

RESEARCH ARTICLE

Psychological risk indicators of disordered eating in athletes

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Abstract

Objectives

This project examined risk factors of disordered eating in athletes by adapting and applying a theoretical model. It tested a previously proposed theoretical model and explored the utility of a newly formed model within an athletic population across gender, age, and sport type to explain disordered eating.

Design

The design was cross-sectional and the first phase in a series of longitudinal studies.

Methods

1,017 athletes completed online questionnaires related to social pressures, internalisation, body dissatisfaction, negative affect, restriction, and bulimia. Structural equation modelling was employed to analyse the fit of the measurement and structural models and to do invariance testing.

Results

The original theoretical model failed to achieve acceptable goodness of fit ($\chi^2 [70, 1017] = 1043.07; p < .0001$. CFI = .55; GFI = .88; NFI = .53; RMSEA = .12 [90% CI = .111-.123]). Removal of non-significant pathways and addition of social media resulted in the model achieving a parsimonious goodness of fit ($\chi^2 [19, 1017] = 77.58; p < .0001$. CFI = .96; GFI = .98; NFI = .95; RMSEA = .055 [90% CI = .043-.068]). Invariance tests revealed that the newly revised model differed across gender, age, level, competition status, and length of sport participation.

Conclusion

This study showed that the formation of disordered eating symptomology might not be associated with sport pressures experienced by athletes. It revealed that disordered eating

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development varies across gender, competition level, sport type, and age, which must be considered to prevent and treat disordered eating in athletes.

Introduction

Participation in competitive sports has the potential to increase the risk of eating disorders and disordered eating in athletes [1, 2]. Disordered eating and eating disorders affect the psychological and physical health of millions worldwide [3]. Understanding this particular pathology in athletes is especially intriguing as regimented diet and intense exercise is often part of competitive sport, but can also be symptoms or maintenance factors of disordered eating and eating disorders [4]. In 2007 (and later re-released in a second edition in 2012), Petrie and Greenleaf published a theoretical etiological model that outlined potential risk factors for the development of disordered eating in athletes as a series of mediators and moderators (see Fig 1). This model was chosen for additional study in this research due to its detailed nature and because it is the only disordered eating model that has been created specifically for athletes rather than a clinical model that has been adapted for use with athletes [5]. Furthermore, as dictated by the original authors of the theoretical etiological model, more testing in athlete samples is needed. This theoretical etiological model is based on the dual-pathway model that posits that social pressure and the internalisation to be thin lead to body dissatisfaction, which in turn leads to negative affect and dietary restraint resulting in eating pathology [6, 7]. The theoretical etiological model also uses evidence from research that explored psychological and social risk factors for disordered eating in athlete and non-athlete samples that consisted primarily of female participants [7–10]. The theoretical etiological model outlines eight factors/mediators that are deemed to be risk factors or causal risk factors based on previous experimental or longitudinal research in the topic area [6]. The factors that are included in the model are (1) sport pressures, (2) societal pressures, (3) internalisation, (4) body dissatisfaction, (5) negative affect, (6) restrained eating, (7) modelled behaviours by peers and family, and (8) binge eating and bulimia. The model also includes five groupings of moderators that affect the intensity and directionality between factors, however this research will focus on the eight risk factors outlined in detail below.

Sport pressures

In the original chapter that accompanies the theoretical etiological model, the higher prevalence of disordered eating in athletes was determined to result from three elements: being an athlete versus a non-athlete, competition level, and type of sport (lean/non-lean)[11]. These three elements that influence prevalence are used in the current study to operationalise sport pressure alongside three additional relevant elements: the number of years of sport participation, training hours per week, and whether an athlete is currently competing or in off-season. These are applied to help to determine whether participating for longer in sport and actively competing creates additional pressure that may relate to the development of disordered eating behaviour.

Previous research findings have been largely consistent in indicating that for lean sports, in which performance or success is influenced by a lean body shape, such as gymnastics or diving, disordered eating has a higher prevalence rate for both men and women (e.g., [12–18]). The level at which the athlete competes is also a relevant sport pressure. However, while some

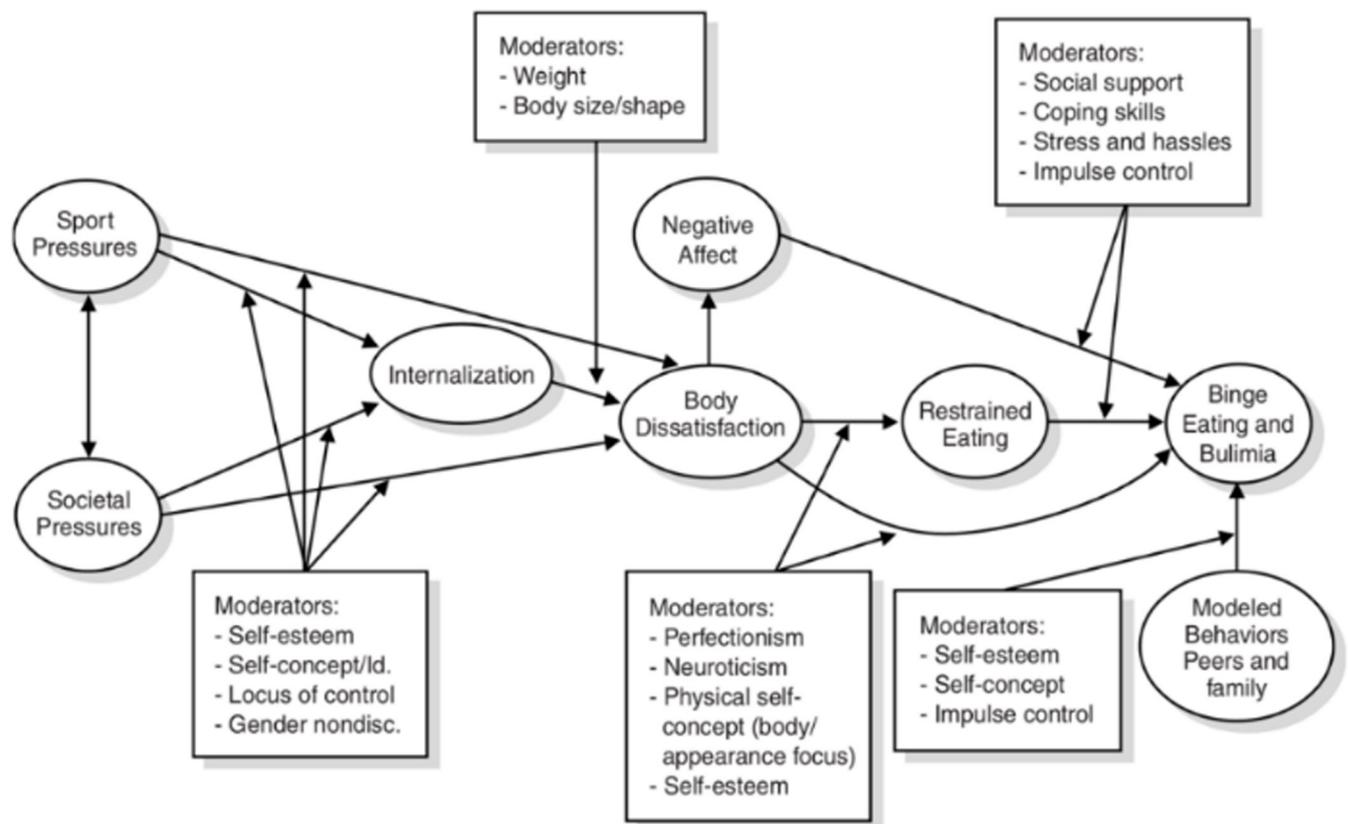


Fig 1. Original theoretical etiological model from Petrie and Greenleaf, 2007, 2012.

