

Compulsive Exercise and Eating Disorder Symptoms: What about Adolescent Athletes?

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Conflict of Interest

The authors declare that they have no conflict of interest.

Predictive Factors for Compulsive Exercise in Adolescent Athletes: A Cross-sectional Study

Abstract

Although exercise is generally considered a healthy lifestyle habit, it may become problematic for some people, which led to a growing study of compulsive exercise, defined as an uncontrollable urge for physical activity despite deleterious effects. A maintenance model of compulsive exercise has been developed for adults identifying weight and shape concerns, weight-control behaviors, and specific psychological states including depression and anxiety, as predictive factors. The present study aimed to identify predicting factors for compulsive exercise in adolescent athletes using this same model framework. Adolescent athletes completed the Compulsive Exercise Test and several well-validated psychometric measures. Gender-specific multiple regression models identified a stronger drive for thinness, perfectionism, and body image investment in sport as significant predictors of compulsive exercise in boys and girls. Among girls, asceticism and bulimia symptoms were also significantly associated with compulsive exercise. These findings support the relevance of the maintenance model for clinical intervention and research on compulsive exercise in adolescent athletes.

Keywords: compulsive exercise, eating behaviors, body image, sports

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Exercise is generally considered an important part of a healthy lifestyle, but in some individuals, exercise may become compulsive and overly time-consuming, thereby negatively impacting the quality of life (Symons Downs et al., 2019). Compulsive exercise is defined as a “rigid and highly driven urge to be physically active, in association with a perceived inability to stop exercising despite the individual being aware of the possible negative consequences” (Meyer et al., 2016, p. 1). Compulsive exercise can manifest as excessive vigorous exercise, a marked increase in daily movements, or motor restlessness (Bratland-Sanda et al., 2019). Since this construct was first introduced and defined in the 1970s, it has been linked etiologically to eating disorders and associated psychological symptoms (Lichtenstein et al., 2017; Carmack & Marten, 1979). Thus, compulsive exercise is considered a response to an obsession driven by a need to prevent dreaded consequences such as weight gain or to avoid negative emotions (Bratland-Sanda et al., 2019; Scharmer et al., 2020a).

Many studies in adults and adolescents have confirmed associations among compulsive exercise, body image and weight concerns, and disordered eating behaviors (i.e., dietary restrictions, drive for thinness, bulimia tendencies); indicating that a theoretical framework for explaining compulsive exercise should also consider the contributions of distorted body image and disordered eating behaviors (Cresswell et al., 2022; Egan et al., 2017; Goodwin et al., 2011a; Holland et al., 2014; Holland & Tiggemann, 2016; Levallius et al., 2017; Noetel et al., 2016; Plateau et al., 2014; Schlegl et al., 2020). Meyer et al. (2011) developed a maintenance model of compulsive exercise, conceptualizing it as a weight-control behavior driven by weight and shape concerns, as well as a strategy to cope with uncomfortable emotions. This model theorizes that an interaction between eating disorder symptoms and related psychological factors (e.g., anxiety, depression) contributes to development and maintenance (Meyer et al., 2011). Studies have

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revealed positive associations between compulsive exercise and rates of both anxiety and depression among adults and adolescents with eating disorders (Schlegl et al., 2020; Noetel et al., 2016) but not in non-clinical samples, suggesting that negative affect related to eating disorders is a significant driver of compulsive exercise (Goodwin et al., 2011a; Scharmer et al., 2020b). Furthermore, the model includes personality traits such as perfectionism, rigidity, and obsessive-compulsiveness that appear to be risk factors for both compulsive exercise and eating disorders (Meyer et al., 2011). Although this model has not been specifically validated in adolescents, its core factors, including a drive for thinness, perfectionism, and obsessive-compulsiveness, have been identified as predictors of compulsive exercise in adolescents from the general population (Goodwin et al., 2011a).

