Original article

Factors associated with disordered eating and eating disorder symptoms in adolescent elite athletes

Nadja Walter[1], Thomas Heinen[2], and Anne-Marie Elbe[1]

[1] Sport Psychology, Faculty of Sport Science, Leipzig University, Germany
[2] Perceptual Research and Movement Arts, Faculty of Sport Science, Leipzig University, Germany

Abstract: *Introduction:* Recent studies indicate high prevalences of disordered eating or eating disorders in adult athletes and a worrying increase in adolescent athletes. Although several risk factors for developing eating disorders have been identified for adult athletes (e.g., personality factors, sport-related pressure), research on risk factors in adolescent athletes is scarce. *Methods:* This study investigates the prevalence of disordered eating and eating disorder symptoms and its association with personality- and sport-related risk factors in a sample of 439 elite athletes aged 13–18 years. Self-regulatory personality factors, sports and social pressure, as well as sports biographical data, were investigated in relation to different weight control methods and the Eating Disorder Examination Questionnaire measuring disordered eating and eating disorder symptoms. *Results:* Results indicate a prevalence rate of clinically significant eating pathology of 5.5% for the total sample, in which female athletes aged 15–18 years show the highest rate (9.6%). The structural equation model indicates a predominant association of sports and social pressure and personality factors with eating disorder symptoms. *Conclusion:* Being in the age range 15–18 years, being female, and being an athlete in a high-risk sport (e.g., aesthetics, weight class, or endurance sports) were identified as risk factors as well as athletes' mental association with weight loss and success, and athletes' perceived social pressure on eating and on body shape. Disordered eating and eating disorders are not only of concern for adults but also for young elite athletes and recommendations for adolescent elite athletes, coaches, and parents are given.

Keywords: eating disorders, adolescent elite athletes, sports and social pressure, personality, structural equation model

Introduction

Eating disorders are characterized by disturbing thoughts and emotions concerning eating and a cognitive distortion of one's body image and appearance, which in turn result in unhealthy eating and weight control behaviours [1]. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, [1]) four clinical eating disorders exist including e.g., anorexia nervosa and bulimia nervosa. However, there are several other problematic eating behaviours, which are termed unspecified eating disorders (F50.9, [1]), hereafter termed disordered eating, that may be exhibited, for example, in unhealthy weight control or in compensatory behaviours such as permanent dieting, excessive exercising, self-induced vomiting, or orthorexic dieting. In the sports context, particularly dieting is often associated with performance improvement and is described on a continuum from healthy dieting to the use of unhealthy weight control methods (i.e., disordered eating) such as fasting and vomiting [2].

In the context of competitive sport, high prevalences of disordered eating or eating disorders in athletes with up to 45% of female and 19% of male athletes are described [3, 4]. Several risk factors have been identified for adult athletes (e.g., personality factors, gender-specific and sociocultural aspects, sport-related pressure) (see Table 1), however, research on adolescent athletes is scarce. This is particularly surprising as ontogenetically, the development of an eating disorder or disordered eating often occurs during the transition from childhood to adulthood [5, 6] and warrants targeted investigation of adolescent athletes. Existing studies merely investigated prevalence rates of adolescent athletes as part of an adult sample [7], physiological aspects, such as the female athlete triad syndrome or injuries [8, 9], and psychopathological aspects such as anxiety disorders and depression [10]. However, studies with adolescent athletes failed to investigate associated (sport-specific) risk factors.

The aims of the present study, therefore, were to investigate (1) symptoms of disordered eating and eating disorder symptoms and their association with gender, age, and type of sport and to investigate (2) the associated personality-related and sport-specific risk factors in adolescent athletes (see Table 1). We hypothesize that adolescent elite athletes

Table 1. Risk factors for eating disorders and investigated aspects in the present study [1, 3, 4, 5, 18, 25, 27, 29, 30, 31]

Risk factors	Indices
Biology	Gender-related (e.g., feminity, drive for muscularity, drive for a thin body type) Genetics
	Age*
	Pubertal status
Psychology	Personality-related (e.g., low self-esteem, high perfectionism, high neuroticism, anxiety, depression) Self-regulatory factors (e.g., self-discipline, impulse control)*
	Obsessive-compulsive tendencies
	Negative affects
	Body dissatisfaction
Sociocultural	Modeled behaviours (e.g., peers and family) Social pressure by peers and the media related to body shape*
	Society's focus on physical appearance and attractiveness
	Bullying
	Media consumption (e.g., appearance-focused social media platforms such as Instagram or Snapchat)*
Sport	Type of sport (e.g., sports emphasize leanness)* Rules and regulations (e.g., weight limits, judging criteria)
	Personality-related (e.g., mental association of weight loss and success, drive for thinness and performance)*
	Early admission to competitive sports (sport-specific training and participation in competitions)*
	Coaching behaviour
	Stress and hassles (e.g., injuries)
	Doping
Eating behaviour	Orthorexic dieting Weight control methods (e.g., permanent dieting)*
	Compensatory behaviours (e.g., excessive exercising, self-induced vomiting)*
Physical and/or sexual abuse	

Note. *Investigated risk factors in the present study.

will show symptoms of disordered eating and eating disorders as a function of gender, age, and type of sport and that disordered eating will predict eating disorder symptoms. Furthermore, we expect that personality and sports risk factors will be associated with disordered eating and eating disorder symptoms.