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research has posited that elite athletes have higher levels of disordered eating than recreational ones, other research has found the opposite [2, 12, 19].

The current study also includes the number of hours spent training per week as a sport pressure, which has rarely been included in previous research, as much of the previous work has been conducted using National Collegiate Athletic Association athletes in the U.S. (whose hours of training are capped at 20 per week) [20]. This study is relatively unique in its investigation of the amount training hours per week as a sport pressure and will build on previous work which claims that level and training regime should be investigated [21]. The original work by Petrie and Greenleaf stated that increased exercise and training is inversely connected with body dissatisfaction and is thus a relevant factor to be included [22]. Therefore, increased hours could be assumed to mean an increased amount of pressure on the athlete with the caveat that not all sports require more than 20 hours of training per week. Furthermore, there is a positive correlation between level and hours per week, with more hours generally required for high-level sports; hence, these two variables tend to be related. The present study also determines whether an athlete's status as currently competing or currently in 'off-season' plays a role as a sport pressure. Each sport has a time of year or season designated for competition. For example, rugby players compete in the winter, while major cycling events are held during the summer. Although athletes continue to train during the off-season, it has been suggested that measuring disordered eating without accounting for whether those athletes are currently feeling the pressures of competition may have resulted in equivocal findings [23, 24].

Societal pressures

Societal pressures affect athletes, and much like the rest of the population in the Western world, female athletes feel pressure to fit a thin ideal, and men feel pressure to fit a muscular one [25]. However, for athletes, these ideals can compound the sport pressures already exacted upon them, or an opposing tension can arise [26–28]. For example, for a female powerlifter, gaining mass may be advantageous for her sport but not for meeting societal ideals. Societal pressures can stem from family, teammates, the media, and more recently, from social media and the internet [29, 30, 21, 31]. Discerning the degree to which these pressures are internalised—the extent to which the pressures are incorporated into one’s values and beliefs—is key to understanding the impact of sport and societal pressures on athletes. It is often only when these pressures are internalised that athletes’ body satisfaction is damaged and disordered eating behaviours become likely to develop [32, 33].

The current study updates the model to fit the demands of the 21st century by including social media pressure as one of the societal pressures faced by athletes. The majority of popular social media involves photographs, and research has shown that viewing photographs decreases self-evaluations in women and is linked to the increased prevalence of eating disorder symptoms, including excessive exercise [33–37]. Social media creates a community in which harmful behaviours associated with disordered eating and eating disorders can be reinforced or seen as commonplace [35]. In fact, those people considered to be part of the online health community—a source of ‘fitspiration’—scored higher on disordered eating questionnaires and presented more symptoms of compulsive exercise than those whose online presence was focused on travel [38]. Research indicates that repeated exposure to photographs of women who possess the athletic-ideal body type increases body dissatisfaction, and as athletes are likely to follow other athletes on social media, the implications of social media usage warrant attention [39].

Internalisation and body dissatisfaction

Internalisation, in this context, is the incorporation of an external, often unattainable body shape ideal into how one measures one’s own self-worth [11]. When sport and societal pressures give rise to an ideal body standard that is then internalised, if an athlete perceives his or her own body to not match to this ideal, body dissatisfaction and disordered eating behaviours can occur [40–42]. This body dissatisfaction has been found to be directly related to the formation and maintenance of eating disorders and disordered eating [8]. Evidence specifically suggests that body dissatisfaction in athletes is strongly related to the development of disordered eating [14, 43]. However, discrepancies regarding which type(s) of athletes experience the most body dissatisfaction and whether athletes experience more dissatisfaction than the general population remains the subject of debate [17, 44–46]. When comparing levels of body dissatisfaction in athletes to nonathlete controls and lean sport athletes to nonlean sport athletes only equivocal conclusions can be drawn; however, despite the debate, there is consensus that body dissatisfaction contributes to disordered eating [14, 17].

Negative affect

While negative affect is presented in the original model as a link between body dissatisfaction and bulimic behaviours based on research in the general population, few studies have examined negative affect in athletes in relation to disordered eating [11, 47]. Research has found that negative affect in athletes, especially constructs such as fear and guilt, influenced bulimic behaviour when tested in conjunction with increased body dissatisfaction and dietary intent [48–50]. Negative affect has been linked with disordered eating in athletes via increased levels

of compulsive exercise [51, 52]. As athletes have a readily available outlet of sport and exercise, over-exercise may be a tempting avenue through which athletes alleviate negative affect [4].

Modelled behaviours

Modelled behaviours are those adopted behaviours that have been reinforced as the norm in a group and those modelled behaviours pertaining to eating psychopathology have been shown to increase disordered eating symptomology [53, 54]. The mediator that is termed modelled behaviour by peers and family is one that much of the literature has overlooked, and research has yet to operationalise or validate a measurement tool for this potential risk factor. Therefore, the present research begins to close this gap in the literature by including questions relating to modelled behaviours of disordered eating among athletes.

Restrained eating, and binge eating and bulimia

Restrained eating refers to the attempted and successful behaviour of limiting food intake in terms of quantity and type [55]. Binge eating and bulimia refer to the symptoms of overeating and compensatory behaviours [56]. These two mediators are conceptually considered part of disordered eating but are examined separately as dictated by the theoretical model. In the model, restrained eating is thought to mediate the relationship between negative affect and binge eating and bulimia [11, 47]. Restrained eating, as well as bulimia and bingeing, have been linked to negative affect resulting from stressful situations [57].

Previous structural testing of the model

Previous studies have tested several elements of the model [58]. However, only a few have used structural equation modelling that allows for the simultaneous analysis of relationships, which is required to move the field forward. First, Anderson, Petrie, and Neumann (2011) tested the eight factors depicted in the model in female collegiate gymnasts, swimmers, and divers. They found that modelled behaviours did not fit the model and that several pathways required adjustment in that sport pressure directly impacted body dissatisfaction and dietary restraint rather than being mediated by internalisation. Several years later, De Sousa Fortes and colleagues (2015) considered the model in a multi-sport sample of male adolescent Brazilian athletes. The researchers originally predicted that the sport pressures of training regimes at the competitive level, body fat percentage, and sociocultural pressures would lead to body dissatisfaction, which in turn may promote disordered eating in male athletes. However, they found that only the sociocultural factors and body dissatisfaction predicted disordered eating. These two studies, the prevalence factors taken from the original 2007 chapter, and the findings of a literature review were all used to guide the operationalisation in the present study to create measurement consistency throughout the research area [2, 59].

Demographic correlates of disordered eating

The current study also aims to test this model between gender and age. Previous studies have tested the elements of the model in single-gender samples [21, 48, 60, 61]. Therefore, in an effort to advance the field this study has included both genders for analysis. The literature on disordered eating has shown higher prevalence rates of disordered eating and eating disorders in female athletes, but a co-ed sample is needed to re-test this element [2]. Due to convenience sampling, the ages of the athletes in previously conducted studies have often been of traditional US university age (*c.f.* [28, 62]). This study instead considers a broader range of ages to ascertain how age may influence disordered eating development. With regard to this demographic

information, elements that are intrinsic to each individual will help to enhance how this research can be utilised in applied care.