It is reasonable to speculate that competitive athletes, who must engage in regular and vigorous structured exercise as training, would be among the most prone to compulsive exercise and thus provide an ideal population to test the maintenance model. While it may be difficult to assess whether an urge to exercise stems from a compulsion or is an adaptation to a competitive or demanding environment (Jankauskiene & Baceviciene, 2019; Joy et al., 2016), the presence or absence of eating disorder symptoms and related psychological factors could distinguish between compulsion and adaptation (or dedication). Consistent with the maintenance model, studies of adult athletes have revealed a relationship between eating disorder symptoms (restrained eating, body and weight-related concerns) and a greater tendency to exercise compulsively (Egan et al., 2017). Moreover, Egan and colleagues (2017) reported that both eating pathology and compulsive exercise are related to perfectionism in adult athletes. A study of adults also found significantly stronger obsessional traits among those who exercise intensively compared to adults who exercised moderately or not at all (Shroff et al., 2006). Compulsive exercise may lead to relative energy

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deficiency, which can be particularly deleterious, both physically and psychologically, to adolescent athletes; adolescence is a crucial developmental period. For example, it has been well established that compulsive exercise combined with an energy deficiency, can impact bone health in boys and girls, which may lead to bone stress injuries and conditions like osteopenia and osteoporosis (Nattiv et al., 2021; De Souza et al., 2019; Brown et al., 2017).

Literature on the relationship between eating pathology and compulsive exercise in adolescent athletes is limited. One such study found that adolescents in competitive sports reported significantly stronger compulsive thoughts toward exercising than adolescent non-athletes (Goodwin et al., 2016). However, studies on the prevalence of eating disorders in adolescent athletes have reported inconsistent results, from no differences (Pustivšek et al., 2019) to a higher prevalence of eating disorders compared to non-athletes (Martinsen & Sundgot-Borgen, 2013). Therefore, more research is needed to better understand compulsive exercise in adolescent athletes and the associations with eating disorders and psychological factors such as depression and anxiety.

Overall, previous research has studied the relationships between eating disorders, its related symptoms and compulsive exercise (in combinations or separately), among adults and adolescents. However, none has specifically examined these variables together using the maintenance model elaborated by Meyer et al. (2011). Supporting and refining it is an important step towards a better understanding of compulsive exercise, and ultimately improve prevention and intervention. Therefore, the general aim of the present study was to replicate this maintenance model of compulsive exercise and test its central components among adolescent athletes. Based on this model and previous research (Egan et al., 2017; Goodwin et al., 2011a), it was hypothesized that body image concerns and weight-control behaviors (i.e., drive for thinness, bulimia symptoms,

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and body image investment in sport) as well as related psychological factors and personality traits such as anxiety, depression, obsessions, and perfectionism, would all be significant predictors of compulsive exercise in adolescent athletes. Findings from this study could help identify adolescent athletes at higher risk of compulsive exercise and related disorders and relevant targets for prevention and intervention in at-risk subgroups.

Methods

Participants and Procedures

In this study, an adolescent athlete refers to someone aged between 14 and 17 years who exercises regularly (at least five hours per week) and belongs to a sports club or organization that engages in competition at a local, regional, or provincial level. A total of 492 French-speaking adolescent athletes aged 14 to 17 years ($M = 14.98$; $SD = 0.89$) participated in the present cross-sectional study (52.9% girls). Recruitment was conducted in the Quebec province of Canada, in two separate phases during 2016. For a sufficient statistical power, a minimum of 208 participants was required for statistical analyses, as estimated using the G*Power software (Faul et al., 2007), considering an average effect size of 0.15, a power of 0.95, a significant level of 0.05 and using 17 independent variables.

In the first phase, 342 athletes from various regions and involved in a variety of sports disciplines were recruited at the provincial finals of the annual Quebec summer Games held in 2016. Prior to the competition, coaches received written instructions from their regional coordinator, who had been trained in data collection by the study first author. Then, coaches invited athletes to participate and submit completed questionnaires and a written consent form in two separate sealed envelopes to ensure anonymity and confidentiality. Due to the participation of

