ORIGINAL ARTICLE

Nr 2023;13 (3):430-435

Epidemiological Study of Foot and Ankle Injuries in Athletes: A Multivariate Logistic Regression Analysis

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DOI:
10.32098/mltj.03.2023.11

LEVEL OF EVIDENCE: 4

SUMMARY

Introduction. Understanding the epidemiological profile of foot and ankle's injuries in athletes is relevant for the prevention and treatment its occurrence.

Objective. To describe the epidemiology and risk factors of foot and ankle injuries in athletes treated at an outpatient sports medicine clinic. The primary hypothesis is that ankle instability is the most frequent injury in athletes in the foot and ankle specialty outpatient clinic.

Methods. Observational, retrospective, descriptive study with patients treated at an outpatient sports medicine clinic, between 2015 and 2020. We performed a multivariate logistic regression analysis to verify the association of gender, age and laterality with the main injuries documented.

Results. 763 patients (387 men/376 women) met the inclusion criteria. The mean age was 35 years, the most prevalent diseases were chronic lateral ankle instability (n = 134, 17.6%), acute lateral ankle sprain (n = 120, 15.7%) and plantar fasciitis (n = 69, 9%). The multivariable analysis by logistic regression identified female gender and age group young adults as a risk factor for lateral ankle instability. In acute lateral ankle sprain, age was identified as a risk factor with statistical significance. In overuse injuries, only the female gender was evidenced as a risk factor.

Conclusions. Our work correlated several factors such as age, gender and laterality with specific sports through multivariate analysis, adding epidemiological data to the literature.

Study registration. The study was registered in Plataforma Brasil under the number 5.037.010.

KEY WORDS

Epidemiology; athletes; foot; ankle; injury.

INTRODUCTION

All recreational and competitive sports activities carry an inherent risk of injuries (1, 2). However, one of the goals of sports medicine is to reduce health risks associated with athletic participation by recognizing and controlling risk factors. Through epidemiological studies, it is possible to identify and quantify risks, along with the incidence and prevalence of injuries in a specific set of conditions (1-8). The classification into intrinsic and extrinsic risk factors can be approached based on the stress/capacity model, which has been used in its classical form in the field of social and preventive medicine to describe the interaction between humans and their environment (3, 9). It can also be applied in sports medicine, especially in injury prevention. In this

model, stress is determined by the athlete's environment (external factors), such as training techniques and playing environment (10, 11), and the athlete's capacity is determined by internal and personal factors, such as skill level, age, and gender (12-15). Preventive measures should therefore be designed to achieve or maintain this balance, either by increasing capacity or reducing stress, or both (16-19). To the best of our knowledge, there is a lack of studies reporting the epidemiological profile of athletes with foot and ankle disorders considering different sports. The aim of this study is to describe the epidemiology of foot and ankle injuries in athletes treated at a specialized outpatient clinic for sports-related injuries. The main hypothesis is that chronic ankle instability (CAI) is the most common injury among athletes in the specialized foot and ankle clinic.

METHODS

Protocol

This is an observational, retrospective, and descriptive level IV evidence study authorized and approved by the Research Ethics Committee of UNIFESP (Protocol number: 5.037.010 - Date of approval: October 14, 2021). The aim of the study was to describe the epidemiology of foot and ankle injuries in athletes treated at a specialized clinic for sports injuries, located in São Paulo, Brazil, between January 1, 2015, and December 31, 2020. The manuscript is organized according to the STROBE guidelines (20).

Eligibility criteria

The study sample consisted of patients treated at a specialized clinic for foot and ankle injuries in sports over a five-year period. This clinic, located in São Paulo, offers multidisciplinary care including physiotherapy, physiology, sports medicine, and orthopedics. Three certified orthopedists reviewed the medical records and documented patients' demographic information, sport, diagnosis, and injury side. The inclusion criteria were patients engaged in amateur or professional sports of all age groups. Only the first consultations and the patient's main sport and diagnosis were counted. The exclusion criteria were insufficient documented data in the medical records, injuries not occurring as a result of sports participation, and patients with conditions unrelated to the foot and ankle. Age was analyzed according to the following age groups: children (< 12 years), adolescents (≥ 12 and < 20 years), young adults (≥ 20 and < 40 years), adults (≥ 40 and < 60 years), and elderly (≥ 60 years). The diagnosed injuries were categorized as follows: chronic ankle instability (CAI), ankle sprain (AS), fractures, plantar fasciitis (PF), insertional or non-insertional Achilles tendonitis, and those due to overuse were defined as injuries without acute trauma, secondary to repetitive loading, such as stress fractures or posteromedial tibial syndrome.

Outcome evaluation

We evaluated patients' demographic information, sport practiced (soccer, amateur runner, fighters, dancers, basketball, volleyball, and athletics, being the most prevalent), diagnosis, and injury side. Injuries were classified according to the sports modality and patients' age group. Overuse injuries were identified and analyzed separately as explained in the eligibility criteria.

