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Alike and different: Associations between orthorexic eating behaviors and exercise addiction

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Abstract

Objective: Symptoms of exercise addiction, a state of compulsively engaging in intense exercise, and orthorexic eating attitudes, the obsession with eating only healthy foods, often occur together. It is assumed that some more general psychological traits underlie this association. Main aim of this report was to examine similarities and differences between orthorexic eating and addictive exercising.

Method: Six hundred and eight individuals completed an online survey (mean age: 27.5, *SD* = 11.0 years; 76.5% women) measuring exercise addiction (Exercise Addiction inventory, EAI), orthorexic eating (Düsseldorfer Orthorexie Skala, DOS), personality domains (Big-Five Inventory-10), anxiety and depression (Hospital Anxiety and Depression Scale).

Results: Correlations between the DOS and EAI were .43 in women and .62 in men. Structural equation models identified gender-specific as well as behavior-specific psychological correlates. Among women, anxiety correlated with both EAI and DOS. In addition, the DOS correlated with depression and neuroticism while the EAI correlated with conscientiousness. In men, both scales were associated with conscientiousness and the EAI also correlated with extraversion. Clusterability analysis provided no evidence for clusters based on DOS and EAI.

Discussion: Present results showed a substantial correlation between addictive exercising and orthorexic eating, however, coefficients were smaller than expected and appeared higher in men. Both behaviors shared few psychological traits (anxiety in women, conscientiousness in men) thereby questioning the assumption of a similar origin. Additionally, gender-specific psychological correlates point to the need for different disease management approaches in women and men.

KEYWORDS
compulsive exercise, exercise addiction, gender differences, mental health, orthorexia, pathological eating, personality, subgroup identification

1 | INTRODUCTION

1.1 | Excessive healthy lifestyle

Eating a healthy diet and regular physical activity are among the most promising practices to increase health and prevent or improve several physical and mental disorders (PAGAC, 2018; WHO, 2010). When pursued obsessively, both healthy eating and exercise may result in adverse consequences, including emotional distress when self-imposed rules are violated, malnourishment and weight loss, and social and functional impairments. Two phenomena have received much media coverage and scientific attention in this regard, orthorexia nervosa and exercise addiction. Orthorexia nervosa (ON) is characterized by the fixation on and preoccupation with healthy eating (for a recent proposal of diagnostic criteria see Cena et al., 2019). Those affected follow a restrictive diet, avoid unhealthy food, perform ritualized patterns of eating, and have rigid dietary rules. Exercise addiction has been described as a behavioral addiction. Its clinical description is based on the criteria for substance-related addictions: exercise plays the most important role in life, exercising creates a positive mood, nonexercising results in unpleasant emotional and physical states, conflicts with the social environment arise, and a tendency to return to one's original training intensity after the attempt to reduce training loads (Griffiths, 1997; Nogueira, Molinero, Salguero, & Marquez, 2018). Neither ON nor exercise addiction are currently recognized as distinct mental disorders in major psychiatric classification schemes. Up to date, there is no commonly accepted set of diagnostic criteria and there is limited empirical evidence for clinically relevant consequences and impairment arising from these problematic behaviors (McComb & Mills, 2019; Strahler & Stark, 2020; Trott et al., 2020). In addition, due to the variety of tools used and some of them showing insufficient psychometric properties (Opitz, Newman, Mellado, Robertson, & Sharpe, 2020), prevalence differed widely among studies: 3 to >40% for exercise addiction (Nogueira et al., 2018) and 1 to >85% for ON (McComb & Mills, 2019).

Some experts question whether excessive healthy behaviors like ON and exercise addition are, if at all, disorders in their own right or variants of other mental disorders such as eating disorders or obsessive–compulsive disorder (Hay, 2021; Lichtenstein, Hinze, Emborg, Thomsen, & Hemmingsen, 2017; Meule & Voderholzer, 2021). Conceptualization of exercise addiction particularly in eating disorders is complex (Freimuth, Moniz, & Kim, 2011) and there are some authors who even doubt the existence of primary exercise addiction, that is exercise addiction without an eating disorder comorbidity (Bamber, Cockerill, Rodgers, & Carroll, 2000). Likewise, there is an ongoing debate whether to place ON within the eating disorder spectrum, for example, as "avoidant/restrictive food intake disorder (ARFID)" or "unspecific eating disorder" (Bartel, Sherry, Farthing, & Stewart, 2020). ARFID can be diagnosed in adults and children but it occurs more frequently in early childhood. Hence, current approaches favor the latter. Indeed, drive for thinness and weight/shape concerns are increasingly recognized to be essential motivators of orthorexic eating, particularly in women (Stutts, 2020). As for exercise addiction, ON is argued to be hardly distinguishable from weight- and shape-concerned disordered eating (Zickgraf, Ellis, & Essayli, 2019). In addition, obsessive–compulsive disorder shows many commonalities with both, ON and exercise addiction (Cena et al., 2019; Holland & Tiggemann, 2017; Koven & Abry, 2015; Müller, Loeber, Söchtig, Te Wildt, & De Zwaan, 2015). It follows that a relationship between ON and exercise addiction is highly likely.