Aims

The existing literature on athletes and disordered eating has presented significant inconsistencies with respect to the utilised tools, methodologies, and general findings. There is also a lack of longitudinal studies in the literature. As a result, it is difficult to identify the underlying causal factors for disordered eating in this population [63, 59]. The original theoretical etiological model is comprehensive in its inclusion of factors and its sport-specific focus, thus providing an ideal starting point. In summary, this study has three aims. The first is to use structural equation modelling (SEM) to determine the utility of the original theoretical etiological model by testing all eight mediators in a diverse sample that includes both men and women and a wide range of sports and levels of participation. The second aim is to develop and test a revised model that includes social media. The third and final aim is to test the newly revised model and determine whether it is equivalent across groups such as gender, sport type, competition level, if currently competing, years of participation, and age.

Methods

Procedure

This study received ethical approval from the Clinical Educational and Health Psychology Department at University College London, Reference for this approval: CEHP/2018/573. Participants were recruited using online social media campaigns as well as by word-of-mouth. Those who identified themselves as athletes and performed at least ten hours of training per week were invited to participate. The questionnaire consisted of 241 questions and took just over 30 minutes to complete. It was administered using Opinio [64] and following informed consent, participants could start the questionnaire and return to it at a later point within a seven-day window. The questionnaire was open from January 27, 2019 to February 24, 2019. Participants who completed the questionnaire were given a £5 Amazon voucher as compensation for their time.

Participants

The inclusion criteria that were applied for this study were that participants had to be over 18; there was no upper cap on the age of potential participants. Participants also had to consider themselves to be an athlete, and a minimum of ten hours a week participating in their sport as well as have been actively competing, thus meaning that competitive sport—rather than zealous exercise—was a significant part of their daily experience. After providing their informed consent, 1,208 participants started the online questionnaire, of whom 1,084 completed it. Only completed questionnaires were kept for analysis. Seventeen participants were excluded due to not fitting the inclusion criteria and another three were deleted as they were based outside of the UK, as this study did not have ethical approval to recruit internationally. Thirty-five more with matching email addresses and exact matching answers were removed due to suspicion from the researcher that the answers were duplicates completed to obtain the £5 gift voucher. A final two were removed as when asked, they did not identify as an athlete. Therefore, the final sample consisted of $N = 1017$ athletes, of whom 56% were male and 44% were female. A wide range of sports was represented in the 1,017 participants, with swimming (18%), tennis (8%), football (soccer) (11%), basketball (18%), volleyball (10%), dancing (7%), and various athletics (track and field) events (19%) making up the majority of the sports represented.

Other less-represented sports included golf, boxing, equestrian, cycling, ping-pong, orienteering, rugby, rowing, and race walking. Slightly over half (58.3%) of the participants were classified as competing in lean sports, with 41.7% classified as non-lean sport participants. Several other demographic variables as well as clinical scores were captured and are presented in [Table 1](#).

Measures

The materials used to operationalise the relevant variables were a combination of existing validated questionnaires and other new measures created for the purpose of this study. It is important to note that the reliability and validity of these measures were largely established in non-athlete samples.

Demographics

Participants' age, gender, sport type information, years spent competing, the teams for which they had competed, and self-reported height and weight were collected.

Sport pressure

Sport pressure was operationalised as lean (where weight and shape are integral to performance success) or non-lean sport participation, the level at which the participants competed, the hours per week that they spent training, their years of participation in that sport, and their current status as competing or in off-season. The categorisation of lean and non-lean sports was decided by the first author, based on previous classifications of sports in the existing literature or based on the first author's applied experience. The hours trained per week were categorised into 10–15, 16–25, 26–40, and 40+ hours. The levels of sport participation were grouped

Table 1. Additional demographic information.

		Percent of Total
Age	18–26	85.7%
	27+	14.3%
Individual or Team	Individual	52.4%
	Team	47.6%
When in Season	Currently Competing	75.2%
	Not Currently Competing	24.8%
Years participated in their sport	1–3 Years	6.4%
	4–8 Years	52.7%
	9–15 Years	40.1%
	16+ Years	0.8%
Hours/Week	10–15 hours/week	17.9%
	16–25 hours/week	60.4%
	26–40 hours/week	20.9%
	40+ hours/week	0.8%
Level	NonElite	82.5%
	Elite	17.5%
BMI (Range)	All Participants	14.1–32.4
BMI (Mean; SD)	All Participants	21.2; 2.5
EDE-Q (Range)	All Participants	0.39–5.49
EDE-Q (Mean; SD)	All participants	2.6; 0.8

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into ‘non-elite’, which was comprised athletes competing at a county or regional level, and ‘elite’, which consisted of those participating at a national or international standard. Athletes determined whether they were part of an individual or team sport, and in the instances where the athletes chose ‘both’, the authors used their discretion to categorise that response appropriately. Athletes could choose from the following categories of the years for which they had taken part in their sports: 1–3 years, 4–8 years, 9–15 years, and 16+ years. Finally, athletes could indicate whether they were currently competing or in their off-season. In the case that N/A was chosen for the answer, it was assumed that those athletes were consistently competing throughout the year and thus were categorised with those who indicated that they were currently competing.

Societal pressure

Societal pressure was measured using the nine-item Information and seven-item Pressures subscales from the Sociocultural Attitudes Towards Appearance Questionnaire-3 (SATAQ-3) [65]. The subscales were summed for a total societal pressures score. An example of a statement from the pressure subscale is “I’ve felt pressure from TV or magazines to lose weight”, and from the information subscale, “Pictures in magazines are an important source of information about fashion and ‘being attractive.’” Cronbach alphas were high for these subscales as well as for the entire SATAQ scale: Information ($\alpha = .94$), Pressures ($\alpha = .94$), and global score ($\alpha = .94$) [66]. Statements related to social media usage were also utilised with similar questions to those that were asked in the SATAQ about TV or magazines, simply by replacing these words with “social media”. For example, “I’ve felt pressure from social media to be thin.” This brief part of the questionnaire consisted of five items, was created for this study, and has not been formally validated; however, reliability calculations for the current study showed an alpha of .75.

Internalisation

Internalisation was also measured by using subscales of the SATAQ-3, specifically the five-item Internalisation-Athlete ($\alpha = .89$) and the nine-item Internalisation-General ($\alpha = .92$) [66]. As above, these two subscales were summed for ease of analysis. An example item from the Internalisation-General is “I compare my body to the bodies of people who are on TV,” and from the athlete scale, “I wish I looked as athletic as sports stars.”

Body dissatisfaction

The nine-item body dissatisfaction subscale (EDI-BD) of the Eating Disorder Inventory (EDI-2) was utilised to measure body dissatisfaction ($\alpha = .88$) [67, 68]. An example of a statement from this subscale is “I think that my stomach is too big.” Notably, this scale shows lower alpha coefficients for men compared to women [69].

Negative affect

Negative affect was measured using the 10-item subscale ($\alpha = .85$; 95% CI = .84–.87) from the Positive and Negative Affect Schedule (PANAS), in which participants had to rate the extent to which they felt various emotions, such as “guilty”, “scared”, and “nervous: from “*Very slightly or not at all*” (1) to “*Extremely*” (5). Alpha reliability for this scale was .87.

Restrained eating

Restrained eating was operationalised by using the Restraint Subscale of the Eating Disorder Examination Questionnaire (EDE-Q-R) [70, 71]. This subscale had high internal consistency in this sample ($\alpha = .78$) and a high test-retest reliability in other mixed-gender samples ($r = .81$) [72]. An example question from this subscale is “Have you **tried** to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?.” It is important to note that one question from this subscale was omitted due to human error, hence, as recommended by the authors of the scale, mean calculations were used with items included. The item missing was “Have you wanted your stomach to be empty?”. It is also key to note that controversy over the content validity of this scale exists, with research indicating that it more accurately measures restriction rather than restraint [55, 73]. The global EDE-Q score was also calculated for each participant to better understand prevalence rates and create clinical relevance ($\alpha = .91$).