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intermediaries (regional coordinators and coaches) in the recruitment process, it was impossible to know how many athletes were invited to participate. Athletes from 11 out of 15 provincial regions present at the competition participated in the study. Within these regions, and based on the rates of adolescent participation to these games, the participation rate was estimated at 22%. Non-participation could be attributed to 1) regional coordinators' refusal or failure to reach each of the coaches, 2) coaches' refusal, 3) athletes' refusal, or 4) not speaking French (most of the population in Quebec speaks French). A second recruitment phase was conducted the same year, to increase our sample size. In this phase, 159 participants were recruited from two high schools within the same Quebec region, with school programs combining sports and education. In these programs, adolescents practiced one specific sport competitively, for which they trained regularly during and after school. Questionnaires were distributed to student athletes by a teacher or coach at their school with the same instructions as in the first phase. The participation rate in this phase was around 98%. Among the questionnaires received, nine were excluded because the respondent indicated less than five hours of training per week, yielding a final sample of 150. Both phases were approved by the research ethics committee of the University of Quebec at Chicoutimi and all participants provided written informed consent. In Quebec, adolescents aged 14 and older have the right to give their own consent. The distribution of sports disciplines among the sample is shown in Figure 1.

Add Figure 1 here (Distribution of sports disciplines among the sample)

Measures

Components from the maintenance model were assessed using various measures, selected based on their psychometric qualities, their availability in the French language, appropriateness for adolescents, and conciseness (i.e., fewer number of items given the recruitment context).

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Sociodemographic information

Participants provided sociodemographic information (e.g., age, gender, and sport discipline).

Compulsive Exercise Test (CET)

The CET is a 24-item Likert-scale measure developed to assess compulsive exercise in the context of eating disorders (Goodwin et al., 2011b; Meyer et al., 2011; Taranis et al., 2011). Item scores range from 0 (never true) to 5 (always true). A total score is calculated by summing the average score for each of the five subscales (avoidant and rule-driven behavior, weight-control exercise, mood improvement, lack of exercise enjoyment, and exercise rigidity), with higher total score indicating more severe compulsive exercise. This measure has been validated for use with adolescents and athletes and has previously shown acceptable internal consistency (Goodwin et al., 2011b; Taranis et al., 2011). Meyer et al. (2016) also identified 15 as the optimal cut-off score to discriminate between individuals with and without compulsive exercise. The CET was translated into French based on the original English version, using a back translation technique (Vallerand, 1989). In the present study, the measure showed a good internal consistency ($\alpha = .87$).

Eating Disorder Inventory 2 (EDI-2)

Five EDI-2 subscales (Espelage et al., 2003), each widely used in research on disordered eating attitudes (Gardner, 1991), were measured to assess body image concerns, weight-control behaviors, psychological factors, and personality traits: drive for thinness, Bulimia symptoms, perfectionism, interoceptive awareness, and ascetism (search for self-discipline). Each item was scored on a 6-point Likert-type scale ranging from 0 (always) to 5 (never) and then recoded from 0 (including never, rarely, and sometimes) to 3 (always). Finally, a total score was computed for each subscale, with a higher score indicating stronger self-reported symptoms. In the present study,

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the five subscales showed acceptable internal consistencies, with Cronbach's Alphas ranging from .71 to .79.

Generalized Anxiety Disorder 7 (GAD-7)

The GAD-7 (Kroenke et al., 2007) was used to assess symptoms of generalized anxiety. All seven items are scored on a Likert-type scale ranging from 0 (never) to 3 (nearly every day). A total score was computed by summing all item scores, with a higher score indicating a greater level of anxiety. The GAD-7 is considered a valid and efficient anxiety screening tool (Spitzer et al., 2006) suitable for adolescents (Quittner et al., 2016). In the present study, this measure showed a good internal consistency ($\alpha = .86$).

Patient Health Questionnaire (PHQ-2)

The PHQ-2, an ultra-brief validated depression screener (Kroenke et al., 2003) recommended for first-line services, was used to assess depressive symptoms. It includes two Likert-type items scored from 0 (never) to 3 (nearly every day), and the total score is calculated as an indicator of depressive symptom severity. In the present study, this brief measure showed an acceptable internal consistency ($\alpha = .72$).

Obsessive-Compulsive Inventory (OCI-R)

The Obsessing subscale from the validated OCI-R (Foa et al., 2002; Zermatten et al., 2006) was used to assess the invasiveness of thoughts. This OCI-R subscale includes three Likert-type items scored from 0 (not at all) to 4 (extremely), and the total score was computed by averaging the three item scores. In the present study, this subscale showed a good internal consistency ($\alpha = .80$).

