Review

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Prevalence of orthorexia nervosa in clinical and non-clinical populations: a systematic review

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Abstract

Objective. Orthorexia nervosa (ON) is characterized by the pursuit of extreme dietary purity due to an exaggerated focus on food quality that could ultimately lead to a new kind of eating disorder. Even though researchers have tried to reach a univocal description of ON, to this date, there is no consensus on its diagnostic criteria, making it considerably more difficult to develop a valid questionnaire for assessing the symptoms of ON and to assess its actual prevalence. The aim of this review was to evaluate and gather scientific evidence about the prevalence of ON in both clinical and non-clinical adult populations, using the main validated scale for ON evaluation.

Methods. Electronic databases (PubMed, Scopus, and Web of Science) were reviewed to identify studies in accordance with PRISMA guidelines; at the end of the selection process, 62 studies were included.

Results. Prevalence rates of ON vary greatly due to the differences in psychometric qualities of the tools used and the socio-cultural norms of the countries, with the lowest being obtained with the Dusseldorf orthorexic scale (DOS) (2.6% up to 36.7% in cancer survivor women) and the BOS-T (12.8% up to 34.7%), the greatest variability concerning the two thresholds of the ORTO-15 (14.6% with the >35 threshold and up to 86% with the >40 threshold) and the higher score being reported with the ORTO-11 in post-partum women (87.7%).

Conclusions. Additional research is necessary to support the development of a thorough, sensitive, and valid questionnaire for assessing the symptoms of ON.

1. Introduction

The first appearance of the term "orthorexia nervosa" (ON) goes back to 1997 when it was coined by Bratman to describe a behavior characterized by the pursuit of extreme dietary purity due to an exaggerated focus on food quality that could ultimately lead to a new kind of eating disorder.[1] The etymology of the term comes from the Greek ortòs, which means right, and orexis, which means appetite. This newly proposed disorder first attracted growing attention in Europe, while in the United States literature on this topic remained scant until 2014, following the growing attention paid by social media to orthorexic behaviors.[2] In the last decades, researchers have tried to reach a consensus on a univocal description of ON: in this framework, four terms have been more widely used to well summarize the main characteristics of this condition: obsession (the most used), fixation, concern, and preoccupation. Indeed, ON is described as a deep concern about following a healthy diet that leads subjects to focus all their attention and thoughts on the choice of the "right" food, ultimately developing persistent and disturbing thoughts (obsession) and stereotyped behaviors (fixation). The typical daily activities of subjects suffering from ON include spending a lot of time planning meals and carefully selecting products to avoid food that is deemed impure and unhealthy.[3] Moreover, the subject also frequently experiences pervasive concerns regarding the source, the packaging, and the processing of food (for instance: the use of pesticides, hormone supplementation, preservative addition, artificial flavoring, and carcinogenic compounds) for it substantially affects the perception of quality and purity of the foods.[4] Interestingly, a branch of literature reports a frequent association of ON with specific dietary regimes such as a rigid focus on veganism, raw food, vegetarianism, and non-dairy organic foods.[4] The pursuit of a correct diet becomes the pivot around which the life of the subject revolves, inevitably leading to social isolation, impairment of global functioning as well as possibly leading to physical complications such as malnutrition due to the elimination of entire food groups.[1,2,4]

Recently, the emergence of new social and cultural habits has favored the development of new kinds of maladaptive eating styles, evolving into new pathological conditions in the dimensional spectrum of feeding and eating disorders (FED), such as reverse anorexia, diabulimia, drunkorexia, and, among these, ON.[4–6] However, the fluidity in the diagnosis across time, typical of FED, as well as the remarkable comorbidities between ON and FED, raised questions about whether ON should be considered as a condition with a separate identity or as a variant of one of the more

common eating disorders, and in particular Anorexia nervosa (AN) or Avoidant restrictive food intake disorder (ARFID).[2,4,7]

In line with the spectrum model for psychiatric disorders, eating disorders can be represented along a continuum of manifestations where the clinical absence of symptoms and the typical diagnostic categories are placed at its extremities.[8–11] Whereas drive for thinness and thin-ideal internalization present in both AN and Bulimia Nervosa (BN) are reported to predict ON, it is still unclear if the presence of an eating disorder can predict the development of orthorexic behaviors and if, on the other hand, ON could precede and eventually precipitate the onset of an eating disorder.[7] In this context, ON may represent a more socially acceptable way to restrict food and calorie intake in order to achieve weight loss.[7] While one of the main characteristics firstly believed to distinguish ON from AN was a lack of concern about body weight, this issue was reconsidered highlighting the fact that often the worries about weight, although not specifically expressed, may still present, masked by or consequent to the concern about healthy eating.[7,12] Furthermore, while AN and BN symptoms' core is based on the amount of food consumed and the need to lose weight, orthorexic people pay attention to the quality of food with the aim of achieving body purity[4,7] and, although these latter may present severe medical consequences as in AN, malnutrition is usually caused by a strict selection of foods deemed acceptable.[2] Another disorder that could potentially be differentially diagnosed with orthorexia is the ARFID, however, differently from subjects manifesting orthorexic behaviors, those affected by ARFID select and refuse food because of adverse experiences, sensory stimuli, and disinterest in nutrition.[2,4]

Since its conceptualization, ON has demonstrated various comorbidities also with other non-dietary disorders.[2,4,7] For instance, various studies highlighted how subjects with high obsessive-compulsive traits are more likely to experience orthorexic tendencies.[7,13] Furthermore, similarly, to what is reported in obsessive compulsive disorders (OCD), orthorexic subjects appear to experience obsessions, in this case concerning contamination and caloric content of food, and follow ritualized and rule-driven patterns such as washing, dressing, and checking compulsions, and a high tendency to perfectionism, need to exert control and elevated anxiety traits.[7,14,15] However, the geosynthonic aspect of obsessions in ON, which is supported by a scarcer insight, deeply distinguishes ON from OCD.[4] Another arising branch of research is focusing on investigating orthorexic symptoms in the context of Autistic Spectrum Disorder (ASD).[4,16] From this point of view, the narrow interest repetitive pattern behaviors, and the inflexible adherence to a routine typical of ASD subjects find themselves declined toward the spasmodic persecution of a diet considered healthy and pure.[4] Moreover, the stance of moral superiority and intolerance to other's food beliefs is compatible with ASD's deficits in social emotion reciprocity, that ultimately leads to a social-function impairment and social isolation.[4] This evidence is in line with the high frequency of eating disorders in ASD subjects, where the tendency to strictly select or be averse to some kind of food for texture, color, or temperature endures from childhood to adulthood.[4] In particular, this branch of studies aims to investigate the association, already reported in the literature, that emerges between ASD and other mental disorders, including eating disorders, concerning both psychopathological and somatic correlates.[17–20]

From what emerges, further investigations are needed to clarify the various boundaries and features between ON and other disorders and to define its identity. Moreover, literacy on risk factors needs to be improved. Indeed, there is still a lack of uniqueness in identifying factors favoring and precipitating this disorder.[7] Surely,

a sociocultural context that validates the individual's belief about healthy food and stigmatizes obesity is an important environmental factor, but not sufficient. Recent literacy shows the importance of psychopathological factors such as personality traits in driving the evolution of ON.[7] Moreover, the role of age and gender in this disorder still remains unclear.[7,16] Growing evidence suggests ON is an autonomous eating disorder that still needs its own place within the main diagnostic manuals such as the Diagnostic and Statistical Manual of Mental Disorder (DSM-5 TR) and ICD-11[2,4,16,21] and for this purpose, recently researchers have proposed some diagnostic criteria for ON in order to define its nature and its causes contributing to better treatment strategies.[2,22]

In this framework, we aimed to systematically review the available literature on the prevalence of ON in both clinical and non-clinical adult populations, using the main validated scale for ON evaluation. We also focused on psychological, physiological, and sociodemographic and characteristics that were reported in the prevalence studies included, in hope to pave the way for future studies on the classification of ON.

2. Methods

2.1 Literature search

A systematic search was conducted from 1st March to 1st April 2023 in accordance with the PRISMA 2020 guidelines[23] and using the electronic databases PubMed, Scopus, and Web of Science. The following search terms, without filters, restrictions, or limits, were used to identify all potentially eligible records: ("orthorexia nervosa" OR "orthorexia"). All studies from 31st January 2002 to 1st April 2023 were included in the databases search.

2.2 Eligibility criteria

The following criteria were utilized to select studies for this review:
- Human studies.
- Studies that included only subjects over the age of 18.
- Study that used a validated scale to evaluate the ON.
- Articles available in English.

Because we aimed to investigate the prevalence of ON in human subjects, studies investigating eating behaviors in animal models were excluded. Moreover, reviews, case reports, and editorials were also excluded due to the nature of the articles.

2.3 Screening and selection process

Four independent reviewers screened papers for inclusion and disagreements were resolved by discussion. The primary database search led to a total of 1411 records. Upon a second screening, 1153 articles were removed after titles because they were duplicates ($N = 806$) or not relevant ($N = 348$). A total of 257 papers were assessed by an abstract of which 181 were removed because they were not pertinent ($N = 130$), the full text was not available or not in English ($N = 21$), or because they were other publication types ($N = 32$). After a full-text reading, the other 12 articles were excluded because they did not fit the eligibility criteria. Finally, a total of 62 articles were included in the present review. Each evaluator completed the procedure independently. The reference list of selected papers was assessed for other eligible studies, and any discrepancies regarding the papers included were thoroughly discussed. The authors' levels of agreement were good. Recommendations from PRISMA 2020[22] are used to create a flowchart that

summarizes decisions on inclusion or exclusion. The study selection process is outlined in a flowchart (see Figure 1).

3. Results

A total of 62 publications were provided by the search, any of them are studies ranging from 2002 to 2023. Details of each study included in the review are reported below.

3.1 Characteristics of the study samples

3.1.1 Population

In the present study, 80.6% of the studies were carried out in non-clinical populations ($n = 50$) of which 11.3% involved the general population ($n = 7$), 46.8% involved students above 18 years old ($n = 29$); 17.7% involved athletes ($n = 11$) and 4.8% involved people following a restrictive dietary regime ($n = 3$).
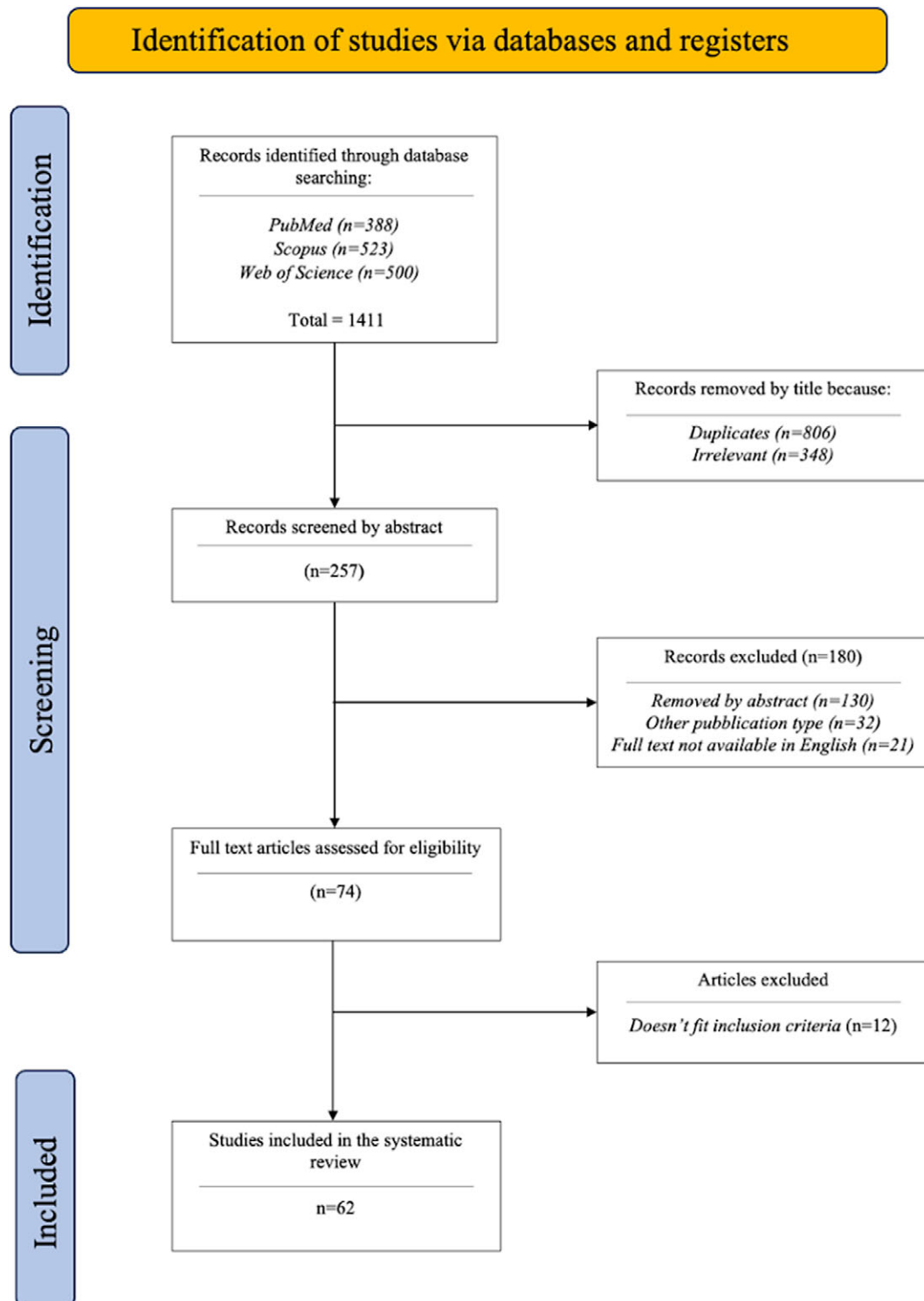

Figure 1. PRISMA flowchart of the study selection process.

Of the studies included, 88.7% included both genders, while 11.3% involved exclusively females.

3.1.2 ON assessment

Considering assessment methods for ON, 55 studies (88.7%) used only one scale. The most utilized scale was the ORTO-15 questionnaire (*n* = 31; 56.4%), followed by the DOS (*n* = 11; 21.1%), the ORTO-11 (*n* = 10; 19.2%), the Bratman Orthorexia Self-Test (BOS-T) (*n* = 2; 3.8%) and the ORTO-R (*n* = 1; 1.9%). The remaining 7 studies used a combination of two scales: the most common combinations were the ORTO-15 with the DOS (*n* = 2; 28.6%) and the ORTO-15 with the ORTO-R (*n* = 2; 28.6%); one article used the BOS-T alongside the ORTO-15 (*n* = 1; 14.3%), one used the DOS alongside the ORTO-11 (*n* = 1; 14.3%), and one used the ORTO-11 alongside the ORTO-R (*n* = 1; 14.3%).