1.2 | Association between orthorexic and (addictive) exercise behaviors

Higher orthorexic eating attitudes in athlete populations seem to confirm this assumption (Eriksson, Baigi, Marklund, & Lindgren, 2008; Rudolph, 2018; Valera, Ruiz, Valdespino, & Visioli, 2014). Reviewing current research, a recent meta-analysis explored whether ON or orthorexic eating tendencies are associated with exercise measures and exercise addiction (Strahler, Wachten, & Mueller-Alcazar, in press). Analyses showed that associations with general exercise measures appeared weak, correlations with exercise addiction were moderate. It must be mentioned that the majority of previous studies used the ORTO-15 or one of its versions, a tool criticized for its poor psychometric properties (Opitz et al., 2020). Studies employing this tool provided smaller correlations. While ON and exercise addiction thus may share common variance, underlying mechanisms are hardly understood. In addition to possibly similar underlying motives, for example, weight and shape (over)evaluation, there are also some characteristics that clearly distinguish the two. In general population samples and among recreational exercisers, men are more addicted to exercise than women (Dumitru, Dumitru, & Maher, 2018). By contrast pathologically relevant orthorexic behaviors are more prevalent in women (Strahler, 2019). Interestingly, orthorexic eating behaviors appear more highly correlated with exercise addiction and fitness orientation in women as compared to men (Brytek-Matera, Donini, Krupa, Poggiogalle, & Hay, 2015; Rudolph, 2018). These findings indicate that mechanisms underlying the relation between exercise addiction and ON may differ between the genders.

1.3 | Common and different characteristics of orthorexic and addictive exercise behaviors

For both ON and exercise addiction, the overemphasis on standards, duties, and rules, and the compulsive need to follow a strict scheme are suggested contributing factors (Freimuth et al., 2011; Strahler & Stark, 2019). While research on the correlates of ON and exercise addiction is still in the beginning, some common risk factors have been proposed. Especially younger age, higher socio-economic status, and lower BMI may be slightly to moderately correlated with orthorexic eating and addictive exercising (Bruno et al., 2014; Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2013; McComb & Mills, 2019; Strahler & Stark, 2019; Symons Downs, MacIntyre, & Heron, 2019). Another factor that could influence both, ON and exercise addiction, and might therefore explain their differences and commonalities, is personality.

On the one hand, personality traits can influence the extent of health-related behaviors. Conscientiousness in particular has been related to lower risky but higher beneficial health-related behaviors (Bogg & Roberts, 2004). In addition, there is evidence for the personality trait impulsivity and addictive behaviors to share underlying neurobiological mechanisms (Grant, Potenza, Weinstein, & Gorelick, 2010). Main dimensions of personality, such as extraversion, neuroticism, conscientiousness, agreeableness, have been linked to exercise addiction (Hausenblas & Downs, 2002) and other behavioral addictions (Andreassen et al., 2013). Associations were, however, not always unequivocally (Bircher, Griffiths, Kasos, Demetrovics, & Szabo, 2017). Research on the personality profile in ON is only just beginning. There is evidence for slightly higher perfectionism, avoidant attachment style, lower persistence, higher need for control, higher harm avoidance, and self-directedness in individuals with higher orthorexic behaviors (Barnes & Caltabiano, 2017; Brytek-Matera et al., 2015; Kiss-Leizer & Rigo, 2019). To our knowledge, only two studies have investigated the personality features of ON using the five-factor model of personality and showed positive correlations of neuroticism (moderate effect) and conscientiousness (small effect) with enthusiasm for healthy eating and orthorexic eating (Gleaves, Graham, & Ambwani, 2013; Strahler et al., 2020). However, no study has explored whether ON and exercise addiction relate alike or different to the main dimensions of the five-factor model of personality. Both phenomena have been related to psychopathology and worse psychological health, that is, higher stress, anxiety, and depression symptoms but lower life satisfaction and well-being (Hayes, Wu, De Nadai, & Storch, 2017; Lichtenstein, Nielsen, Gudex, Hinze, & Jørgensen, 2018; Lukacs, Sasvari, Varga, & Mayer, 2019; Strahler, Hermann, Walter, & Stark, 2018). Currently, however, it remains unknown whether ON and exercise addiction relate to these characteristics in a similar manner.

1.4 | Study objectives

Aim of this report was to advance our understanding of the similarities and differences between orthorexic eating and addictive exercising. Specifically, this study addressed the following questions:

1. To what extent do ON and exercise addiction correlate? (Correlational and structural equation modeling approach)
2. Can distinct subgroups of participants based on orthorexic eating and addictive exercising be identified? (Cluster analysis approach)
3. How are ON and exercise addiction related to psychological characteristics including trait (represented by personality traits) and state (represented by affective psychopathology) variables, and do they have similar characteristics' profiles? (Structural equation modeling approach)
4. Do men and women differ in terms of the common psychological characteristics and supposed mechanisms that are related to ON and exercise addiction?