Statistical analysis

The data were analyzed using SPSS V20, Minitab 16, and Excel Office 2010 software. A multivariate logistic regression analysis was performed to assess the association of gender, age, and laterality with the main documented injuries. The quality and fit of the multivariate logistic regression analysis were tested using the Nagelkerke R2 test and the Hosmer-Lemeshow test. The statistical analyses were conducted with the aim of identifying risk factors for foot and ankle injuries in athletes treated at the specialized sports injury clinic.

RESULTS

Patient recruitment

A total of 872 medical records were analyzed, and 763 patients (387 males and 376 females) met the inclusion criteria. These patients were treated at this specific outpatient clinic, which serves patients from across the national territory, regardless of the region, although the majority of these athletes come from the city of São Paulo.

Summary of results

The mean age was 35 years (SD ± 14.1; minimum 8.9; maximum 77). The most prevalent age group was young adults, accounting for 51.7%, while the least prevalent group was children, at 1.4%. The most prevalent conditions were CAI (n = 134, 17.6%), acute lateral ankle sprain (AS) (n = 120, 15.7%), and plantar fasciitis (PF) (n = 69, 9%) (**table I**). The pattern of injuries in soccer players was, in order of frequency, AS, CAI, and traumatic injuries such as ankle or metatarsal fractures. On the other hand, the pattern of injuries in amateur runners was PF, overuse injuries, and non-insertional Achilles tendon tendinopathy (**table I**). **Table I** is divided according to sports practice and indexed injuries, presenting data on the most prevalent sports modalities in our setting.

Table I. Distribution of main diseases by sport.

Sport	n	%	CLAI	AS	PF	Overuse injuries	Fractures	Noninsercional tendinopathy	Insertional tendinopathy
Football	174	22.8	44	38	5	6	14	7	6
Amateur running	168	22.0	14	14	32	22	-	-	16
Fights	72	9.4	9	9	8	-	8	5	6
Dance	57	7.5	16	4	-	4	5	-	-
Basketball	48	6.3	10	17	3	3	2	-	-
Voleyball	45	5.9	9	6	3	8	-	-	2
Atletism	34	4.5	7	3	2	7	-	-	3

Multivariate logistic regression analysis

The multivariate analysis by logistic regression identified the young adult age group as a risk factor for CAI (OR 0.96, 95%CI 0.95-0.98, p < 0.05), as well as female gender (OR male/female 0.58, 95%CI 0.39-0.86, p < 0.05). In the case of AS, the young adult age group was identified as a risk factor (OR 0.97, 95%CI

Table II. Multivariate logistic regression analysis with the main injuries documented.

	Odds Ratio			P-value
	OR	Inferior limit	Superior limit	
CAI				
Age	0.96	0.95	0.98	< 0.001
Gender male/female	0.58	0.39	0.86	0.007
Laterality: Right/Left	1.13	0.75	1.72	0.556
AS				
Age	0.97	0.95	0.98	< 0.001
Gender Male/Female	1.49	0.99	2.25	0.058
Lateralidade: D/E	1.20	0.80	1.81	0.381
Overuse Injury				
Age	1.00	1.00	1.00	0.866
Gender Male/Female	0.43	0.25	0.73	0.002
Laterality: Right/Left	0.88	0.50	1.54	0.655
Non-insertional Achilles Tendinopathy				
Age	1.00	1.00	1.00	0.872
Gender Male/Female	1.85	0.98	3.49	0.059
Laterality: Right/Left	1.17	0.55	2.48	0.678
Laterality: Bilateral/Left	3.28	1.46	7.35	0.004
Insertional Achilles Tendinopathy				
Age	1.00	1.00	1.00	0.887
Gender Male/Female	4.86	2.22	10.63	< 0.001
Laterality: Right/Left	0.59	0.29	1.20	0.144
Acute Achilles Tendon Rupture				
Age	1.00	1.00	1.00	0.842
Gender Male/Female	2.60	1.13	5.96	0.024
Laterality: Right/Left	1.29	0.60	2.78	0.518

0.95-0.98, $p < 0.05$). In overuse injuries, only female gender was identified as a risk factor (OR male/female 0.43, 95%CI 0.25-0.73, $p < 0.05$). In non-insertional Achilles tendon tendinopathy, bilaterality was commonly found as a factor (OR bilateral/left 3.28, 95%CI 1.46-7.35, $p < 0.05$), while in insertional Achilles tendon tendinopathy, only male gender was identified as a risk factor (OR male/female 4.95, 95%CI 2.22-10.63, $p < 0.05$), as well as in Achilles tendon rupture (OR male/female 2.60, 95%CI 1.13-5.96, $p < 0.05$) (**table II**).

DISCUSSION

Presentation of results

In this study, we described the epidemiology of foot and ankle injuries in athletes treated at a specialized outpatient clinic for sports-related injuries. Each injury was correlated with intrinsic factors using multivariate logistic regression to identify the associated factors. The most prevalent age group with foot and ankle injuries related to sports was young adults (51.7%).

