

Original Article

**Body mass index, body image dissatisfaction, and eating disorder symptoms in female aquatic sports: Comparison between artistic swimmers and female water polo players**

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**Abstract**

Previous studies have suggested that artistic (synchronized) swimming athletes might show eating disorders symptoms. However, systematic research on eating disorders in artistic swimming is limited and the nature and antecedents of the development of eating disorders in this specific population of athletes is still scarce. Hence, the aim of our research was to investigate the eating disorder symptoms in artistic swimming athletes using the EAT-26 instrument, and to examine the relation of the incidence and severity of these symptoms to body mass index and body image dissatisfaction. Furthermore, we wanted to compare artistic swimmers with athletes of a non-leanness (but also an aquatic) sport, therefore we also included a group of female water-polo athletes of the same age. The sample consisted of 36 artistic swimmers and 34 female waterpolo players (both aged 13-16). To test the presence of the eating disorder symptoms the EAT-26 was used. The Mann-Whitney U Test (MWU) was used to test for the differences in EAT-26 scores. The EAT-26 total score and the Dieting subscale (one of the three subscale) showed significant differences between the two groups. The median value for EAT-26 total score was higher in the artistic swimmers' group (C = 11) than in the waterpolo players' group (C = 8). A decision tree classifier was used to discriminate the artistic swimmers and female water polo players based on the features from the EAT26 and calculated features. The most discriminative features were the BMI, the dieting subscale and the habit of post-meal vomiting. Our results suggest that artistic swimmers, at their typical competing age, show higher risk of developing eating disorders than female waterpolo players and that they are also prone to dieting weight-control behaviors to achieve a desired weight. Furthermore, results indicate that purgative behaviors, such as binge eating or self-induced vomiting, might not be a common weight-control behavior among these athletes. The results corroborate the findings that sport environment in leanness sports might contribute to the development of eating disorders. The results are also in line with evidence that leanness sports athletes are more at risk for developing restrictive than purgative eating behaviors, as the latter usually do not contribute to body weight reduction. As sport environment factors in artistic swimming include judging criteria that emphasize a specific body shape and performance, it is important to raise the awareness of mental health risks that such environment might encourage.

**Keywords:** synchronized swimming, leanness sport, eat 26, dieting behavior, sport environment, decision tree, machine learning

**Introduction**

Eating disorder symptoms, i.e. dieting weight management, dietary restraint, binge eating, purging behaviors, drive for muscularity, as well as body weight and shape concerns, are frequently observed in a wide range of elite sports (Martinsen&Sundgot-Borgen, 2013). These symptoms are especially common among female athletes (Di Cagno et al. 2018), which is in compliance with the higher prevalence of eating disorders among females in the general population, explained by gender differences in the stability of self-esteem and personality traits (e.g. perfectionism), together with gender-biased sociocultural factors (e.g. media influence and the history of weight-related bullying) (Raevuori, Keski-Rahkonen& Hoek, 2014;Kuculo, Kozar, Low, 2018). In elite aquatic sports, girls are typically competing at the age of 13-15, which corresponds to the developmental stage of middle adolescence (Lundy, 2011). Middle adolescence is characterized with major changes, including physiological (i.e. sudden growth, body mass increase, body fat formation) and psychological changes (i.e. unstable self-esteem, self-criticism), which are well-established risk factors for developing eating disorders (Striegel-Moore & Bulik, 2007). Also, high school student-athletes are under constant scrutiny and that can lead to an excessive focus on body shape and weight, especially when their “body can influence” their performance

(Ayala,2020).Strongly related to the eating disorder symptomatology is the multi-dimensional concept of *body image* (i.e. individuals' perceptions of and attitudes toward their own body), and, especially, its evaluative component, *body image satisfaction* (i.e. body image evaluation, individuals' satisfaction with their own body) (De Bruin et al., 2011). While a person may have a positive perception of their body shape and size in the social environment (*social body image*, i.e. one that is compatible with social norms or media images), they may have a negative perception of their body shape and size in the specific environment, e.g. a sport environment (*sporting bodyimage*). Specific factors in the sport environment may encourage an unhealthy focus on body weight and shape (Bratland-Sanda andSundgot-Borgen, 2012).

