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"Always do your best!"—The relationship between food addiction, exercise dependence, and perfectionism in amateur athletes

Introduction

Physical activity is beneficial to health (e.g., World Health Organization [WHO], 2011). However, some individuals engage in problematic patterns of physical activity (defined as exercise dependence) that subsequently lead to various adverse effects (Cook, Hausenblas, & Freimuth, 2014), including disordered eating (Cook, Hausenblas, Tuccitto, & Giacobbi, 2011). Little is known about factors that could explain when exercise may develop into exercise dependence and then lead to other related detrimental outcomes, such as disordered eating. Perfectionism is one variable that has been proposed to play a role in individuals struggling with problematic exercising (Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2016; Hall, Hill, Appleton, & Kozub, 2009; Hill, Robson, & Stamp, 2015) and problematic eating (Bardone-Cone et al., 2007; Forsberg & Lock, 2006). Such research may suggest a relationship between perfectionism, exercise, and eating variables. However, little is known about such relationships with emerging patterns of problematic eating quantified as food addiction (Gearhardt, Corbin, & Brownell, 2009a). Thus, more research is needed to determine potential mediating factors that may explain associations between problematic exercising (e.g., exercise dependence) and problematic eating (e.g., food addiction).

Parts of the current work are printed in a modified form in the dissertation of the corresponding author, but have never before been published in a journal. Citation of dissertation: Hauck, C. (2018). *Food Addiction in the German general population, in people with morbid obesity and in performance-oriented endurance athletes—Investigations with the Yale Food Addiction Scale 2.0* (Dissertation). University of Goettingen, Goettingen. Retrieved from http://hdl.handle.net/11858/00-1735-0000-002E-E4E3-5

Food addiction

Food addiction is a relatively recent conceptualization that describes a special type of problematic eating which is not yet covered by the established eating disorders, e.g., binge eating disorder (BED), bulimia nervosa (BN), or anorexia nervosa (AN) (Gearhardt et al., 2009a). Food addiction posits that highly processed foods, with added fats and/or refined carbohydrates, (e.g., chocolate, biscuits) may be capable of triggering an addictive-like response on a substance-based perspective in some individuals, whereby an interaction with individual susceptibilities plays an important role (Gearhardt, Davis, Kuschner, & Brownell, 2011; Schulte, Avena, & Gearhardt, 2015). Food addiction is commonly assessed by the Yale Food Addiction Scale (YFAS; Gearhardt, Corbin, & Brownell, 2009b, 2016), which applies the substance-related and addictive criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM; American Psychiatric Association, 1998, 2013) to abnormal patterns of food intake. Defining specific patterns of eating as a food addiction may offer new insights that can inform the development of therapeutic interventions for individuals struggling with their eating behavior. Nevertheless, the research examining the concept of food addiction remains controversial with regards to evidence that can inform precise definitions that quantify the clinical significance of a food addiction diagnosis (Meule & Kübler, 2012; Ziauddeen, Farooqi, & Fletcher, 2012b, 2012a; Ziauddeen & Fletcher, 2013). For example, there are uncertainties in neurobiological evidence, animal research, and inconsistencies in human research on food addiction (Ziauddeen & Fletcher, 2013). Furthermore it is unclear whether food addiction is an independent disorder or part of an already existing disorder, (e.g., BED, BN or AN) (Hauck, Weiß, & Ellrott, 2016).

In a representative sample of the German population, the overall prevalence rate of food addiction was 7.9% (Hauck, Weiß, Schulte, Meule, & Ellrott, 2017). This is similar to rates of approximately 5%–10% of individuals

exhibiting symptoms of food addiction in community-based samples (Meule & Gearhardt, 2014). However, higher prevalence rates among obese patients (15%–25%) and individuals with morbid obesity, BED, or BN have been reported (Meule & Gearhardt, 2014). The relationship between weight status and food addiction is complex. That is to say, a substantial portion of underweight and normal weight subjects may also meet food addiction criteria (Corwin & Hayes, 2014; Hauck et al., 2017; Schulte & Gearhardt, 2017). For example, 15% of underweight individuals report symptoms reflecting food addiction; and this prevalence is similar to those reported in obese samples (Hauck et al., 2017). Thus, further examination of normal and underweight individuals is needed.