Method

Participants

The sample consisted of $N = 439$ 13- to 18-year-olds ($M_{age} = 14.9$, $SD = 1.4$; 182 females, 257 males) categorized into high-risk ($n = 303$, 69%, e.g., endurance sports, aesthetics and weight class sports), and low-risk sports ($n = 136$, 31%, e.g., technical and team sports) with regard to developing eating disorders [7]. All participants either attended an elite sport school or were members of an elite sports club and competed at a national level.

Procedures and measurements

This study was approved by the university's ethics committee. Participants were informed about the aims of the study and gave written consent. For underaged athletes, their parents gave written consent. Participants completed the following paper and pencil questionnaire anonymously during their annual sports capability test: the German version of the Eating Disorder Examination Questionnaire for children short form (ChEDE-Q8 [11, 12]), the German version of the ATHLETE questionnaire [13], the Appearance-related Social Pressure Questionnaire (FASD [14]) and the German version of the Volitional Components Questionnaire (VCQ [15, 16]). To determine eating behaviour that could represent disordered eating, the number of meals and snacks per day were assessed, as athletes with disordered eating often do not understand the importance of balanced eating and therefore cut down the number of meals to reduce weight [17]. Furthermore, the regularly used weight control methods were assessed, as the regular use of at least one weight control method can be described as disordered eating [5, 7, 8, 9, 18]. Therefore, disordered eating was measured as the sum of weight control methods used and the number of meals and snacks consumed per day.

In addition to the standardized questionnaires, sociodemographics, as well as media consumption, were assessed. Table 2 presents the used measurements in detail.

Data analysis

Statistical analyses for descriptives and group differences (*t*-test, Chi-square test) were conducted using Statistical Package for the Social Sciences (SPSS) version 27. The R Studio version 4.0.4 was used for structural equation modeling (SEM). A level of significance of $\alpha = 5\%$ was defined a priori. To calculate prevalence rates for clinically significant eating pathology for the total sample as well as for gender and age groups the cut-off scores stated in Kliem et al. [12] were used (see Table 2).

First, to analyze group differences between gender, age group, and type of sport with respect to the dependent variables *t*-tests and Chi-square tests were conducted. Independent variables were gender (male vs. female), age group (age group 1: 13–14 years vs. age group 2: 15–18 years), type of sport (low-vs. high-risk sports), eating behaviour, and the ChEDE-Q8 score. Dependent variables were biographical factors (age at the start of sport-specific training and first competition), the ATHLETE, FASD, and VCQ questionnaires, and media consumption items (daily screen time, number of social media channels viewed, number of appearance-related media content items viewed). To analyze group differences 'number of social media channels viewed' and 'number of appearance-related media content items consumed' were counted. Effect sizes are presented as Cohens' *d* for *t*-tests and Cramér's *v* for Chi-square tests [19]. Missing values were imputed with gender, age, and type of sport weighted means.

Second, structural equation modeling was used to test the association of eating disorder symptoms (assessed by the ChEDE-Q8) with self-reported disordered eating (assessed by the number of regularly used weight control methods and the number of meals and snacks per day) and its association with personality factors, sports and social pressure as well as sports biography. For media consumption in the sports and social pressure factor an index was calculated by the mean of the three *z*-transformed variables: daily screen time, the number of social media channels viewed, and the number of appearance-related media content items viewed.

We defined a measurement model consisting of four latent variables, namely the three risk factor categories personality, sports and social pressure, and sports biography as well as disordered eating. Disordered eating was regressed on sports biography, personality, and sports and social pressure, and the score of the ChEDE-Q8 was regressed on disordered eating. Figure 1 graphically depicts the model along with the model coefficients for fitting the complete dataset.

Several fit indices were calculated to evaluate the SEM. First, we calculated χ^2 to assess the overall model fit. χ^2 is known to be sensitive to sample size, and given this study's rather large sample, the comparative fit index (CFI) and the root mean square error of approximation (RMSEA) were additionally calculated [20].

In the first step, the model was fitted to the whole dataset. In a second step, we performed a groupwise analysis for female and male athletes, as well as for age group 1 (13–14 years) and age group 2 (15–18 years) to identify possible differences in factors associated with eating disorder symptoms between the different gender and age groups. For this analysis we used the same model as in the first step.

Results

Demographic characteristics

Descriptive statistics for all questions are presented in Table 3, for the total sample and separately for gender, the two age groups, and type of sport. The response rate was 49.8%.

Participants reported 3.3 hours ($SD = 1.6$) of daily screen time and followed up to five different social media channels ($M = 1.5$, $SD = 0.9$). Regarding content, participants mostly watched series and movies (39.0%) and consumed sports and fitness content (21.2%). Appearance-related content, such as casting shows like *Germany's Next Top Model* or *The Bachelor* were consumed (6.4%), followed by beauty and lifestyle content (4.7%).

Regarding eating behaviour, athletes had around three meals and two snacks per day. 33.0% of participants used at least one weight control method (maximum = 6, females 43.3%, males 25.7%). For these $n = 145$ athletes, the most frequently reported weight control methods were permanent dieting (43.3%) and increased exercising (30.4%).