In aquatic sports, every lack in physique is visible since a swimsuit is the only clothes that athletes wear, both in training and during the performance (Grogan, 2017). Displaying the bodies in tight and revealing sport clothing makes body comparisons easier, which contributes to higher body image dissatisfaction and more dietary behaviors (Steinfeldt et al., 2013). Furthermore, elite athletes' social environment is highly competitive in general - comparisons between individuals are so common that they can be considered a normative behavior. These comparisons are not only made by athletes themselves, but also by coaches: studies have found that the coaching style preoccupied with performance and physical appearance increases body image anxiety, dieting behaviors and fear of gaining weight (Biesecker and Martz, 1999). Additionally, specific factors in the sport environment include sport-specific weight limits, judging criteria that emphasize specific body shape and performance calling for a low body fat (Smolak, Murnen, and Ruble, 2000). These factors are especially pronounced in *leanness sports*, where control over body weight is important for a high peak performance (e.g. Sundgot-Borgen andTorstveit, 2004). Werner et al. (2013) found a direct causal connection between success in several sport disciplines and low body weight, with weight regulation playing a decisive role. Leanness sports, except the usual sporting demands for strength, flexibility, coordination and endurance, lay great value on referees' evaluation of artistic performance. This evaluation is, more often than not, subjective and depends on different aesthetic factors, including athletes' appearance. Although physical appearance is not directly evaluated, it is expected that skinnier athletes score higher in artistic impression (ClaessensLefevre et al., 1999) which might contribute to dieting behaviors. It could also be expected that leanness sports athletes with a greater BMI value are especially at risk for developing eating disorder symptoms. It is considered that they need to be the ideal (i.e. extremely skinny) body weight and shape in these sport disciplines. Moreover, since the ideal body image in leanness sports is described as an underweight body with low percentage of body fat, it can be expected that athletes are more at risk for developing *restrictive* eating behaviors (e.g. severe dietary restrictions), rather than *purgative* eating behaviors (e.g. binge eating and purging). This hypothesis is derived from the findings that purgative behaviors usually do not contribute to body weight reduction as much as restrictive eating behaviors (e.g. Izydorczyk andWojciechowski, 2016).

Artistic swimming is a hybrid water sport which combines swimming, dance and gymnastics performing in a synchronized routine in the water, accompanied with music (Mountjoy, 1999). Complex movements in the water require precise synchronization, which is a part of the technical merit score and therefore contributes to the overall performance result. In artistic swimming, like in swimming, competency is affected by a number of different factors: age, conditions and facilities, as well as anatomical, physiological and functional preconditions (Gorner, Kraučanica, Sawicki, 2020). A typical training program includes specific artistic swimming skills, but also speed swimming, strength, endurance and flexibility. The level of athlete's flexibility is an important prognostic indicator of performance and it could be expected that flexibility is better among skinny athletes (Koryahin et al., 2020). Overall, with the exception of the time spent in learning choreography, artistic swimming is a high-volume and high-intensity sport (Lundy, 2011). Aesthetic sports prioritize leanness;thus,the risks of energy and macronutrient deficiencies are of significant concern (Robertson, 2014). Female gender, vulnerable competing age and specific demands typical for leanness sport disciplines, make artistic swimming athletes a very high-risk group for developing eating disorders (Greenleaf, 2009). Some studies suggest that artistic swimming athletes may demonstrate eating disorders symptoms and that this degree could be higher in artistic swimming compared to *non-leanness* sports and *non-aquatic* sports (Melin et al., 2014).However, systematic research on eating disorders in artistic swimming is limited. Also, the nature and antecedents of the development of eating disorders in this specific, and relatively small population of athletes is still scarce.