Discussion of results

A significant portion of the literature focuses on research by age groups, such as children, adolescents, and adults (21-24), as well as by sports disciplines. The most prevalent conditions in young adults were chronic ankle instability (CAI) and ankle sprain (AS), while plantar fasciitis (PF) was the most prevalent condition in adult males and females. AS and bruises around the foot and ankle are related as the most common injury in athletes (22-26), and CAI secondary to AS is often reported (27). In the case of AS, only the young adult age group was identified as a risk factor. The disparity in the prevalence of ankle sprains between genders appears to be small in the current literature (28), which is consistent with our data. Regarding limb dominance, the results were contrasting, with some studies showing no difference in the incidence of ankle sprains between dominant and non-dominant ankles, while others observed that the dominant leg suffered significantly more ankle injuries in male soccer players. In patients with CAI, the young adult age group and female sex were identified as risk factors.

Discussion of results from similar studies in the literature

Hosea *et al.* (29) conducted a comprehensive prospective study in high school and college basketball players, and female athletes had a 25% increased risk of suffering a grade I ankle sprain compared to male athletes; however, the relative risk between genders for more severe grade II and III sprains, ankle fractures, and syndesmotic sprains was not significantly different. Regarding limb dominance, Surve *et al.* (30) found that soccer athletes reported no difference in the incidence of ankle sprains between dominant and non-dominant ankles. In contrast, Ekstrand and Gillquist (31) observed that the dominant leg suffered significantly more ankle injuries in male soccer players, with 92% of ankle injuries affecting the dominant leg. These contrasting findings may have resulted from different study designs or methods used for data analysis. In patients with CAI, the young adult age group and female sex were identified as risk factors. Lin *et al.* (32) found that female athletes had a higher prevalence of CAI than men at the university level. This is consistent with previous work by Tanen *et al.* (33). The factors causing differences in ankle instability rates between genders may include different anatomical structures, joint laxity, and menstrual cycles (34, 35). Female sex has been most frequently associated with an increased incidence of overuse injuries (36). In particular, female long-distance runners appear to have the highest risk for sustaining stress fractures (37, 38) Although long-distance running itself can predispose runners to stress fractures, it appears that the associated nutritional and menstrual irregularities seen with increased frequency (39).

Limitations

This is a retrospective and descriptive study where the collected data were recorded prior to analysis, without interventions or prospective follow-up, limiting the ability to establish causal relationships between the analyzed facts and injuries. Additionally, foot and ankle injuries related to sports, age, and sex were listed without considering other factors that could be related to the described injuries, such as athlete biomechanics or other musculoskeletal injuries. The data were obtained from patient records, which may be subject to typing errors or lack of detailed information, affecting the precision and reliability of the results.

Future perspectives

We can identify other risk factors beyond those mentioned in this study, such as athlete biomechanics and previous injury history. These new studies could contribute to a more comprehensive understanding of foot and ankle injuries in athletes. Furthermore, the evaluation of specific preventive measures for each identified type of injury is highlighted as an important perspective. Based on the collected data, targeted preventive interventions could be developed and tested, such as specific training programs and strengthening measures. Future studies could assess the effectiveness of these interventions in reducing the incidence of foot and ankle injuries in athletes. Another relevant perspective is the analysis of other types of injuries in different body regions. Although the study focused on foot and ankle-related injuries, future research can investigate other regions and their

respective injuries in athletes, providing a broader view of the epidemiology of sports injuries.

Contributions to current practice

The study provides valuable information about the most common foot and ankle injuries in athletes, as well as the associated risk factors. This enables healthcare professionals to develop targeted prevention strategies, such as specific training programs and strengthening measures, with the aim of reducing the incidence of these injuries. The importance of a multidisciplinary approach to the treatment and prevention of foot and ankle injuries in athletes is also emphasized. The collaboration between physiotherapists, physiologists, and sports physicians, as seen in the mentioned specialized clinic, allows for comprehensive and holistic treatment, aiming to prevent future injuries and promote proper athlete recovery. Furthermore, the study provides a solid foundation of epidemiological data that can be used to support clinical practice. Healthcare professionals can utilize this information when evaluating athletes, identifying risk factors, and making informed decisions regarding the treatment and prevention of foot and ankle injuries. Although the data were obtained from a specific outpatient clinic, the results can be generalized to other sports and clinical contexts. The epidemiological data obtained in this study can be extrapolated and applied in different services, contributing to the improvement of sports practice as a whole. This means that other clinics and healthcare professionals can benefit from these results when developing prevention and treatment strategies for foot and ankle injuries.

CONCLUSIONS

The literature specifically describing foot and ankle injuries during sport is limited, despite being highly prevalent injuries. Our work correlated several factors such as age, gender and laterality with specific injuries in sports through multivariate analysis, adding epidemiological data to the literature that help in the prevention and treatment of foot and ankle injuries in sports.

FUNDINGS

None.

DATA AVAILABILITY

Our data are based on information acquired from the medical records of patients who were treated at the Foot and Ankle Ambulatory of the Sports Traumatology Center of the Paulista School of Medicine

CONTRIBUTIONS

LPBC: data collection, writing – original draft. FGC: data collection. HCMC: data collection and corrections. ESM, AVKCL, CASN: writing – review & editing. NSBM: conceptualization, design.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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