Nutrition 67–68 (2019) 110534

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Review

Sex differences in orthorexic eating behaviors: A systematic review and meta-analytical integration

Jana Strahler Ph.D. *

Psychotherapy and Systems Neuroscience, Department of Psychology and Sport Sciences, Justus Liebig University Giessen, Germany

ARTICLE INFO

Article History:
Received 24 March 2019
Received in revised form 13 June 2019
Accepted 17 June 2019

Keywords:
Orthorexia nervosa
Pathologically healthful eating
Dietary patterns
Sex
Meta-analysis

ABSTRACT

Objectives: Other than the ongoing debate about the epidemiologic and clinical relevance of pathologically healthful eating, a phenomenon called *orthorexia nervosa*, there is not much consensus about sex differences in prevalence rates. The aim of this study was to provide a systematic review and meta-analytical combination of derived data to better conceptualize the presence and size of sex differences in the prevalence and levels of orthorexic eating behaviors and *orthorexia nervosa*.
Methods: Sixty-seven publications were included in the synthesis providing data from $k = 89$ subsamples (39 255 participants, 67.7% women) for meta-analytical procedures. Separate analyses were conducted for each measurement tool. The impact of four moderators proposed to explain sex differences was examined: sample composition (general population versus special interest in health population; subgroup analysis), and in a meta-regression sample's mean age, year of publication, and sex distribution.
Results: The results showed significant sex differences in only one of four instruments in use. Studies measuring orthorexic behaviors showed that women were significantly more likely to report pathologically healthful eating than men (small effect size). Studies employing tools to assess tendencies toward healthy eating indicated similar levels in women and men. Subgroup and moderator analyses showed comparable effects sizes in general population and high-risk samples, and that the sex difference was inconsistently and minimally related to the sample's mean age, year of publication, or sex distribution.
Conclusions: The findings indicate that, depending on the instrument in use, tendencies toward healthy eating are comparable between the genders, although pathologically healthful eating is slightly more pronounced in women. Future studies will have to adopt valid criteria for diagnosing Orthorexia nervosa and investigate additional factors contributing to pathologic healthful eating and orthorexia nervosa.

Introduction

There is little doubt that opting for a healthy diet (i.e., a balanced diet comprising unprocessed foods and rich in fruits and vegetables), is beneficial for physical and mental health [1,2]. However, if performed excessively, eating healthy can grow into a pathologic habit. Orthorexia nervosa (ON), which was introduced in the mid-1990s, has gained increasing attention in the past few years. Orthorexic eating behaviors and ON describe the compulsive fixation on eating healthy while complying with strict nutritional rules. Currently, diagnostic criteria for ON are widely discussed [3], but common classification systems such as the Diagnostic and Statistical Manual of the American Psychiatric Association still do not codify or describe this phenomenon. Questionable prevalence rates of ≤90% (for reviews, see Cena et al, 2019 [3] and Strahler and Stark, 2019 [4]); difficult differential diagnoses of anxiety disorders, eating disorders, and obsessive-compulsive disorder symptoms; and limited knowledge of underlying psychosocial, genetic, neurobiologic, and psychophysiologic mechanisms are the main reasons. Thus, unanswered questions in the field of ON and orthorexic eating behaviors concern the underlying etiology, the understanding of risk factors, and whether ON is distinct from other behaviors (non-pathologic healthy eating) or disorders (e.g., anorexia nervosa).

To our knowledge, there is little consensus about the etiology and risk factors of ON. Predisposing personality factors such as perfectionism or narcissism have been discussed [5], as have education [6], weight status [7], and association with eating disorders [8,9]. Likewise, age has been related to ON, but the picture is rather inconclusive, with studies showing small positive and small negative associations between age and orthorexic eating behaviors [8,10–15]. Previous studies, however, cannot be regarded as representative and further studies assessing representative samples from the general population are pending.

* Corresponding author: Tel.: +49 641 99 26332; Fax: +49 641 99 26309.
E-mail address: jana.strahler@psychol.uni-giessen.de

https://doi.org/10.1016/j.nut.2019.06.015
0899-9007/

Controversy also surrounds the question of whether men or women are at higher risk for developing pathologically healthful eating and ON. Although there is no knowledge about sex-related differences in symptomatology, etiology, and pathophysiology, sex-specific characteristics of orthorexic behaviors (e.g., healthy eating to regulate emotions versus to maintain normative rules) seem reasonable. Likewise, research on prevalence rates and levels of orthorexic eating behaviors between men and women is inconclusive. Earlier publications pointed to an increased risk in men [10]. Most recent research challenges this assumption and hints toward similar numbers for men and women [14,16,17].

Understanding sex differences could begin to shed light on questions about the etiology, risk factors, and whether ON can be regarded as an independent diagnostic category. With regard to the latter, association with eating disorders have been described [8,9]. Eating disorders are much more prevalent in women [18]. Prevalence rates of subclinical eating disorder symptoms appear somewhat more diverse, with the majority of studies reporting higher levels in women [19], and some studies showing similar levels in men and women [20]. One might argue that showing similar rates or only minor sex differences may suggest that ON is distinct from eating disorders; however, this remains only speculation as there is a lack of specific research. Moreover, overlaps with symptoms of obsessive-compulsive–related, anxiety disorder symptoms, and behavioral addictions are assumed [4,21,22]. Interestingly, a lack of pathologic relevance of orthorexic eating behaviors or redundancy in predicting mental health has been discussed previously [17].

Of note, there is a controversial discussion about prevalence rates and the validity of some measurement tools. Prevalence rates and levels of orthorexic eating behaviors differ tremendously. Depending on the population being studied and the instrument being used, rates between 1% and 90% have been reported. The highest rates were found in populations with greater nutritional knowledge and general health conscience (e.g., nutritional or sport science students, dancers, or athletes), and when using the test for the diagnosis of orthorexia ORTO-15 or some of its versions [23]. The face validity of many items of the ORTO has been questioned [24] and there is debate that this tool should not be used to diagnose ON or to investigate ON prevalence, but rather to dimensionally assess orthorexic eating tendencies [25]. Rogoza proposed an abbreviated ORTO version with six items largely reflecting motivations to eat only healthy foods. Another occasionally employed measurement tool is the Bratman Orthorexia Test (BOT [10]) with 10 yes/no questions. Proposed cutoff scores allow for the classification of “health fanatics” and those having “orthorexic eating attitudes.” The present study will consider both the ORTO and the BOT as measures of tendencies toward healthy eating. Furthermore, the Eating Habits Questionnaire (EHQ [26]) has been developed to assess three factors related to orthorexic symptomatology: behaviors/cognitions (i.e., normative healthy eating behaviors), feelings (i.e., positive feelings associated with healthy eating), and problems (i.e., interference/problems from rigid healthy eating). Prevalence numbers with the strongest empirical support seem to stem from studies that employed the Duesseldorf Orthorexia Scale (DOS [27]), ranging between 1.5% [28] and 8.1% [29]. Given these caveats, a tool-specific evaluation of sex differences appears mandatory.

To condense current findings, this review and meta-analysis aimed at examining sex-differences in orthorexic behaviors from the first publication up to January 2019. Because there are reasonable doubts about the validity of some measurement tools [24], separate analyses will examine the different instruments. Additionally, it seems reasonable that sex-specific prevalence rates and levels of orthorexic eating behaviors also correlate with sociodemographic factors. The second aim of this study was to examine the following moderators using subgroup analysis and meta-regression (tool-specific):

1. As greater nutritional knowledge and general health conscience has been related to higher orthorexic tendencies [30–33], population under study (i.e., general population or population assumed to be at risk for developing pathologically healthful eating) was also examined as possible predisposing and risk factors. For the present meta-analysis, high-risk populations were those with greater health and nutrition knowledge than the general public or those presumed to be interested in health and nutrition, such as nutrition and medical students, athletes, or dietitians. More orthorexic tendencies were expected in high-risk populations.
2. The age of the sample was considered as a moderator of sex differences according to previous studies showing positive and negative findings and null findings in this regard [8,10–15]. Given these inconclusive results, no direction of the effect was postulated.
3. Recently, there seems to be an increased popularity of living a healthy lifestyle [34]. This might also be the case for orthorexic tendencies and may thus affect sex differences. To account for heterogeneity in the data related to the age of the specific data set, year of publication will be used as moderator. Given the lack of previous knowledge, no direction of the effect was postulated.
4. Owing to the possibility of biased effects related to unequal sample sizes, sex distribution is considered as a moderator (besides employing a bias-corrected effect estimate). The moderation analysis should be seen as a means to account for sample distribution-related heterogeneity in the data.

Methods

Search strategy and identification of studies

A systematic search of the electronic libraries PubMed, PsycINFO, Web of Science, and ScienceDirect was conducted from the first available year through January 2019. The search string included the keyword *orthorexia*. Manual searches of the reference list of identified records and contact with experts provided further records. Figure 1 shows the flow of information through the different phases of the review. The search was confined to studies conducted in adolescents and adults without restrictions in language. Reviews, commentaries, conference proceedings, papers in preparation, unpublished manuscripts, and doctoral or master/bachelor theses were screened but not considered further on.

Inclusion criteria

The following inclusion criteria were used:

1. The study was published in a peer-reviewed journal through January 2019. Papers in preparation and unpublished manuscripts were not eligible for inclusion.
2. In order to assess sex differences, the sample must be composed of men and women, although there was no restriction on distribution. Sex distribution was considered as a moderator and results will guide interpretation.
3. The study provided sufficient data to calculate an effect size for the sex difference: Mean and SD, percentage of cases versus non-cases, or *t*- or *F*-values. In case of several possible dates, mean and SD was preferred over the other measures.
4. There was no restriction in sample composition (i.e., studies in healthy, high-risk, and patient populations were eligible).
5. In case of insufficient information to calculate the effect size, study authors were contacted to provide missing data. The study was excluded when authors could not be reached or data was no longer available.