The prevalence rate for clinically significant eating pathology based on the ChEDE-Q8 [12] was 5.5% (see Table 2). It ranged between 3.8% (age group 1) and 9.6% (age group 2) for female athletes. No clinically significant eating pathology was found for male athletes in age group 1, whereas 2.6% of the 15- to 18-year-old male athletes were affected. A prevalence rate of 2.6% was found in low-risk and 6.6% in high-risk sports.

Group differences

All significant group differences are displayed in Table 3. Females showed significantly higher scores for both FADS subscales (ideals modeled by team norms $p = .036$; $d = .206$, ideals modeled by friends $p \leq .001$, $d = .316$), for the ATHLETE score ($p \leq .001$, $d = .408$) and for two VCQ subscales (self-discipline $p = .004$, $d = .284$; informed introjection $p \leq .001$, $d = .355$). No differences were found for

Table 2. Instruments, items and questions

Instrument/item	Number of items/subscale(s)	Example item(s)/question(s)	Answer format	Psychometric properties
Sociodemographics and sports biography				
Sociodemographics	7 items	1. Age, 2. gender, 3. body height, 4. body weight, 5. type of sport, 6. training hours per week, 7. competition level/squad	1. – 6. description fields, 7. competition level/ squad: A/OK, B/PK, C/NK1, DC/NK2, D[1]	
Sports biography	2 items	1. "When did you start your career?" 2. "When did you participate in your first competition?"	Age	
Eating behaviour (Disordered eating and eating disorder symptoms)				
Meals, snacks and weight control methods [5, 10, 18, 29]	2 Items	1. "Please record how many meals and snacks per day do you consume!" 2. "Please select the weight control methods that you use regularly!"	1. Number of meals and snacks 2. E.g., permanent dieting, using diet pills, using laxatives, self-induced vomiting, increasing exercising	
Eating Disorder Examination-Questionnaire for children and youth short-form (ChEDE-Q8) [11, 12]	8 items total scale	"Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight?"	7-point Likert-scale from 0 (none of the time/no days/not at all) to 6 (all the time/every day/markedly)	Internal consistency: Cronbach's α = .87 to .90, cut-off scores for clinically significant eating pathology: general cut-off score = 3.25, 13- to 14-year-olds cut-off score = 3.25 resp. 3.75 (males/females), 15- to 18-year-olds cut-off score = 3.13 resp. 3.88 (males/females)
Personality factors				
Volitional Components Questionnaire (VCQ) [15, 16]	18 items subscales: 1. Self-determination 2. Impulse control 3. Self-discipline 4. Informed introjection	1. "Feeling at one with my decision." 2. "Feeling defenseless in view of a temptation." 3. "I often put myself under pressure." 4. "Feeling obliged to meet the expectations of others."	4-point Likert scale from 0 (not at all) to 3 (totally)	Internal sub-scale consistency: Cronbach's α = 0.75 to 0.95
Sports and social pressure and media consumption				
ATHLETE questionnaire [13, 21]	6 items subscale: body and sport	"I often wish I were leaner so I could perform better."	5-point Likert-scale from 1 (strongly disagree) to 5 (strongly agree)	Internal sub-scale consistency: Cronbach's α = .78
Appearance-related Social Pressure Questionnaire (FASD) [14]	8 items subscales: 1. Ideals modeled by friends (mates) 2. Ideals modeled by team norms	1. "My teammates do a lot to look good" 2. "An athlete who doesn't look good in our team is usually an outsider"	5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree)	Internal consistency: Cronbach's α = .65 to .83
Media usage per day, screen time, number of social media platforms and consumed media content [30]	4 items	1. "How much do you use your cell phone per day?" 2. "How much is your daily screen time?" 3. "What type of social media platform do you use most?" 4. "What kind of content do you prefer to consume online?"	1. From medium (≤1 hour per day) to much (>2 hours per day) 2. Daily screen time 3. E.g., Facebook, Twitter, Instagram 4. E.g., casting and dating shows[2], daily-soaps, sports and fitness	

Note. [1]In Germany athletes are assigned to A/OK, B/PK, C/NK1, DC/NK2 or D squads according to age and level of performance, where C/NK1, DC/NK2 and D-squads host junior elite athletes and A/OK and B/PK-squads are for senior/adult elite athletes. [2]Casting and dating shows were divided into appearance-related shows such as Germany's Next Top Model or The Bachelor, and shows such as The Voice or Farmer Wants a Wife.