The aim of our research was to investigate the eating disorder symptoms in artistic swimming athletes using the EAT-26 instrument, and to examine the relation of the incidence and severity of these symptoms to body mass index and body image dissatisfaction. Moreover, assuming similar physiological and psychological developmental changes, we compared a group of female artistic swimmers (AS) with female water polo players (FWP) of the same age. Water polo is an aquatic team sport that requires endurance, strength, power, swimming speed, tactical awareness and specific technical skills, including ball control (Cox, 2014). The game is composed of four quarters played by two teams who attempt to score goals by throwing the ball into the opponent's goal (Smith, 1998, De Castro Maqueda, 2019).Female water polo players were selected as a comparison group in this research since it has substantial similarities with artistic swimming; it is also an aquatic sport, which means it is comparable to artistic swimming in terms of displaying the bodies in tight and revealing sportswear. On the other hand, water polo differs from artistic swimming in terms of being a non-leanness sport; aesthetics is not relevant

for the performance and results. Building on the theoretical considerations and the results of the previous research, we hypothesize that artistic swimmers will demonstrate a substantial degree of eating disorder symptoms, which will be positively associated with body mass index and negatively associated with body image satisfaction. Furthermore, we assume that artistic swimmers will demonstrate a higher degree of eating disorder symptoms than female water polo athletes. Also, we expect that both the body mass index and body image dissatisfaction will be more important predictors of eating disorder symptoms among artistic swimming athletes in comparison to the female water polo athletes.

## Methods

**Participants:** 36 artistic swimmers and 34 female water polo players aged 13 to 16 participated in the research. The inclusion criteria were: a minimum of three years in competitive training, continually and without major breaks. Both groups participated in the 2015-2018 competitive seasons and already attended at least one major sport competition. The participants' personal data in the study were anonymized. The only personal data we collected were: year of birth, current weight and height and also, in which sport these participants compete.

**Measurements:** The Body Mass Index (BMI) calculation was used to determine whether the person is significantly underweight compared to the age matched norms. For 13-16 age group the cut-off value for being underweight is 18 (Rolland-Cachera et al., 1991; Corbin and Lindsey, 1997). The Eating Attitudes Test: Eat26 (EAT: Garner et al., 1982) was administered in order to test the presence of symptoms of an eating disorder. The Eat26 test examines the presence and frequency of extreme behaviors related to eating habits. The questionnaire consists of 26 questions. The Eat26 item self-report scale assesses eating disorder symptoms on three subscales: dieting (13 items), oral control (7 items), bulimia and food preoccupation (6 items). Subscale total scores are a sum of responses to all items in the scale, where the higher score corresponds to higher severity of eating disorder. The participants give responses on a 6-point scale: *never, rarely, sometimes, often, usually, and always*. The first three responses are scored zero, with the other three responses being scored 1, 2 and 3, accordingly. A score greater than 20 is an indicator of an eating disorder risk and individuals who score 20 or more should seek clinical support (Lane H., Lane A. & Matheson, 2004). The severity criteria are adjusted according to the age of the participants. Anonymous self-report questionnaires proved to be the most effective diagnostic tool for eating disorders among athletes, as seeking for help and admitting the problems are not very common in this population (Bardone-Cone, 2011). Following the methodology described for the Eating Disorder Inventory Referral Form (EDI-RF; Garner, 2004), four behavioral questions are included in this version of the EAT-26, in order to determine the presence and frequency of extreme weight-control behaviors. These questions assess self-reported binge eating, self-induced vomiting, use of laxatives, and treatment for an eating disorder over the preceding 6 months.

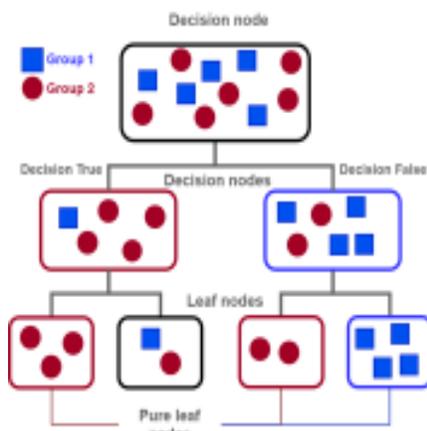
**Procedure:** The collection of the data took place in 2018. The participants were assessed individually, at the swimming pool after training, under the supervision of coaches and researchers. The questionnaire was in a paper-and-pencil format. The statement of informed consent was obtained from the participants' parents. The results of the questionnaire were subsequently entered into free online Google Forms and exported to a .csv file for further processing.