The search of electronic libraries yielded 486 possible studies. Screening of titles and abstracts resulted in 398 exclusions. Four additional records were identified from searching reference lists. Experts mentioned additional data sets but

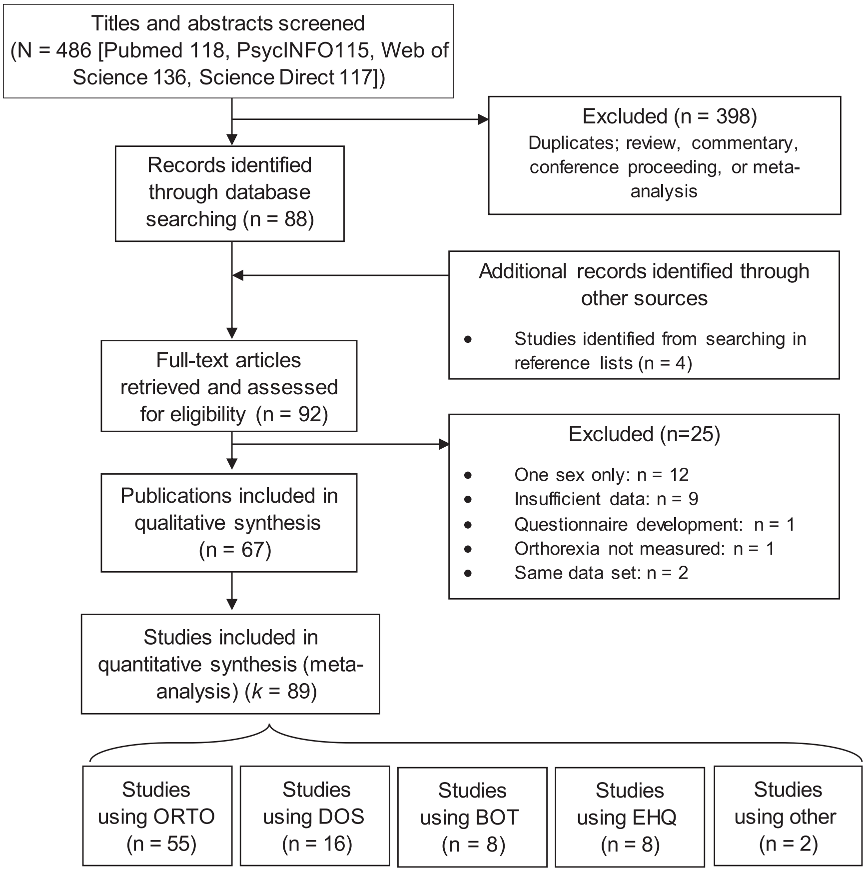


Fig. 1. Flow of information through the different phases of the review (Search term *orthorexia*, from very first publication through January, 2019).

those were not considered. Sixty-seven reports (including 39 255 participants, 67.7% women) met the inclusion criteria and were included in the present meta-analysis (Table 1 [5–7,11,12,14–17,23,27–33,35–83]). The main reasons for exclusion were the investigation of one sex only (n = 12) and insufficient data for statistical procedures (n = 10). Additionally, some studies reported data from different populations. These will be treated as different samples resulting in $k = 89$ studies for meta-analysis.

From the 89 studies, 55 filled-in some version of the ORTO, 16 studies examined the DOS, 8 studies each are available for the BOT and the EHQ, and 2 studies used another tool to measure ON (Orthorexia Screen and a two-item Screener; Table 1).

Data extraction and coding

All studies were coded, and sex-specific questionnaire mean scores, SD, and sample size were extracted. Study authors were contacted in cases of missing data. In most cases, means and SDs were available for effect size calculation. Four additional studies provided sex-specific percent of cases fulfilling some cutoff for pathologically healthful eating, and one study reported Cohen's *d*.

Moderator variables

Instrument

The screening instrument was recorded. As the ORTO and the BOT have been widely criticized for not measuring ON, but instead having a tendency toward healthful eating [15,24] and because there is evidence for significant differences in levels and prevalence rates when employing different tools in the same population [55], this meta-analysis reported effects separately for each tool. Moreover, the EHQ is composed of behaviors/cognitions, feelings, problems subscales and these were considered in separate analyses as well.

Study population

Sixty-nine studies reported data from a general population sample (65.7%) and 36 reported data from a population assumed to be at risk for developing pathologically healthful eating. A subgroup analysis examined a possible contribution of this factor (dichotomous).

Age

Because there is some evidence for age-specific levels and prevalence rates, the mean age of the sample (continuous, 17.4–50.6 y, median 23.8 y) was considered in the meta-regression.

Year of publication

There is an ongoing debate about growing tendencies toward living a healthy lifestyle [34]. Hence, a rise in orthorexic tendencies may be expected. Therefore, year of publication (ranging from 2005 to 2019) was considered in the meta-regression and was expressed as time since publication (continuous).

Sex distribution

The distribution of sex differed markedly between studies. Women were typically overrepresented (proportion of women: 31.5–96.7%, median 71%). Because this may have biased analyses, sex distribution (% women, continuous) was considered in the meta-regression.

Meta-analytical procedures

All analyses were carried out using Meta Essentials: Workbooks for meta-analysis (version 1.4, ERASMUS Research Institute, Rotterdam, Netherlands; as described in Suurmond et al. [84]). The effect size used was Hedge's g^* to take into account unequal or small sample sizes (bias corrected. This version was from Borenstein et al. [85, p. 27]; originally from Hedges [86]). Standardized differences with a positive sign indicate higher levels of pathologically healthful eating in men; a negative sign indicates higher risk in women.

Separately for each measurement tool, average effect sizes were calculated from the random-effects model. Estimations were weighed (inverse variance weighing) and thereby added a between-studies variance component [87]. Cochran's Q test evaluated the degree of heterogeneity in effect sizes [85] and I^2 indicated the percentage of variation across studies that was due to heterogeneity rather than chance [88]. Funnel plots provided an estimate of publication bias, that is, the effect size of each study (x-axis) was contrasted with the standard error (y-axis). The Egger test [89] supported visual inspection. A moderator analysis using a random-effects model was performed to assess factors underlying the

Table 1
Total reports (N = 67) contributing effects sizes to the meta-analysis*

Publication (year of publication)	Country	Sample size	Participants for MA	Women, %	Age, y, mean ± SD	Instrument	Calculation based on
Aksoydan and Camci (2009) [35]	Turkey	94	HR = 94	58.5	33.2 ± 10.9	ORTO-15	M ± SD
Almeida et al. (2018) [36]	Portugal	193	HR = 193	58.5	32.8 ± 11.6	ORTO-15	M ± SD
Alvarenga et al. (2012) [37]	Brazil	392	HR = 392	92.9	31.7 ± 8.9	ORTO-15	M ± SD
Arusoğlu et al. (2008) [38]	Turkey	994	GP = 994	58.1	35.6 ± 9.4	ORTO-11	M ± SD
Asil and Sürücüoğlu (2015) [39]	Turkey	117	HR = 117	86.3	34 ± 11.2	ORTO-15	M ± SD
Barnes and Caltabiano (2017) [5]	Australia	220	GP = 220	79.1	23.8 ± 8.4	ORTO-9	M ± SD
Barnett et al. (2016) [40]	United States	259	GP = 259	83.4	38.2 ± 17.9	ORTO-15	M ± SD
Barthels et al. (2015) [27]	Germany	1406	GP = 1297	69.7	29.3 ± 11	DOS	M ± SD
			GP = 109	58.7	33.3 ± 15.3		
Barthels et al. (2018) [28]	Germany	746	HR = 113	72.6	28.7 ± 8.6	DOS	M ± SD
			HR = 62	72.6	30.7 ± 10.7		
			GP = 82	67.1	37.0 ± 13.7		
			GP = 90	43.3	33.0 ± 11		
			HR = 104	89.4	33.2 ± 10.6		
			HR = 37	64.9	29.2 ± 10.3		
			GP = 258	77.1	28.9 ± 11		
Barthels et al. (2018) [41]	Germany	30	GP = 30	50	22.8 ± 2.9	DOS	M ± SD
Bo et al. (2014) [42]	Italy	440	HR = 440	54.1	19.8 ± 1.7	ORTO-15	%
Bona et al. (2019) [43]	Hungary	207	HR = 207	67.6	31.9 ± 8.7	ORTO-11	M ± SD
Bosi et al. (2007) [44]	Turkey	318	HR = 318	46.9	27.2 ± 2.9	ORTO-15	M ± SD
Brytek-Matera et al. (2014) [45]	Poland	400	GP = 400	85.3	23.2 ± 3.2	ORTO-15	M ± SD
Brytek-Matera et al. (2015) [46]	Poland	327	GP = 327	86.5	22 ± 1.8	ORTO-9	M ± SD
Brytek-Matera et al. (2017) [22]	Italy	120	GP = 120	69.2	22.7 ± 7.3	ORTO-15	M ± SD
Brytek-Matera et al. (2019) [47]	Poland	120	HR = 79	78.5	28.1 ± 9.4	EHQ	M ± SD
			GP = 41	90.2	30.3 ± 10		
Bundros et al. (2016) [48]	United States	448	GP = 448	72.5	22.2 ± 4.8	BOT	M ± SD
Chard et al. (2019) [29]	United States	384	GP = 384	69.5	19.6 ± 2.6	DOS	M ± SD
			GP = 384			EHQ	
Çiçekoğlu and Tunçay (2018) [49]	Turkey	62	HR = 31	71.0	32.7 ± 5.6	ORTO-11	M ± SD
			GP = 31	51.6	34.3 ± 8.1		
Clifford and Blyth (2019) [50]	United Kingdom	215	HR = 116	57.8	21 ± 1	ORTO-15	M ± SD
			GP = 99	74.8	21 ± 2		
Costa and Hardan-Khalil (2019) [51]	United States	270	GP = 270	58	20.2 ± 1.7	ORTO-15	M ± SD
Dell'Osso et al. (2016) [11]	Italy	2826	GP = 2826	59.4	28.9 ± 11.4	ORTO-15	M ± SD
Dell'Osso et al. (2018) [52]	Italy	2130	GP = 2130	58.9	23.8 ± 4.4	ORTO-15	M ± SD
Depa et al. (2017) [12]	Germany	458	GP = 458	70.3	21.7 ± 2.6	DOS	M ± SD
Dittfeld et al. (2016) [30]	Poland	430	HR = 229	95.2	21.5 ± 1.6	BOT	M ± SD
			HR = 201	87.1	20.9 ± 1.5		
Dittfeld et al. (2017) [53]	Poland	1265	GP = 1265	84.7	23.3 ± 5.9	BOT	M ± SD
Donini et al. (2005) [23]	Italy	525	GP = 525	55.2	33 ± 13	ORTO-15	M ± SD
Dunn et al. (2017) [14]	United States	275	GP = 275	68.4	21.7 ± 4.8	ORTO-15	M ± SD
Fidan et al. (2010) [31]	Turkey	878	HR = 878	40.9	21.3 ± 2.1	ORTO-11	M ± SD
Grammatikopoulou et al. (2018) [32]	Greece	176	HR = 176	79.5	21.7 ± 1.9	BOT	M ± SD
Haddad et al. (2019) [54]	Lebanon	806	GP = 806	66.5	27.6 ± 11.8	ORTO-15	M ± SD
Hayes et al. (2017) [55]	United States	404	GP = 404	82.7	20.7 ± 4.4	ORTO-15	M ± SD
			GP = 404			BOT	
Heiss et al. (2019) [56]	United States	381	GP = 106	75.5	29.8 ± 13.3	ORTO-15	M ± SD
			HR = 34	85.3	35.9 ± 15.1		
			HR = 50	84.0	27.8 ± 9.8		
			HR = 191	82.2	31.7 ± 12.9		
Hyrnik et al. (2016) [57]	Poland	1899	GP = 1899	52.2	17.4 ± 1	ORTO-15	M ± SD
Karadag et al. (2016) [58]	Turkey	750	GP = 750	50.0	25.8 ± 6.7	ORTO-15	M ± SD
Karakus et al. (2017) [59]	Turkey	209	HR = 208	86	NA (>18)	ORTO-11	M ± SD
Keller and Konradsen (2013) [60]	Denmark	119	HR = 119	53.8	22 ± 3.4	other	M ± SD
Kiss-Leizer and Rigo (2019) [61]	Hungary	739	GP = 562	76.5	32.2 ± 5.4	ORTO-11	M ± SD
			HR = 177	87.6	29.8 ± 5.3		
Korinth et al. (2010) [62]	Germany	333	GP = 333	88.3	23.9 ± 3.7	BOT	M ± SD
Koven and Senbonmatsu (2013) [63]	United States	100	GP = 100	79	19.3 ± 1.2	ORTO-15	M ± SD
Luck-Sikorski et al. (2019) [16]	Germany	1007	GP = 1007	48.6	50.6 ± 24.1	DOS	M ± SD
Malmborg et al. (2017) [64]	Sweden	207	HR = 118	54.2	22.8 ± 2.2	ORTO-15	M ± SD
			GP = 89	59.6			
Missbach et al. (2015) [15]	German-speaking	1029	GP = 1029	74.6	31.2 ± 10.4	ORTO-9	M ± SD
Moller et al. (2018) [65]	English-speaking	585	GP = 585	82.4	34.7 ± 11.3	ORTO-7	M ± SD
Oberle et al. (2017) [7]	United States	448	GP = 448	80.8	19.9 ± 2.8	EHQ	M ± SD
Oberle et al. (2018) [66]	United States	411	GP = 228	89.5	20.3 ± 1.9	EHQ	M ± SD
			GP = 183	85.3	22.2 ± 4.7		
Oberle and Lipschuetz (2018) [67]	United States	516	GP = 516	81	19.8 ± 2.3	EHQ	M ± SD
Olejniczak et al. (2017) [68]	Poland	981	GP = 981	81	21.6 ± 2	other	%
Parra-Fernández et al. (2018) [69]	Spain	454	GP = 454	65	21.7 ± 4.7	ORTO-11	M ± SD
Parra-Fernández et al. (2018) [70]	Spain	454	GP = 454	65	21.5 ± 6.6	ORTO-15	M ± SD