3.2 Prevalence of ON among non-clinical populations

3.2.1 General population/healthcare professionals

One of the very first studies investigating the prevalence of ON in the general population was carried out by Kinzl et al. and involved a sample of 283 dieticians (mean age: 36.2).[23] All participants were evaluated with the "Fragebogen zum Essverhalten" (FEV) (the German version of the 'Three-Factor Eating Questionnaire') and the BOS-T. In the overall sample, 72.6% of the subjects had a normal weight while 9.3% were underweight, 17.1% were overweight and 1% had some degree of obesity. Moreover, 4.6% of the participants have suffered from AN, 3.5% from BN, and 1.1% from a binge eating disorder (BED). Results showed an ON prevalence of 12.8%, while 34.9% had some kind of orthorexic behaviors. In particular, orthorexic behaviors in the sample were mainly characterized by a heightened sense of self-esteem from eating healthy food, guilt when straying from the diet; avoidance of eating away from home for fear of unhealthy food as well as of eating with other people.[23]

Later, ON and its relationship with FED and OCD were investigated by Ramaciotti et al.[24] For this purpose, the authors recruited a sample of 177 Italian adults (F = 119; M = 58), 52 of whom came from a larger epidemiological study and 125 from the general population, and assessed them with the ORTO-15. Subjects undergoing specific nutritional schemes for a diagnosed health problem were excluded. Noticeably, analyses were performed twice, referring to different diagnostic thresholds: first below the 40-point score and then below 35-point. The prevalence of ON was 102 (57.6%) and 21 (11.9%) respectively, with a statistically significant inverse correlation to the highest grade of scholarity.[24]

A few years later, the Italian Association of Dietology and Clinical Nutrition (ADI-O) study investigated the prevalence of ON in a sample of 517 healthcare professionals (F = 278, M = 239) involved in nutrition education, including medical doctors, dieticians, biologists, and others, using the ORTO-15 questionnaire.[25] Results showed an ON prevalence of 55% considering the threshold score of <40 and 14.6% considering the threshold score of <35. Among several variables, lower scores of the ORTO-15, indicating higher orthorexic behaviors, resulted in divorced people, biologists, freelancers, smokers, and dieting subjects. The multivariate models showed that marital status, body mass index (BMI), and adherence to a diet were the main score predictors.[25]

In 2017, a cross-sectional study conducted by Tremmeling et al. aimed to explore the prevalence of ON and FEDs in a population of dieticians in the United States.[26] Additional aims were to assess whether the presence of ON symptoms related to symptoms of FEDs, including weight, shape, eating, and restraint. A total of 636 subjects (F = 615; M = 21) were evaluated with the ORTO-15 questionnaire and the Eating Disorders Examination Questionnaire (EDE-Q). Among all dieticians, the prevalence of ON was 49.5% (cut-off <40) with a mean ORTO-15 score of 39.3 ± 3.6 points, while the prevalence of FED resulted in 12.9%. The participants were then divided into three groups: 8.2% reporting current or past treatment for a FED (D-ED group), 44.6% having an ORTO-15 score minor than 40 (D-ON group), and 47.2% with no previous treatment for FED and an ORTO-15 greater than or equal to 40 (D-HC group). After proper comparison, the D-ON and D-ED groups reported more dietary restrictions than the D-HC group, but there were no differences related to gender, ethnicity, race, or clinical experience. Moreover, both the D-ED and the D-ON groups had higher scores on the EDE-Q, including subscales, lower current BMI, and lower adult BMI compared to the D-HC group. Lastly, for the D-ED group, 59.6% scored below 40 points on the ORTO-15. These results can help to clarify the relationship between ON and EDs, as ON symptoms appear to be associated with eating disturbances, elevated shape, and weight concerns.[26]

Another study on the general population involved 1007 Germans who were telephonically asked to answer the DOS-21 and the Patient Health Questionnaire (PHQ-9). Results showed a higher ON prevalence than in 2012: 6.9% compared to 3%, both in men (5.9%) and in women (7.5%). Furthermore, results showed no links between orthorexic symptoms and BMI or gender. Instead, lower education levels as well as depressive symptoms were positively associated with higher ON prevalence. Indeed, orthorexic people presented obsessive eating habits that could cause strong isolation and a sense of guilt.[27]

Another major study assessing the prevalence of ON in the general population was carried out by Ferreira et al. in 2020.[28] For the purpose of the study, the authors recruited a sample of 1,054 volunteers divided into two groups: the first group was composed of 513 participants (F = 454; M = 59; mean age: 27.65 ± 9.16) while the second was composed of 541 participants (F = 447; M = 94; mean age. 34.66 ± 11.81). All participants were assessed with the DOS, the Depression Anxiety and Stress Scales-21 (DASS21), the External and Internal Shame Scale (EISS), the Body Image Shame Scale (BISS), the Inflexible Eating Questionnaire (IEQ); the Intuitive Eating Scale −2 (IES-2), the Binge eating scale (BES) and the EDE-Q. Results highlighted an ON prevalence of around 10.52% that, compared to other eating disorders' prevalence, seems to be extremely high. Moreover, the study reported higher rates of ON in female participants, in line with other research suggesting that pathological healthful eating could be more pronounced in women, and in people following specific dietary patterns such as vegetarianism and veganism. On the contrary, no links between ON and BMI were found.[28]

A similar study was carried out by Brytek-Matera,[29] who involved 1262 (F = 854; M = 408) people coming from two different cultural groups, Lebanese and Polish, assessed with the DOS-21 in order to investigate ON prevalence and its association with sociodemographic variables. Results showed a prevalence of 2.6% for the Polish sample and 8.4% for the Lebanese sample. According to the authors, their findings may be explained by the rising awareness about healthy nutrition, increased by the media effect concerning healthy food and several campaigns for healthy diet, in Lebanon. Particularly, marital status seemed to be linked to higher orthorexic symptoms while single women seemed to have more orthorexic-like scores.[29]

Table 1. Prevalence of ON in the general population

Study	Date	Country	Sample size	Population	Mean age	Scales	Main findings
Kinzl et al. [23]	2006	Austria	283	Female dieticians	36.2	BOS-T; FEV	ON prevalence of 12.8%, orthorexic behaviors in 34.9%. Orthorexic behavior is characterized by a heightened sense of self-esteem from eating healthy food (8.8%), feeling of guilt straying from diet (4.6%), avoiding eating away from home for fear of unhealthy food (2.5%) and avoiding eating with other people (2.5%).
Ramaciotti et al. [24]	2011	Italy	177	General population F = 119; M = 58	-	ORTO –15	ON prevalence of 57.6% using the 40-point threshold, with a female/male ratio of 2:1. ON prevalence of 21% using the 35-point threshold. Positive correlation with educational levels.
Maghetti et al. [25]	2015	Italy	517	Healthcare professionals involved in nutrition education F = 278, M = 239	-	ORTO –15	The average score of 38.62; 14.6% scored above 35 and 55% scored above 40. Total scores were significantly lower in divorced people, biologists, freelancers, smokers, and dieting subjects. The main score predictors were marital status, BMI and adherence to a diet.
Tremelling et al. [26]	2017	The U.S.	636	Dieticians F = 615 M = 21	-	ORTO–15; EDE-Q	Overall ON prevalence of 49.5%; overall FED prevalence of 12.9%. Both the group disclosing ED treatment and the group at risk for ON had a lower mean BMI, lower scores on the ORTO–15, and higher scores on the EDE-Q and all its subscales than the comparison group.
Luck-Sikorski et al. [27]	2018	Germany	1007	Randomly selected sample from the General Population	50.6 ± 0.7	PHQ–9 DOS	Higher ON prevalence compared to 2012: 6.9% vs 3%, both in men (5.9%) and in women (7.5%). No with BMI or gender. Positive correlation between ON and lower education levels and depressive symptoms.
Ferreira et al. [28]	2020	Portugal	1054	General population Sample 1: F = 454; M = 59 Sample 2: F = 447; M = 94	Sample 1: mean age: 27.65 ± 9.16 Sample 2: mean age. 34.66 ± 11.81	DOS; DASS21; EISS; BISS; IEQ; IES–2; BES; EDE-Q	ON prevalence of 10.52%. Higher rates in females, and people following specific dietary patterns. No correlation with BMI.
Brytek-Matera et al. [29]	2020	Poland Lebanon	1262	Total. F = 854; M = 408 Polish: F = 571; M = 172 Lebanese F = 283; M = 236	Polish: 24.80 ± 6.76 Lebanese: 35.83 ± 14.48	DOS	ON prevalence of 2.6% for the Polish sample and 8.4% for the Lebanese sample. Positive correlation with the single marital status.

Overall, seven studies examined prevalence rates in the general population; prevalence rates ranged between 2.6% (assessed with the DOS in the Lebanese population) and 57.6% (assessed with the ORTO-15).

The results of the studies discussed above are summarized in Table 1.

3.2.2 Students

Since the conceptualization of ON, one of the more investigated populations for ON were students with various degrees of education.

Interestingly, one of the first studies investigating ON prevalence in a non-clinical population involved resident students at the Faculty of Medicine of Ankara, Turkey.[30] A total of 318 subjects (F = 149; M = 169; mean age: 27.2 ± 2.9), were evaluated by a 39-item questionnaire: the first nine items were related to socio-demographic characteristics, further, 15 items regarded their nutritional habits, and eating behaviors, self-perceptions of their bodies and the extent and forms of physical activity they undertake, while the last 15 questions were the validated Turkish translation of the ORTO-15 test with a diagnostic threshold score for ON of <40.

Results showed that 45.5% of the sample scored for a diagnosis of ON, with a mean score of 39.8 ± 0.22, without any significant difference between the male and female gender. Interestingly, about 40% of females versus 20% of male participants were influenced in food selection by the programs on nutrition/health in mass media ($p < 0.05$). Several other variables, including food shopping by themselves, substitution of meals with salad/fruit, caring about the food quality, and spending time in stores selling natural food products, were found to be predictive of higher ORTO-15 scores, although only "*weight control*" and "*importance in products contents*" remained significant at the multivariate analysis.[30]

Another important study that evaluated ON in these populations came from Bundros et al.,[31] who explored the relationship between the scores obtained at the BOS-T and previously validated measures for FED, body dysmorphia, and obsessive-compulsive tendencies, in a sample of 448 college students (F = 325; M = 121; other = 2; mean age: 22.17 ± 4.83 years). The students were assessed with the BOT, the Eating Attitudes Test-26 (EAT-26), the Body Dysmorphic Disorder Questionnaire (BDDQ), and the OCI-R. Results showed that only five subjects reached the BOS -T diagnostic cut-off for ON, moreover, the average scores of the sample

fell near the cut-off point for Health Fanatic eating behavior, indicating the presence of orthorexic symptoms in the recruited population.

In the same year, Dell'Osso et al. investigated the prevalence and characteristics of orthorexia in a large university sample of 2,826 subjects (F = 1148; M = 1678; mean age: 28.9 ± 11.39), including 2,130 students and 696 university employees at the Pisa Atheneum (Italy).[16] An anonymous online form of the ORTO-15 questionnaire was administered to evaluate the prevalence of ON. According to the 35-point cut-off of ORTO-15, the prevalence of ON was 32.7%. In comparison to men, women displayed statistically significant greater rates of ORTO-15 over-threshold scores (35.3% vs 28.9%), lower BMIs (21.91 ± 3.83 vs 23.40 ± 3.07), higher rates of underweight conditions (10.5% vs 28.9%), and vegan/vegetarian dietary patterns (13.8% vs 7.1%). This study revealed that the most predictive factors of developing ON were being vegetarian or vegan, underweight, female gender, and student.[16]

Differently, a Swedish study by Malmborg et al. compared the health conditions, physical activity levels, and frequency of ON between 118 undergraduate exercise science students and 89 business students.[32] Health status was measured with the Short Form-36 (SF-36) questionnaire, physical activity with the International Physical Activity Questionnaire (IPAQ), and ON with the ORTO-15 questionnaire. The final sample included 207 students (mean age of 22.8 ± 2.2 years) but of these, only 206 completed the IPAQ, and 188 completed the ORTO-15. When program differences were compared, it emerged that students from exercise science performed worse than business students on the SF-36 subscales of physical functioning, role-physical, and bodily discomfort, but they did better on the subscale of general health. There was no difference in the reported physical activity between programs. In the overall sample, the mean ORTO score was 36.7 ± 3.8; 76.6% of students had a score indicating ON after setting the cut-off score < 40, and 26.6% after <35 cut-off. The results showed that students studying exercise science had a higher ON rate than students studying business (84.5% versus 65.4% with the <40 cut-off and 34.5% versus 15.4%; with the <35 cut-off). Interestingly, males from exercise science had the highest frequency of ON, followed by females from the same faculty and males and females from business. A similar trend was seen for high levels of physical activity. Overall, ON in combination with a high level of physical activity was most often seen in males in exercise science studies and less often in females in business studies (45.1% versus 8.3%). The authors also stressed how, since exercise science students are supposed to train others in healthy living when they graduated, a high level of self-reporting of ON symptoms in this population may produce issues in the future.[32]

One year later, Karakus et al.[33] assessed the orthorexic symptoms among undergraduate students in the nutrition and dietetics department of Istanbul, in relation to key sociodemographic factors. The overall sample was composed of 208 students (F = 179; M = 29), all assessed with the ORTO-11. The average participant's score on the ORTO-11 scale was 16.5 ± 4.6. Interestingly, male participants' mean scores were substantially lower than female participants. Moreover, subjects residing at home scored considerably lower than those residing elsewhere. There was no discernible variation in the mean ORTO-11 score between the participant groups when BMI was taken into consideration.

Similarly, the same year, Hayes et al.[14] ascertained the incidence and correlates of ON as well as its correlates, and the impairment associated, in a sample of 404 undergraduate students (F = 334, M = 60; mean age: 20.71 ± 4.36) at a southeastern U.S. university.

The participants were assessed with the BOS-T, the ORTO-15, the EDE-Q, the Appearance Anxiety Inventory (AAI), the Sheehan Disability Scale (SDS), the Frost Multidimensional Perfectionism Scale (FMPS), the obsessive compulsive inventory-revised (OCI-R), the Depression Anxiety Stress Scale-21 (SASS-21) and the Brief Fear of Negative Evaluation Scale (BFNES). Results highlighted a prevalence of high ON symptoms in the sample, endorsed with the BOS-T of 35.4% (N = 143); interestingly, a significantly different result came from the evaluation with the ORTO-15, which reported a presence of high ON symptoms in 79.7% of the total sample (N = 322), based on the threshold score of 40.[34] In light of these results, the authors hypothesized that the prevalence rate obtained with the ORTO-15 does not reflect clinical ORTO but rather specific orthorexic-like features that for some people may become pathological, but for the majority may remain non-impairing.

A similar study was conducted in Germany, where 456 university students (F = 318; M = 136; mean age: 21.7 ± 2.6) from the Faculty of Nutrition Science (NS) and Economic Science (ES) were evaluated to determine ON prevalence and to investigate whether gender or age were positive predictors of ON, or if any difference in prevalence depended on the type of studies undertaken. All participants were assessed with the DOS-21. Results showed a global ON prevalence of 3.3%, with a risk of developing ON equal to 9.9%. Contrary to what was expected, perhaps due to the small sample size, gender was not a predictor of ON, while students at the beginning of their studies had a higher prevalence of ON symptoms than those in the upper semesters, suggesting an acquired greater health consciousness with the increase of the years. Lastly, no differences were determined by the field of study, revealing that the probable better nutrition knowledge and healthy awareness achieved through scientific studies would not lead to an increase in orthorexic behaviors as sometimes hypothesized by the recent literature.[35]

Similarly, a study by Dunn,[36] examined the prevalence of ON in a US sample of 275 college students through the administration of the ORTO-15 along with other questions regarding diet, exercise, and health. Results indicated an ON prevalence of 71%, although only 20% endorsed a dietary practice of removing a particular food type (e.g. meat) from their diet. In contrast with other research, those who followed a vegan diet had the highest (less pathological) mean ORTO-15 score. Interestingly, less than 1% of the sample fell into the category of being concerned about healthy eating, including any diet-related impairment in everyday activities and medical problems. The authors concluded that although a large proportion of subjects scored in the orthorexia range on the ORTO-15, this instrument failed to distinguish between healthy eating and pathologically healthful eating, thus overestimating the real prevalence.[36]

In the same year, Arslantas et al.[37] evaluated the prevalence of ON among nursing students and its associated factors. The study sample included 181 students (F = 141; M = 53) who completed the EAT-40 and the ORTO-11. Results showed that the mean ORTO-11 score was 27.34 ± 4.53 and that 45.3% of the participants were at risk for developing ON.