Co-occurrence of addictions

Addictive disorders often co-occur (Sussman, Lisha, & Griffiths, 2011). It has been estimated that nearly half of the US adult population suffers from at least one addictive disorder and approximately one fourth from at least two co-occurring addictions (Sussman et al., 2011). In previous publications, a co-occurrence between eating disorders, such as AN, and behavioral addictions (e.g., exercise dependence) has been suggested (Cook et al., 2014; Lejoyeux, Avril, Richoux, Embouazza, & Nivoli, 2008; Lejoyeux, Guillot, Chalvin, Petit, & Lequen, 2012; Müller, Loeber, Söchtig, Te Wildt, & De Zwaan, 2015). Nevertheless, there has not yet been an investigation of a co-occurrence of the potentially addictive disorder 'food addiction' and other addictive disorders (e.g., exercise dependence).

Exercise dependence

Exercise dependence is a craving for leisure-time physical activity, resulting in uncontrollable excessive exercise behavior that manifests in physiological and/or psychological symptoms (Hausenblas & Symons Downs, 2002).

Two different variants of exercise dependence with similar symptoms and consequences have been described. Primary exercise dependence occurs when exercise behavior is the sole objective. Alternatively, secondary exercise dependence occurs when the exercise behavior is performed in attempt to control body shape, size, or otherwise influence weight. Thus, secondary exercise dependence describes when exercise dependence is secondary to another more serious dysfunction: typically an eating disorder (D. Bamber, Cockerill, & Carroll, 2000; D. J. Bamber, Cockerill, Rodgers, & Carroll, 2003; Cook et al., 2011, 2013; Coverley Veale, 1987; Zeulner, Ziemainz, Beyer, Hammon, & Janka, 2016). The validated instruments mostly used to assess exercise dependence are the exercise dependence scale (Hausenblas & Downs, 2002) and the exercise addiction inventory (Griffiths, 2005; Szabó, Pinto, Griffiths, Kovácsik, & Demetrovics, 2019). Estimates in Germany assume a manifest disorder of exercise dependence for one in 1000 and a need for treatment for one in 10,000 (Breuer & Kleinert, 2009). Point prevalence of exercise dependence in a German population-based sample has been reported as 3.5% (Müller et al., 2013). Previous research has also determined that sample character heavily influence exercise dependence prevalence. For example, endurance athletes are considered at risk due to the large volumes and long periods of training necessary to achieve performances goals (Lejoyeux et al., 2008; Müller et al., 2015). Accordingly, prevalences of exercise dependence of up to 50% have been reported (Blaydon & Lindner, 2002; Cook et al., 2014).

Suggested co-occurrence of food addiction and exercise dependence

A relationship between the addictions of food and exercise is suggested here. For example, athletes naturally require simple carbohydrates, such as the highly processed foods commonly consumed by individuals with food addiction (Gearhardt et al., 2011; Schulte et al., 2015), to fuel exercise and increase athletic performance (American College of Sports Medicine, 2016). Athletes represent a group that is potentially at-risk for eating problems (Sundgot-Borgen & Torstveit, 2004). It has been suggested that food addiction represents a new type of eating disorder, additional to the established eating disorders BED, BN, and AN (Gearhardt, Boswell, & White, 2014). Thus, athletes may be at increased risk for food addiction, as well as other established eating disorders. The higher risk may be exacerbated by unique challenges and potential problems with eating, training, and psychological factors (Sundgot-Borgen & Torstveit, 2004). In addition, exercise dependence may play a significant role in individuals' eating related pathologies. Exercise dependence and eating disorders seem to be associated. In people with eating disorders, prevalence rates of exercise dependence of between 40% and 70% have been observed (Zeeck et al., 2013). Taken together with the aforementioned ambiguity concerning the distinction between eating disorders and food addiction, such prevalence rates lead to the possibility that exercise dependence could be a significant problem in individuals' eating-related pathologies.