This study also aimed at addressing limitations of previous reports by employing psychometrically valid instruments to assess orthorexic eating and addictive exercising, by recruiting a convenience sample without a focus on specific populations (e.g., health science students or fitness practitioners), and by using statistical procedure that allow to analyze structural relationships and diagnose which observed variables (i.e., personality and affective psychopathology) are good indicators of the latent variables (i.e., ON and exercise addiction). To address the first, main analyses were preceded by psychometric testing and assessing unidimensionality of scales (reliability and confirmatory factor analyses).

We hypothesized that orthorexic eating behavior and addictive exercising are moderately associated, that there are distinct subgroups of individuals showing high or low values on the ON and/or exercise addiction scales, and that both phenomena correlate to psychological characteristics (anxiety, depression, personality) in a similar fashion. Due to gender-specific prevalence of ON and exercise addiction and evidence for separate pathological mechanisms among men and women, gender differences are to be assumed and, therefore, all analyses were performed separately for each gender.

2 | METHODS

2.1 | Sample

The initial sample comprised 678 adults from the general population of Germany. Six participants had to be removed due to extremely short time to complete the questionnaire. The remaining had a mean age of 27.7 years ($SD = 11.1$ years, range 18–78 years) and were predominantly women ($n = 507$, 75.5%). Most of the respondents were university students ($n = 399$, 59.4%) and some indicated to restrict their diet ($n = 63$ vegan, $n = 98$ vegetarian, $n = 16$ only fish and poultry, $n = 122$ infrequent consumption of red meat, that is, 1–2×/month). The majority of participants indicated the absence of any current food intolerances and allergies ($n = 492$, 73.2%).

2.2 | Procedure

Questionnaires were made available via an online platform (soscisurvey.com) and the study's link was accessible from December 2018 to April 2019. The study was advertised as a study on "Health-seeking behavior: Can We Become Addicted to Health?" Recruitment was accomplished through the university's mailing list, social media posts, and announcements on research websites. The survey was started 876 times and completed by 678 participants (77.4%). The only exclusionary criterion was being younger than 18 years. All respondents provided informed consent by clicking on a button that indicated that he/she read the study information, that he/she agrees to participate voluntarily in this research, and that he/she confirms being 18 years or older. The study was approved by the local ethics committee of the Department of Psychology of the University of

Giessen (reference: 2018-0046, date of approval: December 8, 2018). All respondents completing the survey had the opportunity to take part in a lottery (5× 20€ vouchers) for which their electronic mail address was collected in an independent survey. Students could receive course credit for participating in this research study via code word naming.

2.3 | Instruments

The *Düsseldorfer Orthorexie Skala* (DOS) was used to measure orthorexic eating behaviors (Barthels, Meyer, & Pietrowsky, 2015). This scale is a self-report instrument consisting of 10 questions on a four-point scale (from "this applies to me" = 4 to "this does not apply to me" = 1). Higher scores indicate higher orthorexic behaviors and a preliminary cut-off of ≥30 has been proposed to indicate a significant risk of ON. Scores between 25 and 29 are considered conspicuous eating behavior and thus a moderate risk of ON (Chard, Hilzendegen, Barthels, & Stroebele-Benschop, 2019). Both, the original German and the English version show good psychometric properties (Barthels, Meyer, Amrhein, Scharmach, & Pietrowsky, 2018; Chard et al., 2019). Reliability estimates from the present sample are shown in Table 2.

Exercise addiction was measured by means of the six-item *Exercise Addiction Inventory* (EAI) which was developed based on the components of behavioral addiction (Szabo & Griffiths, 2004). Statements are coded on a five-point Likert scale from "strongly disagree" = 1 to "strongly agree" = 5 and sum scores are created. Proposed cut-offs are ≥24 for at-risk of exercise addiction and scores from 13 to 23 are suggested to indicate a symptomatic individual. Good psychometric properties were shown for the original version and the German translation (Griffiths et al., 2015; Ziemainz et al., 2013). Present sample's reliability estimates are shown in Table 2.

The five factors of personality, openness, conscientiousness, extraversion, agreeableness, and neuroticism were assessed using the short 10-item version of the *Big-Five Inventory* (BFI-10) where each factor is captured with a positive and a negative pooled item to account for the dimensional nature of each factor (Rammstedt & John, 2007). Answers are given on a five-point Likert scale from "not applicable at all" = 1 to "fully applicable" = 5. Cronbach's α of the subscales ranged between .76 (extraversion) and .34 (agreeableness) among women, and between .73 (extraversion) and .19 (agreeableness) among men.

State psychological characteristics were also considered by means of affective psychopathology comorbidities. The 14-item *Hospital Anxiety and Depression Scale* (HADS; Zigmond & Snaith, 1983) was used to record symptoms of anxiety and depression. Items are rated on four-point severity scales and sum scores are created for each subscale. Cronbach's α in the present study was for the anxiety subscale .79 (women) and .76 (men), for the depression subscale .79 (women) and .74 (men).