Other important information on ON prevalence in students came from two subsequent researches from Parra-Fernandez et al.[38,39] The first one[38] was a cross-sectional study where the authors assessed 454 college students (F = 295; M = 159; mean age: 21.74 ± 4.73 years) from a variety of faculties (including Nursing, Law, Chemistry, Computer Science, and Education). All participants were assessed with the EDI-2 and the ORTO-11. Results showed that 17% (76 pupils) of the sample had a high risk of having

ON as well as a substantially higher risk for orthorexic behaviors in the female population. In the second study,[39] the authors compared ON prevalence measured with the ORTO-11, to the one obtained with the DOS-ES, a self-report instrument tailored to evaluate the risk of suffering from ON. For this purpose, a sample of 429 university students was recruited (F = 244; M = 185; mean age: 19.97 ± 3.03) and all participants were assessed with the mentioned scales as well as with the Eating Disorder Inventory (EDI-2). The results showed that only 10.5% of students showed ON according to the DOS-ES, while the prevalence of ON rose to 25.2% using the ORTO-11. Moreover, in accordance with previous studies, results highlighted that the female gender was more directly linked to the vulnerability toward orthorexic behavior.

In 2018, another study from Dell'Osso et al. investigated the prevalence of ON and its correlation between gender and nutritional habits in a population of students from the University of Pisa.[40] A total of 2,130 students (F = 1254; M = 876; mean age: 23.82 ± 4.39) filled out the ORTO-15 questionnaire. In the overall sample, 34.9% of subjects presented an ORTO-15 score below the 35-point cut-off, with the mean resulting of 36.93 ± 4.22. Dichotomizing the subjects depending on some socio-demographics variables, the authors found 173 individuals (8.1%) with a low BMI, and 240 subjects (11.3%) following a vegetarian or vegan diet. According to different comparisons, ON was more frequent in females than in males (37.8 vs 30.7%, p = 0.001), in vegetarian or vegan subjects than in ordinary diet (56.3 vs 32.2%, p < 0.001), and in individuals presenting a low BMI vs those with a normal or high BMI (42.8 vs 34.2%, p = 0.029). After a tree analysis, diet type was identified as the strongest predictor of ON and ORTO-15 total score more than gender.[40]

The same year, Reynolds conducted a pilot, cross-sectional, and descriptive online survey on staff and adult students at the University of New South Wales of Sydney, Australia.[41] The purpose was to assess tendencies toward eating disorders, the prevalence of ON, eating behaviors, and body self-image in this population. The ORTO-15 questionnaire, EAT-26, and the Body Shape Questionnaire-34 (BSQ-34) were administered to a final sample of 92 volunteers (F = 67; M = 25; mean age: 24.6 ± 7.5). The prevalence rate of ON was 66% when using the <40 cut-off, and 21% when using the <35 cut-off. Significant inverse correlations were found between ORTO-15 scores and EAT-26 scores, BSQ-34 scores, and negative effects of eating on social life and work life. No associations were found between ORTO-15 scores and age or BMI. Taking into consideration the 19 individuals (21%) classified as suffering from ON (ORTO-15 score < 35), only four had a BSQ-34 score > 140; eight had an EAT-26 score > 20; one an underweight BMI < 18.5 kg/m^2; three stated that their eating negatively affected working 'often' or 'always'; and five stated that their eating negatively affected socializing 'often' or 'always'. According to these results, the author suggested that the ORTO-15 test alone could overestimate the prevalence of ON.[41]

During 2019, Gramaglia et al.,[42] explored the interplay between socio-cultural context and ON through a multicenter, cross-sectional study, involving Italian (N = 216), Polish (N = 206), and Spanish (N = 242) university students. The overall sample was composed of 664 volunteers (F = 480, M = 184; mean age: 24.02 ± 4.94 through self-administered questionnaires such as the ORTO-15, the EAT-26, and the Temperament and Character Inventory (TCI). The overall prevalence of ON was 37.05% and, between the three groups, the highest prevalence was reported in the Polish sample. Additionally, results of the study showed that, in the global sample, ON scores were correlated with the female

gender, the BMI, an ongoing FED, dieting behaviors, an EAT-26 score higher than 20, and low/medium persistence. The differences among students from the three countries suggested a possible role for cultural elements in the construct of ON.[42]

Another study involving university students was the American validation of the English version of the DOS-21[43] which involved a total of 384 university students (F = 267; M = 117; mean age: 21.13 ± 2.23). Results showed an ON prevalence of 8.0% and a prevalence of risk for the development of ON of 12.4%, and a positive correlation between vegetarian and vegan habits.[43]

Plichta et al.[44] assessed instead orthorexic symptoms, eating behaviors, and concerns regarding health and eating in Poland, in a sample of 1120 college students (F = 789; M = 331; mean age: 21.4 ± 2.4) from seven universities, 547 enrolled in health-related majors (Food Technology and Human Nutrition, Dietetics, Physiotherapy, Physical Education, and Wellness), while 573 in other majors. For this purpose, the students completed the ORTO-15 test, the Health Concern Scale (HCS), and the Food Frequency Questionnaire (FFQ-6). The mean score of ORTO-15 was 36.6 ± 4.2, and the prevalence of ON was 28.7% using a cut-off score of <35, and 46.7% had a score between 35 and 40. The health students had significantly lower ORTO-15 scores than the others, and a higher prevalence of ON (32.9% vs 23.9% with the cut-off score of 35). No significant correlations were found between ORTO-15 scores and gender or BMI. The average Health Concern (HC) score was 9.1 ± 3.9, whereas the average Eating Concern (EC) score was 17.1 ± 6.8. Women had significantly higher HC and EC scores than men. A positive correlation was found between both HC and EC scores and BMI, while no differences between health students and other students were observed. Interestingly, subjects with an 'ON score < 35' had lower EC scores than students with an 'ON score between 35 and 39', while there was no significant association between symptoms of ON and HC. Finally, the authors found that the higher symptoms of ON were associated with more frequent consumption of 'Fruits & vegetables,' 'Legumes & nuts,' and 'Meat.' According to the authors, their study may confirm a relatively high prevalence of ON in young university students. Moreover, the ORTO-15 score did not correlate with health and eating concerns, while those with an ORTO-15 score below 35 had the lowest mean EC score.[44]

In 2020, Abdullah and co-workers investigated the prevalence of ON and related variables through a cross-sectional study among 421 nutrition students (F = 294; M = 127) from six universities, and nutritionists in Jordan.[45] Orthorexia Nervosa tendency was measured using the ORTO-15 questionnaire, referring to different diagnostic thresholds (40/35). Orthorexia had a 72.0% prevalence using the 40-point threshold, and 31.8% with the 35-point threshold. BMI categories and gender influenced the results at the 35-point threshold, with males having more ON symptoms (39.4%) than females (28.6%).[45]

A study published in 2020 by Gorrasi et al. aimed to evaluate the prevalence of ON and muscle dysmorphia (MD) in a group of undergraduates, and their association with the type of university course attended, demographics, and individual characteristics.[46] Three specific validated tests were employed: ORTO-15, Muscle Dysmorphia Disorder Inventory (MDDI-ITA) and EAT-26. The self-administered questionnaires were completed by 918 students from three Italian universities (F = 503; M = 415; mean age: 20.2 ± 1.7), with 29.0% of participants demonstrating significant ON symptoms and 5.0% of MD, without differences related to three areas of study (health-scientific, economic-humanistic, and sport sciences). Interestingly, students of sports sciences exhibited a

significantly higher score for MDDI-ITA. Participants with ON and MD symptoms were more on a diet and showed a higher prevalence of ED risk. The simultaneous presence of ON, MD, and ED symptoms was seen in only 5.4%.[46]

The same year, Carpita et al. investigated the relationship between ON and autistic traits in an Italian university population (students and university workers).[47] Subjects were asked to fulfill by email the ORTO-15 and the Adult Autism Subthreshold Spectrum (AdAS Spectrum) questionnaires. A total of 2,426 subjects (F = 1590, M = 836) joined the survey, with 623 (26.3%) reporting a score positive for orthorexic symptoms according to ORTO-15 (ON group) (mean age: 26.17 ± 9.68), while the others were considered as healthy controls (mean age: 27.19 ± 10.35). The ON group scored significantly higher on almost all AdAS Spectrum domains. Moreover, being female and scoring higher on the AdAS Spectrum were statistically predictive factors for the presence of ON symptomatology. Among AdAS Spectrum domains, *inflexibility and adherence to routine* and *restricted interests, rumination*, and lower scores on *verbal communication* were the best predictors of orthorexic symptoms. Based on the results, the authors suggested a possible overlap between orthorexia and autistic traits.[47]

Brytek-Matera et al. in a further study validated the Polish version of the DOS in a sample of 412 university students (F = 318; M = 4; mean age: 24.62 ± 6.86), also assessed with the EDI and the EHQ. Results showed an overall ON prevalence of 6.6% and an ON risk of 11%.[48] Moreover, the same authors[49] analyzed 860 university students (F = 560; M = 300; mean age: 21.17 ± 3.38) from Spain (N = 485) and Poland (N = 375) with the DOS and the EDI. Results showed an overall ON prevalence in the whole sample of around 2.6% (considering 50% of Polish students and 50% of Spanish) while considering the two populations individually, Poland had a higher ON rate (2.9%) compared to Spain (2.3%). The authors highlighted that one point of interest in their results may be associated with the individualism/collectivism concept. Indeed, according to the individualism/collectivism index, the tendency to stand out and to competitiveness, typical of an individualistic culture, can increase abnormal eating patterns such as orthorexic features, more extended in the Polish that reported a higher drive for thinness and less body dissatisfaction then in Spanish sample, both resulting predictors of ON. Contrary, Spain is defined as a collectivist population in which people's focus is placed on the values of collectivity and cooperation, minimizing the expression of ED pathology. However, greater concern with diet and stronger preoccupation with weight gain, considered important ON predictors, were also found in the Spanish student sample.[49]

Similarly, the validation of the Italian version of the DOS,[50] where its psychometric properties were tested through statistical correlation with other tools such as the ORTO-15, the Disordered Eating Questionnaire (DEQ), the Beck Depression Inventory-II (BDI-II), and the Obsessive-Compulsive Inventory-Revised (OCI-R), involved university students. The sample was composed of 422 volunteers (F = 303; M = 119; mean age: 20.70 ± 3.44) recruited among university students of various fields and results showed an ON prevalence of 3.2% and an ON-prevalence risk of 4.9%, summing up for a total of 8.1%.

Also, the French validation of the same questionnaire was carried out on 3235 university students (F = 2901; M = 334; mean age: 21.13 ± 2.23), assessed also with the EHQ and the EAT-26 in order to evaluate DOS convergent and divergent validities.[51] The DOS-21 French version measured a prevalence of the disorder equal to 3.28% with a risk of developing ON equal to 11.28% in line with recent literacy about ON prevalence in the general population. Furthermore, the study also reported a small correlation between BMI and ON as well as a positive link between ON and the drive for thinness, commonly underlined as AN feature, referring to an important relationship between orthorexia and AN. Lastly, higher academic results were strongly related to ON presence, suggesting perfectionism as an important component of ON.[51]

Ruiz and Quiles, in 2021, investigated the prevalence of ON and its relationship with FEDs and self-image in a population of Spanish students.[52] The cross-sectional study included a sample of 534 university students (F = 422; M = 112; mean age: 22.04 ± 3.41). All subjects were assessed with the ORTO-11 and the Terual Orthorexia Scale (TOS), the Multidimensional Body Self Relations Questionnaire (MBSRQ-45), and the EAT. The resulting ON prevalence was 30.5%, with significantly higher scores in women and students adopting a vegan or vegetarian diet. A statistically significant correlation was also found between ON and higher scores on the MBSRQ-45 and the EAT. This study confirmed the high prevalence of ON in young adults and proved that students with ON generally had a worse self-image and restrictive eating behaviors.[52]

The same year, a cross-sectional study conducted by Sunbul and co-workers aimed to evaluate the orthorexic symptoms and eating attitudes in a population of Turkish university students.[53] For this purpose, the ORTO-15 questionnaire and the EAT-40 were administered to a sample of 580 students (F = 330; M = 250; mean age: 20.92 ± 1.69). The results showed that the EAT-40 had a mean score of 18.36 ± 0.56, while the mean score of ORTO-15 was 39.01 ± 0.17. A statistically significant correlation was found between being female and a risk for having an ED, according to EAT-40 results. Regarding the ORTO-15 test, 39.8% of the subjects scored below 40, indicating ON symptoms, with a higher prevalence in females (46.1% vs 31.6% of men). Again, being female had a significant positive association with ON prevalence, such as being underweight and being on a diet. Similar results were found after analyzing the correlation between EAT-40 scores and low BMI or having a restrictive diet. Lastly, there was a moderate negative correlation between EAT-40 and ORTO-15. These results highlight the high prevalence of ON among university students, in particular in females, and how these attitudes increase the risk of developing potentially more serious eating disorders.[53]

Grajek et al. 2022 compared the orthorexic symptoms in a population of Polish students from different fields of study.[54] The subjects completed a questionnaire to assess their dietary habits, physical activity level, and BMI, while the ORTO-15 and the Exercise Motivation Inventory-2 (EMI-2) tests were also employed. The sample consisted of 290 individuals (F = 174; M = 116; mean age: 26 ± 2), of whom 144 were enrolled in a Health-Related Field (HRF, including dieticians and physical education students), and 146 in a Non-Health-Related Field (NRF, including management and computer science students). The results showed that, in the HRF group, 44 subjects (30.6%) were characterized as underweight and the most common dietary patterns (97.2%) were evaluated as "very good" or "good". On the contrary, in the NRF group, no one was underweight, 61 people (41.7%) were overweight and the most common dietary pattern (64.4%) was "sufficient." In both groups, most of the students practiced physical activity, but the activity level was higher in the HRF group. Using the ORTO-15 test, 44.5% of the subjects scored below 40, indicating an increased risk of ON. In the HRF group, the prevalence of ON was higher than in the NRF group (65.5% vs 25.8%). Among the HRF group, the risk of ON was statistically correlated with a low BMI and "good" and "very good" dietary patterns. The authors concluded that ON may be considered an

increasing issue concerning the fields of both social and health sciences.[54]

Similar results came from a study carried out by Bulut et al.[55] that aimed to identify the incidence of ON in academicians working in various departments at Bingol University and the factors that may influence it. For this purpose, 560 academicians (F = 98; M = 462) who worked in various disciplines were recruited and evaluated with the Eating Attitude Test-40 (EAT-40) and the ORTO-11. The overall ORTO-11 mean score was 25.51 ± 4.06 and it was not correlated with the EAT-40 score, BMI, and waist circumference. Results also suggested that older age increased the likelihood of developing an eating disorder, while female gender, age between 34 and 41, and having an undergraduate degree were significant in lowering the incidence of ON.