Modelled behaviours

No previous research has included a validated measure for modelled behaviours of peers and family, so this current study used seven questions to attempt to capture these sentiments. Example statements included “My friends diet or use weight control behaviours” and “My teammates diet or use weight control behaviours.” Reliability analysis for the current study found the alpha to be .61. In the current study, questions were designed based on the qualitative results that had previously discussed the harmful role that modelled behaviours of teammates can have in the development of eating disorders [54].

Binge eating and bulimia

Binge eating and bulimia were measured by using the bulimia subscale of the 64-item EDI-2 (EDI-B) [67]. This subscale is scored from “Never” to “Always” on a six-item Likert scale. An example statement is “I have gone on eating binges where I have felt that I could not stop.” This subscale also has a high internal consistency ($\alpha = .76$).

Data analysis

SEM was conducted using AMOS. Several indicators of model fit were utilised during the analysis: χ^2 significance, the Comparative Fit Index (CFI), Goodness of Fit (GFI), Normed Fit Index (NFI), and Root Mean Square Error Approximation (RMSEA). In general, a nonsignificant χ^2 value shows that the data fits the model well, however, with large samples it is unlikely to obtain a p value $< .05$ [74]. For CFI, GFI, and NFI a value $> .90$ is considered to indicate acceptable fit and for RMSEA a value $< .08$ is needed for acceptable fit [75].

Results

Analysis was conducted using SPSS version 25 and the SPSS add-on AMOS. Excel Macros was also utilised. When analysing the data for normality, it was determined that all variables had distributions within the acceptable range for skewness and kurtosis [75].

Descriptive statistics

Table 2 outlines the descriptive statistics and intercorrelations for all the variables involved in the model. While some of the correlations did show significant relationships between variables the correlations were all weak, suggesting that variables were measuring relatively independent underlying constructs.

Table 2. Table of correlations and means and standard deviations.

	Lean/ NonLean	Hours/ Week	Elite/ Nonelite	Competing/ Offseason	Years done sport	SATAQ-Pressures	SATAQ-Information	Social Media Pressures	Internalisation- General	Internalisation- Athlete	EDI-BD	Modelled Behaviour	EDE-Q Restraint Score	EDI-B
Lean/NonLean	1	.183**	0.051	.069*	.096**	-0.024	0.061	0.001	0.028	0.033	-0.013	.073*	0.048	0.014
Hours/Week		1	.256**	-.321**	.296**	-0.003	-0.002	0.014	0.052	-0.072*	0.015	-1.154**	-2.09**	.107**
Elite/Nonelite			1	-0.013	.163**	0.023	.084**	-0.032	.090**	0.027	-0.049	-0.005	-0.087**	.097**
Competing/ Offseason				1	-.191**	-0.016	0.038	-0.050	-0.051	-0.005	-0.031	.275**	.282**	-0.025
Years done sport					1	-.113**	-0.049	-0.057	0.027	-1.119**	.069*	-.077*	-0.061	0.013
SATAQ-Pressures						1	.372**	.530**	.479**	.454**	-0.014	-0.016	-0.020	.395**
SATAQ-Information							1	.310**	.337**	.193**	-.069*	0.008	0.009	.207**
Social Media Pressures								1	.416**	.423**	-0.005	-0.008	0.005	.276**
Internalisation- General									1	.312**	-0.001	-0.013	-0.028	.230**
Internalisation- Athlete										1	-0.016	0.001	-0.030	.303**
EDI-BD											1	-0.028	0.017	0.051
Modelled Behaviour												1	.564**	-0.022
EDE-Q Restraint													1	-0.015
EDI-B														1
M						22.33	28.04	17.67	28.18	16.15	6.26	15.03	3.03	4.33
SD						3.33	3.07	3.19	3.14	2.35	2.72	3.27	.94	3.57

* p < .05;

** p < .001

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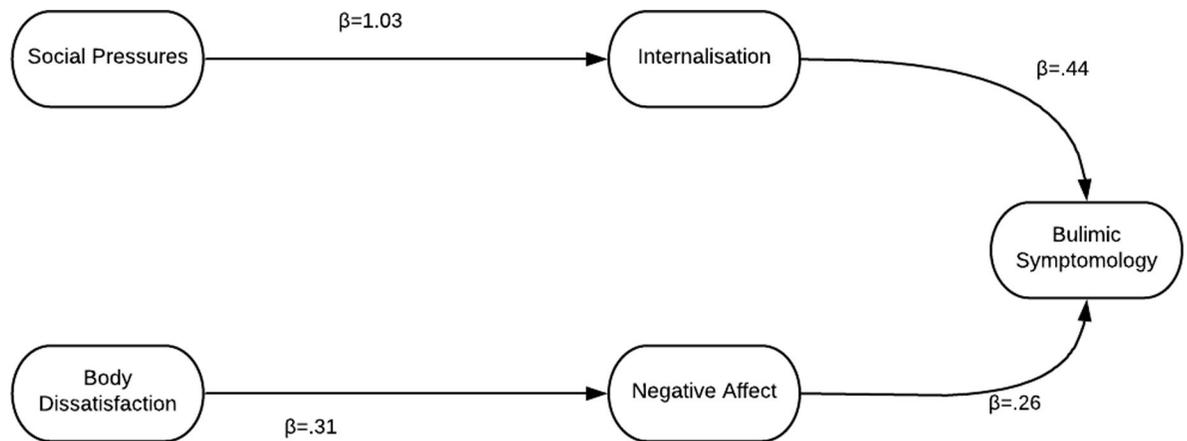


Fig 3. Revised model with best fit for athletes, used for all invariance testing.

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across these pressures as well. When testing for invariance, two methods were employed. First, AMOS multigroup analysis was utilised to examine the Comparative Fit Index to see if the constrained models differed from the unconstrained model by an amount equal or larger than .01, which is then taken as indication that the model differs across groups [74, 79]. Secondly, a Chi Square difference test using AMOS analysis and Excel Macros was also used to give additional insight. While still showing good fit for the vast majority of groups, the model showed that variance was present depending on gender, age, level of athlete, whether athlete was currently competing, and how long that athlete had participated in sport. The model was invariant for lean and nonlean sport types.

Multigroup invariance testing revealed differences between genders (see Table 3). The model fit better for men $\chi^2(19,567) = 54.46; p < .0001; CFI = .96; GFI = .98; NFI = .95; RMSEA = .06$ (90% CI = .040--.076) than for women $\chi^2(19,450) = 46.70, p < .0001; CFI = .95; GFI = .98; NFI = .93; RMSEA = .06$ (90% CI = .037--.078). Excel macros used in conjunction with AMOS revealed that gender differences were explained by differences in the pathway between body dissatisfaction and negative affect at a 99% confidence interval (CI).

Invariant testing between those athletes under age 26 (young) and those above age 26 (mature) also showed a significantly different fit (see Table 4). The model fit better for younger athletes $\chi^2(19,872) = 79.81, p < .0001; CFI = .96, GFI = .98, NFI = .94, RMSEA = .061$ (90% CI = .047--.075) than mature ones $\chi^2(19,145) = 36.98, p = 0.008; CFI = .93, GFI = .94, NFI = .87, RMSEA = .081$ (90% CI = .041--.120). Further testing using excel macros revealed that age specifically moderated the pathways between internalisation and bulimia and negative affect and bulimia at a 99% CI thus explaining the different fit for the two age groups.

Table 3. Gender model fit indices across various model constraints.

