RISK FACTORS FOR STRESS FRACTURES IN MALE ATHLETES

Diana Dimitrova, Evelina Miloshova
National Sports Academy "Vassil Levski", Sofia, Bulgaria

ABSTRACT
Stress fractures (SF) are common injuries in athletes caused by overuse and repetitive activity. The prevalence and risk factors for SF in male athletes are not well documented as they are assumed to be more common in female athletes. Our study was aimed at establishing the prevalence of SF among male athletes and analyzing the selected risk factors for their occurrence. Ninety-three randomly selected volunteer male athletes from different sports aged 19.2±2.8 years participated in this cross-sectional study. The participants provided information about their demographic data, history of SF, and lifestyle risk factors and completed the Eating attitude test (EAT-26) for identifying eating disorders risk. Crude odds ratios (OR) of the groups with and without a history of SF were calculated to assess the association of SF with the studied factors. A total of 23 (24.7%) of the athletes reported at least one SF in the past, and 23.7% of them have had two or more SF. Most of the injuries (69.6%) were located in the lower extremity, and 60% were in the foot and ankle. Participation in competitions and weight loss of more than 10 kg in the past were identified as the only significant factors associated with SF incidents in male athletes (OR 24.8, 95% CI: 1.4-425.4; OR 153.3, 95% CI: 8.5-2770.6, respectively). These results suggest that engagement in competitive sports, which is associated with higher training volume and extreme weight loss practices, should be considered as a factor for increased risk of SF in male athletes.

Keywords*: stress fractures, risk factors, male athletes, EAT-26*

INTRODUCTION

Stress fractures (SFs) are the most common overuse injury in athletes and are a common cause of disability and interruption of the training process. It was recognized that their etiology is multifactorial, and several risk factors were identified. The SFs are associated with increasing age (Bennell et al., 1999), low body weight (Bennell et al., 1995,1996, Nattiv et al., 2000), disordered eating (Bennell et al., 1995,1996, Nattiv et al., 2000), low bone mineral density (Bennell et al., 1995,1996, Carbon et al., 1990, Nattiv et al., 2000), menstrual irregularities (Bennell et al., 1995,1996, Carbon et al., 1990, Nattiv et al., 2000), smoking (Bouillon, 2008), both high volume and intensity of physical activity (Pegrum et al., 2012, Sharma, 2013), low fitness level (Bennell et al., 1999). The findings from studies of female and male athletes are contradictory regarding the associations of stress fractures with these risk factors due to the small sample size and use of different research methodologies.

Until recently, eating disorders were considered a risk factor for SFs, mainly in female athletes, and therefore very little information is available concerning male athletes. However, in recent years there has been an increase in restrictive eating patterns followed by compulsive exercise behaviors in male athletes (Karrer et al., 2020). The main triggering factors are performance pressure, pressure to maintain a specific body weight, perfectionism, and preoccupation with body image. (Filaire et al., 2007, Meyer et al., 2011).

This study aimed to establish the prevalence of SF among male athletes and to analyze the selected risk factors for their occurrence.

METHODS

Ninety-three randomly selected volunteer male athletes from different sports aged between 20 and 36 (mean age19.2±2.8 years) participated in this cross-sectional study. Exclusion criteria were sports experience of fewer than five years and weekly training duration of fewer than 6 hours/per week.

After informed consent and detailed instructions, all athletes completed a comprehensive questionnaire that consisted of four parts.

In the first part of the questionnaire, the participants provided information about their demographic data, sporting experience, training practices, participation in competitions, and competitive level.

The second part of the questionnaire assessed the stress fractures (SF) history. The presence of a stress fracture was assumed if they were diagnosed by a physician or confirmed by x-ray, bone scan, or magnetic resonance imaging.

The athletes were divided into two groups depending on whether or not they had SF in the past five years. The athletes with a history of one or more SF comprised the stress fracture group (SFG) (n=23), and those without a history of SF were the control group (CG) (n=70).

The third part of the questionnaire aims to identify the occurrence of selected lifestyle risk factors for SR, such as smoking, alcohol, and intake of caffeine-containing beverages.

In the fourth part of the questionnaire, the respondents completed the Eating attitude test (EAT-26) to identify the presence of eating disorders risk based on attitudes, feelings, and behaviors related to eating (Garner et al., 1982).

The test consists of three sections, as follows:

1) Total score based on the answers to the EAT-26 questions

The total score ranges between 0 and 78, with higher scores indicating a greater risk of an eating disorder. A score of 20 or above on the EAT-26 was taken as a cutoff for an overall pattern of disturbed eating which includes a high level of concern about dieting, body weight, or problematic eating behaviors.