Body Image Investment in Sport

There are currently no validated tools to assess body image investment in sport. Therefore, our research team developed a brief four-item scale specifically for this study to assess body image

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investment and associated issues related to sport based on previous research (Voelker et al., 2014). The four items were as follows: “When you compare yourself with others who practice your sport, do you feel pressure to modify your shape (muscles, thinness, weight)?”, “Do you feel that your shape (your weight, your body shape) influences your athletic performance?”, “How important is your appearance to you?”, and “Do you feel pressure from your coach to modify your shape (muscles, thinness, weight)?”. Each item was scored on a Likert-type scale ranging from 0 (not at all) to 4 (extremely), and a total score was calculated by summing the individual item scores. This scale showed acceptable internal consistency in the present study ($\alpha = .69$).

Data Analyses

All analyses were performed using SPSS version 27 (IBM Corp., 2020). Data exploration and calculation of descriptive statistics were first conducted to assess basic assumptions prior to statistical testing (Field, 2009; Hanna & Dempster, 2012). Preliminary analyses showed no significant differences in studied variables between recruitment phases (all $p > .05$), so results were merged for subsequent analyses. The distribution was normal for the outcome variable (compulsive exercise) but skewed for most of the predicting variables. Thus, nonparametric tests were used where appropriate (Mann-Whitney U-test, Spearman’s Rho). Due to significant differences between adolescent girls and boys on many study variables, the following analyses were conducted separately by gender. Analyses by sport discipline could not be performed due to the low numbers in certain disciplines. Correlation and multiple linear regression analyses were performed to test our main objective. All variance inflation factors were less than 2.32, indicating no multicollinearity among variables. All variables were also examined for missing data and multivariate outliers. However, missing values were rare (maximum 2% of total observations) and could therefore be considered inconsequential. Further, no extreme data (or outliers) were deleted.

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205 **Results**

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207 **Participant Characteristics and Gender Differences**

208 Overall, 9.1% of our sample ($n = 44$ participants) scored higher than the cut-off score for CET,
209 and according to the standard deviation, most of the sample scored well below this clinical
210 threshold. Descriptive statistics for the variables of interest and group comparisons are presented
211 in Table 1, and correlations in Table 2. There was no difference in mean age between girls and
212 boys, while adolescent girls reported significantly higher scores on drive for thinness, interoceptive
213 awareness, body image investment in sport, obsessing, anxiety, and depressive symptoms.

214 **Add Table 1 here (Descriptives and group comparisons)**

215

216 **Add Table 2 here (Correlations)**

217

218 **Factors Associated with Compulsive Exercise by Multiple Linear Regression Analyses**

219 Separate multiple linear regression analyses were conducted to identify predictive factors for
220 compulsive exercise in adolescent boys and girls. Body image concerns, weight-control behaviors,
221 psychological factors, and personality traits were included in the regression model (Method Enter).
222 The model for adolescent girls (Table 3) revealed that only five variables, drive for thinness,
223 bulimia, perfectionism, ascetism, and body image investment in sport, were significantly
224 associated with compulsive exercise, collectively explaining 33% of the variance. The model for
225 adolescent boys (Table 4) indicated that only three of the nine candidate factors were significantly
226 associated with compulsive exercise, drive for thinness, perfectionism, and body image investment
227 in sport, which collectively explained 20% of the variance. According to Cohen's rules of thumb

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for effect sizes (Cohen, 1988), the adjusted R^2 for boys indicated a moderate effect size while that for girls indicated a large effect size.

Add Table 3 here (model for adolescent girls)

Add Table 4 here (model for adolescent boys)

Discussion

This study aimed to identify variables predicting compulsive exercise in adolescent athletes. For this purpose, we used Meyer's maintenance model (2011) as a framework due to the comprehensive list of factors considered, including weight and shape concerns, weight-control behaviors, psychological factors, and personality traits. Results of multivariable regression revealed that drive for thinness, perfectionism, and body image investment, factors related to eating disorders, were significantly associated with compulsive exercise in both adolescent boys and girls, while asceticism and bulimia symptoms were unique predictors among adolescent girl athletes. These findings suggest that evaluation of drive for thinness, perfectionism, and body image investment may help predict compulsive exercise and that these factors are critical targets for intervention. Further, these results support the utility of Meyer's maintenance model to better understand compulsive exercise among adolescent athletes.