Model	χ^2	DF	CFI	GFI	NFI	RMSEA	CI for RMSEA	
Unconstrained	101.170	38	.960	.977	.938	.040	.031	.050
Measurement weights	107.601	42	.959	.975	.935	.039	.030	.048
Structural weights	130.870	45	.946	.969	.920	.043	.035	.052
Structural covariances	131.040	46	.946	.969	.920	.043	.034	.051
Structural residuals	132.603	49	.947	.969	.919	.041	.033	.049
Measurement residuals	149.089	55	.941	.965	.909	.041	.033	.049

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Table 4. Age model fit indices across various model constraints.

Model	χ^2	DF	CFI	GFI	NFI	RMSEA	CI for RMSEA	
Unconstrained	116.904	38	.951	.973	.930	.045	.036	.055
Measurement weights	138.229	42	.940	.968	.917	.048	.039	.056
Structural weights	160.925	45	.928	.963	.904	.050	.042	.059
Structural covariances	163.515	46	.927	.964	.902	.050	.042	.059
Structural residuals	167.979	49	.926	.962	.899	.049	.041	.057
Measurement residuals	178.351	55	.924	.961	.893	.047	.039	.055

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The model better explained disordered eating for nonelite athletes $\chi^2(19, 839) = 78.56, p < .0001$; CFI = .95, GFI = .98, NFI = .94, RMSEA = .061. (90% CI = .047--.076) than elite athletes $\chi^2(19, 178) = 57.68, p < .0001$; CFI = .88, GFI = .93, NFI = .84, RMSEA = .107 (90% CI = .076--.139) with elite athletes being the only group in which the CFI dipped below the level required for adequate fit. See Table 5 for invariant test results. Excel macros analysis showed that for these groups, the difference could be explained by the path from societal pressures to internalisation at a 90% CI and from internalisation to bulimia at a 95% CI.

Those currently competing and those in off-season were variant in a multi-group analysis test (see Table 6) but only showed a very slight difference in fit for the GFI, but no difference in fit for the CFI with those currently competing showing a fit of $\chi^2(19, 252) = 41.40, p = .002$; CFI = .95, GFI = .96, NFI = .91, RMSEA = .069 (90% CI = .040--.097) and those in offseason with a fit of $\chi^2(19, 765) = 73.02, p < .0001$; CFI = .95, GFI = .98, NFI = .94, RMSEA = .061 (90% CI = .047--.076). Excel macros showed that the difference in fit can be explained by currently competing or being in offseason moderating the pathways from internalisation to bulimia and negative affect to bulimia at a 95% CI and body dissatisfaction to negative affect at a 99% CI.

Finally, the model fit increasingly well the longer an athlete had participated in his/her sport (see Table 7). Those doing sport for one to three years showed a fit of $\chi^2(19, 65) = 33.47, p = .02$; CFI = .84, GFI = .89, NFI = .72, RMSEA = .109. (90% CI = .042--.169), those doing it for four to eight years showed a fit of $\chi^2(19, 536) = 106.22, p < .0001$; CFI = .91, GFI = .96, NFI = .89, RMSEA = .093 (90% CI = .076-.110), and those who had done sport for nine or more years $\chi^2(19, 416) = 76.75, p < .0001$; CFI = .92, GFI = .96, NFI = .90, RMSEA = .086 (90% CI = .066--.106). (An insufficient number of athletes had done their sport for over 16 years and so the 16 + category was combined with the 9–15 years category for analysis). Excel macros exposed that years participated in sport influenced the pathways from internalisation to bulimia at a 99% CI and negative affect to bulimia at a 95% CI and body dissatisfaction to negative affect at a 90% CI.

Discussion

The purpose of this research was to assess the applicability of the theoretical etiological model proposed by Petrie and Greenleaf in 2007 and 2012 in a large, multi-sport, mixed-gender

Table 5. Elite vs Nonelite model fit indices across various model constraints.

Model	χ^2	DF	CFI	GFI	NFI	RMSEA	CI for RMSEA	
Unconstrained	136.387	38	.939	.969	.919	.051	.042	.060
Measurement weights	155.302	42	.930	.964	.908	.052	.043	.060
Structural weights	156.395	45	.931	.963	.907	.049	.041	.058
Structural covariances	160.276	46	.930	.963	.905	.049	.041	.058
Structural residuals	164.555	49	.929	.963	.902	.048	.040	.056
Measurement residuals	208.583	55	.906	.958	.876	.052	.045	.060

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Table 6. Currently competing vs out of season model fit indices across model constraints.

	χ^2	DF	CFI	GFI	NFI	RMSEA	CI for RMSEA	
Unconstrained	114.454	38	.952	.974	.931	.035	.036	.054
Measurement weights	121.960	42	.950	.972	.926	.034	.035	.052
Structural weights	139.598	45	.941	.969	.916	.037	.038	.054
Structural covariances	141.597	46	.940	.968	.915	.037	.037	.054
Structural residuals	145.959	49	.939	.967	.912	.036	.036	.053
Measurement residuals	164.633	55	.932	.964	.901	.037	.037	.052

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sample. This study specifically considered relationships between the eight mediators described in the theoretical model: sport pressure, societal pressure, internalisation, body dissatisfaction, negative affect, modelled behaviours, restrained eating, and binge eating and bulimia, as well as the addition of social media as a societal pressure. This study aimed to expand upon previous research that tested this theoretical model by adding social media in order to create a newly revised parsimonious model with high goodness of fit. It was hoped that by using a larger sample of mixed gender athletes that was not constrained by the convenience sampling of US universities would mean a revised, better fitting model would be revealed. The revised model's utility was also assessed across groups to test for invariance.

The analysis showed poor fit for the original theoretical etiological model, although this fit improved slightly with the inclusion of social media. The relevance of social media as a source of societal pressure has been shown in a range of recent research that has indicated how intimately sociocultural experiences are tied to the online world [80]. The next step was to remove non-significant pathways, which resulted in the creation of a revised model that had good fit on the CFI, GFI, and other relevant indices.

This newly revised model showed that societal pressures (including social media), mediated by internalisation, are associated with binge eating and bulimia, while body dissatisfaction leads to bulimia and binge eating, mediated by negative affect. It is important to note that restrained eating was eliminated from the model and, therefore, this model predicts binge eating and bulimia as only one facet of disordered eating in athletes. Predicting only bulimia symptomology matches with the findings of the dual-pathway model that was the original clinical basis for all modelling by Petrie and Greenleaf [57].

As this study is cross-sectional, causal claims cannot be made. However, these results demonstrate that the formation of binge eating and bulimia is not associated with the sport pressures experienced by athletes, as theoretically suggested. These findings add to the growing body of research that indicates that sport pressures may not directly influence the development of disordered eating symptoms of binge eating and bulimia [5, 21]. The applied implication of this specific finding may be that prevention techniques and interventions utilised in non-athlete samples may be applicable. However, it is still important to note that several aspects of

Table 7. 'Years spent participating in sport' model fit indices across model constraints.

Model	χ^2	DF	CFI	NFI	GFI	RMSEA	CI for RMSEA	
Unconstrained	216.700	57	.910	.883	.952	.053	.045	.060
Measurement weights	357.694	65	.835	.808	.922	.067	.060	.073
Structural weights	403.791	71	.813	.783	.909	.068	.062	.075
Structural covariances	410.205	73	.810	.779	.910	.067	.061	.074
Structural residuals	461.764	79	.784	.752	.903	.069	.063	.075
Measurement residuals	520.471	91	.758	.720	.891	.068	.063	.074

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sport pressure created variance in the model, demonstrating that while sport pressure does not fit within the model, various sport pressures may still be tangentially relevant to the development of disordered eating symptoms of bulimia and binge eating in athletes.