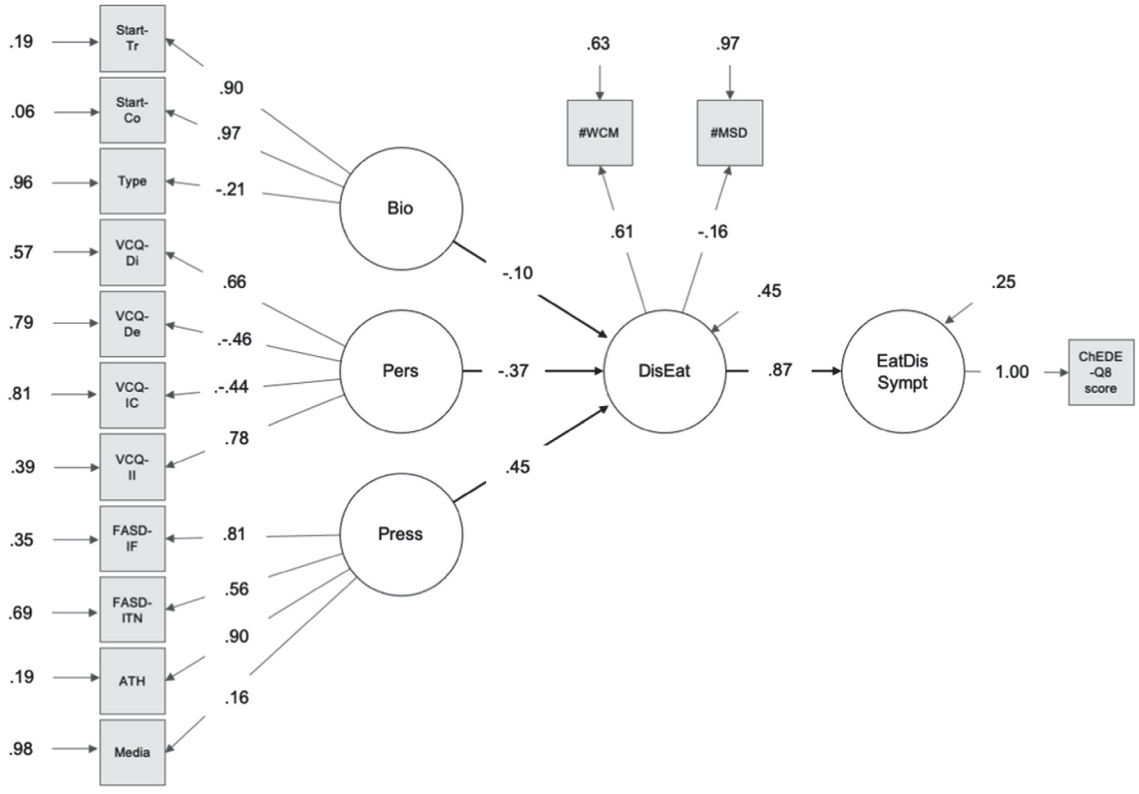

Figure 1. Structural equation model for eating disorder. *Notes*: DisEat = Disordered eating, EatDisSympt = Eating disorder symptoms, Pers = Personality, Bio = Sports biography, Press = Sports/social pressure, #WCM = number of weight control methods, #MSD = number of meals and snacks per day, Start-Tr = Start of sport-specific training, Start-Co = Start competition, Type = Type of sport, VCQ-Di = Self-discipline (VCQ), VCQ-De = Self-determination (VCQ), VCQ-IC = Impulse control (VCQ), VCQ-II = Informed introjection (VCQ), FASD-IF = Social pressure on eating: ideals modeled by friends (FASD), FASD-ITN = Social pressure on eating: ideals modeled by team norms (FASD), ATH = Social pressure on body shape and expectation (ATHLETE), Media = Media consumption index.

daily screen time and number of social media channels, but for appearance-related media content such as casting and dating shows ($p \leq .001$, $v = .234$). Furthermore, females applied significantly more weight control methods ($p \leq .001$, $d = .307$) and scored significantly higher in the ChEDE-Q8 ($p \leq .001$, $d = .858$) than males.

Males in age group 2 (15–18 years) viewed significantly more social media channels ($p = .048$, $d = .125$) and scored significantly higher in the ChEDE-Q8 ($p = .031$, $d = .259$) than males in age group 1. No differences were found for the ATHLETE, FADS, and VCQ questionnaires or media consumption.

Female athletes in age group 2 applied significantly more weight control methods ($p \leq .001$, $d = .543$) and showed significantly higher scores in the ChEDE-Q8 ($p = .050$, $d = .267$), in one FASD subscale (ideals modeled by friends $p = .022$, $d = .327$), the ATHLETE questionnaire ($p = .031$, $d = .326$), and the VCQ subscale self-discipline ($p = .012$, $d = .380$) than younger female athletes.

Group differences regarding the type of sport were found for the number of social media channels ($p = .040$, $d = .213$) and the number of weight control methods ($p = .035$, $d = .202$). Athletes in low-risk sports frequented significantly fewer social media channels and used fewer weight control methods. Athletes in high-risk sports scored significantly higher in both FASD subscales (ideals modeled by team norms $p \leq .001$, $d = .582$; ideals modeled by friends $p = .002$, $d = .292$) and the ATHLETE questionnaire ($p \leq .001$, $d = .520$).

Risk factors associated with eating disorder symptoms

SEM analysis using the complete dataset led to convergence after 121 iterations (diagonally weighted least squares estimator). The model exhibited the following fit indices: $\chi^2(70) = 156.81$, $p < .05$, CFI = .95, RMSEA = .06. The small RMSEA (<.08) and the large CFI (>.90) indicates an acceptable model fit. Eating disorder symptoms could be predicted well with an explained variance of approximately $R^2 = .75$. Disordered eating exhibited an explained variance of $R^2 = .55$. Sports biography explained the smallest amount of variance, followed by personality, and then sports and social pressure. The number of weight control methods

Table 3. Descriptive statistics of sociodemographic aspects, standardized questionnaires, eating behaviour and media consumption