The questions of EAT-26 are related to how often an individual engages in certain behaviors and form three subscales:

- Dieting - related to pathological refusal of high-density foods and concern for physical appearance,
- Bulimia and food preoccupation - refer to episodes of binge eating, followed by purgative behaviors to lose/control body weight,
- Oral control - reflects self-control concerning food and assesses the environmental and social forces that stimulate food intake (Marques et al., 2021).

The responses were scored on a four-point Likert scale as follows: Always = 3 points; Usually = 2 points; Often = 1 point; Never, Rarely, and Sometimes = 0 points. Item 26 was scored in the opposite direction (Never, Rarely, Sometimes = 3, etc.), and a final score was calculated by summing items from 1 to 26.

2) Answers to behavioral questions related to eating symptoms and weight loss

The four questions assess self-reported binge eating, self-induced vomiting, use of laxatives, and treatment for eating disorders. The last question is about weight loss over the preceding six months. We used a six-point Likert scale based on how often a person has engaged in extreme weight control behaviors over the preceding six months ("Never," "Once a month or less," "2–3 times a month," "Once a week," "2–6 times a week," and "Once a day or more") to score the items.

3) Body mass index (BMI)

It was calculated from self-reported height and weight to estimate the low body weight compared to age-matched norms.

Statistical analyzes were performed using SPSS-23.0. The normality of all parametric variables was tested using the Shapiro-Wilk normality test. Descriptive statistics (mean ± standard deviation) were computed for sociodemographic variables (age, height, weight, BMI, sports experience) and EAT-26 total score. The categorical data were presented as percentages. An independent samples t-test was used to evaluate the differences in demographic characteristics and sport experience data of both groups. The comparison of the categorical variables of the SF group and the C group was performed by Chi-square analyses. To determine the association of SF with the studied factors crude odds ratios (OR) and 95% confidential interval (95% CI) of both groups were calculated. The .05 level of significance was selected to test the statistical hypotheses.

RESULTS

Ninety-three male athletes with a mean age of 19.23±2.8 and a training experience of 9.34±4.25 years participated in this study. Sixty-nine of them (74.19%) participated in competitions, of whom 63 (67.74%) were at of national and 6 (6.45%) at of international level. The mean age at commencing competition for the whole group was 12.53±3.59. (Table 1).

Table 1. *Comparison of the demographic characteristics and risk factors of the studied groups*

Variable	Total group n=93	SFG n=23	CG n=70	Mean diff. between SFG and CG
Age and anthropometric characteristics				
Age (years)	19.23±2.80	19.26±2.60	19.21±2.91	0.05
Height (cm)	180.16±7.01	181.04±5.83	179.87±7.37	1.17
Weight (kg)	80.03±11.81	78.78±7.59	80.44±12.93	1.66
BMI ($kg.cm^{-2}$)	24.60±2.98	24.04±2.12	24.78±3.21	0.74
Sports experience				
Training experience (years)	9.34±4.25	10.31±4.59	9.03±4.13	1.28
Training duration (hours/week)	8.95±4.90	9.90±5.58	8.63±4.66	1.27
Participation in competitions (% / n)	74.19 (69)	100.00 (23)	65.71 (46)	34.29*
Age at commencing competition (y)	12.53±3.59	12.50±3.96	12.54±3.46	0.04
Competitive level (% / n)				
- National	67.74 (63)	95.65 (22)	92.86 (41)	2.79
- International	6.45 (6)	4.35 (1)	7.14 (5)	2.79
Behavioral (lifestyle) risk factors				
Smoking history (percent/number)				
- never	64.52 (60)	60.87 (14)	65.71 (46)	4.84
- in the past	21.51 (20)	21.74 (5)	21.43 (15)	0.33
- currently	13.98 (3)	17.39 (4)	12.86 (9)	4.53
Alcohol intake (percent/number)				
- never	49.46 (46)	47.83 (11)	50.00 (35)	2.17
- up to 5 glasses/week	40.86 (38)	52.17 (12)	37.14 (26)	15.03
- 6 and more glasses/week	12.86 (9)	–	12.86 (9)	12.6
Caffeine-containing beverages intake (percent/number)				
- never	17.20 (16)	13.04 (3)	18.57 (13)	5.53
- up to1cup/day	52.69 (49)	60.87 (14)	50.00 (35)	10.87
- more than 1 cup/day	30.11 (28)	26.09 (6)	31.43 (22)	5.34
Eating pathology				
EAT score ≥ 20 (% / n)	6.45 (6)	4.35 (1)	7.14 (5)	2.79
- Dieting	8.52±3.14	8.61±3.77	8.49±2.94	0.12
- Bulimia and food preoccupation	1.04±1.84	0.74±1.14	1.14±2.02	0.40
- Oral control	2.89±2.23	2.45±2.54	3.03±2.13	0.58
Extreme weight control behaviors (% / n)				
- Self-reported binge eating	22.58 (21)	34.78 (8)	18.57 (13)	16.21
- Self-induced vomiting	6.45 (6)	13.04 (3)	4.29 (3)	8.75
- Use of laxatives	10.75 (10)	21.74 (5)	7.14 (5)	14.60
- Treatment for ED	6.45 (6)	8.70 (2)	5.71 (4)	2.99
- Extreme loss of weight	57.12 (12)	57.12 (12)	–	57.12*