**Statistical analysis:** The Mann-Whitney U Test (MWU) was conducted to test the differences in the EAT26 total score, the individual variables (the answers to the questions) and the calculated subscales (bulimia and food preoccupation subscale and oral control subscale) between the two sports' disciplines. In order to evaluate the athlete's perception of their own weight, a new eating disorder relevant variable was calculated from the obtained data, namely the weight dissatisfaction (WD), defined according to the equation (1). The weight dissatisfaction is a measure of what a participant thinks about their own weight and whether or not the weight should be changed, relative to the current weight. The WD was included in the statistical analysis.

$$WD = \frac{\text{weight} - \text{ideal weight}}{\text{weight}} \quad (1)$$

The calculated p-values were Bonferroni corrected, used to counteract with an error when doing multiple comparisons (Kayano, 2008). The complete statistical analysis and data preprocessing was used using Python libraries describes in prior work (Šimić, 2020). A decision tree classification was used to determine the true predictors of eating disorders between the two groups of female athletes. Decision trees have a long history, pre-dating contemporary machine learning approaches (Podgorelec, 2002), and originally such trees were manually assembled. They are designed to model and iteratively partition data, for example to distinguish between multiple classes within the data. Each node in the tree contains a decision rule, which instructs which child node should be traversed next (see Figure 1). When assigning a class to an unseen data point, at first the root node is inspected. Consecutively, the tree is traversed in a series of decisions until a branch is reached, which holds the information, which class should be assigned to the data point. Today, decision trees are usually derived from a data set comprising data points together with their class information, referred to as decision tree learning. Individual decisions are typically derived from ranking the features based on their ability to either partition the data to increase the purity in regard to the classes, to reduce the variance of respective partitions of the data, or to decrease the relative contained information about the classes. One of the main advantages of decision trees is that the results can be more easily interpreted than competing methods like ensemble learners

(Žuvela, 2020) which are showing good results but are considered black boxes. The decision tree algorithm had proven to be widely accepted for decision making in medicine (Chern, 2019) and the analysis of eating disorders (Izydorczyk, 2016).



**Figure I.** A synthetic example of a decision tree. The instances/samples are classified based on a decision for the most important variable first. The instances are iteratively partitioned until satisfying class/group purity (pure leaf nodes) is obtained. Based on these decisions, new instances can be classified as well.

**Table I.** Results of the Mann-Whitney U Test (Bonferroni corrected) showing significant differences in eating behavior on the Eat26 test.

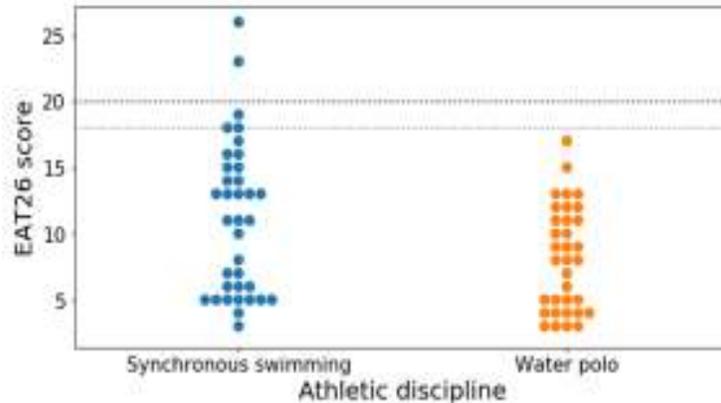
variable/answer to questions	p-value
2p) Ever made yourself sick (vomiting) to control your weight or shape?	<0.01
5) Cut my food into small pieces.	<0.05
6) Aware of the calorie content of foods that I eat.	<0.01
7) Particularly avoid food with a high carbohydrate content	<0.05
10) Feel extremely guilty after eating.	<0.05
11) Am preoccupied with a desire to be thinner.	<0.05
18) Feel that food controls my life.	<0.05
25) Have the impulse to vomit after meals	<0.01
<b>Weight dissatisfaction WD</b>	<b>&lt;0.05</b>
Weight	<0.05
BMI	<0.01
Ideal weight	<0.01
Dieting subscale	<0.05
EAT26 score	<0.05