		Type of sport[1]		Male (*n* = 257)			Female (*n* = 182)		
	Total (*N* = 439)	Low-risk sport (*n* = 136)	High-risk sport (*n* = 303)	Total	13–14 years (*n* = 102)	15–18 years (*n* = 155)	Total	13–14 years (*n* = 78)	15–18 years (*n* = 104)
Age (years)	14.9 (1.4)	14.7 (1.3)$^{\mp}$	15.1 (1.5)$^{\mp}$	15.1 (1.5)†	13.6 (0.5)	16.1 (1.0)	14.7 (1.2)†	13.5 (0.5)	15.6 (0.8)
Weight (kg)	63.4 (12.7)	67.1 (13.5)	61.8 (12.1)	66.5 (13.7)†	59.2 (12.7)*	71.4 (12.1)*	58.8 (9.5)†	56.5 (9.9)*	60.6 (8.8)*
Height (cm)	173.8 (10.3)	178.3 (10.5)	171.7 (9.6)	177.2 (10.8)†	171.9 (11.8)*	180.7 (8.5)*	168.6 (7.0)†	168.3 (8.3)*	168.8 (5.9)*
BMI	20.8 (2.87)	20.9 (2.9)	20.9 (2.8)	21.1 (2.9)	19.8 (2.5)*	21.9 (2.9)*	20.6 (2.8)	19.9 (2.6)	21.2 (2.8)
Start of sport-specific training (age)	7.7 (2.7)	7.9 (2.7)	7.6 (2.6)	7.9 (2.7)†	7.8 (2.6)	8.1 (2.7)	7.4 (2.5)†	7.3 (2.3)	7.5 (2.7)
Age at first competition	8.6 (2.5)	8.9 (2.3)$^{\mp}$	8.4 (2.5)$^{\mp}$	8.8 (2.5)†	8.6 (2.2)	8.9 (2.7)	8.2 (2.3)†	8.1 (2.3)	8.3 (2.5)
Years in sport	7.2 (2.9)	6.7 (2.6)$^{\mp}$	7.5 (2.9)$^{\mp}$	7.1 (3.0)	5.8 (2.7)*	7.9 (2.9)*	7.3 (2.7)	6.2 (2.4)*	8.2 (2.6)*
Media									
Media usage per day, n (%)									
Medium (≤1 hour per day)	64 (14.6)	12 (8.8)	52 (17.2)	35 (13.6)	19 (18.6)	16 (10.3)	29 (15.9)	13 (18.0)	15 (14.4)
Little more (1–2 hours per day)	178 (40.5)	56 (41.2)	122 (40.3)	95 (37.0)	44 (43.1)	51 (32.9)	83 (45.6)	33 (42.3)	50 (48.1)
Much (>2 hours per day)	187 (42.6)	65 (47.8)	122 (40.3)	120 (46.7)	37 (36.3)	83 (53.5)	67 (36.8)	29 (37.2)	38 (36.5)
Daily screen time, n = 137, M (SD)	3.3 (1.6)	3.1 (1.6)	3.3 (1.6)	3.2 (1.7)	2.9 (1.2)	3.7 (1.9)	2.9 (1.2)	3.2 (1.5)	2.8 (1.0)
Social media channels used, n (%)[2]									
Facebook	5 (0.7)	0	1 (1.7)	4 (1.0)	2 (1.4)	2 (0.8)	1 (0.3)	0	1 (0.6)
Twitter	12 (1.7)	1 (0.5)	11 (2.2)	11 (2.7)	2 (1.4)	9 (3.5)	1 (0.3)	0	1 (0.6)
Instagram	262 (37.8)	77 (39.3)	185 (37.2)	139 (34.6)	39 (26.9)	100 (38.9)	123 (42.3)	43 (32.8)	80 (50.0)
Snapchat	117 (16.9)	31 (15.8)	86 (17.3)	55 (13.7)	11 (7.6)	44 (17.1)	62 (21.3)	32 (24.4)	30 (18.8)
YouTube	218 (31.5)	64 (32.7)	154 (31.0)	169 (42.0)	77 (53.1)	93 (35.8)	49 (16.8)	23 (17.6)	26 (16.3)
TikTok	79 (11.4)	23 (11.7)	56 (11.3)	24 (6.0)	14 (9.7)	10 (3.9)	55 (18.9)	33 (25.2)	22 (13.8)
Number of social media channels, M (SD)	1.5 (0.9)	1.4 (0.8)$^{\mp}$	1.6 (0.9)$^{\mp}$	1.5 (0.9)	1.4 (0.9)*	1.7 (0.9)*	1.6 (0.9)	1.7 (0.9)	1.5 (0.9)
Media content consumed, n (%)[2]									
Casting and dating shows 1[3]	52 (6.4)	14 (5.2)	38 (7.0)	4 (0.9)	1 (0.5)	3 (1.1)	48 (13.8)	21 (13.0)	27 (14.5)
Casting and dating shows 2[4]	29 (3.6)	11 (4.1)	18 (3.3)	5 81.1)	3 (1.6)	2 (0.7)	24 (6.9)	13 (8.1)	11 (5.9)
Daily-soaps	25 (3.1)	7 (2.6)	18 (3.3)	12 (2.6)	5 (2.7)	7 (2.5)	13 (3.7)	8 (5.0)	5 (2.7)
Sports and fitness	172 (21.2)	68 (25.5)	104 (19.1)	115 (24.8)	42 (22.5)	73 (26.4)	57 (16.4)	26 (16.1)	31 (16.7)
Beauty and lifestyle	38 (4.7)	10 (3.7)	28 (5.1)	14 (3.0)	3 (1.6)	11 (4.0)	24 (6.9)	7 (4.3)	17 (9.1)
Series and movies	316 (39.0)	101 (37.8)	215 (39.5)	175 (37.7)	69 (36.9)	106 (38.3)	141 (40.6)	62 (38.5)	79 (42.5)
Gaming and e-sport	109 (13.4)	38 (14.2)	71 (13.1)	103 (22.2)	48 (25.7)	55 (19.9)	6 (1.7)	4 (2.5)	2 (1.1)
Music (videos)	70 (8.6)	18 (6.7)	52 (9.6)	36 (7.8)	16 (8.6)	20 (7.2)	34 (9.8)	20 (12.4)	14 (7.5)
Number of appearance-related media content[5], M (SD)	0.6 (0.7)	0.7 (0.1)	0.7 (0.1)	0.5 (0.1)†	0.5 (0.1)	0.6 (0.1)	0.9 (0.1)†	0.8 (0.1)	0.9 (0.1)