Table 1 shows the characteristics and risk factors of the participants with and without a history of stress fractures. As can be seen, all of the participants of the SF group (n=23) were competitive athletes. Their percentage was significantly higher than the percentage of athletes who participated in competitions in CG (65.71%) ($p< .05$). No significant differences were found between the two

groups studied in the other parameters characterizing sports experience, anthropometric indicators, and age. Both groups didn't differ significantly in behavioral risk factors, such as smoking, alcohol intake, and the drinking of caffeine-containing beverages ($p< .05$).

On the EAT-26, most athletes studied were below the cutoff value for screening for abnormal eating attitudes. One athlete (4.35%) of the SFG and five players (7.14%) of the CG scored in the high-risk range (>20), but the difference was insignificant. The comparison between the SFG and CG did not show significant differences in the subscales of the EAT-26 – dieting, bulimia, food preoccupation, and oral control ($p< .05$). Both groups also did not differ significantly in the incidents of extreme weight control behaviors, such as binge eating, self-induced vomiting, or the use of laxatives. The individuals with a history of prior eating disorder treatment were also similar - SFG (8.7%) and CG (5.7%). However, the number of athletes who reduced their weight was significantly higher in the SFG – 57.12% (12) compared to CG (0%).

Twenty-three of the athletes (24.73%), who comprised the SF group, reported having experienced 39 SFs. Fourteen of these 23 athletes (60.87%) had one SF, and the remaining 9 (39.13%) reported two or more SFs (Table 2).

Table 2. *Characteristics of the sustained stress fractures in male athletes*

Variable	**n (%)**	**Variable**	**n (%)**
Stress fractures sustained (n=39)		Localization	
- one SF	14 (60.87)	- arm	2 (5.13)
- more than one SF	9 (39.13)	- forearm	2 (5.13)
Time of occurrence		- wrist, hand, and fingers	4 (10.26)
- during training	27 (69.2)	- spine	1 (2.56)
- during competition	3 (7.7)	- pelvis	2 (5.13)
- other times	9 (23.1)	- thigh	4 (10.26)
Participation restriction time		- calf	6 (15.38)
- up to 1 month	22 (56.4)	- ankle, foot, and fingers	24 (60.0)
- 1-6 months	17 (43.6)		

Most SFs occurred during the training process – 27 (69.2%) and only 3 (7,7%) during competition. The rest of the SFs occurred at other times and were not directly related to sports activity. The most common localization of SFs is the ankle, foot, and fingers 24 (60%), followed by the calf – 6 (15,38%), tight – 4 (10.26%), wrist, hand, and fingers – 4 (10,26%), 2 SFs (5.13%) each occurred in the arm, forearm, and pelvis, and 1 SF (2.56%) involved the spine. More than half of the SFs – 56.4% (22) took to recover for up to 1 month. For the rest of the SFs – 43.6% (17), the participation restriction time was from 1 to 6 months.
We calculated odds ratios to examine the potential association between SF and the possible predictors (Table 3). As shown in Table 3, the odds ratio for participation in competitions in athletes with SF and those without SF was 24.76 (95% CI: 1.44 - 425.38, p=.027). The odds ratio for extreme weight loss of 153.26 (95% CI: 8.48 – 2770.56, p=.0007) was also significant. For all other risk factors, the odds ratio with 95% CI spun the null value and was insignificant.