Compulsive Exercise in Adolescent Athletes and Gender Differences

Body dissatisfaction is highly prevalent among adolescents (Dion et al., 2016), and such concerns are associated with compulsive exercise (e.g., Cunningham et al., 2022; Meneguzzo et al., 2022, Bell et al., 2016). It was expected that that compulsive exercise would more frequent in adolescent athletes. However, 9.1% of our sample reached a clinical score on the CET, slightly higher than the 7% reported in a Norwegian general population sample (Braland-Sanda et al.,

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2022); and similar to a subsample of UK adolescents engaged in sports (Goodwin et al., 2016). Since those studies were conducted in European countries, differences in levels of compulsive exercise could also be explained by social norms and cultural differences; more studies should be conducted in Canada to provide a more accurate comparison.

According to a recent meta-analysis by Chapa and colleagues (2022), eating disorders and problems related to body image and thinness are more frequent and severe in female athletes competing in aesthetic sports or sports in which a lean body may be advantageous or expected (e.g., martial arts, judo, CrossFit, distance running/cross-country running, cycling, dance, gymnastics, cheerleading, baton twirling, synchronized swimming, diving, aerobics, figure skating, triathlons, and rowing) compared to nonaesthetic sports and sports in which leanness is not necessary expected (e.g., volleyball, soccer, basketball, softball, hockey, and tennis). This comparison was not possible considering our mixed sample in terms of sports disciplines and gender; prevalence rates may also differ according to those aspects in adolescent athletes. However, more studies are needed to explore those differences and underlying mechanisms. An alternative explanation for this prevalence rate could be that exercise had not reached the level of compulsion in these relatively young athletes, or as suggested by Bratland-Sandra et al. (2022), that adolescents may be obsessed with exercising, but without being unable to stop exercising. Our results may suggest that at this stage of development, we may have captured an emerging preclinical manifestation of compulsive exercise. Another possible explanation is that sports involvement may represent a protective factor for adolescent athletes (Goodwin, 2016). Current models of athletes' long-term development promoted in Canada and focusing more on healthy development and lifestyle than on performance, could represent a promising avenue to prevent compulsive exercising and related factors in today's athletes (Higgs et al., 2019).

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There were also factors associated with compulsive exercise unique to adolescent girl athletes, albeit with small effect sizes. First, girls reported significantly higher overall levels of compulsive exercise than boys, consistent with a subsample of adolescent girls engaged in sports reported by Goodwin and colleagues (2016), but contradicting the results reported by Bratland-Sandra et al. (2022) for adolescent girls in the general population. Therefore, this higher prevalence of compulsive exercise among adolescent girls may be specific to those engaged in competitive athletics. Girls also reported significantly more body image concerns than boys, in accord with studies of the general population (Baceviciene & Jankauskien, 2020; Lucibello et al., 2023).

Further, adolescent girl athletes reported stronger obsession, depressive, and anxiety symptoms, again consistent with previous reports (Gomez-Baya et al., 2019; McLaughlin & King, 2015). Girls tended to attach greater importance to body shape in their sport, as well as more pressure to modify body shape for performance. Overall, adolescent girl athletes experienced more substantial body image concerns, psychological symptoms, and tendencies to engage in weight-control behaviors, including compulsive exercise, in line with previous research on compulsive exercise in adolescents (e.g., Goodwin et al., 2016). Alternatively, there was no significant gender difference in the average time per week spent on sports and exercising (although it was slightly higher in boys), and time spent was not strongly correlated with compulsive exercise ($r = .07$ for girls and $.06$ for boys). These findings suggest that the subjective experience of compulsivity does not necessarily reflect the time spent exercising by adolescent athletes. This emphasizes the qualitative aspect of exercise over the quantity, supporting the terminology of compulsive (vs excessive) exercise.