**Results**

Only variables (from the EAT26 test) which had more than 10% variance, were used in this work.<sup>1</sup> The results of the MWU test are shown in Table 1. The EAT26 total score and the Dieting subscale show significant differences between the two groups ( $p < 0.05$ ). The median value for EAT26 total score is higher in the artistic swimmers' group ( $C = 11$ ) than within the waterpolo players' ( $C = 8$ ). The other two subscales (bulimia and food preoccupation subscale and oral control subscale) did not show significant differences between the two groups ( $p > 0.05$ ). At the item level, there were also some significant differences (see table 1). Responses to questions 1p, 2p, 5, 6, 7, 10, 11, 18 and 25 (see supplement for test description) show significant differences among the two groups (see Table 1). With the decision tree classification our aim was to show which variables discriminate the two groups the most in a non-linear manner, since the groups can form sub-groups and simple statistics may not suffice (Auguštin, 2020). The variable from our questionnaire which was ranked the first for the discrimination of the two groups was BMI (Figure 3). From the starting root with 34 female water polo athletes and 36 artistic swimmers based on BMI we obtain two nodes with the respective dominant sports discipline. Out of 34 female water polo players, 23 have a BMI above 20.948, while for artistic swimmers there are only 5 above the same

<sup>1</sup> Out of 26 questions in EAT26 only question no.9 had an equal response over both groups, which was 0 for all participants. It was removed from further analysis together with questions no. 2, 3p, 23, 24 which had less than 10% variance.

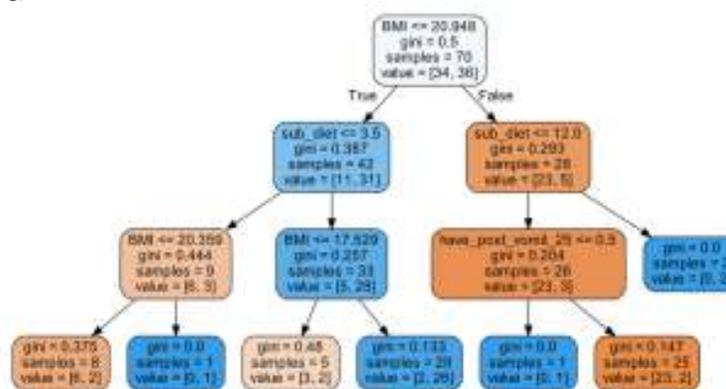
criteria. Another highly ranked discriminative variable in the decision tree is the dieting subscale (sub\_diet in Figure 3) pointing to different dieting behavior between the two groups. Through the models' choice of question 25 as another discriminative variable a satisfying class purity (domination of one athletic group in nodes and tree leaves), where classes are FWP, AS respectively, based on only these three features can be achieved.



**Figure II.** Swarm plot (a one-dimensional scatter plot) of the EAT26 total score values for the female athletes in the two athletic disciplines. The two dashed horizontal lines represent the threshold values at 18 and 20.

**Discussion**

It appears that young artistic swimmers are engaged in pathogenic weight-control behavior despite long-term health being very important for the development of their sports achievement. Due to the nature of the sport, it is impossible to continuously measure VO<sub>2</sub> during training, making it difficult to assess energy requirements and relative contributions of aerobic and anaerobic metabolism (Bante et al, 2007). So far, most studies have focused on adult athletes, but it seems that eating disorders and similar behaviors can be observed much earlier. There is lacking evidence on these aspects in young artistic swimmers. To our knowledge, this is the first research to compare two aquatic team sports (leanness and non-leanness sport) in eating disorders and the first research that is using decision tree in analyses of EAT 26. The decision tree is used for classification of artistic swimmers and female water polo players because we wanted to show which variables discriminate these two groups the most. In our case, the variable that discriminates in the first step is BMI because it turned out that female water polo athletes have a higher weight, which also requires the nature of that sport, but at that age this difference should not be visible. By comparing the results, we can see the significant difference first in BMI, then in other characteristics like weight, WD and ideal weight and also in summed EAT26 results, between the artistic swimmers, who are “forced to” look in a certain way and the female water polo players, who do not need an aesthetic component for success. The artistic swimmers yield a higher median value than the female water polo players. Two of the thirty-six artistic swimmers have values above 20 and three more of them are above 18. The score at or above 20 on the EAT-26 suggests the need to consult a physician or a treatment specialist for a follow-up evaluation (Garner, 2004). These results further show that athletes from these two sports do not engage in purgative weight-control behaviors, such as binge eating or self-induced vomiting, but they do engage in restrictive (dieting) behaviors.