Another interesting study assessed the degree of dread and propensity for ON among university students who received health education during the COVID-19 pandemic.[56] The study included a total of 765 students (F = 626; M = 139) and used an online survey to evaluate the anthropometric parameters, the EAT-26, Fear of COVID-19 Scale (FCV-19S), and ON prevalence with the ORTO-11. The scores on the FCV-19S varied by gender and were higher among female pupils. ON was more prevalent in students who scored highly on the EAT-26. The ORTO-11 scores decreased by 0.10 points for every unit with higher FCV-19S scores, according to calculated regression models. Students with high FCV-19S scores were found to have higher ON symptoms and higher EAT-26 scores. The FCV-19S score had a marginally negative association with the ORTO-11 score and a marginally positive correlation with the EAT-26 score. Globally, this study seemed to highlight that, among students who received health education, the fear of COVID-19 was associated with an increase in the ON prevalence and eating pattern alterations.[56]

Lastly, Dell'Osso et al.,[57] further investigated the presence of ON in a sample of university students with or without subthreshold autism spectrum with the ORTO-R, a revised version of the ORTO-15. The sample was composed of a total of 2,140 students; of these, 1,414 (66.1%) identified themselves as female and 726 (33.9%) as male. Additionally, 1,956 students (94.3%) had an omnivorous diet, while 118 students (5.7%) were on a vegetarian or vegan diet at the time of the survey. For the purposes of the study, two groups of students were examined, dividing the sample into groups with high and low levels of significant autistic traits (AT) measured by the AdAS Spectrum. In line with the validated cut-off,[58] students who reported a score above 43 were placed in the high AT group, while those who did not were placed in the low AT group. Between the high AT and low AT groups, there were no appreciable gender or diet distribution differences. Results highlighted that participants in the high AT group had significantly higher ORTO-R scores than those in the low AT group. Additionally, in the overall sample, women reported substantially higher ORTO-R scores than men, while patients who followed a vegetarian/vegan diet exhibited considerably higher ORTO-R scores than those following an omnivorous diet. Results from the study suggest that women are more likely than men to experience ON behaviors and that there is a connection between ON and a particular interest in nutritional options. Additionally, in line with several earlier studies, the data showed a correlation between AT and ON, highlighting the possibility that this correlation may be higher in females.

Overall, 29 studies examined prevalence rates in students; prevalence rates ranged between 2.6% (assessed with the DOS) and 76.6% (according to the threshold value of >40 of the ORTO-15).

The results of the studies discussed above are summarized in Table 2.

Table 2. Prevalence of ON in students

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Bagˇcı Bosi et al.[30]	2007	Turkey	318	Resident medicine students F = 149; M = 169	27.2 ± 2.9	ORTO –15	ON prevalence of 45.5%, without statistical difference based on gender. 40% of females versus 20% of males were influenced in food selection by the mass-media programs on nutrition/health.
Bundros et al.[31]	2016	California	429	College students F = 244; M = 185	22.17 ± 4.83	BOS -T; EAT–26; BDDQ; OCI-R	5 subjects over the diagnostic cut-off for ON average scores of the sample near the cut-off point for Healthy Fanatic eating behavior.
Dell'Osso et al.[16]	2016	Italy	2826	University students and university employees F = 1678, M = 1148	28.9 ± 11.39	ORTO–15	ON prevalence of 32.7%. Females, vegetarianism or veganism, underweight, and being a student
Malmborg et al.[32]	2016	Sweden	188	Undergraduate Exercise Science students and Business Students F = 107, M = 81	22.8 ± 2.2	ORTO–15; SF–36; IPAQ	The general prevalence of ON of 76.6% (ORTO score < 40) or 26.6% (ORTO score < 35). Exercise science students presented a higher frequency of ON than business students. The highest prevalence of ON was in men from exercise science programs.
Karakus B. et al.[33]	2017	Turkey	208	Nutrition and Dietetics students F = 179, M = 29	>18	ORTO–11	The orthorexic tendency was significantly higher in females and in students who lived with their
Hayes et al.[14]	2017	The U.S.	404	Undergraduate students F = 334, M = 60	20.71 ± 4.36	BOS-T; ORTO–15	Prevalence was evaluated with a BOS-T of 35.4%, significantly lower than the prevalence assessed with the ORTO–15 (79.7%).

Table 2. *Continued*

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Depa et al. [35]	2016	Germany	456	Total: 456 (F = 318; M = 136) NS: 188 (F = 176; M = 12) ES: 266 (F = 142; M = 124)	21.7 ± 2.6	DOS	Overall ON prevalence of 3.3%. ON-risk prevalence of 9.9%. Higher prevalence of ON at the beginning of the academic career. No differences were determined by field of study.
Dunn et al. [36]	2017	United States	275	College students F = 188; M = 85; other = 2	21.7 ± 4.8	ORTO–15	ON prevalence of 71% (cut-off <40), and 22.5% (cut-off <35), although only 20% endorsed a dietary practice of removing a particular food. Vegans had the least pathological mean ORTO–15 score Less than 1% of the sample were concerned about healthy eating, including any diet-related impairment in everyday activities and medical problems.
Arslantas et al. [37]	2017	Turkey	181	Nursing students F = 141; M = 53	-	ORTO–11; EAT–40	Mean ORTO–11 score: 27.34 ± 4.53. ON-risk prevalence of 45.3%.
Parra – Fernandez et al. [38]	2018	Spain	454	University students F = 295, M = 159	21.74 ± 4.73	ORTO–11; EDI–2	Overall ON incidence of 17% (N = 76) Higher risk for orthorexic behaviors in the female population.
Parra-Fernández et al. [39]	2019	Spain	429	University students F = 244; M = 185	19.97 ± 3.03	ORTO–11; DOS-ES; EDI–2	10.5% of students showed ON according to the DOS-ES; 25.2 of students showed ON according to the ORTO–11. Female gender is more directly linked to the predisposition for orthorexic behaviors
Dell'Osso et al. [40]	2018	Italy	2130	University students F = 1254, M = 876	23.82 ± 4.39	ORTO–15	Overall ON prevalence of 34.9% (<35 cut-off). ON related to female sex, vegetarian or vegan diet, and low BMI. Diet types as the strongest predictors of ON.
Reynolds R. [41]	2018	Australia	92	University staff and students F = 67; M = 25	24.6 ± 7.5	ORTO–15, EAT–26, BSQ–34	ON prevalence of 21% with the <35 cut-off.
Gramaglia et al. [42]	2019	Italy Poland Spain	664	University students, F = 480, M = 184	24.02 ± 4.94	ORTO–15, EAT–26, TCI	Overall ON prevalence of 37.05%. A higher prevalence was found in the Poland sample. Positive correlation with female gender, BMI, current FED, dieting, EAT–26 score ≥ 20, and low/medium Persistence
Chard et al. [43]	2019	The U.S.	384	University students F = 267; M = 117	19.64 ± 2.6	DOS; EHQ; EAT–26	ON prevalence of 8.0%. ON-risk prevalence of 12.4%. Positive correlation between ON and vegetarianism/veganism.
Plitcha et al. [44]	2019	Poland	1120	University students (N = 547 health-related students, N = 573 other students) F = 789, M = 331	21.4 ± 2.4	ORTO–15, HCS, FFQ–6	ON prevalence of 28.7% (cut-off <35). Health students scored significantly less than the other students. No correlations between ORTO–15 scores and eating and health concern measures; subjects with ON had lower eating concerns than subjects without ON. Individuals with ON preferred to eat vegetables, fruits, nuts, and meat.
Abdullah et al. [45]	2020	Jordan	421	Nutrition students and nutritionists F = 294, M = 127	18–22: N = 248 (58.9%) 23–30: N = 119 (28.3%) 31–40: N = 33 (7.8%) >40: N = 21 (5%)	ORTO–15	ON prevalence of 72.0% using the 40-point threshold, and 31.8% with the 35-point threshold. BMI and gender influenced the results at the 35-point threshold, with males having more tendency to ON (39.4%) than females (28.6%).
Gorrasi et al. [46]	2020	Italy	918	Undergraduates F = 503; M = 415	20.2 ± 1.7	ORTO–15, MDDI-ITA, EAT–26	ON prevalence of 29% and 5.0% of MD. Students of sports sciences exhibited a significantly higher score for MDDI-ITA. Participants with ON and MD traits were more on a diet and showed a higher prevalence of ED risk.

Table 2. *Continued*

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Carpita et al. [47]	2020	Italy	2426	University students and workers F = 1590, M = 836	26.17 ± 9.68 ON 27.19 ± 10.35 HC	ORTO–15 AdAS	ON prevalence of 26.3% (cut-off <35). The ON group scored significantly higher on almost all AdAS Spectrum domains. Female gender and scoring higher on AdAS predicted ON symptomatology.
Brytek-Matera et al. [48]	2020	Poland	412	Students F = 318; M = 4	24.62 ± 6.86	DOS EHQ EDI	Overall ON prevalence of 6,6%. ON-risk prevalence of 11%.
Brytek-Matera et al. [49]	2020	Poland Spain	860	University students (F = 560; M = 300) Spanish:485 (F = 275; M = 210) Polish: 375 (285; M = 90)	Total: 21.17 ± 3.38 Spanish: 19.76 ± 2.18 Polish: 22.99 ± 3.77	DOS EDI	ON prevalence in the whole sample of 2.6%. Higher ON prevalence in the Polish than in the Spanish (2.9% vs 2.3%).
Cerolini et al. [50]	2021	Italy	422	University students F = 303; M = 119	20.70 ± 3.44	DOS–21 ORTO–15 DEQ BDI-II OCI-R	ON prevalence of 3.2% ON-risk prevalence of 4.9%. The total prevalence of ON and risk of 8.1%.
Lasson et al. [51]	2021	France	3235	University students F = 2901; M = 334	21.13 ± 2.23	DOS EHQ EAT–26	ON prevalence of 3.28%. ON-risk prevalence of 11.28%. Small correlation between BMI and ON; positive correlation between ON and the drive for thinness; strong correlation between higher academic results and On presence
Ruiz et al. [52]	2021	Spain	534	Undergraduate and postgraduate university students F = 422 M = 112	22.04 ± 3.41	ORTO–11, TOS, MBSRQ–45, EAT	ON prevalence of 30.5%. ON was correlated with worse self-image, restrictive diet, and being female.
Sunbul et al. [53]	2021	Turkey	580	University students F = 330 M = 250	20.92 ± 1.69	ORTO–15, EAT–40	ON prevalence of 39.8%; high risk for having an eating disorder, based on EAT–40 score, was found in 15.2% of the subjects. v Significant correlation between the risk of ON and being a female, having a BMI < 18.5, and being on a diet. Similar associations were found regarding EAT–40 scores, with a high risk of ED in the same categories of the sample.
Grajek et al. [54]	2022	Poland	290	University students from Health-Related Field (N = 144) and Non-Health-Related Field (N = 146) F = 174, M = 116	26 ± 2	ORTO–15, EMI–2, Dietary assessment	ON prevalence of 44.5% (cut-off <40). Higher prevalence of ON in HRF students (65.5% vs 25.8%). Among the HRF, the risk of ON was statistically correlated with a low BMI and "good" and "very good" dietary patterns.
Bulut et al. [55]	2022	Turkey	560	Academicians working in various departments at Bingol University (F = 98 M = 462)	-	ORTO–11; EAT40	Overall ORTO–11 mean score of 25.51 ± 4.06, not correlated with the EAT–40 score, BMI, and waist circumference. Older age increases the likelihood of developing an eating disorder. Female gender, age between 34 and 41, and undergraduate degree significantly lowering the incidence of ON.
Uzdil et al. [56]	2022	Turkey	765	university students who received health education during the COVID–19 pandemic F = 626; M = 139	-	ORTO–11; EAT–26; FCV–19S	Fear of COVID–19 is associated with an increased inclination toward ON.
Dell'Osso et al. [57]	2022	Italy	2140	University students with or without AT F = 1414 M = 726	23.80 ± 4.80	ORTO-R; AdAS Spectrum	The high AT group scored significantly higher than the low AT group In the overall sample, women reported substantially higher ORTO-R scores Patients who followed a vegetarian/vegan diet exhibited considerably higher scores than those following an omnivorous diet

3.2.3 Athletes

Another group of particular interest for research on the prevalence of ON was that of athletes and regular gym goers.

Acknowledging the enlarged denomination of "athletes", we decided to insert in this paragraph one of the first studies that were carried out on such a population, specifically on performance artists from the State Opera and Ballet and the Bilkent University Symphony Orchestra. Such a study was carried out by Aksoydan and Camci[59] on a sample of 94 artists (F = 55; M = 39; mean age: 33.2 ± 10.88), assessed with the ORTO-15. Results showed a mean score of 37.9 ± 4.46, and 56.4% of the artists obtained a score diagnostic for ON. Among the artists, opera singers showed the highest prevalence of ON (81.8%) when compared with ballet dancers (32.1%) or symphony orchestra musicians (36.4%). No significant differences were found between ORTO-15 scores and age, gender, educational level, BMI, or other baseline characteristics. Notably, the study group presented a high prevalence of ON, leading the authors to suggest that this result may have been due to the higher socio-economic and educational level of Turkish artists compared to the general population, and to the role model they assume in terms of lifestyle and physical appearance.[59]

Similarly, in 2014 Herranz Valera et al.[60] investigated the prevalence of ON in a Spanish Ashtanga Yoga Community. Sociodemographic questions, eating habits questions, and ORTO-15 test were administered to 136 alumni (F = 89; M = 47; mean age: 36.96 ± 6.69). Results highlighted an ON prevalence of 86% using the 40-point threshold and 43.4% with the 35-point one. Interestingly, scores were higher than those collected by previous studies among the general population. No significant association with age or BMI was recorded. Females were generally more affected by ON, although the difference was not statistically significant. Results showed a significant association between the ORTO-15 score and vegetarianism.[60]

Almeida et al. in 2017 evaluated the prevalence of ON in a non-random sample of 193 Portuguese adult fitness class participants (F = 113; M = 80; mean age: 32.81 ± 11.58), including their common characteristics.[61] The subjects answered a Portuguese version of the ORTO-15 questionnaire, together with additional questions. Using the cut-off score of 35 points, ON prevalence resulted in 51.8% of the sample, with a mean score of 34.43 ± 4.23. The results showed a statistically significant association between ON and younger ages, with a mean age in the ON group of 30.96 ± 1.04 versus 34.80 ± 1.30 in the no-ON group. ON was also associated with physical appearance, and frequent exercising, while no correlation with gender and educational field was found. Furthermore, consumption of special food, dissatisfaction with physical appearance, and frequent exercising seemed to be predictors of the presence of ON in the sample. The authors concluded that, despite the use of a convenience sample, these results showed that ON was not exclusively concerned about pursuing a pure diet, but it was associated also with other non-dietary behaviors, allied to a healthy lifestyle and aesthetic concerns.[61]

Another study on athletes was carried out by Bona et al., who evaluated the demographic characteristics, health and exercise practices, and other correlates of orthorexic symptoms among gym goers in Hungary. The sample was composed of 207 subjects (mean age: 31.9 ± 8.7) assessed with the ORTO-11, the EDI-2, and the Maudsley Obsessional-Compulsive Inventory (MOCI), which gauges OCD by recognizing self-reported obsessions and compulsivity.[62] Results showed a mean ORTO-11 score of 27.7 ± 5.1 and highlighted how these symptoms were significantly correlated with two eating disorder features (desire for thinness and interpersonal distrust), a younger age, daily exercise, and yoga practice, but not

with obsessive-compulsive characteristics. Moreover, higher EDI scores were linked to higher orthorexic tendencies.