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Predictors of Compulsive Exercise in Adolescent Boys and Girls

Multiple significant associations were found between compulsive exercise and factors related to body image, eating and weight-control behaviors, and mental health, supporting Meyer's maintenance model (2011). The regression model for girls identified drive for thinness as the strongest predictor of compulsive exercise, followed by asceticism, bulimia symptoms, perfectionism, and body investment in sports. In contrast, body investment in sports was the strongest predictor among adolescent boys, followed by perfectionism and drive for thinness. The effect sizes for the tested predictive factors were intermediate for boys (.20) but large for girls (.33) (Cohen, 1988). These results suggest that the drive for thinness, perfectionism, and body investment in sport are relatively stable and ubiquitous predictors of compulsive exercise in adolescent athletes. Among girls, however, asceticism and bulimia symptoms were also significantly associated with compulsive exercise. Asceticism is a self-control trait that manifests as self-discipline, self-denial, and control of one's needs (Garner, 2004). Like perfectionism, it is frequently considered a facet of overcontrol (Obeid et al., 2019). Higher levels of bulimia symptoms were significantly associated with lower levels of compulsive exercise. Previous studies have reported that compulsive exercise is more strongly associated with anorexia than bulimia (Alcaraz-Ibáñez et al., 2020; Shroff et al., 2006). Thus, it is possible that compulsive exercise is part of a more restrictive and self-controlled profile, including certain weight-control behaviors but not binge-purge behaviors among adolescent girls in competitive sports.

Relevance of the Maintenance Model for Adolescent Athletes

The current results are consistent with several predictions of Meyer's maintenance model (2011), thereby partially supporting its use for the study and treatment of compulsive exercise in

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adolescents. First, a higher level of drive for thinness and body investment in sports were significant factors contributing to compulsive exercise among adolescent athletes in both boys and girls, suggesting that compulsive exercise is, at least in part, a weight-control behavior driven by body image concerns. Meyer and colleagues (2011) also emphasized the contributions of personality traits and negative psychological factors to the maintenance of compulsive exercise. Some of these traits were associated with compulsive exercise among adolescent girls (but not boys), namely perfectionism and asceticism, both of which reflect a tendency for self-control.

Negative affect (i.e., depressive and anxiety symptoms) and obsessional traits were not significant predictors in either boys or girls. Since significant correlations were observed between compulsive exercise and depressive and anxiety symptoms in both boys and girls, the contribution of this component (identified as affect regulation in the initial model) should not be excluded. It may be possible that exercise is not a significant coping strategy for negative affect at this stage. In the initial model, Meyer et al. (2011) proposed that growing psychological dependence could explain the link between affect regulation and compulsive exercise, and this process could still be at an early stage in adolescent athletes. Alternatively, it is possible that negative affect related specifically to body image and sports performances (and thus not detected by the GAD-7 or PHQ-2) would better predict compulsive exercise. Also, since we used measures of negative affect instead of affect regulation, we might not have precisely captured the components described by Meyer et al. (2011). Finally, active investment in a chosen sport may help constrain negative emotions or serve as a general coping mechanism. Such an effect could be revealed by comparing currently competing adolescent athletes with adolescents no longer competing, either by choice (e.g., retirement or disinvestment) or circumstance (e.g., the

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COVID-19 pandemic or injury). For example, studies on the impact of COVID-19-related lockdowns revealed increased body image concerns and weight-control behaviors (Buckley et al., 2021) as well as anxiety and depressive symptoms (Antoniak et al., 2022) among athletes.

A seminal finding of the present study is the differences in predictive model value between boy and girl athletes as it suggests that symptoms related to eating disorders are more frequent or stronger drivers of compulsive exercise in girls. This proposition aligns with the existing literature (Alcaraz-Ibáñez et al., 2020); however, the initial model was mainly conceptualized using studies including only adult and adolescent girls. The greater explanatory power of this model in girls suggests that other mechanisms, such as muscularity-related variables, may contribute to the development and maintenance of compulsive exercise in boys. As in previous studies, (Dion et al., 2015, 2016), there was a trend in our sample toward female wishing to lose weight and male wishing to gain muscle mass. Indeed, this notion is supported by the growing literature on muscle dysmorphia, characterized by a preoccupation over one's muscularity, which is more prevalent in adult and adolescent males (Ganson et al., 2023; Mitchison et al., 2022) and is frequently linked to eating disorder symptoms in men (Badenes-Ribera et al., 2019; Bégin et al., 2019). Moreover, compulsive exercise has been identified as a core component of muscle dysmorphia (Pope et al., 1997; Martenstyn et al, 2021). Therefore, a modified maintenance model including muscle dysmorphia could predict compulsive exercise more accurately in adolescent boys.