Sociodemographic and *descriptive* data included age, gender (men, women, diverse), highest educational attainment, current occupation, partnership status (with or without partner), height and weight (from which the body mass index [BMI] was calculated in kg/m^2), and dietary restrictions (nonrestrictive or restrictive, that is, infrequent red meat consumption, only fish and poultry, vegetarian, vegan).

2.4 | Statistics

Data preparation: To obtain accurate results, the first step of statistical analyses included the creation of personal fit indexes to identify careless responders. Normed Guttman errors for polytomous items (Molenaar, 1991) were used whereby large values are assumed to indicate aberrant response behavior. To avoid selection induced bias in DOS and EAI data, only data from HADS, and four questionnaires not considered in this report, were used to identify participants with aberrant response patterns. In more detail, the present examination stems from a larger project where the WHO-Five Well-Being Index (WHO-5; Topp, Østergaard, Søndergaard, & Bech, 2015), the Yale Food Addiction Scale (YFAS; Gearhardt, Corbin & Brownell, 2016), the Mood Regulation, Compulsive Use, and Negative Outcome subscale of the Generalized Problematic Internet Use Scale-2 (GPIUS; Caplan, 2010), and the Bratman Orthorexia Self-Test (BOT; Bratman & Knight, 2000) were also employed. These scales were not further considered. All participants that showed Guttman errors with $p < .001$ in any of these scales were considered inconsistent. This procedure identified $n = 64$ (9.5%) participants to show aberrant patterns which were therefore excluded from the following analyses. Consistent and inconsistent cases did not differ in age ($p = .11$), BMI ($p = .34$), gender distribution ($p = .06$), highest educational attainment ($p = .71$), current occupation ($p = .11$), partnership status ($p = .80$), or their regular form of diet ($p = .20$). Due to the programming of the presentation of questionnaires, there were no missing values with the exception of one weight score which was unrealistically low and could not be restored meaningfully. One respondent indicated "diverse" as their gender. This participant's data were not included in the following analyses. The final sample included data from 608 respondents (607 for analyses considering BMI).

Reliability and factors analysis: Cronbach's α and confirmatory factor analyses with one factor assessed reliability and unidimensionality of the DOS and the EAI scale, respectively. Exploratory estimation of the number of components in a set of variables used Velicer's minimum average partial (Velicer, 1976) and parallel analyses (Horn, 1965).

Correlational analyses and structural equation modeling: To what extent DOS and EAI scores correlate was examined by means of Pearson correlations. To overcome the attenuation of scale correlations by imperfect reliabilities, we additionally fitted structural equation models (SEM) for the relation of the latent variable ON with the DOS items as manifest variables and of the variable exercise addiction with the EAI items, respectively. For testing equality of both constructs, we compared a model with a fixed relation of ON and exercise addiction to one with a model, where this relation was entered as a free parameter. Comparison of the models with a Chi^2 test with df = 1 tested if the correlation of the latent variables ON and exercise addiction is perfect (representing ON and exercise addiction to be identical). Structural equation modeling (SEM) was also used to investigate how ON and exercise addiction are related to

psychological characteristics. In all cases, model fit was determined according to recommendations of Hooper, Coughlan, and Mullen (2008): goodness of fit was indexed by (thresholds in parentheses) standardized root mean squared residual (SRMR < .08), comparative fit index (CFI > .95) and root mean square error of approximation (good RMSEA < .07, mediocre RMSEA < .10).

Cluster analysis: Cluster analysis should identify distinct subgroups of participants with similar characteristics of orthorexic eating and addictive exercising. Prior to cluster analysis, DIP test was applied to test for unimodality of the bivariate DOS and EAI distribution (Adolfsson, Ackerman, & Brownstein, 2019). The DIP test indicates whether the distribution was sufficiently different from unimodality and thus evaluated whether cluster structure is present.

Software: R (version 3.6.1, R Core Team, 2019) was used for the following procedures (packages): creation of personal fit indices (PerFit, version 1.4.3, Tendeiro, Meijer, & Niessen, 2016), DIP tests (diptest, version 0.75-7), MAP, and parallel analysis (psych, version 1.9.12.31, https://personality-project.org/r/psych/). All other statistics were calculated with Statistica (version 13, https://www.statsoft.de/de/software/statistica).

3 | RESULTS

3.1 | Descriptive analysis

Table 1 provides the overview of the descriptive statistics and gender comparison of variables under study. The final sample comprised 465 women (76.5%) and 143 men. The majority of participants indicated "Abitur" (12 years of schooling and general qualification for university entrance) as their highest educational attainment ($n = 549$, 90.3%). More than half of the sample were university students ($n = 365$, 60.0%) and reported to have a partner ($n = 352$, 57.9%).

Men reported a slightly higher subjective social status and markedly higher BMI. In terms of psychological characteristics, women showed more anxiety, neuroticism and openness. Marked gender differences were also found in habitual dietary behaviors: 50.5% of women but only 25.2% of men restricted their diet.