In the same year, Bert et al. aimed to assess the prevalence of ON in endurance athletes and to compare the results with a sedentary population and in athletes playing other sports, in Northern Italy.[63] Socio-demographics data, physical activity level, type of diet, ORTO-15 scores, and EHQ values were collected from a sample of 549 individuals (F = 139; M = 407; mean age: 26.7 ± 5.39), recruited among participants in local sports events. Setting an ORTO-15 score cut-off of 40, ON was present in 68.8% of the "No sport" group, in 71.1% of the "Sport <150 minutes/week") and in 72.8% of "Sport>150 minutes/week". Setting the cut-off to 35 points, these percentages were reduced to 19.9%, 24.4%, and 21.5% respectively. Interestingly, none of the above-mentioned differences between groups were significant. Analyzing the ORTO-15 final scores as a continuous variable showed that, among different socio-demographics and behavioral variables, the adhesion to a dietary treatment plan was the only one statistically predictive of lower ORTO-15 scores. Otherwise, the EHQ score resulted to be positively correlated with endurance sport practice >150 minutes/week.[63]

Similarly, Clifford et al. explored the prevalence of ON among British university students and its relation to sports habits.[64] The global sample was composed of 215 subjects (F = 141; M = 74) divided into 116 athletes (SA, mean age: 21 ± 1) and 99 non-athlete controls (NAS, mean age: 21 ± 2). Participants were assessed with the ORTO-15, and the global prevalence using the 40-point cut resulted to be 76%, with no significant difference between the two groups (36.6 ± 3.9 versus 37.2 ± 3.8; *p* = 0.279). Interestingly, subjects who performed more than 10 h of exercise per week scored significantly lower than those who did less than 10 h a week (36.65 ± 4.38 versus 37.38 ± 3.65). Despite the intrinsic limits of the ORTO-15 test, the study failed to identify the condition of being a student-athlete as a risk factor for ON, although there is a greater risk for those who undertake high volumes of exercise.[64]

In a similar way, Özdengül et al.[65] compared the prevalence of ON among three different groups of subjects, based on the level of physical activity. Overall, a total of 878 participants were evaluated; 514 belonged to the sedentary group (F = 312; M = 202; mean age: 28.57 ± 10.98), 271 to the recreationally active group (F = 143; M = 128; mean age: 29.70 ± 10.98), and 92 were competitive athletes (F = 46; M = 46; mean age: 30.51 ± 12.4). Participants were evaluated with the ORTO-11 and the ORTO-R. This time, results showed no differences in the ORTO-R scores between people who engaged in different levels of physical activity, nor any gender-based difference.

Uriegas and co-workers, examined instead the risk for ON and EDs in collegiate athletes, and their relation with gender and sport types.[66] The sample included 1090 individuals (F = 756; M = 334; mean age: 19.6 ± 1.4). The sample was evaluated with questionnaire regarding demographics and pathogenic behaviors, the ORTO-15 test (<40 and < 35 threshold values), and the EAT-26. Using the <40 threshold value for the ORTO-15, 67.9% were at risk for ON, while with the <35 cut-off only 17.7% were at risk. Female gender influenced these results positively, with both thresholds. Overall, the ED risk (EAT-26 and/or pathogenic behavior) resulted in a 20.9% prevalence, with significant differences across sex (higher in females) and sport-type (higher in endurance) categories. Multiple logistic regressions indicated a significant association between EAT-26 subscales scores and ON, and between ORTO-15 scores, and risk for EDs. The authors concluded that the risk for ON and ED was present in the evaluated population.[66]

In 2022, the prevalence of ON in athletes from Croatia was investigated by Martinovic et al.[67] In this cross-sectional study, a

total of 300 subjects were recruited (F = 135; M = 165: mean age: 24.2 ± 4.8); the final sample was made of 150 Professional athletes (PA) (F = 63; M = 87; mean age: 24.5 ± 4.0) and 150 Recreational athletes (RA) (F = 72; M = 78; mean age: 24.0 ± 5.5) that were assessed using the ORTO-15 questionnaire, the International Physical Activity Questionnaire (IPAQ) and the Mediterranean Diet Serving Score (MDSS). Significant differences between PA and RA were found in BMI, body weight, body height, and educational level (the higher percentage of subjects finished high school among PAs, while it was most common to have a master's degree in the RAs). Moreover, the prevalence of ON (cut-off score < 35) was significantly higher in the PA than in the RA group (56% vs 32%). PA was also more adherent to the Mediterranean Diet compared to the RA. According to the authors, a possible interpretation of these results may be that PAs were more concentrated on their healthy dietary patterns than RAs, at the price of having a higher risk of developing ON.[67]

The same year, Yesildemir and co-workers conducted a study to determine the prevalence of ON among people who exercise regularly (twice a week) and to identify associated factors.[68] A total of 206 individuals (F = 104; M = 102) were included. The ORTO-15 test was applied to the participants. With the ORTO-15 cut-off of 40 points, a total of 168 (81.5%) resulted in being affected by ON. Gender, marital status, education, and income did not relate to orthorexic tendency, although exercise frequency was significantly higher in individuals with ON than in non-ON individuals.

Some differences in total, carbohydrate-derived, and protein-derived energy intake were found between ON/gender status. Body weight, percentage of body fat, and BMI were higher in orthorexic females than in non-orthorexic females. The authors concluded that individuals who exercise regularly shared a higher risk of developing ON.[68]

Lastly, in 2023, Athanasaki et al.[69] investigated the prevalence of ON (using the ORTO-15 questionnaire) among a cohort of 96 professional dancers (F = 92; M = 3; other = 1; mean age: 23.41 ± 5.13) in Greece, as well as its relationship with nutrition (Mediterranean Diet), BMI, body image flexibility (using the Body Image-Acceptance and Action Questionnaire 5, BI-AAQ-5), and parental bonding, using the parental bonding instrument (PBI). The whole sample was dichotomized according to BMI in a normal-weight and underweight group. Results showed a global ON prevalence of 74% (cut-off <40), with a mean score of 35.75 ± 5.69. Body image inflexibility was linked with ON symptoms in the normal-weight but not in the underweight group, and was significantly correlated with a low bonding relationship as perceived in childhood.[69]

Overall, 11 studies examined prevalence rates in athletes; prevalence rates ranged between 20.58% (according to the threshold value of >35 of the ORTO-15) and 86% (according to the threshold value of >40 of the ORTO-15).

The results of the studies discussed above are summarized in Table 3.

Table 3. Prevalence of ON in athletes

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Aksoydan et al.[59]	2008	Turkey	94	Performance artists F = 55; M = 39	33.2 ± 10.88	ORTO–15	ON prevalence of 56.4%, with an average score of 37.9 ± 4.46. Opera singers had the highest ON prevalence (81.8%) compared to symphony orchestra artists (36.4%) or ballet dancers (32.1%), and this different ON prevalence was statistically significant. No differences were found between ORTO–15 scores and other baseline characteristics.
Herranz Valera et al.[60]	2014	Spain	136	Ashtanga Yoga Community F = 89, M = 47	36.96 ± 6.69	ORTO –15	Mean ORTO–15 score of 35.27 ± 3.69. ON prevalence of 86% using the 40-point threshold, and 43.4% with a 35-point. No significant association with age or BMI. but positive correlation with vegetarianism.
Almeida et al.[61]	2017	Portugal	193	Gym members F = 113; M = 80	32.81 ± 11.58	ORTO–15	Overall ON prevalence of 51.8% (ORTO–15 score < 35). Association with younger ages, dissatisfaction with physical appearance, consumption of special food, and frequent exercising. No correlation between gender and the educational field.
Bona et al.[62]	2019	Hungary	207	Hungarian gym attendees F = 140; M = 67	31.9 ± 8.7	ORTO–11; EDI–2; MOCI	Orto–11 score significantly correlated with Higher EDI–2 scores, desire for thinness and interpersonal distrust, a younger age, daily exercise, and yoga practice, but not with OC characteristics.
Bert et al.[63]	2019	Northern Italy	549	Sport local event participants F = 139 M = 407	26.7 ± 5.39	ORTO–15, EHQ	Overall ON prevalence of 20.58% with a cut-off score of < 35, 69.22% with a cut-off score of < 40. No correlation between ORTO–15 scores and physical activity level, while dietary restrictions were significantly correlated with lower scores of ORTO–15.
Clifford et al.[64]	2019	Britain	215	116 SA and 99 NSA F = 141, M = 74	SA:21 ± 1 NAS: 21 ± 2	ORTO–15	Overall ON prevalence of 76%, (cut-off <40). No significant difference between the SA and NAS. Lower scores for those who completed ≥10 h of exercise per week than those who did ≤10 h a week.

Table 3. *Continued*

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Özdengül et al. [65]	2021	Turkey	877	Total: 877 (F = 501; M = 376) Sedentary: 514 (F = 312; M = 202); recreationally active: 271 (F = 143; M = 128); competitive athletes: 92 (F = 46; M = 46)	Total: 29.12 ± 11.15 Sedentary: 28.57 ± 10.98; recreationally active group: 29.70 ± 10.98; competitive athletes: 30.51 ± 12.4	ORTO–11; ORTO-R	No differences between people who engaged in different levels of physical activity. No gender-based differences.
Uriegas et al. [66]	2021	United States	1090	Collegiate student-athletes F = 755; M = 334	19.6 ± 1.4	ORTO–15, EAT–26	ON prevalence of 67.9% (<40 cut-offs) and 17.7% (<35 cut-offs). Higher ON tendencies in females for both thresholds. EAT–26 and/or pathogenic behavior in 20.9%, with differences across gender and sport type. Significant association between EAT–26 subscales scores and ON, and between ORTO–15 scores, and risk for EDs.
Martinovic et al. [67]	2022	Croatia	300	Total: 300 (F = 135, M = 165) PA: 150 (F = 63; M = 87) RA: 150 (F = 72; M = 78)	Total: 24.2 ± 4.8 PA: 24.5 ± 4.0 RA: 24.0 ± 5.5	ORTO–15, IPAQ-SF, MDSS	PA had lower BMI, and educational level, higher body weight, and height. ON (cut-off <35) was more prevalent in PA than in RA (56% vs 32%, p < 0.001).
Yesildemir et al. [68]	2022	Turkey	206	Exercisers F = 104, M = 102	F: 26.5 ± 9.07 M: 25.8 ± 7.86	ORTO–15	Overall ON prevalence of 81.5%. Gender, marital status, education, and income did not relate to orthorexic tendency, although exercise frequency was significantly higher in individuals with ON than in non-ON individuals. Body weight, percentage of body fat, and BMI were higher in orthorexic females than in non-orthorexic females. Individuals who exercise regularly are at risk of developing ON.
Athanasaki et al. [69]	2023	Greece	96	Professional dancers F = 92; M = 3; Other = 1	23.41 ± 5.13	ORTO–15, BI-AAQ–5, PBI	ON was present in 74% (cut-off score < 40). Significant correlation with BMI and body image inflexibility. Body image inflexibility was significantly correlated with a low bonding relationship as perceived in childhood.

3.2.4 Subjects with restricted dietary regimes

The investigation of orthorexic symptoms in subjects following dietary regimes is gaining increasing interest and relevance.

In this framework, Barthels[70] investigated ON in a sample of vegans and vegetarians and in a sample of individuals on a diet to lose weight. For this purpose, two main samples were recruited: the first was composed of 351 volunteers divided into four subgroups, *vegan, vegetarian, rare meat consumption*, and *frequent meat consumption*, based on their dietary habits; the second was made of 406 subjects divided into: *diet with dietary change, diet without dietary change*, and *no diet control group*. Results highlighted how vegetarian and vegan individuals had higher levels of orthorexic symptoms than individuals who usually eat meat. However, their DOS mean score did not exceed the cut-off for pathological ON, thus suggesting that vegan/vegetarian habits were not linked to pathological eating behaviors. Moreover, diets that significantly altered eating behavior produced more orthorexic manifestations than diets that did not alter daily eating behaviors.[70]

Parra-Fernandez et al.[71] compared people with vegan, vegetarian, and omnivorous diets in terms of ON behaviors and looked at their main reasons for being on diet, attitudes, and behaviors related to food. The study sample was made of 466 volunteers recruited online: 101 vegans (F = 79; M = 22; mean age: 33.3 ± 11.1), 109 vegetarians (F = 90; M = 19; mean age: 29.2 ± 11.1), and 256 omnivores (F = 185; M = 71; mean age 33.0 ± 11.7). All participants were evaluated with the ORTO-11 and the Food Choice Questionnaire (FCQ-SP). Results showed that 58.2% of vegans, 24.1% of vegetarians, and 17.7% of omnivores were at risk for ON behaviors, implying that people who maintain a dietary restriction - in this case, abstaining from meat or other animal products - may be more prone to exhibit a pathological obsession with good eating. Another aim of the study was to compare the reasons behind the food choices of those who follow vegan, vegetarian, and omnivorous diet patterns. Results highlighted that those who were at risk of developing ON were less motivated to choose foods based on their mood, their health, the natural content of the food, and weight control than those who had normal eating habits, which in turn were not at risk of developing ON. This would suggest that people who are more likely to develop ON may use food to control their emotions, both positive (like relaxation and feeling good) and negative (like tension) ones, to a lesser extent than people who are not at risk of getting ON. It is possible, therefore, that they manage their emotions more adaptively than people who are not at risk for ON.

Table 4. Prevalence of ON in subjects following restricted dietary regimes

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Barthels et al. [70]	2017	Germany	757	Vegetarians & Vegans: 351 (F = 221; M = 130) Restrained eating behaviors: 406 (F = 321; M = 85)	Vegetarians & Vegans: 32.2 ± 10.1 Restrained eating behaviors: 30.7 ± 10.92	DOS-RS	higher levels of orthorexic symptoms in vegetarian and vegan individuals. Diets that significantly altered eating behavior produced more orthorexic manifestations than diets that did not alter daily eating behaviors. No differences were found regarding restrained eating.
Parra – Fernandez et al. [71]	2020	Spain	466	Total: 466 (F = 354; M = 112) Vegans: 101 (F = 79; M = 22) Vegetarians: 109 (F = 90; M = 19) Omnivores: 256 (F = 185; M = 71)	Total: 32.2 ± 11.08 Vegans: 33.3 ± 11.1 Vegetarians: 29.2 ± 11.1 Omnivores: 33.0 ± 11.7	ORTO–11; FCQ-SP	58.2% of vegans, 24.1% of vegetarians, and 17.7% of omnivores were at risk for ON behaviors.
Voglino et al. [72]	2021	Italy	240	OSC:121 Non-OSC: 119 F = 165, M = 75	44	ORTO–15, EHQ	Overall prevalence of ON of 61.3% (cut-off <40), and of 16.3% (cut-off 35). OSCs had a higher probability to result positive at ORTO–15 compared to non-OSCs, with both cut-offs. Higher EHQ scores were reported among OSCs. Potential predictors were being an OSC or following food restrictions.

Lastly, in 2021, Voglino et al.[71] explored the prevalence and risk factors for developing ON among Italian organic store customers (OSCs), a special subgroup at risk of developing EDs. Their cross-sectional survey was carried out on a total of 240 subjects (F = 165; M = 75; mean age: 44): 121 OSCs and 119 non-OSCs assessed with the ORTO-15 and the EHQ. As the main results, OSCs had a higher probability to result positive at ORTO-15 compared to non-OSCs, both with 40 and 35 cut-off. The positivity at ORTO-15 among OSCs was 69.4% and 23.1% (40 and 35 cut-off). Significantly lower ORTO-15 and higher EHQ scores were reported among OSCs. Potential predictors were mainly being an OSC or following food restrictions, with some other predictors variations using different cut-off of ORTO-15 and EHQ. These results suggested an association between OSCs and ON symptoms.[72]

Overall, three studies examined prevalence rates in subjects with restricted dietary regimes; prevalence rates ranged between 16.3% (according to the threshold value of >35 of the ORTO-15) and 61.3% (according to the threshold value of >40 of the ORTO-15).