Table 3. *Odds ratios for the various risk factors for stress fractures*

Variable	Odds ratio	95 % CI:	*P*
BMI<age-matched norms	0.58	0.03 to 12.59	0.731
Participation in competitions	24.76	1.44 to 425.38	0.027*
Higher competitive level	0.59	0.07 to 5.34	0.639
Smoking history	1.23	0.47 to 3.26	0.674
Alcohol intake	1.09	0.42 to 2.80	0.856
Caffeine-containing beverages intake	1.52	0.39 to 5.89	0.544
EAT score<20	0.59	0.07 to 5.34	0.639
Self-reported binge eating	2.34	0.82 to 6.67	0.112
Self-induced vomiting	3.35	0.63 to 17.91	0.16
Use of laxatives	3.61	0.94 to 13.86	0.061
Treatment for ED	1.57	0.27 to 9.20	0.616
Extreme weight loss	153.26	8.48 to 2770.56	0.0007*

DISCUSSION

In this study, 23 of 93 male athletes, representing 24.73 %, experienced stress fractures in the past five years. This incident rate is comparable with this in females and shows that the problem with stress fractures in male athletes is underestimated. The distribution of stress fractures in this study correlates well with previous studies. The ankle, foot, and fingers were the most common stress fracture sites, followed by the calf and tibia. 69.6% of all fractures were located in the lower limb, and this result is consistent with data from other authors (Rizzone et al., 2017, Sharma & Heagerty, 2017).

All of the athletes who experienced SFs participated in competitions in the past. We identified two risk factors for the incidents of stress fractures in male athletes – participation in competitions and weight loss of more than 10 kg in the past. Our study failed to identify any differences between SFG and CG in terms of other studied risk factors related to anthropometric characteristics, sports participation, lifestyle risk factors, and eating pathology.

One possible explanation for the higher incidence of SFs in competitive athletes could be the greater workloads than those in CG. Several articles were devoted to the study of the association between sport participation patterns and injury risk in athletes, but the results are conflicting (Gabbett et al., 2014, Denay, 2017, Tiernan et al., 2020, Verstappen et al., 2021). As the main factors for injuries in athletes, a disturbed balance between training loads and the body's capacity to tolerate these loads is highlighted. The training load is a function of the training volume (intensity, frequency, and duration) and recovery. An increase in the training volume and insufficient recovery will therefore affect the risk of injuries. The athletes in both groups had similar mean training duration per week, respectively 9.90±5.58 for SFG and 8.63±4.66 for CG. However, this study does not provide information on the training intensity of the athletes. Along with higher physiological demands, competitive sport is accompanied by increased psychological stress, which also plays a pivotal role in the increased risk of injuries (Pedersen et al., 2016, Jia-Sheng, & Kok-Yong, 2021).

The global EAT score of £ 20 identified individuals at risk of an eating disorder (Garner et al., 1982). The differences in this score between both groups were insignificant, as were the differences in its subscales. Although the percentage of athletes from the SF group practicing different purging behaviors, such as self-induced vomiting, and use of laxatives and diet pills, was higher than those from the HP group, no significant differences were found. However, 57,12% of the participants in the SF group engaged in pathogenic weight loss methods, and no athlete in the control group reported extreme weight loss in the previous five years. The calculated odds ratios confirm the association between weight loss and SF risk. The weight loss rises by 153.26 times (95% CI: 8.48 to 2770.56) the risk of having SF ($p = 0.0007$).

One of the explanations for this result is that the reduction of the lean and fat mass associated with

insufficient nutrition contributes to impaired the bone metabolism (Misra & Klibanski, 2014). Dietary restraint can also depress immune function and is associated with micronutrients and vitamin deficiencies that may affect bone mineral density and elevate the risk of SF (Ghoch et al., 2013). In addition to the deficit of Vitamin D and calcium, minerals and trace elements such as zinc and magnesium also are required for normal bone metabolism (Moran et al., 2012).

This study has several limitations. The retrospective pattern of the study may be a source of erroneous findings. Furthermore, the use of self-reported questionnaires to assess behavioral and dietary risk factors always carries risks. Although EAT-26 is a widely used self-report measure for symptoms and behaviors associated with eating disorders and is recommended for use in both clinical and non-clinical settings. We also did not have information about the intensity of the athletes' physical exertion and their psychological characteristics. Finally, the questionnaire did not examine the energy and nutrient intake of the athletes to detect possible nutritional deficiencies.

CONCLUSION

These results from this study suggest that male athletes are at increased risk for stress fractures, as are females, and this is an underrecognized problem. Engagement in competitive sports of male athletes, which is associated with higher training volume and extreme weight loss practices, should be considered as a factor for increased risk of SF in male athletes. Further analysis of the training practices and dietary analysis could provide more information on risk factors for stress fractures in male athletes and contribute to the implementation of prevention strategies.

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Corresponding author:

Prof. Diana Dimitrova, MD, PhD

Department of Sports Medicine,

National Sports Academy "Vassil Levski"

Sofia, Bulgaria

e-mail: diana.dimitrova@nsa.bg

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