Thus, the elevated rates of exercise dependence in athletes (Cook et al., 2014, 2013), the suggested comorbidity of both exercise dependence and food addiction (Sussman, 2017), and the observation of similar types of food consumed by individuals with food addiction and exercise dependence tacitly suggests that athletes may be an interesting population in which to examine the co-occurrence of food and exercise addictions. In addition, athletes represent a group of mostly normal or underweight individuals that represent precisely the target group of the examination, since high values of food addiction were found within this subgroup (Hauck et al., 2017).

Perfectionism in disordered eating and exercise dependence

Perfectionism is defined as a multidimensional personality disposition characterized by a striving for flawlessness and setting exceedingly high standards of performance, accompanied by an overly critical evaluation of one's behavior (Frost, Marten, Lahart, & Rosenblate, 1990; Stoeber, 2018), and has been implicated in the etiology of both eating disorders (Bardone-Cone et al., 2007;

Forsberg & Lock, 2006) and exercise dependence (Costa et al., 2016; Hall et al., 2009; Hill et al., 2015). For example, perfectionism as an eating disorder trait has previously been shown to be associated with exercise dependence (Lichtenstein, Christiansen, Elklit, Bilenberg, & Støving, 2014). Perfectionism has been conceptualized as having two different dimensions: perfectionistic strivings and perfectionistic concerns (Limburg, Watson, Hagger, & Egan, 2017). The dual-nature of perfectionism may help distinguish the role of perfectionism in various populations. That is to say, improved athletic performance may be related to perfectionistic strivings (Stoeber, 2011), while perfectionistic concerns like perfectionistic self-presentation are related to eating disorders (Stoeber, Madigan, Damian, Esposito, & Lombardo, 2017).

Research gap and purpose of the study

Nevertheless, there is currently little research on prevalence rates of food addiction, exercise dependence, and perfectionism in amateur athletes. More specifically, little is known about possible associations between perfectionism, exercise dependence, and food addiction. Given that the extant literature suggests perfectionism may play a key etiological role in both eating and exercise-related disorders (Bardone-Cone et al., 2007; Bastiani, Rao, Weltzin, & Kaye, 1995; Costa et al., 2016; Flett & Hewitt, 2005), research is needed to further elucidate such potential relationships, since they may relate to emerging disordered eating patterns such as food addiction.

The purpose of this study was to examine the relationship between perfectionism, food addiction, and exercise dependence. It was hypothesized that: (1) food addiction, exercise dependence, and perfectionism will be correlated (Cook et al., 2014; Costa et al., 2016; Sussman, 2017). It was further hypothesized that: (2) the relationship between perfectionism and food addiction will be mediated by exercise dependence (Cook & Hausenblas, 2008; Cook, Hausenblas, Crosby, Cao, & Wonderlich, 2015; Cook et al., 2014, 2011, 2013; Gearhardt et al., 2014).

Abstract · Zusammenfassung

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"Always do your best!"—The relationship between food addiction, exercise dependence, and perfectionism in amateur athletes

Abstract

Objective. Food addiction is discussed as a substance-related addictive disorder, which is prevalent in normal and underweight subjects. Addictions often co-occur. It was suggested that food addiction and exercise dependence (behavioral addiction), may co-occur in vulnerable athletes. This assumption was made since the eating behavior of athletes in certain situations is similar to the eating behavior seen in food addiction. In addition, exercise dependence may play a significant role in individuals' eating related pathologies, and thus possibly also in food addiction. Athletes may be an interesting population to examine the co-occurrence of food and exercise addictions, as athletes represent a group that is potentially at-risk for both, eating problems and exercise dependence. Perfectionism is a construct that has been implicated in both, exercise dependence and eating disorders. Current study explores potential relationships among the two addictive disorders food addiction and exercise dependence—with perfectionism being the common thread between the two.
Method. A total of 1022 German speaking amateur athletes completed an online questionnaire consisting of the questionnaires Yale Food Addiction Scale 2.0, Questionnaire to diagnose exercise-dependence in endurance sports and Multidimensional inventory of perfectionism in sport.
Result. A mediator effect of exercise dependence on the relationship between perfectionism and food addiction was found. Approximately 4 % (positive)/6 % (negative) of the variance in food addiction were accounted for by the mediator.
Conclusion. The appearance of food addiction in normal/underweight individuals may partially be explained by sports-related reasons, e.g. exercise dependence and perfectionism.