(*continued*)

Table 1 (*Continued*)

Publication (year of publication)	Country	Sample size	Participants for MA	Women, %	Age, y, mean ± SD	Instrument	Calculation based on
Parra-Fernández et al. (2018) [71]	Spain	492	GP = 492	56.9	20 ± 3	ORTO-11	M ± SD
Penaforte et al. (2018) [72]	Brazil	141	HR = 141	90.8	21.5 ± 3.5	ORTO-15	M ± SD
Plichta et al. (2019) [73]	Poland	1120	GP = 573	72.8	22.3 ± 2.9	ORTO-15	M ± SD
			HR = 547	68	20.4 ± 1.3		
Ramacciotti et al. (2011) [74]	Italy	177	GP = 177	63.8	38 ± 15.1	ORTO-15	M ± SD
Reynolds (2018) [75]	Australia	92	GP = 92	73	24.6 ± 7.5	ORTO-15	M ± SD
Roncero et al. (2017) [76]	Spain	242	GP = 242	63.2	24.9 ± 1.1	ORTO-11	Cohen's d
Rudolph et al. (2017) [77]	Germany	759	HR = 759	71	23.5 ± 3.1	DOS	M ± SD
Rudolph (2018) [78]	Germany	1008	HR = 1008	44.5	29.4 ± 11.6	DOS	M ± SD
Sanlier et al. (2016) [6]	Turkey	900	GP = 900	58	20.4 ± 1.7	ORTO-15	M ± SD
Segura-García et al. (2012) [33]	Italy	850	HR = 600	31.5	22.6 ± 6	ORTO-15	M ± SD
			GP = 250	31.6	22.9 ± 5.2		
Strahler et al. (2018) [17]	Germany	713	GP = 713	79.8	29.4 ± 11.2	DOS	M ± SD
Tremelling et al. (2017) [79]	United States	636	HR = 636	93.7	45.3 ± 12.5	ORTO-15	M ± SD
Valera et al. (2014) [80]	Spain	136	HR = 136	65.4	37 ± 6.7	ORTO-15	M ± SD
Varga et al. (2014) [81]	Hungary	810	GP = 810	89.4	32.4 ± 10.4	ORTO-11	M ± SD
Vital et al. (2017) [82]	Brazil	40	HR = 40	37.5	NA (>18)	ORTO-15	M ± SD
Zickgraf et al. (2019) [83]	United States	449	GP = 449	49.4	33.6 ± 9.5	EHQ	M ± SD

%, percent of cases fulfilling some cutoff for pathologically healthful eating; BOT, Bratman Orthorexia Test; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; GP, general population; HR, population assumed to be at risk for developing pathologically healthful eating; MA, quantitative meta-analysis; NA, not available; ORTO-15/11/9/7, test for the diagnosis of orthorexia.
*Publications are cited in alphabetical order. Reference numbers are cited with brackets and for complete citation, see the Reference section.

variance between studies using the resources provided by Meta Essentials. In short, the chosen continuous moderator variable (i.e., the sample's mean age, year of publication, and sex distribution) was regressed on the study's effect size. Additionally, subgroup analysis was performed to explore a possible difference between populations being studied. These analyses gave a combined effect size for the *general population* studies and another combined effect size for the *population at risk* studies.

Results

The average effect sizes and related statistics separately for each measurement tool are shown in Table 2. Study-specific effect sizes are provided in Figures 2–5.

Analysis of studies using the ORTO

The sample size in the primary reports employing the ORTO or one of its forms ranged from 31 to 2826 ($k = 55$; N = 24 914; Fig. 2). The average standardized difference across all studies did not show significant results implicating similar tendencies toward healthy eating in men and women ($g^* = -0.06$; 95% confidence interval [CI], −0.168 to 0.043; $P = 0.234$). The *Q*-test showed significant heterogeneity of effect sizes ($P < 0.001$), with an I^2 value of 92%. Graphical inspection of the Funnel plot did not reveal a strong asymmetry. This was supported by a non-significant Egger test, with $t = -1.54$; $P = 0.130$, indicating no publication bias. Because of the high level of heterogeneity, however, this should be interpreted with caution.

Analysis of studies using the DOS

The sample size in the primary reports employing the DOS ranged from 30 to 1297. Across all studies ($k = 16$; N = 6511; Fig. 3), the results revealed a small but significant overall average effect size ($g^* = -0.192$; 95% CI, −0.312 to −0.072; $P = 0.001$). Studies employing this tool provided evidence for higher orthorexic tendencies and pathologically healthful eating in women. Again, there was rather high heterogeneity of effect sizes ($Q = 60.2$; $P < 0.001$; $I^2 = 75\%$). Despite some imputed data points, indicating potentially missing studies, there was neither a marked asymmetry nor did the Egger's regression suggest publication bias ($t = -1.10$; $P = 0.289$).

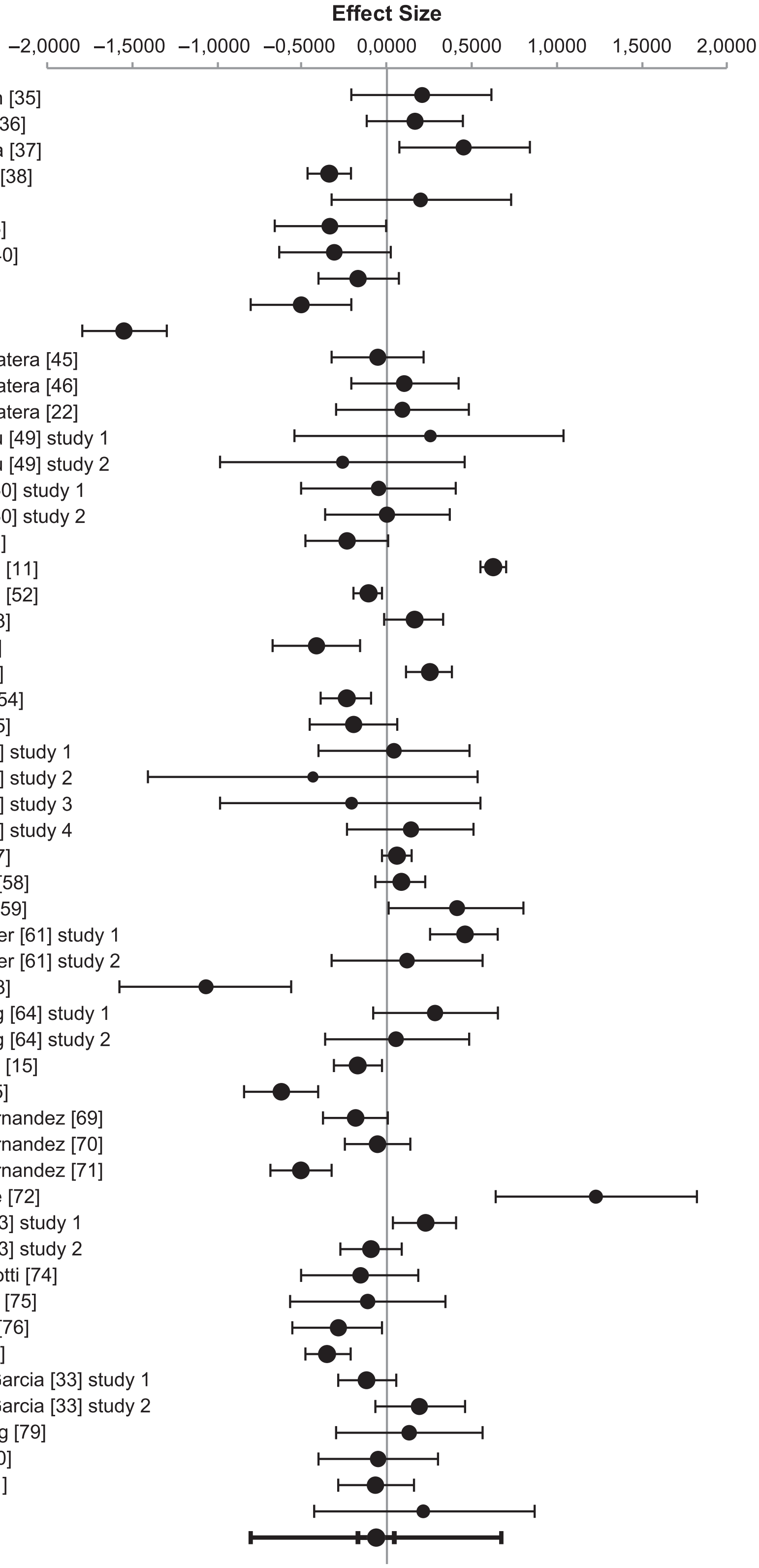
Analysis of studies using the BOT

The sample size in the primary reports employing the BOT ranged from 176 to 1346 ($k = 8$; N = 4402; Fig. 4). Similar to the