Table 3. Descriptive statistics of sociodemographic aspects, standardized questionnaires, eating behaviour and media consumption (Continued)

		Type of sport[1]		Male (*n* = 257)			Female (*n* = 182)		
	Total (*N* = 439)	Low-risk sport (*n* = 136)	High-risk sport (*n* = 303)	Total	13–14 years (*n* = 102)	15–18 years (*n* = 155)	Total	13–14 years (*n* = 78)	15–18 years (*n* = 104)
Eating behaviour									
Meals per day, M (SD)	2.8 (0.4)	2.8 (0.4)	2.8 (0.5)	2.8 (0.4)	2.8 (0.4)	2.8 (0.4)	2.8 (0.5)	2.8 (0.5)	2.8 (0.4)
Snacks/energy bars per day, M (SD)	2.3 (1.5)	2.3 (1.3)	2.3 (1.6)	2.4 (1.5)	2.6 (1.4)	2.3 (1.5)	2.2 (1.5)	2.1 (1.5)	2.3 (1.5)
Number of weight control methods, M (SD)	0.5 (0.9)	0.4 (0.7)$^{\mp}$	0.6 (0.9)$^{\mp}$	0.4 (0.8)	0.3 (0.7)	0.4 (0.8)	0.7 (0.9)	0.4 (0.5)*	0.9 (1.2)*
Use of at least one weight control method, n (%)	145 (33.0)	36 (26.5)	109 (36.0)	66 (25.7)	23 (22.5)	43 (27.7)	79 (43.4)	27 (34.6)	52 (50.0)
Use of two weight control methods, n (%)	38 (8.7)	9 (6.6)	29 (9.6)	23 (8.9)	8 (7.8)	15 (9.7)	15 (8.2)	2 (2.6)	13 (12.5)
Use of > 3 weight control methods, n (%)	18 (4.1)	4 (2.9)	14 (4.6)	7 (2.7)	2 (2.0)	5 (3.2)	11 (6.0)	0	11 (10.6)
No use of weight control methods, n (%)	294 (67.0)	100 (73.5)	194 (64.0)	191 (74.3)	79 (77.5)	112 (72.3)	103 (56.6)	51 (65.4)	52 (50.0)
Weight control methods used, n (%)[6]									
Diet pills	19 (8.5)	5 (9.4)	14 (8.2)	7 (6.8)	2 (5.7)	5 (7.4)	12 (9.9)	3 (10.3)	9 (9.8)
Laxatives	4 (1.8)	1 (1.9)	3 (1.8)	1 (1.0)	0	1 (1.5)	3 (2.5)	2 (6.9)	1 (1.1)
Diet trends[7] (vegan, paleo)	24 (10.7)	9 (17.0)	15 (8.8)	11 (10.7)	4 (11.4)	7 (10.3)	13 (10.7)	5 (17.2)	8 (8.7)
Fasting (permanent dieting)	97 (43.3)	19 (35.8)	78 (45.6)	41 (39.8)	12 (34.3)	29 (42.6)	56 (46.3)	14 (48.3)	42 (45.7)
Increase exercise/training	68 (30.4)	18 (34.0)	50 (29.2)	38 (36.9)	16 (45.7)	22 (32.4)	30 (24.8)	4 (13.8)	26 (28.3)
Vomiting	5 (2.2)	0	5 (2.9)	1 (1.0)	0	1 (1.5)	4 (3.3)	0	4 (4.3)
Others	7 (3.1)	1 (1.9)	6 (3.5)	4 (3.9)	1 (2.9)	3 (4.4)	3 (2.5)	1 (3.4)	2 (2.2)
ChEDE-Q8 global score, M (SD)	0.88 (1.13)	0.76 (0.95)	0.94 (1.20)	0.51 (0.79)†	0.39 (0.61)*	0.59 (0.88)*	1.40 (1.32)†	1.21 (1.17)*	1.56 (1.42)*
ChEDE-Q8 prevalence rate, n (%)[8]	24 (5.5)			6 (2.3)	0	4 (2.6)	18 (9.9)	3 (3.8)	10 (9.6)
ATHLETE, M (SD)	1.8 (0.8)	1.5 (0.5)$^{\mp}$	1.9 (0.8)$^{\mp}$	1.7 (0.7)†	1.6 (0.5)	1.7 (0.8)	1.9 (0.8)†	1.8 (0.7)	2.1 (0.9)
FASD 1, M (SD)[9]	2.2 (0.8)	1.9 (0.6)$^{\mp}$	2.3 (0.8)$^{\mp}$	2.2 (0.8)†	2.1 (0.7)	2.2 (0.8)	2.3 (0.9)†	2.2 (0.7)	2.4 (0.9)
FASD 2, M (SD)[9]	1.9 (0.7)	1.8 (0.6)$^{\mp}$	2.0 (0.7)$^{\mp}$	1.8 (0.7)†	1.8 (0.6)	1.9 (0.7)	2.1 (0.7)†	1.9 (0.6)*	2.2 (0.8)*
VCQ self-discipline, M (SD)	6.2 (2.5)	6.2 (2.3)	6.1 (2.5)	5.9 (2.3)†	5.6 (2.3)	6.0 (2.2)	6.6 (2.7)†	5.9 (2.7)*	6.9 (2.5)*
VCQ self-determination, M (SD)	9.4 (1.9)	9.5 (1.8)	9.4 (2.0)	9.6 (1.9)	9.8 (1.8)	9.4 (2.1)	9.2 (1.9)	9.4 (1.9)	9.1 (1.9)
VCQ impulse control, M (SD)	10.1 (2.4)	10.5 (2.5)	10.0 (2.3)	10.3 (2.3)	10.2 (2.3)	10.4 (2.3)	9.9 (2.4)	9.9 (2.4)	9.8 (2.4)
VCQ informed introjection, M (SD)	5.3 (3.4)	5.3 (3.1)	5.3 (3.5)	4.8 (3.1)	4.6 (2.9)†	4.8 (3.2)	5.9 (3.7)†	5.7 (3.8)	6.1 (3.6)