Keywords
Food addiction · Exercise dependence · Perfectionism · Amateur athletes · Athletes

„Gib dein Bestes!" – Zusammenhang zwischen ‚food addiction', Sportsucht und Perfektionismus bei Amateursportlern

Zusammenfassung

Hintergrund. Das Konstrukt der ‚food addiction' postuliert einen Zusammenhang zwischen Nahrungsaufnahme und Sucht. ‚Food addiction' findet sich unter anderem bei Personen mit Normal- und Untergewicht. Suchterkrankungen treten häufig gemeinsam auf. Es wurde vermutet, dass ‚food addiction' und Sportsucht (Verhaltenssucht) bei vulnerablen Athleten gemeinsam auftreten könnten. Diese Vermutung resultierte daraus, dass das Essverhalten bei Athleten in bestimmten Situationen dem suchtartigen Essverhalten bei ‚food addiction' ähnlich ist. Zudem spielt Sportsucht eine bedeutsame Rolle bei individuellen Ess-Pathologien, und damit auch bei ‚food addiction'. Athleten stellen eine gute Studienpopulation zur Untersuchung der Kookkurrenz von ‚food addiction' und Sportsucht dar, da bei Athleten sowohl das Risiko für Essstörungen, als auch für Sportsucht erhöht ist. Perfektionismus ist ein Konstrukt, das an Essstörungen und Sportsucht beteiligt ist. Die vorliegende Studie untersucht mögliche Zusammenhänge zwischen ‚food addiction' und Sportsucht, und erfasst dabei zudem Perfektionismus, als gemeinsames Merkmal der beiden Störungsbilder.
Methodik. An der Studie nahmen 1022 deutschsprachige Amateurathleten teil. Sie füllten einen Onlinefragbogen mit den drei Fragebögen Yale Food Addiction Scale 2.0, Fragebogen zur Erfassung des Sportverhaltens von Ausdauersportlern und Mehrdimensionales Inventar zu Perfektionismus im Sport aus.
Ergebnis. Es wurde ein Mediatoreffekt von Sportsucht auf den Zusammenhang zwischen Perfektionismus und ‚food addiction' gefunden. Rund 4 % (positiver Perfektionismus)/6 % (negativer Perfektionismus) der Varianz von ‚food addiction' konnten durch den Mediator erklärt werden.
Schlussfolgerung. Das Auftreten von ‚food addiction' bei normal-/untergewichtigen Individuen könnte teilweise durch sportbedingte Gründe, wie Sportsucht und Perfektionismus, erklärt werden.

Schlüsselwörter
‚Food addiction' · Sportsucht · Perfektionismus · Amateurathleten · Sportler

Table 1 Continuous variables of study population ($n = 1022$)

Variable	Mean, median, standard deviation, minimum–maximum of study variables
Sex	43.6% male, 56.4% female
Age (years)	36.44 ($\tilde{x}$= 35.00; SD = 18.88; 18–78)
BMI (kg/m^2)	22.83 ($\tilde{x}$= 22.32; SD = 3.06; 14.71–45.78)
Years of practiced exercise (years)	10.96 ($\tilde{x}$= 8.00; SD = 9.45; 1–70)
Hours of exercise per week (h)	7.85 ($\tilde{x}$= 7.00; SD = 3.73; 4–28)
Importance of exercise	7.82 ($\tilde{x}$= 8.00; SD = 1.20; 1–10)
Participation in competition	81.6% yes, 18.4% no
Frequencies of practiced type of sport	60.8% Running, 9.2% triathlon, 8.2% cycling, 7.1% fitness, 5.2% team sports, 9.5% other
Prevalence YFAS 2.0 food addiction (%)	6.2
Prevalence exercise dependence (%)	30.5
Positive perfectionism	3.52 ($\tilde{x}$= 3.6; SD = 1.44; 1–6)
Negative perfectionism	2.62 ($\tilde{x}$= 2.40; SD = 1.15; 1–6)