Table 2
Measurement tool-specific analysis of mean ES

Instrument	Number of ES*	Min ES	Max ES	Mean ES	−95% CI	+95% CI	Z	*P*-value†	Homogeneity analysis	I^2, %	♀, ♂
ORTO	55	−1.55	1.23	−0.063	−0.168	0.043	−1.19	0.234	Q = 687.6, df 54, *P* < 0.001	92.2	♀ = ♂
DOS	16	−0.58	0.19	**−0.192**	−0.312	−0.072	−3.42	**0.001**	Q = 60.2, df 15, *P* < 0.001	75.1	♀ > ♂
BOT	8	−0.35	0.29	−0.078	−0.280	0.124	−0.92	0.359	Q = 24.1, df 7, *P* = 0.001	71.0	♀ = ♂
EHQ behaviors	8	−1.02	0.59	0.171	−0.194	0.536	1.11	0.269	Q = 30.5, df 7, *P* < 0.001	77.0	♀ = ♂
EHQ feelings	8	−0.61	0.24	−0.089	−0.203	0.025	−1.85	0.064	Q = 6.6, df 7, *P* = 0.474	<1	♀ = ♂
EHQ problems	8	−0.62	0.51	0.074	−0.140	0.288	0.81	0.415	Q = 15.4, df 7, *P* = 0.031	54.5	♀ = ♂
other	2	−1.19	1.84	0.333	−18.952	19.617	0.22	0.827	Q = 14.1, df 1, *P* < 0.001	92.9	♀ = ♂

BOT, Bratman Orthorexia Test; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; ES, effect size; ORTO, test for the diagnosis of orthorexia.
Hedges' g, a positive sign indicates higher levels of pathologically healthful eating/tendencies toward healthy eating in men;; a negative sign indicates higher risk in women.
†$P < 0.05$ considered significant highlighted in **bold**.



Study	*ES*	CI LL	CI UL
Aksoydan [35]	0.20	–0.21	0.62
Almeida [36]	0.17	–0.12	0.45
Alvarenga [37]	0.46	0.07	0.84
Arusoğlu [38]	–0.34	–0.47	–0.21
Asil [39]	0.20	–0.33	0.73
Barnes [5]	–0.33	–0.66	0.00
Barnett [40]	–0.31	–0.63	0.02
Bo [42]	–0.17	–0.41	0.07
Bona [43]	–0.50	–0.80	–0.20
Bosi [44]	–1.55	–1.80	–1.30
Brytek-Matera [45]	–0.05	–0.33	0.22
Brytek-Matera [46]	0.11	–0.21	0.43
Brytek-Matera [22]	0.09	–0.30	0.48
Çiçekoğlu [49] study 1	0.25	–0.54	1.04
Çiçekoğlu [49] study 2	–0.26	–0.98	0.46
Clifford [50] study 1	–0.05	–0.51	0.41
Clifford [50] study 2	0.00	–0.37	0.37
Costa [51]	–0.24	–0.48	0.01
Dell'Osso [11]	0.62	0.55	0.70
Dell'Osso [52]	–0.11	–0.20	–0.03
Donini [23]	0.16	–0.01	0.33
Dunn [14]	–0.41	–0.67	–0.15
Fidan [31]	0.25	0.12	0.39
Haddad [54]	–0.24	–0.38	–0.09
Hayes [55]	–0.19	–0.45	0.06
Heiss [56] study 1	0.05	–0.40	0.49
Heiss [56] study 2	–0.43	–1.40	0.53
Heiss [56] study 3	–0.21	–0.98	0.55
Heiss [56] study 4	0.14	–0.23	0.51
Hyrnik [57]	0.06	–0.03	0.15
Karadag [58]	0.08	–0.06	0.23
Karakus [59]	0.41	0.01	0.80
Kiss-Leizer [61] study 1	0.46	0.26	0.65
Kiss-Leizer [61] study 2	0.12	–0.33	0.57
Koven [63]	–1.07	–1.58	–0.56
Malmborg [64] study 1	0.29	–0.08	0.65
Malmborg [64] study 2	0.06	–0.37	0.48
Missbach [15]	–0.17	–0.31	–0.03
Moller [65]	–0.62	–0.84	–0.40
Parra-Fernandez [69]	–0.05	–0.24	0.14
Parra-Fernandez [70]	–0.19	–0.38	0.01
Parra-Fernandez [71]	–0.50	–0.68	–0.32
Penaforte [72]	1.23	0.64	1.82
Plichta [73] study 1	0.22	0.04	0.41
Plichta [73] study 2	–0.09	–0.27	0.09
Ramacciotti [74]	–0.16	–0.50	0.18
Reynolds [75]	–0.11	–0.57	0.35
Roncero [76]	–0.29	–0.55	–0.03
Sanlier [6]	–0.35	–0.48	–0.21
Segura-Garcia [33] study 1	–0.12	–0.29	0.06
Segura-Garcia [33] study 2	0.20	–0.07	0.46
Tremelling [79]	0.13	–0.30	0.57
Valera [80]	–0.05	–0.41	0.30
Varga [81]	–0.06	–0.29	0.16
Vital [82]	0.22	–0.43	0.87
Total	**–0.06**	**–0.17**	**0.04**

Fig. 2. Forest plot of all studies employing the test for the diagnosis of orthorexia (ORTO) or one of its forms. Note that positive values indicate higher tendencies toward healthy eating in men, negative values indicate higher levels in women. Studies are cited in alphabetical order. Complete reference citation (within brackets) can be located in the reference section. ES, effect size Hedge's *g*; LL, lower level 95%; UL, upper level 95%.

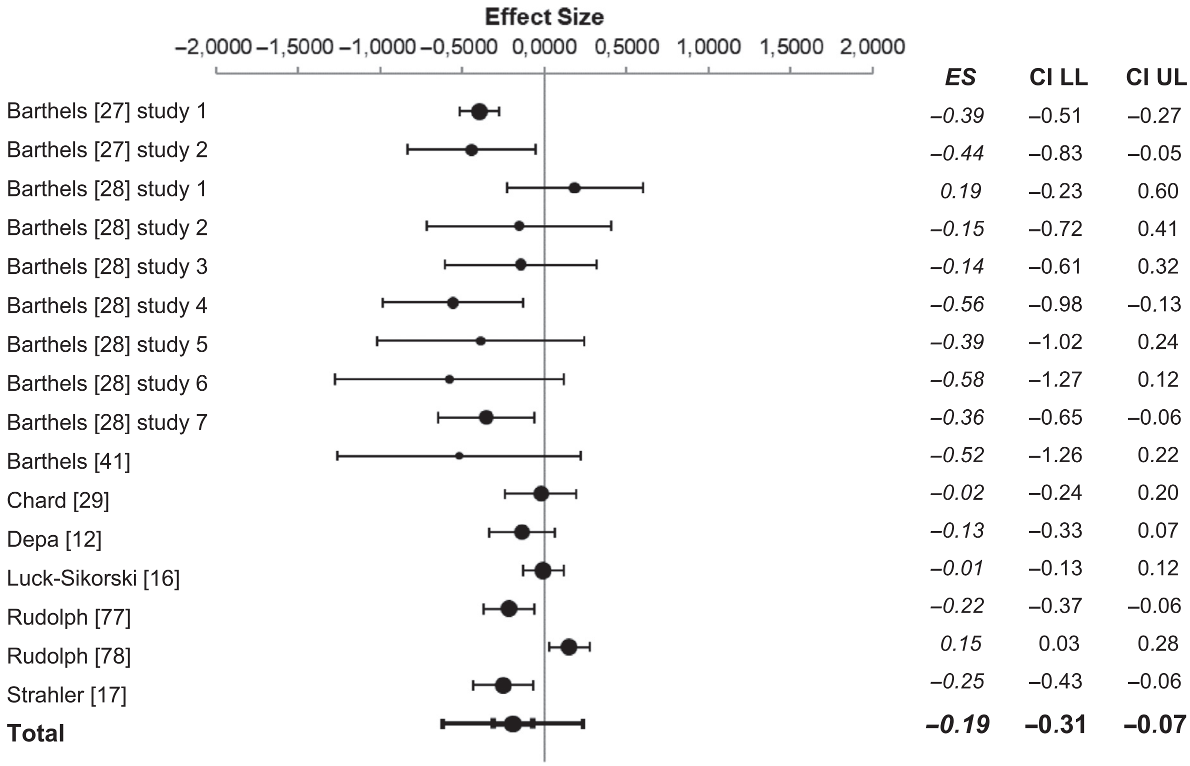


Fig. 3. Forest plot of all studies employing the Duesseldorf Orthorexia Scale (DOS). Note that positive values indicate higher orthorexic tendencies/pathologically healthful eating in men; negative values indicate higher levels in women. Studies are cited in alphabetical order. Complete reference citation (within brackets) can be located in the reference section. ES, effect size Hedge's *g*; LL, lower level 95%; UL, upper level 95%.