This study has several limitations that must be highlighted. First, many sports disciplines were underrepresented; therefore, there may be additional predictive factors for specific disciplines or types of sports (team vs. individual, aesthetic vs. strength based). Also, the data were based exclusively on self-reports, which may have introduced bias related to social pressure, stigma,

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selective recall, and limited introspection capacity. In addition, the questionnaire used to investigate body image investment in sport was created by the research team and its psychometric qualities have not been tested in independent samples. Finally, the cross-sectional nature of this study precludes investigation of causal associations among body image concerns, psychological and personality traits, and compulsive exercise; it also limits the generalizability of our results and conclusions. Longitudinal studies, studies including specific types of sports, a structured interview for compulsive exercise, and examination of a modified model for boys, are needed to address these limitations.

Clinical Implications

These results underscore the need for adolescent athletes' parents, teachers, and coaches to be aware of compulsive exercise risk and be informed about detection and prevention strategies (Conviser et al., 2018). Particular attention should be paid to the screening of athletes who seek thinness, attach great importance to body image in their sport, are perfectionists, and (or) are particularly rigorous and disciplined in training and everyday life. Emphasis on long-term development models for young athletes focusing on healthy development and a balanced lifestyle rather than weight control and performance may protect against eating disorders and compulsive exercise (for example, Sport for life; Higgs et al., 2019).

Conclusions

To our knowledge, this is the first study to explore predictive factors of compulsive exercise among adolescent athletes using the maintenance model proposed by Meyer et al. (2011). Our findings partially support the relevance of this model framework for the study of compulsive exercise

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389 among adolescent athletes, especially girls. Our findings suggest that compulsive exercise is
390 explained mainly by the drive for thinness, perfectionism, and body image investment in sport in
391 both boys and girls as well as by asceticism and bulimia symptoms (negatively) in girls.

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Data Availability Statement

Due to ethical constraints, data cannot be made openly accessible, but are available upon request from the corresponding author.

Authors Contribution

All conditions for authorship recommended by the ICMJE (a, b, c, and d) are met by each author.

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Table 1*Means, Standard Deviations, and Group Comparisons*

Variables	Range		Mean (<i>SD</i>)/Median			Median Comparisons			
			Girls		Boys	<i>n</i>	<i>U</i>	<i>p</i>	<i>ES</i>
CET total score	0-25	10.66 (3.45)	10.61	9.63 (3.81)	9.68	469	30 826	<.01**	0.15
EDI-2 Drive for thinness	0-21	4.28 (4.88)	3	2.29 (2.20)	2	489	34 059	<.01**	0.17
EDI-2 Bulimia	0-21	1.17 (2.22)	0	1.06 (2.01)	0	489	28 859	.82	0.01
EDI-2 Int. awareness	0-30	3.23 (3.42)	2	2.43 (2.92)	2	483	32 221	<.01**	0.14
EDI-2 Perfectionism	0-18	4.19 (3.95)	3	4.35 (3.92)	3	485	27 219	.56	0.03
EDI-2 Asceticism	0-24	2.25 (2.95)	1	2.46 (2.78)	2	483	25 660	.13	0.07
GAD-7	0-21	4.96 (4.32)	4	3.09 (3.59)	2	473	34 877	<.01**	0.26
PHQ-2	0-6	1.11 (1.31)	1	0.81 (1.13)	0	473	30 540	<.01**	0.13
OCI-R Obsessing	0-4	0.61 (0.73)	.33	0.52 (0.76)	.33	472	29 636	.03*	0.10
Body image inv. in sport	0-16	5.88 (3.07)	6	5.09 (3.31)	5	473	30 672	<.01**	0.12

Note. Higher scores are more problematic in all scales. *ES* = effect size (*r*) was calculated as follows: $z / \sqrt{N}$. CET = Compulsive Exercise Test; EDI-2 = Eating Disorder Inventory-2 subscales; GAD-7 = seven-item version of the Generalized Anxiety Disorder scale; PHQ-2 = two-item version of the Patient Health Questionnaire; OCI-R = Obsessing scale of the Obsessive-Compulsive Inventory – Revised.