BMI body mass index, *YFAS* Yale Food Addiction Scale

Method

Participants and procedure

For this study, an online questionnaire was accessed via a secure online data collection website (e.g., https://www.soscisurvey.de). The questionnaire was available over the study period of 1 month. Participants were recruited via an online link that was distributed by email among sports associations throughout Germany (especially Bavaria, Baden-Wuerttemberg, Lower Saxony, and Hesse), German Facebook groups for amateur athletes (e.g., Runner's World Deutschland, Challenge Roth, Achim Achilles) and word-of-mouth recommendations, reposts, and forwarding among participants. Participation was limited to individuals of at least 18 years of age. A total of 10,756 clicks on the study website were recorded within this month. Of these, a total of 1204 participants completed the full questionnaire.

Previous research has found that endurance athletes at risk for exercise dependence must engage in at least 4 h of exercise per week (Schipfer, 2015). Therefore, all participants who self-reported less than 4 h of physical exercise per week were excluded, resulting in a final sample of 1022 (43.6% male, mean age 36 years, mean body mass index [BMI] 22.8 kg/m^2) participants. No further restrictions (e.g., type of sports, etc.) were applied. Demographic data and continuous variables of the study population are listed in **Table 1**.

Measures

The online-survey contained the following questionnaires, which were used in their German versions:

Yale food addiction scale 2.0 (YFAS 2.0)

The Yale food addiction scale 2.0 (YFAS 2.0) (Gearhardt et al., 2016) applies the Diagnostic and Statistical Manual of Mental Disorders (5th version, DSM-5; American Psychiatric Association, 2013) criteria for substance-related and addictive disorders (SRAD; e.g., tolerance, withdrawal, etc.) to the consumption of foods. It is the only validated instrument to operationalize addictive-like eating behavior in humans. The YFAS 2.0 is a 35-item self-report questionnaire and measures individual meets on a continuous scale ranging from 0–11. The threshold for an YFAS 2.0 food addiction is met by endorsing two or more DSM-5 SRAD criteria, plus showing clinically significant distress or impairment. Within the validation study by Gearhardt et al., the YFAS 2.0 has demonstrated internal reliability ($\alpha = 0.90$) and convergent validity with other measures of problematic eating (Gearhardt et al., 2016). The YFAS has been translated to German (Meule, Müller, Gearhardt, & Blechert, 2016).

Questionnaire to diagnose exercise dependence in endurance sports (*Fragebogen zur Erfassung des Sportverhaltens von Ausdauersportlern*, FESA)

The questionnaire to diagnose exercise dependence in endurance sports (Schipfer, 2015) measures exercise dependence via 16 items on a seven-point Likert scale. It includes the following five factors: expected positive consequences, interference with social life, health, withdrawal symptoms, and exercise as a possibility to compensate for psychological problems. The factors "interference with social life" and "exercise as a possibility to compensate psychological problems" correlate with perfectionistic concerns and striving for perfectionism (Schipfer, 2015). The FESA can be used to screen and categorize athletes into three groups: committed to exercise, focused on exercise, and at risk of exercise dependence. The FESA has demonstrated acceptable internal reliability ($\alpha = 0.643–0.808$) and convergent validity (standardized root mean square residual [SRMR]: 0.045; root mean square error of approximation [RMSEA]: 0.035; comparative fit index [CFI]: 0.975; Tucker-Lewis index [TLI]: 0.986) (Schipfer, 2015).