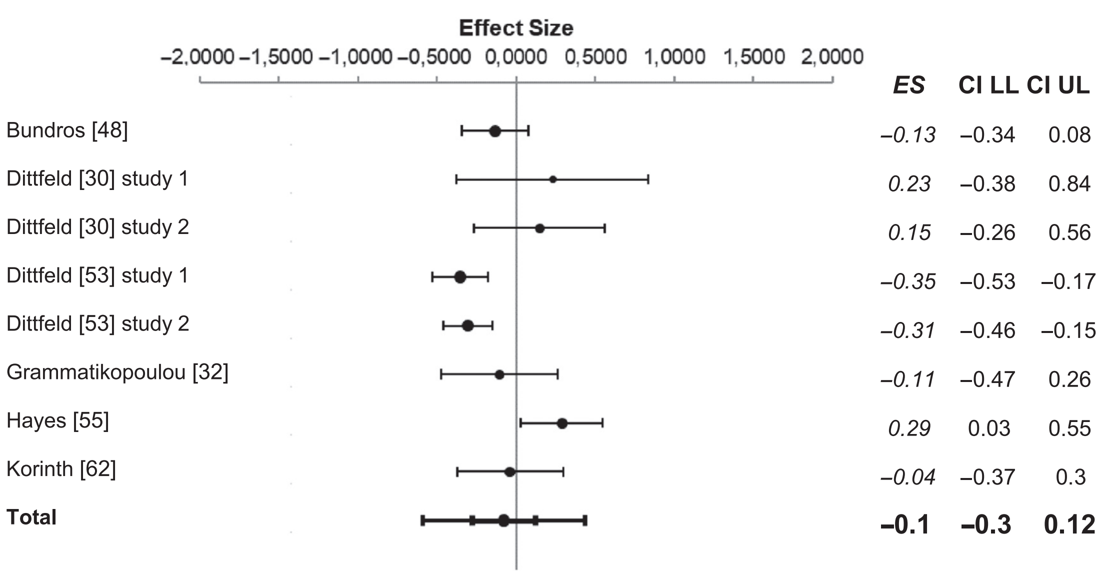


Fig. 4. Forest plot of all studies employing the Bratman Orthorexia Test (BOT). Note that positive values indicate higher tendencies towards healthy eating in men; negative values indicate higher levels in women. Studies are cited in alphabetical order. Complete reference citation (within brackets) can be located in the reference section. ES, effect size Hedge's *g*; LL, lower level 95%; UL, upper level 95%.

ORTO, the results revealed comparable BOT levels in men and women ($g^* = -0.078$; 95% CI, –0.280 to 0.124; $P = 0.359$). Effect sizes were quite heterogeneous according to the *Q*-test ($P = 0.001$) and an I^2 value of 71%. Although the Funnel plot (Fig. 6) did not reveal marked asymmetry, the Egger test ($t = 2.33$; $P = 0.058$) indicated at least some publication bias.

Analysis of studies using the EHQ

The sample size in the primary reports employing the EHQ ranged from 41 to 516 ($k = 8$; $N = 2328$; Fig. 5). When divided by subscale, all three scales, behaviors/cognitions ($P = 0.269$), feelings ($P = 0.064$), and problems ($P = 0.415$) yielded non-significant

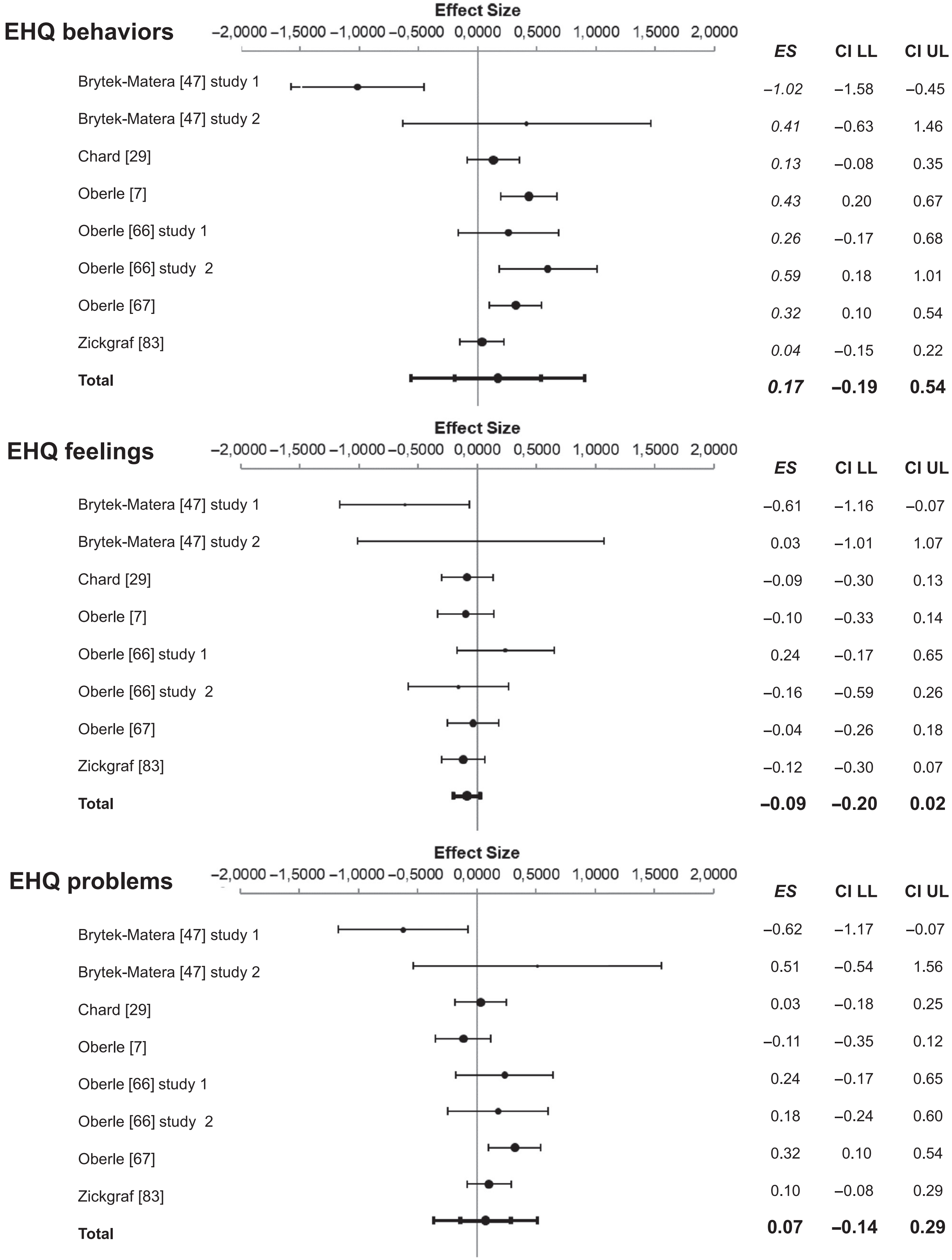


Fig. 5. Forest plot of all studies employing the Eating Habits Questionnaire (EHQ) with the behaviors, feelings, and problems subscale separately displayed. Note that positive values indicate higher orthorexic tendencies/pathologically healthful eating in men; negative values indicate higher levels in women. Studies are cited in alphabetical order. Complete reference citation (within brackets) can be located in the reference section. ES, effect size Hedge's *g*; LL, lower level 95%; UL, upper level 95%.

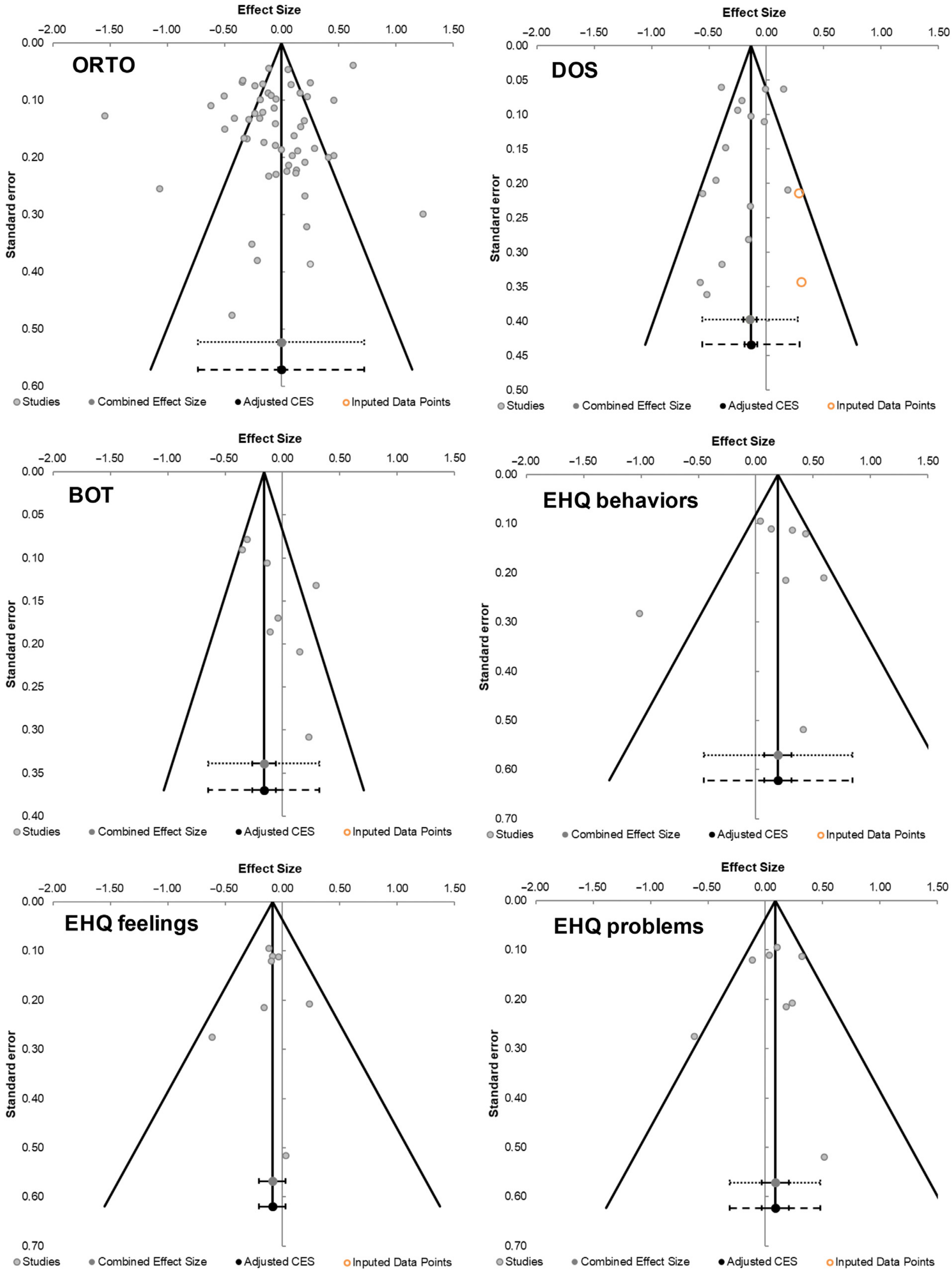


Fig. 6. Measurement tool-specific funnel plots. BOT, Bratman Orthorexia Test; CES, combined effect size; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; ORTO, test for the diagnosis of orthorexia.

findings. Of note, the mean effect size for the feeling subscale indicated that women reported slightly more positive feelings about healthy eating. There was a significant heterogeneity of effect sizes on the behavior ($P < 0.001$; $I^2 = 77\%$) and problems subscales ($P = 0.031$; $I^2 = 54\%$), but not on the feelings subscale ($P = 0.474$; $I^2 = <1\%$). Visual inspection of Funnel plots and Egger's tests (all $P > 0.781$) did not suggest publication bias.