The results of the studies discussed above are summarized in Table 4.

3.3 Prevalence of ON among clinical populations

Another branch of research focused instead on assessing ON in clinical populations, including patients with psychiatric disorders but also subjects suffering from a variety of other illnesses.

3.3.1 Psychiatric disorders

In the framework of the conceptualization of ON as a new FED, one of the first studies examining its prevalence was carried out in a sample of women with eating disorders.[73] The authors compared a sample of 32 patients with AN or BN, evaluated by means of the ORTO-15, the Yale-Brown-Cornell Eating Disorder Scale (YBC-EDS) and the Eating Attitude Test (EAT-26) before (t0) (mean age: 7.7 ± 3.5) and 3 years after their treatment (t1) (mean age: 22.2 ± 3.4), and compared them to 32 female HC matched by gender, age, and BMI at t1 (mean age: 21.9 ± 3.4). Results showed a significantly higher

percentage of patients either at t0 (28%) or t1 (58%) resulted positive to the ORTO-15 questionnaire, if compared to controls (6%). YBC-EDS and EAT-26 scores were higher among ED patients than among HCs, although they decreased from t0 to t1.[73]

Soon later, Gramaglia et al. investigated whether there was any difference in orthorexic behaviors between female patients with AN and HC from different cultural contexts.[74] The sample included 23 AN patients and 39 HCs from Italy as well as 35 AN and 39 HCs from Poland. The orthorexic behavior was measured with the ORTO-15 test (cut-off <40 points). Statistically significant differences were found between Italian women in the AN and HC group (60.9 versus 46%), but none among Polish women (85.6 versus 82%). Both Italian groups scored significantly higher than the Polish ones on the ORTO-15. This study highlighted possible cross-cultural differences in ON, both in the percentage of orthorexic behaviors and in the mean ORTO-15 scores in the AN and HC groups.[74]

Busatta and co-workers, in 2020, investigated the prevalence of ON between ED patients, student dietitians (SD), and the general population (control group, CG).[75] The final sample consisted of 90 female subjects, including 30 ED patients (mean age: 21.89 ± 3.17), 30 SD (mean age: 22.70 ± 3.10), and 30 CG (mean age: 22.41 ± 3.11). ORTO-15, EDE-Q, and Symptom Checklist-90-Revised (SCL-90-R) were used to assess ON, ED, and general psychopathology, respectively. Compared to the other groups, ED patients showed a higher prevalence of ON, and higher EDE-Q and SCL-90-R scores, while there were no statistically significant differences between the SD and CG groups. In addition, ORTO-15 scores were negatively correlated with the EDE-Q total score in the ED group but not in the SD or CG groups, which implies a more severe ED psychopathology in-patients with higher orthorexic tendencies.[75]

Vaccari et al.[3] analyzed the prevalence of ON symptoms in a "high risk" category represented by subjects suffering from OCD (N = 50) comparing them to two control groups: one composed of subjects suffering from other psychiatric disorders belonging to the anxiety-depressive spectrum (N = 42) and one composed of subjects with no psychiatric conditions (N = 236). All subjects were

assessed with the OCI-R, the ORTO-R, and the ORTO-15; for the latter, a cut-off score of 40 was used. Results highlighted an overall prevalence of ON assessed with the ORTO-15 of 59.5% and a higher prevalence of ON symptoms in the OCD sample but only after introducing the revised version of the ORTO-15, the ORTO-R, thus supporting the hypothesis of an underlying correlation between ON and OCD.

Similarly, Hessler-Kauffman et al.,[76] analyzed the prevalence of ON among in-patients with mental disorders, evaluating their responses at the time of admission and discharge, using the DOS-21 and the EDI-2. Of the 1167 participants who completed the assessment at the moment of admission, only 647 completed the evaluation at the time of discharge. It was observed that orthorexic tendencies at entry were more marked among patients with other FED, while in the other diagnostic groups, the prevalence was comparable to that of non-clinical samples. Furthermore, orthorexic features showed a stronger association with restrictive behaviors rather than with binge/purging behaviors, confirming the greater association between ON and AN compared to BN. Lastly, orthorexic symptoms were more pronounced at the time of admission, suggesting that also ON tendency may have responded to the administered treatment.[76]

Overall, five studies examined prevalence rates in subjects with a mental disorder; prevalence rates ranged were estimated to be higher in-patients with a diagnosed ED or OCD compared to HCs, with an ON prevalence of up to 85.6% in Polish women with AN.

The results of the studies discussed above are summarized in Table 5.

3.3.2 Nonpsychiatric illnesses

Pökön et al.[77] assessed a sample of 801 people aged above 18 (F = 452; M = 349; mean age: 31.5 ± 10.9 years) with a BMI under 25 (mean BMI: 22.1 ± 2.2 kg/m^2), who were admitted to the family medicine clinics of a tertiary hospital between April 2017 and October 2017, looking for the prevalence of ON. All the subjects were assessed with ORTO-11, obtaining a mean score of 25.1 ± 4.5 points. In the 18–30 age group, the mean ORTO-11 score was 25.8 ± 4.5; in the 31–50 age group, it was 24.6 ± 4.4; and in the over 50 age group, it was 22.6 ± 4.4 ($p < 0.001$). Results showed that 505 (63.0%) participants tested positive for the presence of the ON inclination and that age and ORTO-11 score were negatively correlated, meaning that higher age was associated with lower ORTO-11 scores.

Another interesting study involved a sample of post-partum women. According to the available literature, the majority of women experience body image issues during the postpartum time due to physiological and medical changes. As a result, they tend to alter their lifestyles, which can put new moms at risk for the development of ON. In this framework, Ayham Baser et al.[78] aimed to evaluate postpartum women's inclinations toward ON and look into its associated aspects. For this purpose, 511 women who recently gave birth (mean age: 31.92 ± 4.44 years) were assessed with the ORTO-11 and a questionnaire form investigating the mother's sociodemographic and anthropometric traits, health state, delivery and feeding characteristics, and details of their lifestyle modifications. The overall ORTO-11 mean score was 22.68 ± 4.09 and it was significantly correlated with age, employment status, occupation, and family structure. Results showed that

Table 5. Prevalence of ON in psychiatric patients

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Segura-Garcia et al. [73]	2015	Italy	64	Women with ED (pre and after treatment) and HC	ED: t0:17.7 ± 3.5; t1:22.2 ± 3.4; HC: 21.9 ± 3.4	ORTO–15 YBC-EDS EAT–26	Significantly higher percentage of patients positive to ORTO–15 questionnaire at both times of evaluation. Higher YBC-EDS and EAT–26 scores among ED patients.
Gramaglia et al. [74]	2017	Italy and Poland	136	Women with AN and healthy Controls	Ita AN 30.39 Ita HC 34.41 Pol AN 22.97 Pol HC 23	ORTO–15	Significant difference in the prevalence of ON in Italian groups (60.9% versus 46%), but none among Polish women (85.6 versus 82%). Italian groups scored significantly higher than the Polish ones on the ORTO–15. scores in the AN and HC groups.
Busatta et al. [75]	2020	Italy	90	Females ED:30 DS: 30 CG: 30	ED: 21.89 ± 3.17 SD: 22.70 ± 3.10 CG: 22.41 ± 3.11	ORTO–15 EDE-Q SCL–90-R	ED group had significantly higher ON prevalence than other groups. No differences were observed between SD and CG groups. ON was positively correlated to ED psychopathology in ED patients, but not in SD or CG groups.
Vaccari et al. [3]	2021	Italy	328	Total: N = 328 (F = 186; M = 142) OCD: N = 50 (F = 16, M = 34) Control 1: N = 42 (F = 35, M = 7) Control 2: 236 (F = 135, M = 101)	Total: 36.5 ± 13.8 OCD: 38.3 ± 12.7 Control 1: 46.2 ± 13.7 Control 2: 34.5 ± 13.5	ORTO–15, ORTO-R, OCI-R	Higher prevalence of ON symptoms in the OCD sample.
Hessler-Kauffman et al. [76]	2021	Germany	1167	Mental Health In-patients of Munich Hospital	-	DOS EDI–2	Greater ON tendencies among patients with ED at the admission Association between ON tendencies and restrictive behaviors. Orthorexic traits more pronounced at the admission.

87.7% of the sample was at risk for developing ON, suggesting that post-partum women had a significant predisposition for ON. Moreover, 35.2% of the participants reported that, after delivering the child, they changed their eating habits completely (both the frequency and the order of their meals); interestingly, in this subgroup, the mean ORTO-11 score was 22.15 ± 3.645, and 91.3% of the population had strong orthorexic tendencies.

Another important study investigated ON prevalence in 93 young adult women with cancer (mean age: 31.4 ± 4.8).[79] All participants were assessed with the DOS and the EHQ. Results showed how 36.7% of the sample reported ON symptoms, suggesting that a cancer diagnosis may motivate them to modify behaviors believed including eating habits.[79] Higher levels of body image dissatisfaction associated with cancer and longer educational tenure were correlated with higher perceived nutrition knowledge, while a positive correlation between the severity of orthorexic symptoms and intolerance to uncertainty, and between eating habit problems and fear of cancer recurrence were close to statistical significance, together with a negative correlation between internet use and feelings of well-being related to eating healthily. After receiving a cancer diagnosis, 44.1% of young adult women altered their overall eating habits, and 69.5% planned to do so within the next year.

In 2022 Kujawowicz et al.[80] administered the ORTO-15 test to investigate the prevalence of ON in individuals diagnosed with celiac disorder, in the Polish population. The sample consisted of 123 women (mean age: 34 ± 8.7), with 76% being celiac patients for at least 3 years, and 24% newly diagnosed. All the subjects declared a strict adherence to a gluten-free diet. The median BMI was 21.4 kg/m^2, with a normal body weight observed in 73%. Common comorbidities were lactose intolerance (23%) and Hashimoto's disease (22%). The mean score of the ORTO-15 test was 37.73 ± 5.45 points, and the risk of ON resulted in 71% at the 40 cut-off point and 32% at the 35 cut-off point. Interestingly, a positive correlation was found between age and ORTO-15 scoring in the Spearman correlation test. Other statistically significant results were found after dividing the sample into two groups: in the group with ON risk, meals were more commonly self-prepared (94% vs 78%), the concern about food was higher (64% vs 8%), but the attention to the caloric content of food was less likely (46% vs 69%). However, the authors stressed the difficulties of assessing ON in the specific population of subjects with celiac disease.[80]

One year later, Cosentino et al.[81] investigated the prevalence of ON in 44 patients with type 1 diabetes (T1D) (F = 27; M = 17; mean age: 39.7 ± 15.7) and 44 genders and age-matched HC (F = 27; M = 17; mean age: 40.2 ± 16.2). All participants were assessed with the ORTO-15, the DOS, the EDE-Q, and the Brief Symptom Inventory (BSI). Results showed an ON prevalence of 72% in the T1D group and of 65% in the HC group (cut-off score of <40) according to the ORTO-15. No association between any of the metabolic indicators and the psychometric tests in T1D was highlighted. Patients with T1D demonstrated higher scores than HC at the DOS but not on the ORTO-15 questionnaire, without any significant link with metabolic parameters, despite the fact that the prevalence of ON was not significantly higher in T1D than in controls.[81]

Lastly, in 2023 Sifakaki[82] published a cross-sectional study to evaluate ON tendencies in a sample of 133 adult patients (F = 126; M = 7; mean age: 46.52 ± 9.78) suffering from rheumatoid arthritis using the ORTO-15 questionnaire. More than half of the patients were overweight/obese (53.4%). The median ORTO-15 score reached 36, revealing significant ON tendencies in the sample, although no specific cut-off was set. The univariate linear regression analysis revealed that greater ON tendency was associated with the female gender, while lower ON tendencies with older age and BMI. The paper also highlighted the need for a detailed assessment of the problem of ON in-patients with RA.[82]

Overall, six studies examined prevalence rates in clinical subjects without mental disorders; prevalence rates ranged between 36.7% (assessed with the DOS) and an ON risk of 87.7% (according to the ORTO-11).

The results of the studies discussed above are summarized in Table 6.

4. Discussion

Since its conceptualization, ON has been the focus of many studies that aimed to assess its prevalence in different populations and identify its sociodemographic and clinical correlates. Reviewing data about possible ON prevalence ultimately leads to substantially heterogeneous results, firstly depending on the specific population.

Studies conducted on the general population showed an ON prevalence ranging between 6.9% when assessed with the DOS, and 57.6% when evaluated with the ORTO-15 threshold score of <40[24,27]; interestingly, the heterogeneity of these results is significantly reduced considering the threshold value of <35 for the ORTO-15 (14.6%). This great variability suggests that ORTO-15 may not reflect the clinical prevalence of ON but rather specific orthorexic-like features that for the majority of the people may remain non-impairing. ON tendencies were mainly associated with a heightened sense of self-esteem from eating healthy food, guilt when straying from diet, and avoidance of eating away from home,[23] while they were negatively correlated with a higher grade of scholarity.[24,27] However, results about the associations with gender were contrasting.[26,28]

One of the most investigated populations were students with different levels of education. Studies reported a prevalence varying between 1.12% when assessed with the BOS-T[31] and 79.7% in studies considering the ORTO-15 threshold score < 40,[14] suggesting still that ORTO-15 fails to distinguish between healthy eating and pathologically healthful eating, thus overestimating the real prevalence.[36,41] While studies that have analyzed the association with BMI have consistently reported a positive correlation between ON trend and lower BMI,[14,16,42,45] results from studies investigating the correlation with gender and dietary habits were sometimes contrasting. Indeed, while some authors highlighted a positive correlation between ON and a vegetarian or vegan diet[14,40,43,52,57] and the female gender,[16,39,40,42,52,53,55,57] others reported that vegans had less pathological scores[36] and that the male gender was positively correlated with ON tendencies.[33,45] Interestingly, in this population, some authors also suggested AT as a predictive factor for the presence of ON symptomatology.[47,57] Another peculiar correlation that emerged concerned the choice of study course and, in particular, the enrollment in healthcare-related degree courses for which some authors suggested the possibility of future problematic issues if these behaviors are not timely corrected.[32,44]

Studies conducted on athletes involved an extremely heterogeneous population ranging from classical dancers to yoga practitioners and gymgoers. ON prevalence was assessed with the ORTO-15 and its variants and spaced between 43.4% with the 35-point threshold score and 86% using the 40-point threshold.[60] Interestingly, in this population, no significant differences were found between genders, educational levels, BMI, or other baseline