Women yielded higher scores in the DOS and showed a slightly higher risk of ON according to proposed DOS cut-offs (no risk for 93.7% of men and 85.6% of women). The EAI scores and the risk for exercise addiction according to given limits were very similar for both genders.

Altogether, several gender differences in DOS, EAI categories, and some psychological scales required separate analyses for women and men to avoid confounding of results by gender. The following analyses, therefore, concerned women and men separately.

3.2 | Scale characteristics of DOS and EAI

Both scales gave a good Cronbach's α of .85 for women but for men the DOS internal consistency was slightly lower but acceptable (.80, see Table 2).

Measurement models (confirmatory factor analyses with one factor) were fitted for DOS and EAI for assessing unidimensionality of scales. The fit indices gave a good support for the unidimensionality of the EAI whereas the DOS failed in both genders (see Table 2). To explore the dimensionality of the DOS we performed tests for the number of components (Velicer's MAP and parallel analyses) but found no evidence for more than one component. It seems that the DOS items contain correlated residuals which could bias the DOS total scores.

3.3 | Association of ON and exercise addiction

First, Pearson correlations of DOS and EAI scores were large in men $r = .500$ ($p < .001$) and moderate in women $r = .337$ ($p < .001$). The gender difference in correlations remained insignificant ($p = .09$).

Second, gender-specific SEMs that assumed identity of ON and exercise addiction gave a very bad fit and improved significantly when the correlation between ON and exercise addiction was allowed to be lower than one ($p < .001$ in both genders; see Table 3(a)). Indeed, the correlation of ON and exercise addiction was $r = .426$ in women and $r = .622$ in men. The gender difference was tested by comparing a model with identical correlations with a model where the correlation was allowed to vary between the genders. Even though both models gave similar fit coefficients, the difference test favored the model with unequal correlations in genders ($p = .029$; see Table 3(b)). From these analyses, it could be concluded that ON and exercise addiction as measured by DOS and EAI are far from being identical and that the correlation between them appeared higher in men than in women.

3.4 | Clusters of participants based on DOS and EAI scores

We performed dip tests in women and men to assess clusterability by testing the bivariate distribution of *z*-transformed DOS and EAI scores against unimodality. Both tests were clearly insignificant (women: $D < 0.001$, $p > .999$; men: $D = 0.002$, $p = .99$). Thus, we found no evidence for clusters based on DOS and EAI scores. A clustering algorithm was therefore not run. The bivariate distributions of z-transformed DOS and EAI scores are included as supplemental material (Figure A1).

3.5 | Shared and different psychological characteristics of ON and exercise addiction

To assess the relationship between ON and exercise addiction on the one hand and several psychological traits (extraversion, neuroticism, openness, conscientiousness, agreeableness), and states (anxiety, depression), we built a structural equation model with the items of the respective scales as manifest variables and entered the correlations of all latent variables as free parameters.

TABLE 1 Variables under study among women and men

Variable	Women ($n = 465$)		Men ($n = 143$)		Gender comparison			
	M	*SD*	*M*	*SD*	*t*	df	*p*	ES
Age, in years	27.14	10.41	28.48	12.64	−1.15	204.8	.253	−0.12
BMI, in kg/m^2	22.58	4.16	25.09	4.01	−6.47	243.5	<.001	−0.61
HADS (0–21)								
Anxiety	6.65	3.61	5.55	3.36	3.37	251.0	<.001	0.31
Depression	3.88	3.16	3.98	2.97	−0.36	249.0	.719	−0.03
BFI (1–5)								
Extraversion	3.29	0.98	3.36	0.93	−0.78	247.2	.437	−0.07
Neuroticism	3.22	0.94	2.58	0.90	7.41	246.0	<.001	0.69
Conscientiousness	3.60	0.78	3.48	0.77	1.62	239.3	.106	0.15
Agreeableness	3.28	0.83	3.14	0.79	1.89	248.0	.059	0.17
Openness	3.62	0.98	3.42	0.98	2.16	234.9	.032	0.20
DOS (10–40)	19.11	5.48	17.29	4.61	3.92	275.9	<.001	0.34
EAI (6–30)	14.15	5.38	14.86	5.81	−1.29	221.8	.197	−0.13
	n	%	*n*	%	χ^2	*Df*	*p*	ES
Partnership								
Yes	275	59.1	77	53.8	1.26	1	.262	0.05
No	190	40.9	66	46.2				
Eating style								
Nonrestrictive	230	49.5	107	74.8	28.48	1	<.001	0.22
Restrictive	235	50.5	36	25.2				
Risk ON								
No risk (DOS ≤24)	398	85.6	134	93.7	6.59	2	.037	0.06
Moderate risk	46	9.9	6	4.2				
High risk (DOS ≥30)	21	4.5	3	2.1				
Risk ExAdd								
No risk (EAI ≤12)	182	39.1	55	38.5	0.02	2	.990	−0.01
Symptomatic	261	56.1	81	56.6				
At risk (EAI ≥24)	22	4.7	7	4.9				

Notes: Possible ranges of questionnaire scores are given in parentheses. Genders were compared by Welch tests and χ^2 tests. Effect sizes are given as Cohen's *d* for continuous data, Kendall's τ_c for rank data and φ for dichotomous data.
Abbreviations: BFI, Big Five Inventory; BMI, Body Mass Index; DOS, Dusseldorf Orthorexia Scale; EAI, Exercise Addiction Inventory; ExAdd, exercise addiction; ES, effect size; HADS, Hospital Anxiety and Depression Scale; ON, orthorexia nervosa.