Analysis of studies using another tool

The sample sizes in the two primary reports employing another tool were 119 and 981 (N = 1100). Again, there was no difference between men and women in pathologically healthful eating when combining the effect sizes of both reports ($g^* = 0.333$; 95% CI, −18.952 to 19.617; $P = 0.827$). Because there were only two reports included, heterogeneity and publication bias testing cannot be interpreted meaningfully.

Subgroup analysis

Moderator analysis was preceded by a subgroup analysis to explore a potential dispersion of effect sizes. In cases where a subgroup was rather homogenous (i.e., only low dispersion of effect sizes), there was also limited variance to be explained. Therefore, including this subgroup in the moderator analysis was not advisable. Analyses of ORTO, DOS, and BOT did not indicate significant sex differences between general population and high-risk samples (see Table 3). Because there was only one EHQ-measuring study examining a population assumed to be at risk for developing pathologically healthful eating [47], and one of the two studies that used another tool assessed a general population sample while the other assessed a high-risk sample, moderator analyses did not considered these.

Moderator analysis

The possible moderators age, year of publication, and sex distribution were tested in a random-effects model (Table 4). Age had a significant influence on sex-specific BOT values. Here, a negative slope estimate (B = −0.11) indicated that the higher the sample's mean age the more negative the mean effect size (i.e., in older age study samples, women were more likely to show higher BOT levels and vice versa; in younger age samples men were more likely). Year since publication and sex distribution significantly influenced the behaviors subscale of the EHQ. Negative slope estimates indicated that older studies and studies employing a greater number of women showed more positive mean effect sizes (i.e., higher normative healthy eating behaviors in men). None of the other moderation analyses appeared significant.

Table 3
Measurement tool-specific analysis of subgroup-specific ES

Instrument	ES	−95% CI	+95% CI	Q	*P*-value*	GP, HR
ORTO						
GP	−0.111	−0.219	0.003	1.25	0.264	GP = HR
HR	0.031	−0.192	0.254			
DOS						
GP	−0.238	−0.374	−0.102	1.09	0.296	GP = HR
HR	−0.092	−0.380	0.195			
BOT						
GP	−0.060	−0.465	0.344	0.02	0.886	GP = HR
HR	−0.089	−0.515	0.337			
EHQ behaviors						
GP	0.264	−0.087	0.441	NA	NA	NA
HR	−1.016	NA	NA			
EHQ feelings						
GP	−0.071	−0.156	0.013	NA	NA	NA
HR	−0.614	NA	NA			
EHQ problems						
GP	0.115	−0.038	0.268	NA	NA	NA
HR	−0.621	NA	NA			
Other						
GP	1.844	NA	NA	NA	NA	NA
HR	−1.191	NA	NA			

BOT, Bratman Orthorexia Test; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; ES, effect size; GP, general population; HR, population assumed to be at risk for developing pathologically healthful eating; NA, not available; ORTO, test for the diagnosis of orthorexia; Q, sum of squares analysis of variance.
P* < 0.05 considered significant highlighted in **bold.

Table 4
Measurement tool-specific moderator analysis of ES

Instrument	B*	SE†	Q	*P*-value‡	R^2, %
ORTO					
Age	0.003	0.009	0.11	0.741	0.23
Year	−0.018	0.016	1.24	0.265	2.48
Women %	0.003	0.004	0.74	0.391	1.47
DOS					
Age	0.002	0.008	0.06	0.807	0.55
Year	−0.060	0.052	1.34	0.248	10.04
Women %	−0.005	0.004	1.62	0.203	9.51
BOT					
Age	**−0.110**	0.033	11.29	**0.001**	67.89
Year	0.013	0.041	0.10	0.756	1.61
Women %	0.002	0.015	0.01	0.915	0.21
EHQ§ behaviors					
Age	−0.018	0.011	2.85	0.091	37.33
Year	**0.198**	0.067	8.72	**0.003**	75.23
Women %	**0.010**	0.004	8.63	**0.003**	74.43
EHQ feelings					
Age	−0.003	0.008	0.18	0.670	6.45
Year	−0.021	0.067	0.10	0.754	3.48
Women %	0.002	0.004	0.49	0.485	17.23
EHQ problems					
Age	0.002	0.013	0.02	0.892	0.44
Year	−0.041	0.097	0.17	0.678	3.78
Women %	0.002	0.005	0.22	0.642	4.85

BOT, Bratman Orthorexia Test; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; ES, effect size; ORTO, test for the diagnosis of orthorexia; Q, sum of squares analysis of variance.
*B = coefficient of the slope (i.e., estimate of the association between moderator and effect size).
†Standard error of B.
‡*P* < 0.05 considered significant highlighted in **bold**.
§EHQ with its subscales behaviors, problems, feelings; this analysis was based on seven studies.

Discussion

Summary of findings

In early research on ON, a higher prevalence of this phenomenon was assumed in men [10]. After research, however, this assumption has been questioned. This meta-analysis and systematic review brought together the research on sex differences available to date. It also informed the debate about possible correlates of orthorexic eating tendencies. Overall, 67 reports including 39 255 individuals, two-thirds of whom were women, were deemed eligible and provided 89 effect sizes. The different instruments assessing pathologic healthful eating (DOS, EHQ) or tendencies toward healthy eating (ORTO-15, BOT) were evaluated in separate analyses. Most of the reports employed the ORTO-15 or one of its versions (55 studies). The second most employed tool was the DOS (16 studies), and the BOT and EHQ were assessed in 8 studies each. Data from 2 reports employing a self-developed tool were also considered. The meta-analytical summary of these studies did not provide indication for different mean levels between men and women when using the ORTO, BOT or EHQ. By contrast, studies using the DOS showed more orthorexic tendencies in women. The average effect size of these studies can be regarded as small. Additionally, women scored somewhat higher on the EHQ feelings subscale (i.e., they had more positive feelings toward healthy eating). Samples derived from the general population and those with an assumed risk for developing pathologically healthful eating (e.g., individuals on diets, those performing a restrictive form of diet, those with a special knowledge in nutrition, or individuals with a particular focus on health and fitness) showed similar tendencies toward (pathologically) healthy eating across the sexes. The moderators age, year of publication, and sex distribution provided little explanation for the variation in effect sizes. In older age study samples, women were more likely to show higher BOT levels. However, this finding should be interpreted with caution because of the small number of studies (n = 8) and the restricted age range (20.7–25.6 y). Men showed higher scores on the EHQ behavior subscale, representing higher normative healthy eating behaviors, when the study was older and employed a larger number of women. Again, this should be interpreted in the context of small sample bias. Visual inspection of funnel plots and statistical testing demonstrated no relevant publication bias. However, interpretation of results is subject to some caveats, as detailed here.

Integration

With the emerging discussion as to whether ON should be regarded as an eating disorder, an obsessive-compulsive disorder, a behavioral addiction, or an affective disorder, a debate was also triggered about sex-specific levels and prevalence rates and how comparable men and women actually are in symptomatology and etiology. It seems reasonable that men and women differ in specific characteristics of orthorexic behaviors (e.g., motivations: having a focus on eating healthy with the objective of increasing physical fitness and body shaping compared with becoming healthier).

Tendencies toward healthy eating

ORTO effect sizes differed largely between 1.23 [72] and −1.55 [44], with 37 of 55 studies showing at least somewhat higher tendencies toward healthy eating in women. One might wonder whether the origin of the sample might have added to this diversity. With the ORTO being the most widely used tool examining tendencies toward healthy eating, data stems from a variety of countries. Comparing effect sizes from English-speaking populations (n = 15, mean effect size [ES], −0.24) to those of southern European populations (n = 14, mean ES, −0.03) and Turkish populations (n = 10, mean ES, −0.11) did demonstrate a slight influence of country of origin or nationality. Studies from English-speaking countries were somewhat more likely to show higher ORTO levels in women. Interestingly, none of the assumed moderators significantly predicted sex differences in ORTO levels. Thus, heterogeneity in men's and women's interest in healthy eating seems to be unrelated to age and risk status based on nutrition knowledge or interest in fitness, health, or dieting.

Comparing the BOT studies providing the most different effect sizes also indicated an effect of nationality. Both, Hayes et al. [55] and Dittfeld et al. [53] investigated a sample from the general population that was composed of >80% women but showed different effect directions. However, the Dittfeld et al. sample was collected in Poland and showed a negative effect size, whereas the Hayes et al. sample was collected in the United States and showed a positive effect size. The effects of cultural differences have repeatedly been debated [4,24,34]. Tools aimed at assessing orthorexic behaviors should consider the cultural and religious background where the behavior occurs; most recently proposed definition criteria are already taking cultural aspects into account [3]. The significant effect of age on sex-specific BOT levels can only be cautiously interpreted (number of studies, restricted age range). Whether the missing sex difference can be attributed to the demographic characteristics of samples under study remains speculative. However, this finding highlights the need to investigate samples that reflect the diversity of the population.

Orthorexic and pathologically healthful eating

Although there was also some variation in DOS effect sizes, most of the studies showed higher orthorexic eating behaviors in women (14 of 16). However, DOS findings are limited in generalizability, as this scale was mainly employed in German-speaking samples. Importantly, the DOS recently was translated into English [29], Chinese [90], and Spanish [91]. Future studies including samples from different countries will enhance the knowledge of sex-specific DOS levels and the moderating effects of sociocultural background. Looking at two studies from Rudolph et al. [77,78] reveals an important aspect to consider when interpreting findings. Both studies included populations assumed to be at risk for developing ON (fitness club members). One study [77] provided a negative effect size (i.e., higher DOS levels in women), and this study was conducted in a rather young sample and included a larger number of women. The other report [78] included similar numbers of men and women and was of slightly higher age. Here, a positive effect size was found (i.e., higher DOS levels in men). One can assume that studies in younger samples and those oversampling women might overestimate DOS levels in women. The moderation analysis, however, did not confirm this assumption. Nevertheless, future studies should cover wider age ranges and ensure a balanced sex ratio.