Table 6. Prevalence of ON in non-psychiatric patients

Study	Date	Country	Sample size	Population	Mean age	ON scale	Main findings
Vaccari et al. [3]	2021	Italy	328	Total: N = 328 (F = 186; M = 142) OCD: N = 50 (F = 16, M = 34) Control 1: N = 42 (F = 35, M = 7) Control 2: 236 (F = 135, M = 101)	Total: 36.5 ± 13.8 OCD: 38.3 ± 12.7 Control 1: 46.2 ± 13.7 Control 2: 34.5 ± 13.5	ORTO–15, ORTO-R, OCI-R	higher prevalence of ON symptoms in the OCD sample.
Pökön et al. [77]	2021	Turkey	801	Non-obese individuals (F = 452 M = 349)	31.5 ± 10.9	ORTO–11	ORTO–11 mean score of 25.1 ± 4.5 points. 505 (63.0%) participants tested positive for the presence of the ON inclination. Negative correlation between age and ORTO–11 score.
Ayham et al. [78]	2021	Turkey	511	Postpartum Women	31.92 ± 4.44	ORTO–11	Overall ORTO–11 mean score of 22.68 ± 4.09, significantly correlated with age, employment status, occupation, and family structure. 87.7% of the sample at risk for developing ON. 35.2% of the participants after giving delivery, changed their eating habits completely; in this subgroup, the mean ORTO 11 score was 22.15 ± 3.645, and 91.3% had strong orthorexic tendencies.
Waterman et al. [79]	2022	Canada	93	Women recruited trough social media and cancer organizations	31.4 ± 4.8	DOS EHQ	Overall ON prevalence of 36,7% suggesting that cancer diagnosis may motivate to modify eating behaviors.
Kujawowicz et al. [80]	2022	Poland	123	Women with Celiac disease F = 123	34 ± 8.7	ORTO–15	ON risk prevalence of 71% (cut-off<40) and 32% (cut-off <35). Positive correlation between age and ORTO–15 test scores.
Cosentino et al. [81]	2023	Italy	88	Patients with type 1 diabetes and controls (F = 54; M = 34)	T1D: 39.7 ± 15.7 HC: 40.2 ± 16.2	ORTO–15; DOS; EDE-Q; BSI	ON prevalence of 72% in the T1D group and of 65% in the HC group (cut-off score of <40). No association between any of the metabolic indicators and the psychometric tests in T1D. Patients with T1D demonstrated higher scores on certain, but not all, measures indicating ON.
Sifakaki et al. [82]	2023	Greece	133	Patients with rheumatoid arthritis F = 126, M = 7	46.52 ± 9.78	ORTO–15	Median ORTO–15 score of 36. Greater association with female gender, lowered tendencies with older age and BMI.

characteristics,[59–61,65] while some studies reported an association between ON prevalence, younger age[61,62] and vegetarianism.[60]

Moreover, growing interest is nowadays revolving around subjects following restricting dietary regimes and their possible psychopathological correlates. In this population, some studies collected reported a significant correlation between ON and restrictive dietary habits, with a prevalence of 58.2% in vegans and 24.1% in vegetarians when assessed with the DOS.[71] Contrariwise, other authors suggested that vegan/vegetarian habits were not linked to pathological eating behaviors.[70]

Another branch of research focused on assessing ON behaviors in clinical populations, both in-patients with psychiatric disorders and in subjects suffering from other systemic illnesses. In the first case, most studies focused on assessing ON prevalence in clinical samples of patients suffering from other FEDs,[75,76] in particular, reporting a significantly higher prevalence of in-patients suffering from AN[73,74] and BN,[73] while other authors focused on its association with OCD, highlighting a higher prevalence of ON symptoms in the OCD subjects but only when evaluated with the ORTO-R.[3] Additionally, some authors described how orthorexic symptoms were more pronounced at the time of admission compared to discharge, suggesting that they may respond to certain types of treatment.[76] Moreover, studies focusing on non-psychiatric patients reported a significant predisposition for developing ON in post-partum women (87.7%),[78] in young adult women with cancer (36.7%),[77] in TD1 patients[81] and in-patients suffering from rheumatoid arthritis.[82]

Another element of heterogeneity is the instrument used for measuring ON, while one of the most used instruments, the ORTO-15, has been widely criticized in the literature.[83] Moreover, it has been suggested that one of the causes of important differences in ON prevalence rates may be due to the difference in psychometric qualities of the ORTO-15 based on the Country and respective language employed.[29,84–88] However, it is due to be said that the ORTO-15 was one of the first tools that, from the beginning, tried to shed light on this pathology while raising awareness among scientists and the general public about the early emergence of ON in our 21st-century culture increasingly focused on healthy eating.[39] Moreover, neither at the time nor today there is a consensus on ON diagnostic criteria, making it considerably more difficult to decide whether or not specific items should be included.[1,2,22] Contrarily, the DOS and the BOS-T are relatively new and their structure and established cut-off of the translations were fully maintained by the original authors of the questionnaires.[43,89] To this date, better outcomes have been recorded in the validation of these new tools, both in terms of construction and psychometric qualities,[43,84] encouraging researchers to carry out further research along this path to comprehend a still-unknown behavior.

An important limitation in assessing the actual prevalence of ON is that socio-cultural differences appear to be part of the discussion in many validated ON tools, especially in the ORTO-15 and the DOS.[84,89] Many societies have a well-established cultural relationship with food, increasing the difficulties in differentiating the desire to follow a healthy diet or lifestyle from demonstrating a fixation with the same, which is seen as compulsive eating behavior. Indeed, some cultures have traditionally placed a great priority on healthy food as the cornerstone of their way of life, but other civilizations may have quite different beliefs on the matter.[39] For instance, a study conducted in China by Jinbo He et al. revealed a prevalence of 7.8% using validation of the DOS, with the authors speculating that the risk of ON in this population may be higher given that it is a culture with a long history of maintaining a healthy diet.[85]

Another controversial factor that arose in many studies assessing the prevalence of ON is its possible correlation with gender. Indeed, while some studies reported a significantly higher risk of orthorexic behaviors in females,[24,27,30,90–92] others noted a greater prevalence among men[84,92–94] and some more did not find any type of correlation with sex.[24,50,59,95–97] The conclusion drawn from all of these findings is that ON may be less heavily linked to female sex than other restrictive eating disorders such as AN.

Our result should be seen in light of some important limitations. For instance, prevalence rates reported by many studies were particularly high, both in clinical and non-clinical samples, raising concerns about the reliability of the instruments used. Moreover, socio-cultural factors and translation of the questionnaire used may have influenced the results of some studies. Also, since for many studies the recruitment was carried out on a voluntary basis, it is possible to assume that people who identified with the characteristics described were more motivated to join and complete the tests, leading to an over-representation of ON in the sample assessed.

5. Conclusions

In conclusion, the different prevalence rates reported to this date in various studies prompt us to state that additional research involving clinical patients is necessary to support the development of a thorough, sensitive, and valid questionnaire for assessing the symptoms of ON. For instance, it appears pivotal the need for a unanimous and unambiguous definition of ON along with the formulation of standardized diagnostic criteria. This is essential for allowing a true and realistic assessment of ON, its prevalence, and its associated characteristics. Secondarily, we need a throughout revision of the available questionnaires, based on said definition and criteria, and precise cultural adaptation for specific contexts based on the culturally accepted relationship with food. Moreover, it is crucial to keep in mind that, while questionnaires are useful tools for patient screening in a clinical setting, they do not take the role of the clinician's diagnostic standards. Thus, in this framework, research should advance in both directions, by screening sizable populations who are prone to be at risk of ON, where a measurement tool would be helpful for prevention, and promoting the development of possible diagnostic criteria for clinical settings.

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References

1. Bratman S. Health food junkie. *Yoga J.* 1997;**136**:42–50.
2. Dunn TM, Bratman S. On orthorexia nervosa: A review of the literature and proposed diagnostic criteria. *Eat Behav.* 2016;**21**:11–17.
3. Vaccari G, Cutino A, Luisi F, Giambalvo N, Navab Daneshmand S, Pinelli M, Maina G, Galeazzi GM, Kaleci S, Albert U, Atti AR, Ferrari S. Is orthorexia nervosa a feature of obsessive-compulsive disorder? A multicentric, controlled study. *Eat Weight Disord.* 2021;**26**(8):2531–2544.
4. Dell'Osso L, Abelli M, Carpita B, Pini S, Castellini G, Carmassi C, Ricca V. Historical evolution of the concept of anorexia nervosa and relationships with orthorexia nervosa, autism, and obsessive-compulsive spectrum. *Neuropsychiatr Dis Treat.* 2016;**12**:1651–1660.
5. Davidson J. Diabulimia: how eating disorders can affect adolescents with diabetes. *Nurs Stand.* 2014;**29**(2):44–49.
6. Roosen KM, Mills JS. Exploring the motives and mental health correlates of intentional food restriction prior to alcohol use in university students. *J Health Psychol.* 2015;**20**(6):875–886.
7. McComb SE, Mills JS. Orthorexia nervosa: A review of psychosocial risk factors. *Appetite.* 2019;**140**:50–75.
8. Dell'Osso L, Nardi B, Benedetti F, Cremone IM, Casagrande D, Massimetti G, Carmassi C, Carpita B. Orthorexia and autism spectrum in University workers: relationship with gender, body mass index and dietary habits. *Eat Weight Disord.* 2022;**27**(8):3713–3723.
9. Dell'Osso L, Rucci P, Cassano GB, Maser JD, Endicott J, Shear MK, Sarno N, Saettoni M, Grochocinski VJ, Frank E. Measuring social anxiety and obsessive-compulsive spectra: comparison of interviews and self-report instruments. *Compr Psychiatry.* 2002;**43**(2):81–87.
10. Dell'Osso L, Amatori G, Cappelli A, Cremone IM, Massimetti G, Gravina D, Nardi B, Benedetti F, Chiarantini I, Luciano M, Berardelli I, Brondino N, De Gregorio M, Deste G, Nola M, Reitano A, Muscatello MRA, Pompili M, Politi P, Vita A, Carmassi C, Maj M. Catatonia spectrum: validation of a questionnaire investigating catatonia spectrum. *Front Psychiatry.* 2022;**13**:913286.
11. Dell'Osso L, Amatori G, Nardi B, Bonelli C, Gravina D, Benedetti F, Massimetti E, Cremone IM, Carpita B. Validation of the short version of the panic agoraphobic spectrum (PAS-SV) questionnaire. *Clin Neuropsychiatry.* 2023;**20**(2):151–156.
12. Bratman S. Orthorexia vs. theories of healthy eating. *Eat Weight Disord.* 2017;**22**(3):381–385.
13. Roncero M, Barrada JR, Perpiñá C. Measuring orthorexia nervosa: psychometric limitations of the ORTO-15. *Span J Psychol.* 2017;**20**:E41.
14. Hayes O, Wu MS, De Nadai AS, Storch EA. Orthorexia nervosa: an examination of the prevalence, correlates, and associated impairment in a university sample. *J Cogn Psychother.* 2017;**31**(2):124–135.
15. Poyraz CA, Tüfekçioğlu EY, Özdemir A, Baş A, Kani AS, Erginöz E, Duran A. Relationship between orthorexia and obsessive-compulsive symptoms in patients with generalised anxiety disorder, panic disorder and obsessive compulsive disorder. In *Yeni Symposium.* Vol. **53**, No. 4; 2015.
16. Dell'Osso L, Abelli M, Carpita B, Massimetti G, Pini S, Rivetti L, Gorrasi F, Tognetti R, Ricca V, Carmassi C. Orthorexia nervosa in a sample of Italian university population. *Riv Psichiatr.* 2016;**51**(5):190–196.
17. Carpita B, Muti D, Cremone IM, Fagiolini A, Dell'Osso L. Eating disorders and autism spectrum: links and risks. *CNS Spectr.* 2022;**27**(3):272–280.
18. Carpita B, Marazziti D, Palego L, Giannaccini G, Betti L, Dell'Osso L. Microbiota, immune system and autism spectrum disorders: an integrative model towards novel treatment options. *Curr Med Chem.* 2020;**27**(31):5119–5136.
19. Dell'Osso L, Cremone IM, Amatori G, Cappelli A, Cuomo A, Barlati S, Massimetti G, Vita A, Fagiolini A, Carmassi C, Carpita B. Investigating the relationship between autistic traits, ruminative thinking, and suicidality in a clinical sample of subjects with bipolar disorder and borderline personality disorder. *Brain Sci.* 2021;**11**(5):621.

20. Dell'Osso L, Lorenzi P, Carpita B. The neurodevelopmental continuum towards a neurodevelopmental gradient hypothesis. *J Psychopathol.* 2019; **25**(4):179–182.

21. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*, fifth edition, text revision. Washington: American Psychiatric Association; 2022.

22. Moroze RM, Dunn TM, Craig Holland J, Yager J, Weintraub P. Microthinking about micronutrients: a case of transition from obsessions about healthy eating to near-fatal "orthorexia nervosa" and proposed diagnostic criteria. *Psychosomatics.* 2015;**56**(4):397–403.

23. Kinzl JF, Hauer K, Traweger C, Kiefer I. Orthorexia nervosa in dieticians. *Psychother Psychosom.* 2006;**75**(6):395–396.

24. Ramacciotti CE, Perrone P, Coli E, Burgalassi A, Conversano C, Massimetti G, Dell'Osso L. Orthorexia nervosa in the general population: a preliminary screening using a self-administered questionnaire (ORTO-15). *Eat Weight Disord.* 2011;**16**(2):e127–e130.

25. Maghetti A, Cicero AFG, D'Ignazio E, Vincenzi M, Paolini B, Lucchin L. Orthorexia prevalence among health care professionals involved in nutrition education: the ADI-O study. *Mediterr J Nutr Metab.* 2015;**8**: 199–204.

26. Tremelling K, Sandon L, Vega GL, McAdams CJ. Orthorexia nervosa and eating disorder symptoms in registered dietitian nutritionists in the United States. *J Acad Nutr Diet.* 2017;**117**(10):1612–1617.

27. Luck-Sikorski C, Jung F, Schlosser K, Riedel-Heller SG. Is orthorexic behavior common in the general public? A large representative study in Germany. *Eat Weight Disord.* 2019;**24**(2):267–273.

28. Ferreira C, Coimbra M. To further understand orthorexia nervosa: DOS validity for the Portuguese population and its relationship with psychological indicators, sex, BMI and dietary pattern. *Eat Weight Disord.* 2021;**26**(7): 2127–2134.

29. Brytek-Matera A, Sacre H, Staniszewska A, Hallit S. The prevalence of orthorexia nervosa in Polish and Lebanese adults and its relationship with sociodemographic variables and BMI ranges: a cross-cultural perspective. *Nutrients.* 2020;**12**(12):3865.

30. Bağci Bosi AT, Camur D, Güler C. Prevalence of orthorexia nervosa in resident medical doctors in the faculty of medicine (Ankara, Turkey). *Appetite.* 2007 Nov;**49**(3):661–666.

31. Bundros J, Clifford D, Silliman K, Neyman Morris M. Prevalence of Orthorexia nervosa among college students based on Bratman's test and associated tendencies. *Appetite.* 2016;**101**:86–94.

32. Malmborg J, Bremander A, Olsson MC, Bergman S. Health status, physical activity, and orthorexia nervosa: A comparison between exercise science students and business students. *Appetite.* 2017;**109**:137–143.

33. Karakus B, Hidiroglu S, Keskin N, Karavus M. Orthorexia nervosa tendency among students of the department of nutrition and dietetics at a university in Istanbul. *North Clin Istanb.* 2017;**4**(2):117–123.

34. Donini LM, Marsili D, Graziani MP, Imbriale M, Cannella C. Orthorexia nervosa: validation of a diagnosis questionnaire. *Eat Weight Disord.* 2005; **10**(2):e28–e32.

35. Depa J, Schweizer J, Bekers SK, Hilzendegen C, Stroebele-Benschop N. Prevalence and predictors of orthorexia nervosa among German students using the 21-item-DOS. *Eat Weight Disord.* 2017;**22**(1):193–199.

36. Dunn TM, Gibbs J, Whitney N, Starosta A. Prevalence of orthorexia nervosa is less than 1%: data from a US sample. *Eat Weight Disord.* 2017; **22**(1):185–192.