Note. [1]low-risk sports = technical sports, ballgame/team sports, high-risk sports = aesthetics, weight class sports, endurance sports, [2]multiple choice, [3]includes shows such as *Germany's Next Top Model* or *The Bachelor*, [4]includes shows such as *The Voice* or *Farmer Wants a Wife*, [5]includes items casting and dating shows 1, beauty and lifestyle and sport and fitness, [6]refers to participants that used at least one weight control method, multiple choice, [7]includes diet trends such as vegan or paleo diet, [8]cut-off-scores for prevalence rates according to Kiem et al. [12], [9]FASD 1 = ideals modeled by team norms; FASD 2 = ideals modeled by friends, $^{\mp}$significant differences between low- and high-risk sports, †significant differences between male and female athletes, *significant differences between age groups 1 and 2 within the gender group male or female.

seemed to strongly more influence disordered eating than the sum of meals and snacks per day. With regard to sports biography, the age of the first competition, as well as the start of sport-specific training, explained more variance than the type of sport. Informed introjection was most closely related to personality, followed by self-discipline, impulse control, and self-determination. Finally, the body and sport subscale (ATHLETE questionnaire) was most closely related to sports and social pressure, followed by modeling by friends, and team norms (both FASD questionnaires). Media consumption was less related to sports and social pressure.

Examining the model with the data for females and males as well as for the two age groups revealed the following: Eating disorder symptoms could be predicted slightly better in female athletes ($R^2 = .74$) than male athletes ($R^2 = .72$). For both genders, sports and social pressure had the strongest association with disordered eating (.56 and .49). Biography was not significantly related to disordered eating in females (.01, $p > .05$) and of minor association in male athletes (-.16). Personality was significantly related to disordered eating in females (.39) but not in males (.20, $p > .05$). Concerning age groups, eating disorder symptoms could be predicted better in older (R^2 = .81) than younger athletes (R^2 = .60). For younger and older athletes, personality had approximately the same influence on disordered eating as sports and social pressure (.40 and .42). Sports biography, however, exhibited a nonsignificant relationship to disordered eating in both age groups (−.10 and −.01, $p > .05$). Additionally, media consumption played a stronger role for male athletes (.36) and no significant role for females (.02, $p > .05$). It played a small yet significant role for older athletes (.18), but not for younger athletes (.14, $p > .05$). Type of sport showed an effect in older (−.34) but no effect in younger athletes (−.05, $p > .05$). On average, type of sport had a small effect on male (−.19) and no effect on female (−.15, $p > .05$) athletes.

Discussion

The results showed a higher prevalence rate for clinically significant eating pathology for female athletes (3.8% to 9.6%), for athletes in high-risk sports (6.6%), and for age group 2 (males: 2.6%, females: 9.6%). The prevalence rate for female athletes in age group 2 is particularly alarming, as this means that almost every tenth 15- to 18-year-old female athlete shows symptoms of an eating disorder. These age differences within the gender groups are a novel finding and highlight that adolescence is a sensitive period for developing an eating disorder and indicates that an athlete's age might play an important role in developing an eating disorder [5, 6].