The three scales of the EHQ showed different directions of effects (all not significant). Most studies found men to score somewhat higher on the behavior and problems subscales; whereas women more often scored higher on the feelings subscale. This result might indicate different characteristics of pathologically healthful eating and related consequences between men and women. It is possible that men focus more on normative behaviors and show more problems from this rigid eating behavior, whereas women's (pathologically) healthful eating behaviors are more related to having positive feelings about their eating. Future studies will need to demonstrate whether this hypothesis holds true. Additionally, one might wonder whether personality factors and the attribution of sex roles in different cultures might explain some of the variances found in effect sizes of sex differences. Although cross-cultural sex differences in personality traits are rather small, the magnitude of this difference seems to vary between countries and across cultures [92]. At this point, it is too early to draw any conclusions given the small number of studies measuring personality traits in relation to healthy eating and pathologically healthful eating and, to our knowledge, no previous study has explored this association across cultures. Of note, EHQ findings need to be interpreted in light of the moderating effect of year since publication and sex distribution. Women showed higher mean levels on the behaviors subscale than men when the study was older and when it oversampled women. Against this background, sex differences on this scale might be underestimated so far.

Implications

Studies employing the ORTO-15 and the BOT, which have been said to not measure orthorexic eating behaviors and should not be used to diagnose ON or investigate ON prevalence [15,24], indicated equal levels in men and women. This corresponds well with studies showing similar levels of subclinical eating disorder behaviors between men and women [20]. However, it also should be emphasized that the majority of studies showed higher subclinical eating disorder symptoms in women [19]. In line with this data, a slight sex difference was found on the DOS. Women showed slightly higher levels of orthorexic and pathologically healthful eating. This finding may support the assumption that orthorexic behaviors and eating disorders share relevant commonalities. From a phenomenological point of view, ON and eating disorders conceptually overlap: the ritualized and obsessive preoccupation with food and nutrition, the rigorous orientation toward following strict dietary rules, the need to control and "medicate" the discomfort of emotions, and functional impairments due to dietary behaviors. Although ON may thus fit best into the category of eating disorders (e.g., as another subtype of anorexia nervosa [8]), the findings from the present meta-analysis are not able to answer equally important questions regarding the syndrome's co-occurrence with other mental health disorders, its medical and psychiatric complications, or whether it can be distinguished from other healthy lifestyle features.

Limitations

The interpretation of the findings from the present meta-analysis does not come without some limitations. First, only mean levels of pathologically healthful eating were examined. Analyses did not compare numbers of cases and non-cases. Although this precluded any conclusion about prevalence rates of clinically relevant cases, this procedure was deemed more appropriate. It may be not suitable to use proposed cutoffs as these were created rather arbitrary and not based on clinical data. Second, some of the subanalyses were performed with only a small number of effect sizes. Future studies with larger and more representative samples are needed. Research on cohort effects needs to go beyond student samples and include samples from across the full life span, particularly with participants >50 years of age. Third, some of the measurement tools reviewed have been criticized for their weak psychometric properties [15,24]. To address this and to not overinterpret findings from criticized tools, this meta-analysis made a clear distinction between tools measuring tendencies toward healthy eating and those allowing for conclusions about pathologically healthful and orthorexic eating. Additionally, this meta-analysis considered only a small number of theoretically conceivable factors that moderate sex differences. Personality, physical and mental well-being, body mass index (BMI), or sociocultural aspects are just some of the numerous additional factors. Research suggesting interactions between sex and BMI in levels of orthorexic eating behaviors [7,83] highlight the particular relevance of this factor and demand future research efforts. Finally, meta-analyses do not allow for making causal inferences. Thus, implications for understanding the causes of sex differences could not be drawn. Moderation analyses provided suggestive evidence for orthorexic eating behaviors to not vary with age or year of publication (as our proxy for generation). Due to the cross-sectional nature of all reports included in this meta-analysis, the findings cannot be used to infer stable sex differences.

Future tasks and objectives

The results have implications for future research by pointing out limitations and need for future research. First of all, primary studies were based on self-report data. Future research needs to adopt valid criteria for diagnosing ON (for a most current proposal see Cena et al. [3]) and substantiate these with biological or neuropsychological markers. Although sex differences in psychological traits are generally small [93,94], they should not be regarded as having no consequences. Even small effects can have profound consequences at the individual and societal levels, or they may accumulate over time or when summed across domains [95]. The study of sex differences in pathologically healthful eating will help to theorize on the phenomenon's etiology as they suggest specific biological (neurologic, hormonal), social (social regulation, sex identity), and contextual factors (governance, local, cultural) of explaining those differences.

References

[1] Katz DL, Meller S. Can We say what diet is best for health? Annu Rev Public Health 2014;35:83–103.
[2] Mujcic R, Oswald AJ. Evolution of well-being and happiness after increases in consumption of fruit and vegetables. Am J Public Health 2016;106:1504–10.
[3] Cena H, Barthels F, Cuzzolaro M, Bratman S, Brytek-Matera A, Dunn T, et al. Definition and diagnostic criteria for orthorexia nervosa: A narrative review of the literature. Eat Weight Disord 2019;24:209–46.
[4] Strahler J, Stark R. Orthorexia nervosa: a behavioral condition or a new mental disorder? Suchttherapie 2019;20:24–34.
[5] Barnes MA, Caltabiano ML. The interrelationship between orthorexia nervosa, perfectionism, body image and attachment style. Eat Weight Disord 2017;22:177–84.
[6] Sanlier N, Yassibas E, Bilici S, Sahin G, Celik B. Does the rise in eating disorders lead to increasing risk of orthorexia nervosa? Correlations with gender, education, and body mass index. Ecol Food Nutr 2016;55:266–78.
[7] Oberle CD, Samaghabadi RO, Hughes EM. Orthorexia nervosa: assessment and correlates with gender, BMI, and personality. Appetite 2017;108:303–10.
[8] Barthels F, Meyer F, Pietrowsky R. Orthorexic eating behavior. a new type of disordered eating. Ernährungsumschau 2015;62:156–61.
[9] Brytek-Matera A, Rogoza R, Gramaglia C, Zeppegno P. Predictors of orthorexic behaviours in patients with eating disorders: a preliminary study. BMC Psychiatry 2015;15:252.
[10] Bratman S, Knight D. Health food junkies: overcoming the obsession with healthful eating. New York, NY: Broadway Books; 2000.
[11] Dell'Osso L, Abelli M, Carpita B, Massimetti G, Pini S, Rivetti L, et al. Orthorexia nervosa in a sample of Italian university population. Riv Psychiatr 2016;51:190–6.
[12] 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;22:193–9.
[13] Donini L, Marsili D, Graziani M, 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;9:151–7.
[14] 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;22:185–92.
[15] 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.
[16] 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;24:267–73.
[17] Strahler J, Hermann A, Walter B, Stark R. Orthorexia nervosa: a behavioral complex or a psychological condition? J Behav Addict 2018;7:1143–56.
[18] Galmiche M, Déchelotte P, Lambert G, Tavolacci MP. Prevalence of eating disorders over the 2000−2018 period: a systematic literature review. ThAm J Clin Nutr 2019;109:1402–13.
[19] Smith KE, Mason TB, Murray SB, Griffiths S, Leonard RC, Wetterneck CT, et al. Male clinical norms and sex differences on the Eating Disorder Inventory (EDI) and Eating Disorder Examination Questionnaire (EDE−Q). Int J Eat Disord 2017;50:769–75.
[20] Mond J, Mitchison D, Hay P. Prevalence and implications of eating disordered behavior in men. In: Cohn L, Lemberg R, editors. Current findings on males with eating disorders, Philadelphia, PA: Routledge; 2014.
[21] McComb SE, Mills JS. Orthorexia nervosa: a review of psychosocial risk factors. Appetite 2019;140:50–75.
[22] Brytek-Matera A, Fonte ML, Poggiogalle E, Donini LM, Cena H. Orthorexia nervosa: Relationship with obsessive-compulsive symptoms, disordered eating patterns and body uneasiness among Italian university students. Eat Weight Disord 2017;22:609–17.
[23] Donini L, Marsili D, Graziani M, Imbriale M, Cannella C. Orthorexia nervosa: validation of a diagnosis questionnaire. Eat Weight Disord 2005;10:e28–32.
[24] Missbach B, Dunn TM, König JS. We need new tools to assess orthorexia nervosa. A commentary on "prevalence of orthorexia nervosa among college students based on Bratman's test and associated tendencies.". Appetite 2017;108:521–4.
[25] Rogoza R. Investigating the structure of ORTO-15: a meta-analytical simulation study. Eat Weight Disord 2019;24:363–5.
[26] Gleaves DH, Graham EC, Ambwani S. Measuring 'orthorexia': development of the Eating Habits Questionnaire. Int J Educ Psychol Ass 2013;12:1–18.
[27] Barthels F, Meyer F, Pietrowsky R. Die Düsseldorfer Orthorexie Skala−Konstruktion und Evaluation eines Fragebogens zur Erfassung orthorektischen Ernährungsverhaltens. Z Kl Psych Psychot 2015;44:97–105.