The fit of this model was acceptable for women and slightly worse in men (see Table 4, lower part). For clarity, only the correlations between the psychological latent variables and ON and exercise addiction are presented here (see Table 4). In women, both ON and exercise addiction were related to anxiety. Additionally, ON was related to depression and neuroticism whereas exercise addiction correlated with conscientiousness. Results for the sample of men differed. Among men, both ON and exercise addiction were related to conscientiousness and exercise addiction additionally correlated with extraversion. Gender differences in the correlations between psychological variables and ON or exercise addiction were not significant. Differences between ON and exercise addiction in their correlations with the examined psychological characteristics were significant for all variables except openness and agreeableness in women. Among men, only the correlation with depression differed significantly between ON and exercise addiction.

4 | DISCUSSION

4.1 | Summary of main findings

Main objective of this report was to examine similarities and differences between orthorexic eating and addictive exercising. Examining the structure of both constructs, we found good support for the EAI to be unidimensional while the dimensionality of the DOS was less clear. Furthermore, the correlation between the DOS and the EAI was substantial but neither perfect nor as high as

TABLE 2 Confirmatory factor analyses of DOS and EAI

Gender	Model fit indices				α
	χ^2 (*p*)	SRMR	RMSEA [90% CI]	CFI	
DOS					
Women	332.87 (<.001)	.072	.140 [.127, .153]	.811	.851
Men	97.16 (<.001)	.083	.117 [.092, .144]	.810	.799
EAI					
Women	26.50 (.002)	.029	.064 [.036, .093]	.983	.845
Men	15.89 (.069)	.039	.075 [0, .133]	.978	.841

Abbreviations: CFI, comparative fit index; α, Cronbach's α; DOS, Dusseldorf Orthorexia Scale; EAI, Exercise Addiction Inventory; RMSEA, root mean squared error of approximation; SRMR, standardized root mean squared residual.

TABLE 3 Structural equation models for the relationship of orthorexia nervosa and exercise addiction

Model		Model fit indices				Model comparison[a]	
	r	χ^2 (*p*)	SRMR	RMSEA [90% CI]	CFI	$\Delta\chi^2$	*p*
(a) Tests of identity of ON and ExAdd							
Women							
R.fixed	1.0	1,183.04 (<.001)	.123	.186 [.179, .194]	.603		
R.free	0.426	493.61 (<.001)	.063	.093 [.085, .101]	.857	689.43	<.001
Men							
R.fixed	1.0	306.04 (<.001)	.103	.139 [.125, .154]	.716		
R.free	0.622	206.37 (<.001)	.081	.091 [.075, .107]	.854	99.67	<.001
(b) Test of gender differences in the relationship of ON and ExAdd							
R.equal		704.75 (<.001)	.080	.092 [.085, .099]			
R.unequal		699.98 (<.001)	.073	.092 [.085, .099]		4.76	.029

Notes: Models differ only in modeling the correlation *r* of ON and ExAdd: R.fixed, *r* is fixed to one; R.free, *r* is a free parameter; R.equal, *r* is set to be equal in genders; R.unequal, *r* is allowed to be unequal in genders. ON, Orthorexia nervosa (latent variable); ExAdd, Exercise addiction (latent variable); SRMR, standardized root mean squared residual; RMSEA, root mean squared error of approximation; CFI, comparative fit index.
[a]The model in the current row is compared to the model in the previous row.

expected. This suggests that the two instruments share some variance but do not capture the same construct. Correlations appeared slightly stronger in men than in women. Clusterability analysis did not indicate that the data possessed sufficient cluster structure. Cluster analysis was therefore not suitable for the given data. This study also identified the level of diversity, or similarity, for selected psychological characteristics of ON and exercise addiction. Among women, both behaviors were positively associated with anxiety and the correlation was stronger for ON than for exercise addiction. In addition, orthorexic eating correlated with depression and neuroticism while addictive exercising correlated with conscientiousness. In men, by contrast, both behaviors correlated with conscientiousness to a similar extent. Additionally, exercise addiction was related to extraversion. Correlations between ON or exercise addiction and psychological variables were not statistically different between genders.