37. Arslantaş H, Adana F, Öğüt S, Ayakdaş D, Korkmaz A. Relationship between eating behaviors of nursing students and orthorexia nervosa (obsession with healthy eating): a cross-sectional study. *J Psychiatric Nurs.* 2017;**8**(3), 137–144.

38. Parra-Fernández ML, Rodríguez-Cano T, Onieva-Zafra MD, Perez-Haro MJ, Casero-Alonso V, Fernández-Martinez E, Notario-Pacheco B. Prevalence of orthorexia nervosa in university students and its relationship with psychopathological aspects of eating behaviour disorders. *BMC Psychiatry.* 2018;**18**(1):364.

39. Parra-Fernández ML, Onieva-Zafra MD, Fernández-Martínez E, Abreu-Sánchez A, Fernández-Muñoz JJ. Assessing the prevalence of orthorexia nervosa in a sample of university students using two different self-report measures. *Int J Environ Res Public Health.* 2019;**16**(14):2459.

40. Dell'Osso L, Carpita B, Muti D, Cremone IM, Massimetti G, Diadema E, Gesi C, Carmassi C. Prevalence and characteristics of orthorexia nervosa in a sample of university students in Italy. *Eat Weight Disord.* 2018;**23**(1): 55–65.

41. Reynolds R. Is the prevalence of orthorexia nervosa in an Australian university population 6.5%? *Eat Weight Disord.* 2018;**23**(4):453–458.

42. Gramaglia C, Gambaro E, Delicato C, Marchetti M, Sarchiapone M, Ferrante D, Roncero M, Perpiñá C, Brytek-Matera A, Wojtyna E, Zeppegno P. Orthorexia nervosa, eating patterns and personality traits: a cross-cultural comparison of Italian, Polish and Spanish university students. *BMC Psychiatry.* 2019;**19**(1):235.

43. Chard CA, Hilzendegen C, Barthels F, Stroebele-Benschop N. Psychometric evaluation of the English version of the Düsseldorf Orthorexie Scale (DOS) and the prevalence of orthorexia nervosa among a U.S. student sample. *Eat Weight Disord.* 2019;**24**(2):275–281.

44. Plichta M, Jezewska-Zychowicz M. Eating behaviors, attitudes toward health and eating, and symptoms of orthorexia nervosa among students. *Appetite.* 2019;**137**:114–123.

45. Abdullah MA, Al Hourani HM, Alkhatib B. Prevalence of orthorexia nervosa among nutrition students and nutritionists: Pilot study. *Clin Nutr ESPEN.* 2020;**40**:144–148.

46. Gorrasi ISR, Bonetta S, Roppolo M, Abbate Daga G, Bo S, Tagliabue A, Ferraris C, Guglielmetti M, Arpesella M, Gaeta M, Gallé F, Di Onofrio V, Liguori F, Liguori G, Gilli G, Carraro E. Traits of orthorexia nervosa and muscle dysmorphia in Italian university students: a multicentre study. *Eat Weight Disord.* 2020;**25**(5):1413–1423.

47. Carpita B, Cremone IM, Amatori G, Cappelli A, Salerni A, Massimetti G, Borgioli D, Carmassi C, Massai R, Dell'Osso L. Investigating the relationship between orthorexia nervosa and autistic traits in a university population. *CNS Spectr.* 2022;**27**(5):613–620.

48. Brytek-Matera A. The Polish version of the Düsseldorf Orthorexia Scale (PL-DOS) and its comparison with the English version of the DOS (E-DOS). *Eat Weight Disord.* 2021;**26**(4):1223–1232.

49. Brytek-Matera A, Onieva-Zafra MD, Parra-Fernández ML, Staniszewska A, Modrzejewska J, Fernández-Martínez E. Evaluation of orthorexia nervosa and symptomatology associated with eating disorders among European university students: a multicentre cross-sectional study. *Nutrients.* 2020;**12**(12):3716.

50. Cerolini S, Vacca M, Zagaria A, Donini LM, Barbaranelli C, Lombardo C. Italian adaptation of the Düsseldorf Orthorexia Scale (I-DOS): psychometric properties and prevalence of orthorexia nervosa among an Italian sample. *Eat Weight Disord.* 2022;**27**(4):1405–1413.

51. Lasson C, Barthels F, Raynal P. Psychometric evaluation of the French version of the Düsseldorfer Orthorexia Skala (DOS) and prevalence of orthorexia nervosa among university students. *Eat Weight Disord.* 2021; **26**(8):2589–2596.

52. Ruiz Á, Quiles Y. Prevalence of orthorexia nervosa in Spanish university students: relationship with body image and eating disorders. *An De Psicol.* 2021;**37**:493–499.

53. Sünbül S, Bayrak E. Eating attitudes and orthorexia nervosa tendencies in a sample of Turkish university students: A cross-sectional study. *Prog Nutr.* 2021;**23**(4), 1–9.

54. Grajek M, Krupa-Kotara K, Sas-Nowosielski K, Misterska E, Kobza J. Prevalence of orthorexia in groups of students with varied diets and physical activity (Silesia, Poland). *Nutrients.* 2022;**14**(14):2816.

55. Bulut A, Yigitbas C. Prevalence of orthorexia nervosa in academicians and the influencing factors. *Clin Exp Health Sci.* 2022;**12**:346–351.

56. Uzdil Z, Üstüner AS. Evaluation of orthorexia nervosa tendency and fear of COVID-19 in university students receiving health education. *Nutr Food Sci.* 2022;**52**(8):1231–1241.

57. Dell'Osso L, Cremone IM, Chiarantini I, Arone A, Casagrande D, Massimetti G, Carmassi C, Carpita B. Investigating orthorexia nervosa with the ORTO-R in a sample of university students with or without subthreshold autism spectrum: focus on dietary habits and gender differences. *Front Psychiatry.* 2022;**13**:900880.

58. Dell'Osso L, Carmassi C, Cremone IM, Muti D, Salerni A, Barberi FM, Massimetti E, Gesi C, Politi P, Aguglia E, Maj M, Carpita B. Defining the optimal threshold scores for adult autism subthreshold spectrum (AdAS

spectrum) in clinical and general population. *Clin Pract Epidemiol Ment Health*. 2020;**16**:204–211.

59. Aksoydan E, Camci N. Prevalence of orthorexia nervosa among Turkish performance artists. *Eat Weight Disord*. 2009;**14**(1):33–37.

60. Herranz Valera J, Acuña Ruiz P, Romero Valdespino B, Visioli F. Prevalence of orthorexia nervosa among ashtanga yoga practitioners: a pilot study. *Eat Weight Disord*. 2014;**19**(4):469–472.

61. Almeida C, Vieira Borba V, Santos L. Orthorexia nervosa in a sample of Portuguese fitness participants. *Eat Weight Disord*. 2018;**23**(4):443–451.

62. Bóna E, Szél Z, Kiss D, Gyarmathy VA. An unhealthy health behavior: analysis of orthorexic tendencies among Hungarian gym attendees. *Eat Weight Disord*. 2019;**24**(1):13–20.

63. Bert F, Gualano MR, Voglino G, Rossello P, Perret JP, Siliquini R. Orthorexia Nervosa: A cross-sectional study among athletes competing in endurance sports in Northern Italy. *PLoS One*. 2019;**14**(8):e0221399.

64. Clifford T, Blyth C. A pilot study comparing the prevalence of orthorexia nervosa in regular students and those in University sports teams. *Eat Weight Disord*. 2019;**24**(3):473–480.

65. Özdengül F, Yargic MP, Solak R, Yaylali O, Kurklu GB. Assessment of orthorexia nervosa via ORTO-R scores of Turkish recreational and competitive athletes and sedentary individuals: a cross-sectional questionnaire study. *Eat Weight Disord*. 2021;**26**(4):1111–1118.

66. Uriegas NA, Winkelmann ZK, Pritchett K, Torres-McGehee TM. Examining eating attitudes and behaviors in collegiate athletes, the association between orthorexia nervosa and eating disorders. *Front Nutr*. 2021;**8**:763838.

67. Martinovic D, Tokic D, Martinovic L, Vilovic M, Vrdoljak J, Kumric M, Bukic J, Ticinovic Kurir T, Tavra M, Bozic J. Adherence to mediterranean diet and tendency to orthorexia nervosa in professional athletes. *Nutrients*. 2022;**14**(2):237.

68. Yesildemir O, Tek NA. A cross-sectional study: orthorexia nervosa in regular exercising individuals for healthy life. *Prog Nutr*. 2022;**24**(1):e2022027,

69. Athanasaki D, Lakoumentas J, Feketea G, Vassilopoulou E. The prevalence of orthorexia nervosa among Greek professional dancers. *Nutrients*. 2023;**15**(2):379.

70. Barthels F, Meyer F, Pietrowsky R. Orthorexic and restrained eating behaviour in vegans, vegetarians, and individuals on a diet. *Eat Weight Disord*. 2018;**23**(2):159–166.

71. Parra-Fernández ML, Manzaneque-Cañadillas M, Onieva-Zafra MD, Fernández-Martínez E, Fernández-Muñoz JJ, Prado-Laguna MDC, Brytek-Matera A. Pathological preoccupation with healthy eating (orthorexia nervosa) in a Spanish sample with vegetarian, vegan, and non-vegetarian dietary patterns. *Nutrients*. 2020;**12**(12):3907.

72. Voglino G, Parente E, Bert F, Lo Moro G, Corradi A, Lapiccirella M, Gualano MR, Siliquini R. Orthorexia nervosa, a challenging evaluation: analysis of a sample of customers from organic food stores. *Psychol Health Med*. 2021;**26**(4):478–486.

73. Segura-Garcia C, Ramacciotti C, Rania M, Aloi M, Caroleo M, Bruni A, Gazzarrini D, Sinopoli F, De Fazio P. The prevalence of orthorexia nervosa among eating disorder patients after treatment. *Eat Weight Disord*. 2015;**20**(2):161–166.

74. Gramaglia C, Brytek-Matera A, Rogoza R, Zeppegno P. Orthorexia and anorexia nervosa: two distinct phenomena? A cross-cultural comparison of orthorexic behaviours in clinical and non-clinical samples. *BMC Psychiatry*. 2017;**17**(1):75.

75. Busatta D, Cassioli E, Rossi E, Campanino C, Ricca V, Rotella F. Orthorexia among patients with eating disorders, student dietitians and general population: a pilot study. *Eat Weight Disord*. 2022;**27**(2):847–851.

76. Hessler-Kaufmann JB, Meule A, Greetfeld M, Schlegl S, Voderholzer U. Orthorexic tendencies in inpatients with mental disorders. *J Psychosom Res*. 2021;**140**:110317.

77. Pökön M, Mercan Başpınar M, Basat O. Prevalence of orthorexia nervosa tendency in non-obese population: a cross-sectional study. *Anatol J Family Med*. 2021;**4**(3):252–256.

78. Ayhan Başer D, Cankurtaran M. The assessment of the orthorexia nervosa tendencies among postpartum women. *Konuralp Med J*. 2021;**13**(2):218–225.

79. Waterman M, Lee RM, Carter JC, Garland SN. Orthorexia symptoms and disordered eating behaviors in young women with cancer. *Eat Behav*. 2022;**47**:101672.

80. Kujawowicz K, Mirończuk-Chodakowska I, Witkowska AM. Dietary behavior and risk of orthorexia in women with celiac disease. *Nutrients*. 2022;**14**(4):904.

81. Cosentino C, Rossi E, Pala L, Lelmi R, Campanino C, Ricca V, Mannucci E, Dicembrini I, Rotella F. Orthorexia nervosa and type 1 diabetes: results of a cross-sectional study. *Acta Diabetol*. 2023;**60**(5):681–686.

82. Sifakaki M, Gkiouras K, Lindqvist HM, Marakis G, Petropoulou A, Donini LM, Bogdanos DP, Grammatikopoulou MG. Orthorexia nervosa practices in rheumatoid arthritis: the DORA study. *Nutrients*. 2023;**15**(3):713.

83. Rogoza R, Donini LM. Introducing ORTO-R: a revision of ORTO-15: based on the re-assessment of original data. *Eat Weight Disord*. 2021;**26**(3):887–895.

84. Arusoğlu G, Kabakçi E, Köksal G, Merdol TK. Orthorexia nervosa and adaptation of ORTO-11 into Turkish. *Turk Psikiyatri Derg*. 2008;**19**:283–291.

85. Varga M, Thege BK, Dukay-Szabó S, Túry F, van Furth EF, Bratman S et al. When eating healthy is not healthy: orthorexia nervosa and its measurement with the ORTO-15 in Hungary. *BMC Psychiatry BioMed Cent*. 2014;**14**:59.

86. Brytek-Matera A, Krupa M, Poggiogalle E, Donini LM. Adaptation of the ORTHO-15 test to Polish women and men. *Eat Weight Disord*. 2014;**19**:69–76.

87. Missbach B, Hinterbuchinger B, Dreiseitl V, Zellhofer S, Kurz C, König J. When eating right, is measured wrong! A validation and critical examination of the ORTO-15 questionnaire in german. *PLoS One*. 2015;**10**:e0135772.

88. Parra-Fernandez ML, Rodríguez-Cano T, Onieva-Zafra MD, Perez-Haro MJ, Casero-Alonso V, Muñoz Camargo JC, Notario-Pacheco B. Adaptation and validation of the Spanish version of the ORTO-15 questionnaire for the diagnosis of orthorexia nervosa. *PLoS One*. 2018;**13**(1):e0190722.

89. Bratman S, Knight D. *Health food junkies: Orthorexia nervosa: Overcoming the obsession with healthful eating*. New York, NY: Broadway Books; 2000.

90. Montagner MI, Montagner MÂ. Orthorexia nervosa: Cultural adaptation of ortho-15. *Demetra*. 2014;**9**:533–548.

91. He J, Ma H, Barthels F, Fan X. Psychometric properties of the Chinese version of the Düsseldorf Orthorexia Scale: prevalence and demographic correlates of orthorexia nervosa among Chinese university students. *Eat Weight Disord*. 2019;**24**(3):453–463.

92. Segura-García C, Papaianni MC, Caglioti F, Procopio L, Nisticò CG, Bombardiere L, Ammendolia A, Rizza P, De Fazio P, Capranica L. Orthorexia nervosa: a frequent eating disordered behavior in athletes. *Eat Weight Disord*. 2012;**17**(4):e226–e233.

93. Fidan T, Ertekin V, Işıkay S, Kirpinar I. Prevalence of orthorexia among medical students in Erzurum, Turkey. *Compr Psychiatry*. 2010;**51**(1):49–54.

94. Donini LM, Marsili D, Graziani MP, Imbriale M, Cannella C. Orthorexia nervosa: a preliminary study with a proposal for diagnosis and an attempt to measure the dimension of the phenomenon. *Eat Weight Disord*. 2004;**9**(2):151–157.

95. Jerez FT, Lagos HR, Valdés-Badilla P, Pacheco PE, Pérez CC. Prevalencia de conducta ortoréxica en estudiantes de educación media de Temuco. *Rev Chil Nutr*. 2015;**42**:41–44.

96. Brytek-Matera A, Donini LM, Krupa M, Poggiogalle E, Hay P. Erratum to: Orthorexia nervosa and self-attitudinal aspects of body image in female and male university students. *J Eat Disord*. 2016;**4**:16.

97. Oberle CD, Samaghabadi RO, Hughes EM. Orthorexia nervosa: Assessment and correlates with gender, BMI, and personality. *Appetite*. 2017;**108**:303–310.