Invariance testing across several groups showed that the newly created model differed across several groups, and the results showed in which pathways these differences arose. This variance is something that must be taken into account when considering the prevention and treatment of disordered eating in athletes. With sport pressures removed from the model, invariance testing was also conducted across the factors that were originally described as measuring sport pressure.

While the newly revised model showed very good fit for both males and females, tests of gender differences revealed that the model fit better for male than for female athletes, which is notable, as the original model was designed based on literature that included mainly females. However, research has found increasing evidence that significant numbers of male athletes suffer from disordered eating [1, 81]. The model also fit better for young athletes, specifically those younger than age 27, which is also noteworthy, as the vast majority of research on athletes originates from convenience sampling in US universities, where the ages are often limited to 18–22 years. The model also fit better for those athletes of a non-elite level (i.e., those at a regional or county level), which indicates that these athletes, who are serious yet aspiring, may not have adequate support in coping with the pressure that they experience, whereas elite athletes have access to such support. The model fit better for athletes who completed the questionnaire while currently in their off-season, something that is rarely taken into account when surveying athletes. This finding may indicate that when training intensifies around competition time, it provides an outlet for athletes that allows them to fully fuel their bodies without internalising societal pressures or experiencing negative feelings around food. This finding is in line with previous work that has found athletes score higher on DE measures in the pre-competition time of the season than when currently competing [82]. Finally, invariance testing showed that the longer an athlete had participated in a sport, the better the model fit for that athlete, indicating an increasing pressure on athletes who had participated in a sport for over nine years. Notably, the model was invariant across lean and non-lean sport types. This final lack of variance may be due to societal pressures playing a larger role in the creation of disordered eating symptomology rather than the sport classification as lean or nonlean. In other words, perhaps it is society's image of an athlete that creates pressure for weight and shape to be managed in a way that defies the physiological demands of the sport (Stoyel, Shanmuganathan-Felton, Stoyel, & Serpell, Under Review).

Invariance testing gives indications of how lived experiences in sport and therefore disordered eating symptoms can fluctuate sport to sport, level to level, and season to season. Noticing the variance between demographics of athletes acknowledges that formation, prevention, and treatment of disordered and eating disorders in this population is not one size fits all, and gives early clues as to how to best tailor care.

Limitations

This study is limited by its cross-sectional nature; however, future longitudinal phases of this project are currently underway. The measurement scales used in the current study were the ones most commonly found in eating disorder and disordered eating literature; however, none were specifically designed for athletes. Perhaps this use of general scales can explain why restrained eating also no longer fit. Additionally, in the absence of other acceptable measures, the scales for social media usage and modelled behaviours were purpose-built for this study and thus were not formally validated in previous research and so had lower Cronbach alpha

coefficients than would normally be acceptable. However, the sample, the range of different sports, and the fact that this study did not rely on a convenience sample of US university athletes from a similar age-range make it a unique study in this area of research. Finally, while clinical information was collected and superficially analysed, this research is limited in its ability to make sound assumptions on clinical implications.

Future directions

Future research should use a longitudinal design to determine whether the relevant factors are able to predict future disordered eating in an athlete sample, something that this research group aims to do over the course of the next year. Repeating this research with athletes younger than 18 years old would also provide additional insight as it is a high-risk population for the development of eating disorders. A qualitative investigation to further understand the differences between the original etiological model and the revised model will also be undertaken.

Conclusion

In conclusion, this study provides a large amount of empirical data to further test the original theoretical model with a more diverse sample than previously used. In doing so, a newly revised model was created that can begin to explain the presentation of disordered symptomology specifically related to binge eating and bulimia in a wide range of male and female athletes. Future research should study samples in repeated measures designs so that it is possible to begin to predict the development of disordered eating symptoms in athletes.

Supporting information

S1 Table.
(XLSX)

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References

1. Petrie TA, Greenleaf C, Reel J, Carter J. Prevalence of eating disorders and disordered eating behaviors among male collegiate athletes. *Psychology of Men & Masculinity*. 2008; 9(4):267.
2. Sundgot-Borgen J, Torstveit MK. Prevalence of eating disorders in elite athletes is higher than in the general population. *Clinical journal of sport medicine*. 2004; 14(1):25–32. <https://doi.org/10.1097/00042752-200401000-00005> PMID: 14712163
3. Smink FR, Van Hoeken D, Hoek HW. Epidemiology of eating disorders: incidence, prevalence and mortality rates. *Current psychiatry reports*. 2012; 14(4):406–14. <https://doi.org/10.1007/s11920-012-0282-y> PMID: 22644309
4. Meyer C, Taranis L, Goodwin H, Haycraft E. Compulsive exercise and eating disorders. *European Eating Disorders Review*. 2011; 19(3):174–89. <https://doi.org/10.1002/erv.1122> PMID: 21584911

5. Shanmugam V, Jowett S, Meyer C. Application of the transdiagnostic cognitive-behavioral model of eating disorders to the athletic population. *Journal of Clinical Sport Psychology*. 2011; 5(2):166–91.
6. Stice E, Agras WS. Predicting onset and cessation of bulimic behaviors during adolescence: A longitudinal grouping analysis. *Behavior therapy*. 1998; 29(2):257–76.
7. Stice E. Review of the evidence for a sociocultural model of bulimia nervosa and an exploration of the mechanisms of action. *Clinical psychology review*. 1994; 14(7):633–61.
8. Jacobi C, Hayward C, de Zwaan M, Kraemer HC, Agras WS. Coming to terms with risk factors for eating disorders: application of risk terminology and suggestions for a general taxonomy. *Psychological bulletin*. 2004; 130(1):19. <https://doi.org/10.1037/0033-2909.130.1.19> PMID: 14717649
9. Stice E. Risk and maintenance factors for eating pathology: a meta-analytic review. *Psychological bulletin*. 2002; 128(5):825. <https://doi.org/10.1037/0033-2909.128.5.825> PMID: 12206196
10. Striegel-Moore RH, Cachelin FM, Dohm FA, Pike KM, Wilfley DE, Fairburn CG. Comparison of binge eating disorder and bulimia nervosa in a community sample. *International Journal of Eating Disorders*. 2001; 29(2):157–65. [https://doi.org/10.1002/1098-108x\(200103\)29:2<157::aid-eat1005>3.0.co;2-8](https://doi.org/10.1002/1098-108x(200103)29:2<157::aid-eat1005>3.0.co;2-8) PMID: 11429978
11. Petrie TA, Greenleaf CA. Eating disorders in sport. *Handbook of sport psychology*. 2007:352–78.
12. Kong P, Harris LM. The sporting body: body image and eating disorder symptomatology among female athletes from leanness focused and nonleanness focused sports. *The Journal of psychology*. 2015; 149(2):141–60.
13. Reinking MF, Alexander LE. Prevalence of disordered-eating behaviors in undergraduate female collegiate athletes and nonathletes. *Journal of athletic training*. 2005; 40(1):47. PMID: 15902324
14. Krentz EM, Warschburger P. Sports-related correlates of disordered eating in aesthetic sports. *Psychology of Sport and Exercise*. 2011; 12(4):375–82.
15. Milligan B, Pritchard M. The relationship between gender, type of sport, body dissatisfaction, self esteem and disordered eating behaviors in division I athletes. *Athletic Insight*. 2006; 8(1):32–46.
16. Rousselet M, Guérineau B, Paruit M, Guinot M, Lise S, Destrube B et al. Disordered eating in French high-level athletes: association with type of sport, doping behavior, and psychological features. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*. 2017; 22(1):61–8.
17. Thiemann P, Legenbauer T, Vocks S, Platen P, Auyeung B, Herpertz S. Eating disorders and their putative risk factors among female German professional athletes. *European Eating Disorders Review*. 2015; 23(4):269–76. <https://doi.org/10.1002/erv.2360> PMID: 25828261
18. Torstveit M, Rosenvinge J, Sundgot-Borgen J. Prevalence of eating disorders and the predictive power of risk models in female elite athletes: a controlled study. *Scandinavian journal of medicine & science in sports*. 2008; 18(1):108–18.
19. Hopkinson R, Lock J. Athletics, perfectionism, and disordered eating. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*. 2004; 9(2):99–106.
20. NCAA Athletes Work Long Hours, Survey Says. 2009. <https://diverseeducation.com/article/13021/>.
21. de Sousa Fortes L, Ferreira MEC, de Oliveira SMF, Cyrino ES, Almeida SS. A socio-sports model of disordered eating among Brazilian male athletes. *Appetite*. 2015; 92:29–35. <https://doi.org/10.1016/j.appet.2015.05.005> PMID: 25963103
22. Hausenblas HA, Downs DS. Comparison of body image between athletes and nonathletes: A meta-analytic review. *Journal of applied sport psychology*. 2001; 13(3):323–39.
23. Petrie TA, Greenleaf C, Carter JE, Reel JJ. Psychosocial correlates of disordered eating among male collegiate athletes. *Journal of Clinical Sport Psychology*. 2007; 1(4):340–57.
24. Sundgot-Borgen J, Torstveit M. Aspects of disordered eating continuum in elite high-intensity sports. *Scandinavian Journal of Medicine & Science in Sports*. 2010; 20:112–21.
25. Murnen SK, Smolak L, Mills JA, Good L. Thin, sexy women and strong, muscular men: Grade-school children's responses to objectified images of women and men. *Sex roles*. 2003; 49(9–10):427–37.
26. Anderson CM, Petrie TA, Neumann CS. Effects of sport pressures on female collegiate athletes: A preliminary longitudinal investigation. *Sport, Exercise, and Performance Psychology*. 2012; 1(2):120.
27. Cooper H, Winter S. Exploring the conceptualization and persistence of disordered eating in retired swimmers. *Journal of Clinical Sport Psychology*. 2017; 11(3):222–39.
28. Greenleaf C, Petrie TA, Carter J, Reel JJ. Female collegiate athletes: Prevalence of eating disorders and disordered eating behaviors. *Journal of American College Health*. 2009; 57(5):489–96. <https://doi.org/10.3200/JACH.57.5.489-496> PMID: 19254889
29. Andersen AE, & DiDomenico L. Diet vs. shape content of popular male and female magazines: A dose-response relationship to the incidence of eating disorders?. *International journal of eating disorders*. 1992; 11(3):283–7. <https://doi.org/10.1002/1098-108X>.

