research extends the ON literature by showing a moderately positive association of ON symptoms and dieting behavior with food preoccupation. Still, food preoccupation in ON might differ from that of other clinical conditions based on a combination of reasons for dieting, and levels of worries and preoccupations about food. This suggests the utility of future work investigating how the

content of preoccupation relates to eating pathology. Also, if replicated and extended in forthcoming studies, these findings might potentially enhance the development and testing of interventions focused on food preoccupation within the broader context of ED. For example, the gold standard treatment for ED, cognitive-behavioral therapy (CBT) (i.e., unwanted mental intrusions; Pascual-Vera et al., 2019) focuses on pre-occupation (i.e., both food/eating and shape/weight preoccupation) as a maladaptive cognitive style central to the maintenance of ED (Agras, 2019; Sivyer et al., 2020). Indeed, research highlights the importance of considering preoccupations and worries as part of the CBT treatment planning and delivery, particularly regarding eating concerns and dietary restraint (Bottesi, Martignon, Cerea, & Ghisi, 2018; Lydecker, White, & Grilo, 2017; Mitchison et al., 2017).

Still, there is no 'one size fits all' approach to treating eating and weight problems, and people presenting dysfunctional eating patterns may also benefit from cognitive remediation strategies to improve neurocognitive abilities such as cognitive flexibility and planning, and executive functioning, which are known to reinforce their tendency to worry/ruminate (Meneguzzo, Tenconi, Todisco, & Favaro, 2021; van Passel et al., 2016). Simultaneously, it is crucial to foster transdiagnostic protective factors such as emotional regulation abilities (Rossi, Panzeri & Mannarini, 2023), tolerance to worries and uncertainty (Bottesi, Ghisi, Sica, & Freeston, 2017), and social support (Panzeri et al., 2023).

5. Conclusions

The present study may enhance the current understanding of the nature of ON and its treatment. Findings suggest that both ED attitudes (e.g. dieting) and OCD are related to ON and that these associations are mediated by food preoccupations. These results highlight the importance that food preoccupation plays in the development and maintenance of orthorexic symptomatology.

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Author contribution

GP and AAR conceived the study. GP collected the data and wrote part of the first draft. AAR performed statistical analyses, displayed tables and figures, and wrote part of the first draft. GC, SS, SM, and LMD provided supervised the work and revised the final version of the manuscript. All the authors read and approved the work.

Ethical statement

This study was approved by the Ethics Committee of the IRCCS Istituto Auxologico Italiano (protocol n° 2020_02_18_04). All procedures were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on a reasonable request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2024.107164>.

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