Multidimensional inventory of perfectionism in sport

The multidimensional inventory of perfectionism in sport (MIPS; Stöber, 2004) is a 20-item questionnaire with four subscales: striving for perfectionism in training/competition and perfectionistic concerns in training/competition. Each of the four subscales consists of five items on a six-point Likert scale. The questionnaire is validated for use in training and competition situations. The current study uses the 10 questions focusing on positive and negative perfectionism in training in order to specifically focus on the training situations which

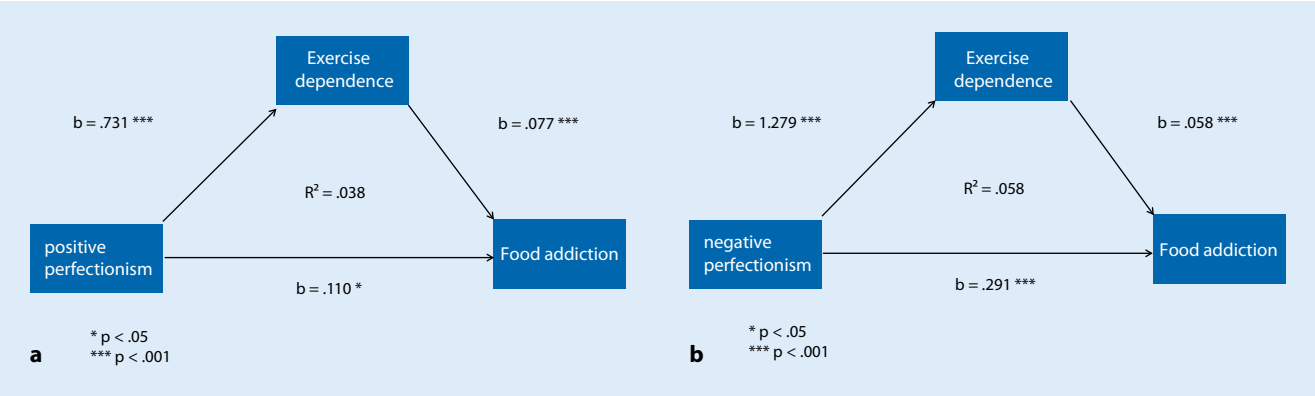

Fig. 1 ▲ **a,b** Conceptual models of mediation—for positive and negative perfectionism

are more relevant in everyday life. The MIPS has demonstrated good internal reliability (α = 0.82–0.90) (Gotwals, Stoeber, Dunn, & Stoll, 2012; Stoeber, Stoll, Salmi, & Tiikkaja, 2009).

Statistical analysis

Data were analyzed using SPSS 25. Descriptive analyses include mean, median, standard deviation, minimum, and maximum of study variables. Pearson correlations and mediation analyses were performed. Mediation analysis was run with the PROCESS 31 macro for SPSS. The method uses a bias-corrected bootstrap procedure (Hayes & Scharkow, 2013). The procedures specified by Hayes (2018) for examining mediation analysis in a three-step mediation model were followed (Hayes, 2018). The choice of conducting mediation analyses was based on several conceptual and methodological issues. First, a temporal order (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001), whereby perfectionism precedes eating disorders, has been previously reported (Bardone-Cone et al., 2007). Therefore, this study is exploratory in that the focus is on food addiction as a specific variant of an eating disorder (Brewerton, 2014; Granero et al., 2014, 2018), whereby perfectionism may also precede food addiction. People with high levels of perfectionism are likely to become athletes and therefore they exercise (Stoeber & Stoeber, 2009). This behavior may represent the first stage of exercise dependence (Freimuth, Moniz, & Kim, 2011; Scully, Kremer, Meade, Graham, & Dudgeon, 1998). Previous research has established exercise dependence as a mediator of the exercise and eating disorders relationship (Cook & Hausenblas, 2008; Cook, Brian & Hausenblas, 2011; Cook et al., 2015, 2014, 2011, 2013). Thus, this exploratory research set to examine the potential mediation role of exercise dependence on previously established relationships among perfectionism and eating pathology (defined as food addiction in this study).

Results

Cronbach alpha coefficients (internal consistency) in the present sample were α = 0.935 for the YFAS 2.0, α = 0.760 for the FESA and α = 0.949 for the MIPS.

Correlations between food addiction, exercise dependence, and perfectionism

First, correlations were used to determine the relationship between food addiction symptoms (M = 0.00, SD = 1.98), exercise dependence scores (M = 24.25, SD = 4.09), positive perfectionism scores (M = 3.60, SD = 1.44), and negative perfectionism scores (M = 2.40, SD = 1.15).