30. Grogan S. *Body image: Understanding body dissatisfaction in men, women and children*. Routledge; 2016.
31. de Vries DA, Peter J, de Graaf H, Nikken P. Adolescents' social network site use, peer appearance-related feedback, and body dissatisfaction: Testing a mediation model. *Journal of youth and adolescence*. 2016; 45(1):211–24. <https://doi.org/10.1007/s10964-015-0266-4> PMID: 25788122
32. Knauss C, Paxton SJ, Alsaker FD. Relationships amongst body dissatisfaction, internalisation of the media body ideal and perceived pressure from media in adolescent girls and boys. *Body image*. 2007; 4(4):353–60. <https://doi.org/10.1016/j.bodyim.2007.06.007> PMID: 18089281
33. Hobza CL, Walker KE, Yakushko O, Peugh JL. What about men? Social comparison and the effects of media images on body and self-esteem. *Psychology of men & masculinity*. 2007; 8(3):161.
34. Monro F, Huon G. Media-portrayed idealized images, body shame, and appearance anxiety. *International Journal of Eating Disorders*. 2005; 38(1):85–90. <https://doi.org/10.1002/eat.20153> PMID: 15971241
35. Ransom DC, La Guardia JG, Woody EZ, Boyd JL. Interpersonal interactions on online forums addressing eating concerns. *International Journal of Eating Disorders*. 2010; 43(2):161–70. <https://doi.org/10.1002/eat.20629> PMID: 19308991
36. Stice E, Schupak-Neuberg E, Shaw HE, Stein RI. Relation of media exposure to eating disorder symptomatology: an examination of mediating mechanisms. *Journal of abnormal psychology*. 1994; 103(4):836. <https://doi.org/10.1037//0021-843x.103.4.836> PMID: 7822589
37. Tiggemann M. Media exposure, body dissatisfaction and disordered eating: Television and magazines are not the same! *European Eating Disorders Review: The Professional Journal of the Eating Disorders Association*. 2003; 11(5):418–30.
38. Holland G, Tiggemann M. “Strong beats skinny every time”: Disordered eating and compulsive exercise in women who post fitspiration on Instagram. *International Journal of Eating Disorders*. 2017; 50(1):76–9. <https://doi.org/10.1002/eat.22559> PMID: 27302867
39. Homan K, McHugh E, Wells D, Watson C, King C. The effect of viewing ultra-fit images on college women's body dissatisfaction. *Body Image*. 2012; 9(1):50–6. <https://doi.org/10.1016/j.bodyim.2011.07.006> PMID: 21880562
40. Stice E, Shaw HE. Role of body dissatisfaction in the onset and maintenance of eating pathology: A synthesis of research findings. *Journal of psychosomatic research*. 2002; 53(5):985–93. [https://doi.org/10.1016/s0022-3999\(02\)00488-9](https://doi.org/10.1016/s0022-3999(02)00488-9) PMID: 12445588
41. Lester R, Petrie TA. Personality and physical correlates of bulimic symptomatology among Mexican American female college students. *Journal of Counseling Psychology*. 1995; 42(2):199.
42. Hargreaves D, Tiggemann M. The effect of “thin ideal” television commercials on body dissatisfaction and schema activation during early adolescence. *Journal of youth and adolescence*. 2003; 32(5):367–73.
43. Byrne S, McLean N. Eating disorders in athletes: a review of the literature. *Journal of science and medicine in sport*. 2001; 4(2):145–59. [https://doi.org/10.1016/s1440-2440\(01\)80025-6](https://doi.org/10.1016/s1440-2440(01)80025-6) PMID: 11548914
44. BACHNER-MELMAN R, Zohar AH, Ebstein RP, ELIZUR Y, CONSTANTINI N. How anorexic-like are the symptom and personality profiles of aesthetic athletes? *Medicine & Science in Sports & Exercise*. 2006; 38(4):628–36.
45. Gapin JI, Kearns B. Assessing prevalence of eating disorders and eating disorder symptoms among lightweight and open weight collegiate rowers. *Journal of Clinical Sport Psychology*. 2013; 7(3):198–214.
46. Van Durme K, Goossens L, Braet C. Adolescent aesthetic athletes: A group at risk for eating pathology? *Eating behaviors*. 2012; 13(2):119–22. <https://doi.org/10.1016/j.eatbeh.2011.11.002> PMID: 22365793
47. Petrie T, Greenleaf C. Eating disorders in sport. *Oxford Handbook Sport Performance Psychology*. 2012. p. 635–59.
48. Anderson CM, Petrie TA, Neumann CS. Psychosocial correlates of bulimic symptoms among NCAA division-I female collegiate gymnasts and swimmers/divers. *Journal of sport and exercise psychology*. 2011; 33(4):483–505. <https://doi.org/10.1123/jsep.33.4.483> PMID: 21808076
49. Greenleaf C, Petrie T, Reel J, Carter J. Psychosocial risk factors of bulimic symptomatology among female athletes. *Journal of Clinical Sport Psychology*. 2010; 4(3):177–90.
50. Petrie T, Galli N, Greenleaf C, Reel J, Carter J. Psychosocial correlates of bulimic symptomatology among male athletes. *Psychology of sport and exercise*. 2014; 15(6):680–7.
51. Goodwin H, Haycraft E, Meyer C. Disordered eating, compulsive exercise, and sport participation in a UK adolescent sample. *European Eating Disorders Review*. 2016; 24(4):304–9. <https://doi.org/10.1002/erv.2441> PMID: 26892196