**Figure III.** The decision tree for classification of athletes in the two sport disciplines. Each node shows the splitting variable used for separating the two athlete groups, the Gini index indication node purity and the number of athletes (instances) in the respective class. The color coding corresponds to the major class present in the node or leaf of the decision tree, blue being artistic swimming and orange water polo. The first square consists of 34 water polo athletes and 36 artistic swimmers. At BMI of 20.948 the groups are split into two

nodes: the left one consists of major artistic swimming (31 to 11), while the right one consists mostly of female water polo players (23 to 5). The algorithm continues iteratively until a tree depth of 3.

Because of the anonymity of the questionnaire, we (strongly) assume that most participants gave honest responses, thus the information obtained about the eating symptoms and eating disorder concerns are very useful. Because of the different demands connected to different types of sport, we further analyzed the related studies we found. Long training sessions and technical movements performed within the high resistance of water require a broad range of cardiovascular and musculoskeletal strength (Mountjoy, 2018). Three studies (Parks, 2007; Reinking, 2005; Rosendahl, 2009) found evidence of prevalence of weight-control problems in leanness sports and three other studies (Greenleaf, 2009; Martinsen, 2010; Anderson, 2011) did not find any differences in the prevalence between leanness and non-leanness sports. Sundgot-Borgen described a sport-specific variant of anorexia nervosa referred to as “anorexia athletica”, where female athletes suffering from it show an intense fear of gaining weight or becoming fat, although the athlete is not overweight at all. These athletes use a variety of pathogenic weight-control techniques to achieve their individually ideal weight. Self-report questionnaires, which often tend to overestimate psychopathology, are an important study limitation (Fairburn & Bohn, 2005). Although, regarding the specific theme - weight restriction behaviors, which is not a socially acceptable behavior, we argue that the problem of overestimating symptoms is probably not an issue. Also, we must note the relatively small sample size. However, the sample size includes almost the whole population of artistic swimmers and female water polo players in Croatia<sup>2</sup>.

### Conclusion

In sum, our results suggest that artistic swimmers, at their typical competing age, show a higher risk of developing eating disorders than female water polo players and that they are also prone to dieting weight-control behaviors to achieve a desired weight. Furthermore, our results indicate that purgative behaviors, such as binge eating or self-induced vomiting, might not be a common weight-control behavior among these athletes. The results corroborate the findings that sport environment in leanness sports might contribute to the development of eating disorders. The results are also in line with the evidence that leanness sports athletes are more at risk for developing restrictive than purgative eating behaviors, as latter usually do not contribute to body weight reduction. As sport environment factors in artistic swimming include judging criteria that emphasize specific body shape and performance, it is important to raise the awareness of mental health risks that such an environment might encourage. For the artistic swimming athletes, it is apparent that a thin, attractive body cliché is an important performance advantage. Consequently, the female artistic swimmers “confronts body-image pressures at a number of levels, ranging from the performance-related pressures reinforced by coaches and teammates to those inherent in the judging criteria that give physically attractive athletes the winning edge” (Davis, 1997). The implications of the study thus include educating the athletes about this mental health risk. The interventions should also be aimed at all relevant individuals in the athlete’s environment – parents, coaches and judges. It is not to say that a specific sport does not demand certain nutrition and weight of an athlete, but this should be achieved with help from an educated expert team (e.g. a nutritionist and a psychologist).

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<sup>2</sup>Our research was accompanied by 36 artistic swimmers, and throughout Croatia there were about 40 of them. It is the same with female water polo players.

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