* $p < .05$. ** $p < .01$.

Table 2*Spearman's Correlations*

		Girls (<i>n</i> = 255)									
		1	2	3	4	5	6	7	8	9	10
Boys (<i>n</i> =227)	1. CET		.43**	.10	.27**	.39**	.46**	.27**	.22**	.27**	.39**
	2. EDI-2 Drive for thinness	.21**		.25**	.39**	.33**	.48**	.21**	.24**	.25**	.40**
	3. EDI-2 Bulimia	.06	-.81		.30**	.30**	.31**	.20**	.22**	.18**	.20**
	4. EDI-2 Int. awareness	.07	.13	.11		.35**	.40**	.44**	.45**	.38**	.33**
	5. EDI-2 Perfectionism	.36**	.08	.16*	.08		.55**	.30**	.18**	.27**	.35**
	6 EDI-2 Asceticism	.23**	.08	.26**	.26**	.39**		.30**	.27**	.41**	.42**
	7. GAD-7	.20**	.14*	.07	.36**	.24**	.25**		.55**	.53**	.29**
	8. PHQ-2	.23**	.14*	.06	.34**	.23**	.22**	.52**		.50**	.20**
	9. OCI-R Obsessing	.12	.18**	.08	.35**	.18**	.21**	.54**	.51**	-	.28**
	10. Body image inv. in sport	.33**	.22**	.08	-.01	.26**	.18*	.32**	.30**	.29**	

Note. For all scales, higher scores are more problematic. CET = Compulsive Exercise Test; EDI-2 = Eating Disorder Inventory-2 subscales; GAD-7 = seven-item version of the Generalized Anxiety Disorder scale; PHQ-2 = two-item version of the Patient Health Questionnaire; OCI-R = Obsessing scale of the Obsessive-Compulsive Inventory – Revised.

Table 3*Multiple Regression Analysis Results for Compulsive Exercise in Girls*

	<i>B</i>	Beta	<i>t</i>	<i>p</i>
(Constant)	7.93		19.34	< .01**
EDI-2 Drive for thinness	.24	.34	4.90	< .01**
EDI-2 Bulimia	-.23	-.14	-2.63	.01*
EDI-2 Int. awareness	-.05	-.05	-.73	.46
EDI-2 Perfectionism	.12	.14	2.11	.04*
EDI-2 Ascetism	.19	.16	2.20	.03*
GAD-7	.056	.070	.945	.346
PHQ-2	.071	.027	.402	.688
OCI-R Obsessing	-.009	-.002	-.028	.978
Body image inv. in sport	.151	.134	2.015	.045*

n = 245; Adjusted R^2 = 0.33; $F(4, 241)$ = 31.23.**p* < .05. ***p* < .01.**Table 4***Multiple Regression Analysis Results for Compulsive Exercise in Boys*

	<i>B</i>	Beta	<i>t</i>	<i>p</i>
(Constant)	6.35		13.06	< .01**
EDI-2 Drive for thinness	.32	.19	2.87	< .01**
EDI-2 Bulimia	-.15	-.07	-1.05	.30
EDI-2 Int. awareness	.06	.05	.64	.52
EDI-2 Perfectionism	.18	.19	2.78	< .01**
EDI-2 Ascetism	.08	.06	.83	.41
GAD-7	.09	.08	.88	.38
PHQ-2	.03	.01	.11	.91
OCI-R Obsessing	-.30	-.06	-.75	.46
Body image inv. in sport	.27	.24	3.45	< .01**

n = 210; Adjusted R^2 = 0.20; $F(3, 207)$ = 18.56.**p* < .05. ***p* < .01.

Figure 1

Distribution of sports disciplines among the sample