52. Plateau CR, Arcelus J, Meyer C. Detecting eating psychopathology in female athletes by asking about exercise: use of the Compulsive Exercise Test. *European Eating Disorders Review*. 2017; 25(6):618–24. <https://doi.org/10.1002/erv.2561> PMID: 29057602
53. Crandall CS. Social contagion of binge eating. *Journal of personality and social psychology*. 1988; 55(4):588. <https://doi.org/10.1037//0022-3514.55.4.588> PMID: 3193348
54. Arthur-Cameselle JN, Quatromoni PA. Factors related to the onset of eating disorders reported by female collegiate athletes. *The Sport Psychologist*. 2011; 25(1):1–17.
55. Anokhina A, Serpell L. Implicit and explicit self-esteem discrepancy and eating disorder pathology. 2012.
56. Fairburn CG, Marcus MD, Wilson GT. *Cognitive-behavioral therapy for binge eating and bulimia nervosa: a comprehensive treatment manual*. 1993.
57. Stice E. Risk factors for eating pathology: Recent advances and future directions. 2001.
58. Petrie TA, Greenleaf C, Reel J, Carter J. Personality and psychological factors as predictors of disordered eating among female collegiate athletes. *Eating Disorders*. 2009; 17(4):302–21. <https://doi.org/10.1080/10640260902991160> PMID: 19548147
59. Stoyel H, Slee A, Meyer C, Serpell L. Systematic review of risk factors for eating psychopathology in athletes: A critique of an etiological model. *European Eating Disorders Review*. 2020.
60. Brannan M, Petrie TA, Greenleaf C, Reel J, Carter J. The relationship between body dissatisfaction and bulimic symptoms in female collegiate athletes. *Journal of Clinical Sport Psychology*. 2009; 3(2):103–26.
61. Petrie TA, Greenleaf C, Reel JJ, Carter JE. An examination of psychosocial correlates of eating disorders among female collegiate athletes. *Research Quarterly for Exercise and Sport*. 2009; 80(3):621–32. <https://doi.org/10.1080/02701367.2009.10599601> PMID: 19791649
62. Galli N, Petrie TA, Greenleaf C, Reel JJ, Carter JE. Personality and psychological correlates of eating disorder symptoms among male collegiate athletes. *Eating behaviors*. 2014; 15(4):615–8. <https://doi.org/10.1016/j.eatbeh.2014.08.007> PMID: 25238289
63. Papathomas A, Lavallee DE. Eating disorders in sport: A call for methodological diversity. 2012.
64. Manual OU. User Manual for Opinio Survey Software. 2008. www.objectplanet.com/opinio/documentation.html.
65. Heinberg LJ, Thompson JK, Stormer S. Development and validation of the sociocultural attitudes towards appearance questionnaire. *International Journal of Eating Disorders*. 1995; 17(1):81–9. [https://doi.org/10.1002/1098-108x\(199501\)17:1<81::aid-eat2260170111>3.0.co;2-y](https://doi.org/10.1002/1098-108x(199501)17:1<81::aid-eat2260170111>3.0.co;2-y) PMID: 7894457
66. Thompson JK, Van Den Berg P, Roehrig M, Guarda AS, Heinberg LJ. The sociocultural attitudes towards appearance scale-3 (SATAQ-3): Development and validation. *International journal of eating disorders*. 2004; 35(3):293–304. <https://doi.org/10.1002/eat.10257> PMID: 15048945
67. Garner DM, Olmstead MP, Polivy J. Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *International journal of eating disorders*. 1983; 2(2):15–34.
68. Thiel A, Paul T. Test–retest reliability of the Eating Disorder Inventory 2. *Journal of psychosomatic research*. 2006; 61(4):567–9. <https://doi.org/10.1016/j.jpsychores.2006.02.015> PMID: 17011367
69. Spillane NS, Boerner LM, Anderson KG, Smith GT. Comparability of the Eating Disorder Inventory-2 between women and men. *Assessment*. 2004; 11(1):85–93. <https://doi.org/10.1177/1073191103260623> PMID: 14994957
70. Fairburn CG, Beglin S. Eating disorder examination questionnaire. *Cognitive behaviour therapy and eating disorders*. 2008; 309:313.
71. Mond JM, Hay PJ, Rodgers B, Owen C, Beumont P. Validity of the Eating Disorder Examination Questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behaviour research and therapy*. 2004; 42(5):551–67. [https://doi.org/10.1016/S0005-7967\(03\)00161-X](https://doi.org/10.1016/S0005-7967(03)00161-X) PMID: 15033501
72. Rose JS, Vaewsorn A, Rosselli-Navarra F, Wilson GT, Weissman RS. Test-retest reliability of the eating disorder examination-questionnaire (EDE-Q) in a college sample. *Journal of eating disorders*. 2013; 1(1):42.
73. Laessle RG, Tuschl RJ, Kotthaus BC, Prike KM. A comparison of the validity of three scales for the assessment of dietary restraint. *Journal of abnormal psychology*. 1989; 98(4):504. <https://doi.org/10.1037//0021-843x.98.4.504> PMID: 2592686
74. Cheung GW, Rensvold RB. Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural equation modeling*. 2002; 9(2):233–55.
75. Ryu E. Effects of skewness and kurtosis on normal-theory based maximum likelihood test statistic in multilevel structural equation modeling. *Behavior research methods*. 2011; 43(4):1066–74. <https://doi.org/10.3758/s13428-011-0115-7> PMID: 21671139

76. Luce KH, Crowther JH, Pole M. Eating disorder examination questionnaire (EDE-Q): Norms for undergraduate women. *International Journal of Eating Disorders*. 2008; 41(3):273–6. <https://doi.org/10.1002/eat.20504> PMID: 18213686
77. Mond JM, Hay PJ, Rodgers B, Owen C. Eating Disorder Examination Questionnaire (EDE-Q): norms for young adult women. *Behaviour research and therapy*. 2006; 44(1):53–62. <https://doi.org/10.1016/j.brat.2004.12.003> PMID: 16301014
78. Rø Ø, Reas DL, Stedal K. Eating disorder examination questionnaire (EDE-Q) in Norwegian adults: Discrimination between female controls and eating disorder patients. *European Eating Disorders Review*. 2015; 23(5):408–12. <https://doi.org/10.1002/erv.2372> PMID: 26094887
79. Milfont TL, Fischer R. Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of psychological research*. 2010; 3(1):111–30.
80. Pegoraro A. Look who's talking—Athletes on Twitter: A case study. *International journal of sport communication*. 2010; 3(4):501–14.
81. Baum A. Eating disorders in the male athlete. *Sports Medicine*. 2006; 36(1):1–6. <https://doi.org/10.2165/00007256-200636010-00001> PMID: 16445307
82. Neves CM, Filgueiras Meireles JF, Berbert de Carvalho PH, Schubring A, Barker-Ruchti N, Caputo Ferreira ME. Body dissatisfaction in women's artistic gymnastics: A longitudinal study of psychosocial indicators. *Journal of sports sciences*. 2017; 35(17):1745–51. <https://doi.org/10.1080/02640414.2016.1235794> PMID: 27690759