[28] Barthels F, Meyer F, Pietrowsky R. Orthorexic and restrained eating behaviour in vegans, vegetarians, and individuals on a diet. Eat Weight Disord 2018;23:159–66.
[29] 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;24:275–81.
[30] Dittfeld A, Gwizdek K, Koszowska A, Nowak J, Brończyk-Puzoń A, Jagielski P, et al. Assessing the risk of orthorexia in dietetic and physiotherapy students using the BOT (Bratman Test for Orthorexia). Pediatr Endocrinol Diabetes Metab 2016;22:6–13.
[31] Fidan T, Ertekin V, Işikay S, Kırpınar I. Prevalence of orthorexia among medical students in Erzurum, Turkey. Compr Psychiatry 2010;51:49–54.
[32] Grammatikopoulou MG, Gkiouras K, Markaki A, Theodoridis X, Tsakiri V, Mavridis P, et al. Food addiction, orthorexia, and food-related stress among dietetics students. Eat Weight Disord 2018;23:459–67.
[33] Segura-García C, Papaianni MC, Caglioti F, Procopio L, Nisticò CG, Bombardiere L, et al. Orthorexia nervosa: a frequent eating disordered behavior in athletes. Eat Weight Disord 2012;17:e226–33.
[34] Cinquegrani C, Brown DH. 'Wellness' lifts us above the food chaos: a narrative exploration of the experiences and conceptualisations of orthorexia nervosa through online social media forums. Qual Res Sport Exerc Health 2018;5:585–603.
[35] Aksoydan E, Camci N. Prevalence of orthorexia nervosa among Turkish performance artists. Eat Weight Disord 2009;14:33–7.
[36] Almeida C, Borba VV, Santos L. Orthorexia nervosa in a sample of Portuguese fitness participants. Eat Weight Disord 2018;23:443–51.
[37] Alvarenga M, Martins M, Sato K, Vargas S, Philippi ST, Scagliusi F. Orthorexia nervosa behavior in a sample of Brazilian dietitians assessed by the Portuguese version of ORTO-15. Eat Weight Disord 2012;17:e29–35.
[38] Arusoğlu G, Kabakçi E, Köksal G, Merdol TK. Orthorexia nervosa and adaptation of ORTO-11 into Turkish. Turk Psikiyatri Derg 2008;19:283–91.
[39] Asil E, Sürücüoğlu MS. Orthorexia nervosa in Turkish dietitians. Ecol Food Nutr 2015;54:303–13.
[40] Barnett MJ, Dripps W, Blomquist KK. Organivore or organorexic? Examining the relationship between alternative food network engagement, disordered eating, and special diets. Appetite 2016;105:713–20.
[41] Barthels F, Meyer F, Amrhein J, Scharmach K, Pietrowsky R. Konvergente Konstruktvalidität der Düsseldorfer Orthorexie Skala. Zeitschrift für Klinische Psychologie und Psychotherapie 2018;47:109–18.
[42] Bo S, Zoccali R, Ponzo V, Soldati L, De Carli L, Benso A, et al. University courses, eating problems and muscle dysmorphia: Are there any associations? J TRansl Med 2014;12:221.
[43] Bona E, Szei Z, Kiss D, Gyarmathy VA. An unhealthy health behavior: analysis of orthorexic tendencies among Hungarian gym attendees. Eat Weight Disord 2019;24:13–20.
[44] Bosi ATB, Çamur D, Güler Ç. Prevalence of orthorexia nervosa in resident medical doctors in the faculty of medicine (Ankara, Turkey). Appetite 2007;49:661–6.
[45] 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.
[46] Brytek-Matera A, Donini LM, Krupa M, Poggiogalle E, Hay P. Orthorexia nervosa and self-attitudinal aspects of body image in female and male university students. J Eat Disord 2015;3:2.
[47] Brytek-Matera A, Czepczor-Bernat K, Jurzak H, Kornacka M, Kołodziejczyk N. Strict health-oriented eating patterns (orthorexic eating behaviours) and their connection with a vegetarian and vegan diet. Eat Weight Disord 2019;24: 441–52.
[48] Bundros J, Clifford D, Silliman K, Morris MN. Prevalence of orthorexia nervosa among college students based on Bratman's test and associated tendencies. Appetite 2016;101:86–94.
[49] Çiçekoğlu P, Tunçay GY. A comparison of eating attitudes Between Vegans/Vegetarians and Nonvegans/Nonvegetarians in Terms of Orthorexia Nervosa. Arch Psychiatr Nurs 2018;32:200–5.
[50] 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;24:473–80.
[51] Costa CB, Hardan-Khalil K. Orthorexia nervosa and obsessive-compulsive behavior among college students in the United States. J Nurs Ed Pract 2019;9:67–75.
[52] Dell'Osso L, Carpita B, Muti D, Cremone I, Massimetti G, Diadema E, et al. Prevalence and characteristics of orthorexia nervosa in a sample of university students in Italy. Eat Weight Disord 2018;23:55–65.
[53] Dittfeld A, Gwizdek K, Jagielski P, Brzęk A, Ziora K. A study on the relationship between orthorexia and vegetarianism using the BOT (Bratman Test for Orthorexia). Psychiatr Pol 2017;51:1133–44.
[54] Haddad C, Obeid S, Akel M, Honein K, Akiki M, Azar JSH. Correlates of orthorexia nervosa among a representative sample of the Lebanese population. Eat Weight Disord 2019;24:481–93.
[55] 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;31:124–35.
[56] Heiss S, Coffino JA, Hormes JM. What does the ORTO-15 measure? Assessing the construct validity of a T common orthorexia nervosa questionnaire in a meat avoiding sample. Appetite 2019;135:93–9.
[57] Hyrnik J, Janas-Kozik M, Stochel M, Jelonek I, Siwiec A, Rybakowski JK. The assessment of orthorexia nervosa among 1899 polish adolescents using the ORTO-15 questionnaire. Int J Psychiatry Clin Pract 2016;20(3):199–203.
[58] Karadag MG, Elibol E, Yildiran H, Akbulut G, Celik MG, Degirmenci M, et al. Evaluation of the relationship between obesity with eating attitudes and orthorexic behavior in healthy adults. Gazi Med J 2016;27(3):107–14.
[59] 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;4:117.
[60] Keller M, Konradsen H. Ortoreksi blandt unge fitness-medlemmer. Klin Sygepleje 2013;27:63–71.
[61] Kiss-Leizer M, Rigo A. People behind unhealthy obsession to healthy food: the personality profile of tendency to orthorexia nervosa. Eat Weight Disord 2019;24:29–35.
[62] Korinth A, Schiess S, Westenhoefer J. Eating behaviour and eating disorders in students of nutrition sciences. Public Health Nutr 2010;13:32–7.
[63] Koven NS, Senbonmatsu R. A neuropsychological evaluation of orthorexia nervosa. Open J Psychiatr 2013;3:214–22.
[64] 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;109:137–43.
[65] Moller S, Apputhurai P, Knowles SR. Confirmatory factor analyses of the ORTO 15-, 11- and 9-item scales and recommendations for suggested cut-off scores. Eat Weight Disord24:21−8.
[66] Oberle CD, Watkins RS, Burkot AJ. Orthorexic eating behaviors related to exercise addiction and internal motivations in a sample of university students. Eat Weight Disord 2018;23:67–74.
[67] Oberle CD, Lipschuetz SL. Orthorexia symptoms correlate with perceived muscularity and body fat, not BMI. Eat Weight Disord 2018;23:363–8.
[68] Olejniczak D, Bugajec D, Panczyk M, Brytek-Matera A, Religioni U, Czerw A, et al. analysis concerning nutritional behaviors in the context of the risk of orthorexia. Neuropsychiatric Dis Treat 2017;13:543.
[69] 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;18:364.
[70] Parra-Fernández ML, Rodríguez-Cano T, Onieva-Zafra MD, Perez-Haro MJ, Casero-Alonso V, Camargo JCM, 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:e0190722.
[71] Parra-Fernández ML, Rodríguez-Cano T, Perez-Haro MJ, Onieva-Zafra MD, Fernandez-Martinez E, Notario-Pacheco B. Structural validation of ORTO-11-ES for the diagnosis of orthorexia nervosa, Spanish version. Eat Weight Disord 2018;23:745–52.
[72] Penaforte FR, Barroso SM, Araújo ME, Japur CC. Ortorexia nervosa em estudantes de nutrição: Associações com o estado nutricional, satisfação corporal e período cursado. J Bras Psiquiatr 2018;67:18–24.
[73] Plichta M, Jezewska-Zychowicz M, Gębski J. Orthorexic tendency in Polish students: exploring association with dietary patterns, body satisfaction and weight. Nutrients 2019;11:100.
[74] Ramacciotti C, 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:e127–30.
[75] Reynolds R. Is the prevalence of orthorexia nervosa in an Australian university population 6.5%? Eat Weight Disord 2018;23:453–8.
[76] Roncero M, Barrada JR, Perpiñá C. Measuring orthorexia nervosa: psychometric limitations of the ORTO-15. Span J Psychol 2017;20:1–9.
[77] Rudolph S, Göring A, Jetzke M, Großarth D, Rudolph H. Zur Prävalenz von orthorektischem Ernährungsverhalten bei sportlich aktiven Studierenden: Zur Prävalenz von orthorektischem Ernährungsverhalten bei sportlich aktiven Studierenden. Deutsche Zeitschrift für Sportmedizin 2017;68(1).
[78] Rudolph S. The connection between exercise addiction and orthorexia nervosa in German fitness sports. Eat Weight Disord 2018;23:581–6.
[79] 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;117:1612–7.
[80] Valera JH, Ruiz PA, Valdespino BR, Visioli F. Prevalence of orthorexia nervosa among ashtanga yoga practitioners: a pilot study. Eat Weight Disord 2014;19:469–72.
[81] Varga M, Thege BK, Dukay-Szabó S, Túry F, van Furth EF. When eating healthy is not healthy: orthorexia nervosa and its measurement with the ORTO-15 in Hungary. BMC Psychiatr 2014;14:59.
[82] Vital ANS, Silva ABA, Garcia EI, de Omena Messias CMB. Risco para desenvolvimento de ortorexia nervosa e o comportamento alimentar de estudantes universitários. Saúde e Pesquisa 2017;10:83–9.
[83] Zickgraf HF, Ellis JM, Essayli JH. Disentangling orthorexia nervosa from healthy eating and other eating disorder symptoms: relationships with clinical impairment, comorbidity, and self-reported food choices. Appetite 2019;134:40–9.
[84] Suurmond R, van Rhee H, Hak T. Introduction, comparison, and validation of Meta−Essentials: a free and simple tool for meta−analysis. Res Synth Meth 2017;8:537–53.

[85] Borenstein M, Hedges LV, Higgins JP, Rothstein HR. Introduction to meta-analysis. Chichester: John Wiley & Sons, Ltd.; 2011.
[86] Hedges LV. Distribution theory for Glass's estimator of effect size and related estimators. J Educ Stat 1981;6:107–28.
[87] Sánchez-Meca J, Marín-Martínez F. Confidence intervals for the overall effect size in random-effects meta-analysis. Psychol Meth 2008;13:31.
[88] Huedo-Medina TB, Sánchez-Meca J, Marín-Martínez F, Botella J. Assessing heterogeneity in meta-analysis: Q statistic or I^2 index? Psychol Meth 2006;11:193.
[89] Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. Br Med J 1997;315:629–34.
[90] 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;24:453–63.
[91] Parra-Fernández ML, Onieva-Zafra MD, Fernández-Muñoz JJ, Fernández-Martínez E. Adaptation and validation of the Spanish version of the DOS questionnaire for the detection of orthorexic nervosa behavior. PLoS One 2019;14:e0216583.
[92] Costa PT JR, Terracciano A, McCrae RR. Gender differences in personality traits across cultures: robust and surprising findings. J Pers Soc Psychol 2001;81:322.
[93] Hyde JS. The gender similarities hypothesis. Am Psychol 2005;60:581.
[94] Zell E, Krizan Z, Teeter SR. Evaluating gender similarities and differences using metasynthesis. Am Psychol 2015;70:10.
[95] Del Giudice M, Booth T, Irwing P. The distance between Mars and Venus: measuring global sex differences in personality. PLoS One 2012;7:e29265.