Mean values of the DOS and the EAI were in ranges comparable to previous reports. Our data confirmed previous research indicating higher levels of orthorexic eating in women as compared to men when considering general population or university student samples (summarized in Strahler, 2019); 4.5% of women versus 2.1% of men reported scores indicating high risk for ON given commonly used cut points for risk (Barthels et al., 2015). Mean values on the EAI scale were slightly higher in men but there was no gender difference in exercise addiction risk prevalence; 4.7% of women versus 4.9% of men. This finding confirms earlier studies conducted among general population or recreational exercising samples (Dumitru et al., 2018). Rates for the present sample, however, were higher than those found in the general population (<1%; Mónok et al., 2012) but rather coincided with studies on regular exercisers (3–9%; Griffiths et al., 2015).

4.2 | Association of orthorexic eating and addictive exercising

To identify the level of similarity of orthorexic eating and addictive exercising, this study examined the association of both behaviors by means of correlation and structural equation models, and we inspected the behaviors' correlation with specific psychological characteristics. Overall, analyses indicated a clear association between

TABLE 4 Structural equation models for the regression of orthorexia nervosa and exercise addiction on latent psychological characteristics

Latent variable	ON			ExAdd		
	b[a]	*T*	*p*	*b*[a]	*T*	*p*
Women						
Anxiety	.412[b]	8.668	.000*	.156[b]	2.872	.004*
Depression	.307[b]	6.077	.000*	.061[b]	1.114	.265
Extraversion	−.128[b]	−2.272	.023	.056[b]	0.993	.321
Neuroticism	.311[b]	5.316	.000*	.023[b]	0.376	.707
Openness	.050	0.803	.422	−.111	−1.766	.077
Conscientiousness	.157[b]	2.442	.015	.373[b]	5.612	.000*
Agreeableness	.024	0.473	.636	.131	2.651	.008
Men						
Anxiety	.144	1.422	.155	−.036	−0.358	.721
Depression	.091[b]	0.883	.377	−.215[b]	−2.188	.029
Extraversion	.139	1.304	.192	.347	3.615	.000*
Neuroticism	.133	1.323	.186	−.002	−0.024	.981
Openness	.137	1.503	.133	−.036	−0.395	.693
Conscientiousness	.254	2.911	.004*	.300	3.626	.000*
Agreeableness	.014	0.151	.880	.051	0.565	.572
Model fit indices						
Gender	χ^2 (*p*)		SRMR	RMSEA [90% CI]		CFI
Women	1,681.76 (<.001)		.067	057 [.054, .061]		.838
Men	1,056.59 (<.001)		.082	.055 [.047, .063]		.781

Abbreviations: CFI, comparative fit index; RMSEA, root mean squared error of approximation; SRMR, standardized root mean squared residua.
[a]Standardized parameter.
[b]$p < .05$ for the difference of parameters between ON and ExAdd after Bonferroni correction for seven tested psychological variables.
*$p < .05$ after Bonferroni correction for seven tested psychological variables.

orthorexic eating and addictive exercising but they were far from being identical. Similar to previous reports (Oberle, Watkins, & Burkot, 2018; Rudolph, 2018), correlation coefficients indicated a moderate relationship. Moreover, the genders differed with more pronounced associations in men. This is in contrast to previous work that indicated closer links between orthorexic or healthful eating and addictive exercising or fitness orientation in women as compared to men (Brytek-Matera et al., 2015; Rudolph, 2018). Finally, we evaluated whether the data could be meaningfully partitioned, that is, whether there are subgroups based on DOS and EAI scores. Our data did not possess sufficient cluster structure. Any categorization would thus be questionable. Our data therefore indicated orthorexic eating and additive exercising as behaviors that represent a continuum rather than defined homogenous subgroups.

Gender differences in effect sizes highlight the need to determine factors that moderate the magnitude of differences. Possible factors could include age, education level, socioeconomic status or psychological risk factors such as need for control, high anxiety or tendencies toward perfectionism (McComb & Mills, 2019; Strahler & Stark, 2019). Adding to this research of affective psychopathology and personality as potential risk factors, the present study identified gender-specific as well as behavior-specific psychological characteristics. In women, anxiety correlated with both behaviors but stronger with orthorexic eating. Orthorexic eating was also related to depressive symptoms. This supports data from earlier studies conducted in nonclinical samples showing ON to be linked with psychopathology (Barthels, Barrada, & Roncero, 2019; Lichtenstein et al., 2018; Luck-Sikorski, Jung, Schlosser, & Riedel-Heller, 2019; Lukacs et al., 2019; Strahler et al., 2018). Neither anxiety nor depression explained a significant amount of variance in men. Previous research has hardly examined gender differences in factors contributing to ON and exercise addiction. But given pronounced differences in health beliefs (Courtenay, McCreary, & Merighi, 2002) and diverse risk factors underlying related disease states such as eating disorders or obsessive compulsive disorder (Lundahl, Wahlstrom, Christ, & Stoltenberg, 2015; Mathes, Morabito, & Schmidt, 2019), gender-specific disease processes are highly likely.