The following significant correlations were observed: food addiction scores and exercise dependence scores (r = 0.180, $p < 0.001$), exercise dependence scores and positive perfectionism scores (r = 0.256, $p < 0.001$), exercise dependence scores and negative perfectionism scores (r = 0.360, $p < 0.001$), food addiction scores and positive perfectionism scores (r = 0.121, $p < 0.001$) and food addiction scores and negative perfectionism scores (r = 0.213, $p < 0.001$).

Mediation analysis

A mediator effect for exercise dependence on the relationship between perfectionism and food addiction was observed (**Fig. 1a, b**). **Fig. 1a**, shows the results for positive perfectionism. The indirect effect was tested using a bootstrap estimation with 1000 samples (Shrout & Bolger, 2002). These results indicated the indirect effect was significant (b = 0.056, SE = 0.013, CI 0.033, 0.085).

Second, the mediation analysis for negative perfectionism was run (**Fig. 1b**). The indirect effect was tested using bootstrap estimation with 1000 samples (Shrout & Bolger, 2002). These results indicated the indirect effect was significant (b = 0.074, SE = 0.021, CI 0.035, 0.116).

Discussion

This study set out to examine the potential mediational role of exercise dependence in the perfectionism and eating disorder relationship. This is novel in that food addiction was specified as a potential variant of an eating disorder (Brewerton, 2014; Cook et al., 2014). Moreover, this is the first study to date to examine exercise dependence as a potential mediator of the perfectionism and eating disorder relationship in a unique group of athletes that commonly engages in patterns of eating that may represent a food

addiction (Gearhardt et al., 2011; Hauck et al., 2017; Schulte et al., 2015). The finding here of a mediation relationship for exercise dependence has several implications that may inform whether food addiction is an eating disorder variant, the need for more research on specific populations such as athletes, and clinical implications that should account for psychological variables as well as eating to fuel athletic performance outcomes.

Correlations between food addiction, exercise dependence, and perfectionism

All of the variables were significantly correlated, which supported the authors' first hypothesis that correlations between food addiction, exercise dependence, and perfectionism would be observed (Cook et al., 2014; Costa et al., 2016; Sussman, 2017). Thus, the results suggest that perfectionism may be correlated not only to eating disorders (Forsberg & Lock, 2006) and exercise dependence (Costa et al., 2016; Hall et al., 2009; Hill et al., 2015), but also to food addiction, as measured by the YFAS 2.0.

Nutrition strategies in athletes often include ingesting highly-processed energy-dense foods (e.g., sports gels, sports drinks, sports bars) to improve athletic performance. Some athletes seem to struggle with their eating behavior and reported problems in the consumption of these foods that were expressed in a YFAS 2.0 symptom score. It is unclear whether this association is simply driven by the high energy requirements of athletes or by a potential addictive-like response to highly-processed energy-dense foods. The observation of food addiction and exercise dependence being significantly correlated was expected, since both are addictive diseases and addictions often occur together (Sussman, 2017). However, further longitudinal research is needed to establish the etiology of these variables.

It should be mentioned that, in general, most people show at least some perfectionistic tendencies (Stoeber & Stoeber, 2009), which must not be confused as psychopathologic by nature. This is relevant to the context of the results presented insofar that the higher the level of positive perfectionism in a person, the higher is his/her desire to give their best performance and the higher is the possibility of elite performance in sports (Gould, Dieffenbach, & Moffett, 2002). Some athletes, however, show detrimental perfectionistic tendencies in exercise performance and in disordered eating (Hill, Mallinson-Howard, & Jowett, 2018). One study found that a striving for perfectionism combined with narcissism predicted a greater degree of exercise dependence (Miller & Mesagno, 2014). The present study found a significant association between positive perfectionism and exercise dependence. Thus, a high level of positive perfectionism could be detrimental to the individual.