The SEM confirmed that disordered eating can precursor eating disorder symptoms. In general, eating disorder symptoms could be predicted well with the aforementioned risk factors. Sports and social pressure had the strongest association. Within this risk factor, the ATHLETE questionnaire and one FASD subscale (ideals modeled by friends) were most strongly associated with sports and social pressure, whereas the FASD subscale ideals modeled by team norms and media consumption were less related to sports and social pressure. This means that athletes' mental association of weight loss and success and perceived social pressure on eating and body shape have the strongest association with athletes' eating behaviour and predict symptoms of eating disorders. This finding is in line with earlier studies on adults [21] and highlights the strong impact others can have on developing an eating disorder. With regard to personality, particularly informed introjection and self-discipline had the highest association with athletes' eating behaviour, compared to impulse control and self-determination. Again, this emphasizes the aforementioned result, as informed introjection measures athletes' perceived obligation to meet the expectations of others and therefore highlights perceived external pressure [16]. The influence of self-discipline and impulse control on disordered eating and eating disorder symptoms can be considered in line with earlier studies regarding similar personality traits such as high perfectionism in adult athletes [3, 4].

Limitations and future research perspectives

The survey was conducted in 2020 during the athletes' annual sports capability test. It is possible that due to the COVID-19 pandemic, training and competition restrictions during the year also impacted the answers given. Future studies, therefore, should be conducted when the pandemic is over. Additionally, disordered eating was assessed with two questions concerning eating behaviour, i.e., number of meals and snacks per day and number of regularly used weight control methods. A limitation of the latter is that in our analyses, possible healthy methods such as "diet trends" scored the same as unhealthy eating behaviours such as "vomiting". In future research, this could be addressed by using the disordered eating continuum [2] or using standardized instruments to assess subclinical forms of eating disorders, such as early-onset restrictive eating disturbances or orthorexic dieting [22, 23, 24]. Moreover, our brief assessment of media risk factors could be examined in more depth. In addition, questions regarding muscularity-oriented body image concerns or the desire for muscle gain in male participants warrant further investigation. Last but not least, our cross-sectional study does

not permit causal interpretation of results warranting longitudinal studies.

Practical implications

Several recommendations, particularly for coaches, can be made based on results concerning the detection and prevention of early-onset disordered eating. Our results highlight that athletes' disordered eating behaviour can precursor eating disorder symptoms. Therefore we recommend that not only coaches but also athletes, parents, and relevant personnel (e.g., physicians, physiotherapists, teachers) should be made aware of the symptoms of disordered eating (i.e., regular use of unhealthy weight control methods) and that it is a warning sign that should not be taken lightly or ignored [25, 26]. 33% of participants use at least one weight control method regularly, and athletes use up to six weight control methods at the same time, which both can be described as disordered eating [5, 7, 8, 9, 18]. However, concerning the used weight control methods, differences should be made between benign or healthy weight control methods to pursue slow and steady weight loss compared to the use of several methods at the same time and unhealthy methods such as the use of diet pills or laxatives [2]. On the other hand, although the most frequently used weight control methods – permanent dieting and increased exercising – might at first seem less dangerous when compared to methods such as vomiting or the use of medication. However, their regularity should not be taken lightly given that the dangers of regular use of weight control methods might be underestimated by athletes [27], and that disordered eating may lead to eating disorders [18].

Consequently, particularly coaches should be aware of the potential consequences when making comments that suggest an association between leanness/thinness and performance (i.e., athletes use methods to lose weight fast). Instead, coaches should educate athletes about the negative short- and long-term psychological and physiological consequences of fast and unhealthy weight loss and give appropriate advice for healthy dieting or refer athletes to an expert [9, 25, 26]. Results also indicated that athletes' attitudes and expectations regarding an ideal body are modeled by friends and team norms. Thus, another recommendation is to discourage activities and comments that draw attention to athletes' weight, such as public weighing or comparing athletes' bodies [17, 27]. Coaches should also intervene when they hear negative body-related comments expressed by athletes on the team.

Conclusion

Our study identified personality- and sport-related risk factors associated with eating disorder symptoms in adolescent elite athletes. To our knowledge, this is the first study investigating prevalence together with such a large number of risk factors in two age groups of adolescent elite athletes. Our findings are in line with previous studies conducted with adult elite athletes and illustrate that competitive, sport-related pressures are associated with athletes' eating behaviour and symptoms of eating disorders. In this study, the sports-related factors most closely associated with these behaviours and symptoms are (1) pressure on body shape, (2) emphasis on physical appearance imposed by friends und team norms, (3) the mental association between weight loss and success and (4) the drive for thinness and performance. Furthermore, self-regulatory personality factors play an essential role. Finally, not only the female gender but an athlete's age is also relevant to the development of an eating disorder. Both the onset of disordered eating and the existence of an eating disorder during adolescence can have serious long-term negative consequences. Short-term physiological effects such as weakness, injuries, or stress fractures impact performance. More alarming are the long-term psychophysiological consequences of an adolescent eating disorder, such as heart palpitations, dyspnea, depression, anxiety, or even suicidal thoughts, which can seriously impact an athlete's well-being [9, 25, 26]. Therefore, and according to previous suggestions, we call for the timely screening of disordered eating and eating disorders in male and female athletes, for all types of sports, and particularly during athletes' transition from early to late adolescence [5, 6, 17, 18, 28].

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ORCID
Nadia Walter
https://orcid.org/0000-0002-2413-9563
Thomas Heinen
https://orcid.org/0000-0003-0176-3221
Anne-Marie Elbe
https://orcid.org/0000-0002-8392-2451

Nadia Walter
Faculty of Sport Science
Leipzig University
Jahnallee 59
04109 Leipzig
Germany
nadja.walter@uni-leipzig.de