In regard to personality, conscientiousness in particular seems of importance in the data presented here. Participants who considered themselves as someone who does a thorough job with little tendency to be lazy reported higher levels of addictive exercising and, but only for men, higher orthorexic eating. Here, the strength of the correlation was comparable between exercise addiction and ON. For ON, this result was to be expected given previous studies showing a small but positive association between conscientiousness and orthorexic attitudes (Gleaves et al., 2013; Strahler et al., 2020). This finding also fits

with studies that show associations with related constructs such as perfectionism, high need for control, and body image (Barnes & Caltabiano, 2017; Kiss-Leizer & Rigo, 2019; Oberle et al., 2018). Earlier findings in exercise addiction were less consistent with one study showing a positive correlation with conscientiousness (Costa & Oliva, 2012) while another failed to do so (Hausenblas & Giacobbi Jr, 2004). These studies, however, were consistent in showing a positive association with extraversion and this confirms our result for men. Our analyses also suggested that neuroticism or emotional instability may be an underlying factor in orthorexic eating in women with no effect in men. Gender differences in the association between ON features and personality have not yet been investigated. Taken together, present findings suggest that ON and exercise addiction are two interrelated, but different phenomena, which have some common (anxiety in women, conscientiousness in men) but also several distinct correlates. Thus, findings do not support the hypothesis of a similar origin (Håman, Barker-Ruchti, Patriksson, & Lindgren, 2015; Håman, Lindgren, & Prell, 2017; Holland & Tiggemann, 2017).

4.3 | Cautionary note on defining and diagnosing ON

The DOS has been proposed to measure the extent of orthorexic eating and scores >30 have been suggested to indicated a high risk of ON (Barthels et al., 2015). Research, however, demonstrated that there are problems in respect of the assessment and diagnosis of orthorexic eating (Meule & Voderholzer, 2021). Diagnosis of a mental disorder is made on the basis of symptoms, co-morbidity, and related emotional, social and financial impairments. In the present study, thereby confirming previous work (Barthels et al., 2015), internal consistency of the DOS was in acceptable (men) and good (women) ranges. Confirmatory factor analyses did not support this scale's unidimensionality but the following Velicer's MAP and parallel analyses did not find more than one component. Two conclusions can be drawn from this finding. First, obviously correlated residuals indicate that the DOS mainly measures orthorexic eating but is also confounded by another construct to some extent. This scale measures orthorexic eating, but also something else. Second, and possibly related to the first issue, orthorexic eating may not be a one-dimensional construct. Most recent evidence seems to confirm this assumption and proposes to differentiate between healthy orthorexia, that is, the nonpathological interest in eating healthy, and orthorexia nervosa, that is, the pathological dimension of obsessive healthy eating (Barrada & Roncero, 2018; Barthels et al., 2019). However, the currently proposed tools to assess risk for ON capture the impairment and suffering related to this eating behavior only very limited. Negative effects on the individual's everyday life are a crucial part of the ON diagnosis. Diagnostic assessment must include and gather data from neuropsychological evaluation, laboratory testing, patient history, and behavioral assessments. In terms of ON, we are not there yet.

4.4 | Study limitations

Employed measures were based on self-report questionnaires which may be biased by response styles, such as acquiescent responding or central tendency. This might have blurred the clear delineation of clusters. The BFI-10 did not allow for a full-scale assessment of personality. Future research should employ scales that adequately examine the trait domains but also allow more fine-grained facets of personality to be assessed. Having not examined restrictive disordered eating is another limitation of this study. Thus, this study cannot address eating disorder pathology as a possible common characteristic in both ON and exercise addiction. Similarly, another important construct to be added in future studies is the motive(s) for the respective behavior. In particular, weight and shape concerns may not only account for a share of variance but could also moderate gender differences in the pattern or magnitude of relationships with psychopathology and personality. While sample size ensured enough power for precise parameter estimation in the sample of women, the relatively small sample size of the group of men poses a limitation for generalization, for example, small effects found in women may have been overlooked in men. In addition, findings are not generalizable across different ethnic, social or educational backgrounds as they stem from a population fitting the WEIRD criteria, that is, white, educated, industrialized, rich, and democratic. Finally, we cannot exclude the possibility of sampling bias. Study advertisement and recruitment procedures may have appealed primarily to individuals who have an interest in healthy lifestyle. Therefore, replications in more diverse samples are required.

5 | CONCLUSIONS

This study's main objective was to add knowledge to the current debate of ON and exercise addiction to be one or different phenomena, with our data tending to support the latter. From a methodological point of view, our analyses support the note that the DOS as screening instrument for the ON risk assessment also suffers from psychometric problems and needs to be developed further to overcome some limitations. Present findings suggest certain variables as possible risk factors. While anxiety was a common correlate for women, this was the personality trait conscientiousness in men. Future long-term studies will have to examine their causal relevance. Finally, our results may also point to different etiologies in women and men. Understanding underlying risk and protective factors as well as gaining insights into the behaviors' heterogeneity may eventually improve our understanding of the development and diagnostic validity of ON and exercise addiction.

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CONFLICT OF INTEREST

The authors declare that there is no potential conflicts of interest.

DATA AVAILABILITY STATEMENT

Data is available upon request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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