In previous research, negative perfectionism was associated with personal and interpersonal difficulties, such as negative mental, emotional, physical, and relationship experiences (Hill et al., 2015). In order to improve their individual performance, some athletes train more intensively, which in turn may contribute to exercise dependence (Coverley Veale, 1987). Such increases in training can also be supplemented with a nutritional strategy that focuses on specific foods and/or an adapted body weight. This in turn may lead to any number of eating disorder variants—including food addiction (Cook et al., 2014). The results of this study, whereby food addiction was directly correlated to positive and negative perfectionism, suggest further research is needed to delineate the etiology of these variables.

Mediation analysis

The purpose of this study was to determine whether exercise dependence may serve as a mediator of the relationship between perfectionism and food addiction. The results of the study indicated that perfectionism was associated with both exercise dependence and food addiction. Furthermore, exercise dependence mediated the relationship between perfectionism and food addiction. This unidirectional causal model suggests that exercise dependence may be a critical component that plays a mediation role in the context of disordered eating, or food addiction in vulnerable athletes. While the cross-sectional design prevents inferences of causality, the results do suggest intervening on exercise dependence may be a clinically relevant target in addressing food addiction in exercising individuals with high levels of perfectionism.

Conclusion

The results presented here expand on previous research, since they offer a possible explanation for the high prevalence rates of food addiction in underweight (and normal weight) individuals (Hauck et al., 2017). That is, endurance athletes may need energy-dense, high-fat, high-sugar foods in order to maintain their athletic performance. In some exercise-related situations, addictive-like eating may occur in athletes, since they subjectively overeat or are unable to stop eating due to their homeostatic energy needs. In these special situations, addictive-like eating is not harmful, but necessary. For example, one case study showed that self-claimed exercise addiction was perceived positively by a female athlete and the author concluded that addiction, commitment, and passion need to be differentiated (Szabo, 2018). Nevertheless, harmful patterns of addictive-like eating may occur in athletes. Exercise dependence may be a critical component that plays a mediation role in the context of disordered eating, or food addiction in vulnerable athletes. Further (qualitative) research is needed to define the form of addictive-like eating in athletes.

Since physical activity and a slim body are regarded as highly positive in Western society (Lichtenstein, Emborg, Hemmingsen, & Hansen, 2017), the transition to exercise dependence and pathological eating is often not recognized; neither by the individual nor by others. Coaches, parents, medical staff, and other people involved should be trained to detect early signs of harmful exercising and eating behavior. An athlete's perfectionist disposition may further indicate an increased risk for exercise dependence and food addiction. Therefore, the results of this study may have implications for the pre-

vention and therapy of both co-occurring addictions (Lichtenstein, Nielsen, Gudex, Hinze, & Jørgensen, 2018).

Limitations

The results of this study must be considered in context of at least the following limitations. First, the cross-sectional design prevents inference of causality. Therefore, this study can be used as initial exploratory data to justify further investigation that may elucidate etiological relationships between perfectionism, exercise dependence, and food addiction. Second, participation was not limited and the online link was distributed at one time point via several channels. The use of an online survey was selected for a variety of reasons and included validated measures. However, clinical assessments are needed to more accurately assess all variables included in this study and determine the clinical significance of the elevated food addiction symptoms scores that were observed in this sample. Moreover, an alternative measure of exercise dependence that is validated for endurance athletes—the specific population examined in this study—was used. Future studies are needed that include gold standard measures such as the exercise dependence scale (Hausenblas & Downs, 2002) to increase the generalizability of these results. Similarly, anthropometric data of the participants were self-reported. This is an interesting consideration given the role of weight and shape concerns in both athletes and eating disorders (American Psychiatric Association, 2013). In athletes, the significance of BMI should be carefully considered, since it may not be indicative of the true body composition. Nonetheless, BMI is considered as the most appropriate assessment method in online surveys. Finally, the results should be examined in their context. Several factors have been established as confounds in food addiction, perfectionism, exercise dependence, and amateur athletics. Therefore, this exploratory study should guide future research that can account for such confounds.

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Compliance with ethical guidelines

Conflict of interest C. Hauck, M. Schipfer, T. Ellrott, and B. Cook declare that they have no competing interests.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and its later amendments. Informed consent to be included in the study was obtained from all participants.

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