

Risk factors for ankle sprains in children and adolescent athletes: an integrative review

Fatores de risco nas entorses de tornozelo em crianças e adolescente atletas: uma revisão integrativa

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ABSTRACT

Introduction: Ankle sprains are the most common lower limb injuries in children and teen athletes. Identifying risk factors related to sports helps elaborate strategies to prevent these injuries. **Objectives:** Review the literature's available data about risk factors related to the incidence of ankle sprains in children and teens who practice sports. **Methods:** It's an integrative literature review made in the portals SciELO, PubMed, and BVS. Were included articles published between 2015 and 2021, obtained by the combination of the descriptors: sprains, ankle, child, adolescent, sports, and risk factors, that answered the question: "Which are the risk factors for ankle sprains in children and teens who practice sports?". **Results:** Nine studies were selected to review. The risk factors associated with a greater chance of ankle sprains were: previous ankle sprain history, balance deficit, decrease in hip extension strength, higher one-repetition maximum at the leg press, higher quadriceps isokinetic strength, the difference between the legs related to hip abduction strength, feminine sex, high BMI, higher age, more than six years of playtime, the incidence in basketball is higher than in soccer, anatomical alterations like genu recurvatum, and navicular drop. **Conclusion:** The variety of outlines in the studies, samples, and sports addressed in the reviewed literature resulted in the identification of several risk factors related to ankle sprains in children and teen athletes.

Keywords: Sprains; Ankle; Children; Adolescent; Sports; Risk Factors.

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RESUMO

Introdução: As entorses de tornozelo são as lesões em membros inferiores mais frequentes em crianças e adolescentes atletas. Identificar os fatores de risco envolvidos nas práticas esportivas auxilia o planejamento de estratégias preventivas dessas lesões. **Objetivos:** Revisar os dados disponíveis na literatura sobre os fatores de risco relacionados à ocorrência de entorse de tornozelo em crianças e adolescentes praticantes de esportes. **Métodos:** Trata-se de uma revisão integrativa da literatura realizada nos portais SciELO, PubMed e BVS. Foram incluídos trabalhos publicados entre 2015 e 2021, obtidos pelas combinações dos descritores “entorse”, “tornozelo”, “criança”, “adolescente”, “esportes” e “fatores de risco”, que respondiam a questão de pesquisa: “Quais os fatores de risco para entorses de tornozelo em crianças e adolescentes praticantes de esportes?”. **Resultados:** Nove estudos foram selecionados para revisão. Os fatores de risco associados a maior chance de ocorrência de entorse de tornozelo foram a história de entorse de tornozelo prévia, equilíbrio deficiente, déficit na força de extensão do quadril, maior repetição máxima no *leg press*, maior força isocinética do quadríceps, diferença entre as pernas em relação à força de abdução de quadril, sexo feminino, alto IMC, maior idade, tempo de prática maior que seis anos, jogo de basquete em relação ao jogo de futebol, alterações anatômicas como joelho recurvado e aumento da queda do navicular. **Conclusão:** A variedade de delineamentos de estudos, amostras e esportes abordados na literatura revisada resultou na identificação de diversos fatores de risco associados a entorses de tornozelo em crianças e adolescentes atletas. **Palavras-chave:** Entorses; Tornozelo; Crianças; Adolescentes; Esportes; Fatores de Risco.

INTRODUCTION

The incidence of ankle injuries in young athletes is high, especially sprains^{1,2}. Between athletes of 14 to 17 years old, the ankle sprains correspond to 92.2% of all ankle injuries³. The sports with the higher rates of ankle sprains in US high school athletes are women's basketball, men's basketball, and women's gymnastics⁴.

The most common ankle sprains is lateral, which frequently occurs by the mechanism of inversion and plantar flexion of the foot, in high velocity and higher intensity than usual, resulting in anterior talofibular and calcaneofibular ligaments injuries^{5,6}. Ankle sprains have relevant consequences for athletes, such as time lost in sport and, in the long-term, chronic ankle instability^{4,7}. In this scenario, identifying the intrinsic and extrinsic risk factors for the occurrence of ankle sprains in children and adolescents whom practice sports is a powerful tool to prevent such injuries⁸.

Among the potential risk factors for ankle sprains found in the literature are: sports type, the role of the athlete, training regime, previous anterior ankle sprain historic, sex, age, high body mass index (BMI), sleep quality, anatomy, biomechanics, flexibility, postural stability, agility, strength, and proprioception deficit⁹⁻¹¹.

The risk factors for ankle sprains in athletes are well investigated. However, little was discussed about risk factors for children and adolescent athletes. In this sense, this study aims to review the data available in the literature on risk factors related to the occurrence of ankle sprains in children and adolescents whom practice sports.

METHODS

The elaboration of this review followed the steps of an integrative review, with the definition of the theme and the goals, selection of keywords and their use for literature search, selection of the inclusion and exclusion factors, selection of the studies by the application of these factors, data collection, data analysis, and its descriptive display^{12,13}.

The literature search was guided by the following question: “Which are the risk factors for ankle sprains in children and adolescents athletes?”. The question was elaborated based on the PICO strategy¹⁴. The descriptors used were: *entorses* (sprains, *esquinces*), *tornozelo* (ankle, *tobillo*), *criança* (child, *niño*), *adolescente* (adolescent, *adolescente*), *esportes* (sports, *deportes*), *fatores de risco* (risk factors, *factores de riesgo*). The logical operators “AND” and “OR” were used in the literature search.

The inclusion factors were articles that have been published between 2015 and 2021 May in the platforms SciELO, PubMed, and BVS; primary and secondary studies; in Portuguese, English, and Spanish; that had an average age lower than 19 years old; and displayed in its results evidence for risk factors for ankle sprains in children and adolescents athletes.

The studies were excluded when their goal was to study chronic ankle instability, not display the ankle sprains as the most related injury, and the objective was not the study of risk factors.

The search was made in 2021 May and resulted in 1,151 articles. After the duplication removal, 474 were left and organized with reference management software. A selection was performed by reading the articles' abstracts based on the exclusion and inclusion criteria. Twenty-nine publications were chosen for full reading and, of these, nine met all defined standards. The search strategies are displayed in Figure 1 as recommended by PRISMA declaration¹⁵.

A validated tool was used for data extraction in the selected articles¹⁶. To reduce the interpretation bias possibility, two respondents analyzed the articles independently, selecting them based on the inclusion and exclusion criteria.

Subsequently, the selection result of each researcher was compared. Selection differences were resolved through discussion between the two researchers and a third researcher. The articles were ranked according to scientific evidence level conforming to the Agency for Healthcare Research and Quality (AHRQ).

RESULTS

Among the nine selected articles, two were published in 2015, two in 2016, two in 2017, one in 2018, one in 2020 and one in 2021. Regarding origin of the publications, 66.7% (n=6) were performed in the United States of America, 11.1% (n=1) in Brazil, 11.1% (n=1) in Finland and 11.1% (n=1) in Iran. Regarding the type of study, there was a predominance of observational studies, with 44.4% (n=4) cohort studies, 11.1% (n=1) case-control, 22.2% (n=2) cross-sectional, 11.1% (n=1) systematic review and 11.1% (n=1) non-systematic review.

The selected studies analyzed the relationship between different variables and the incidence of ankle sprains in athletes younger than 19 years. The history of a previous ankle injury was presented as a risk factor in two articles, as well as poor performance in balance tests.

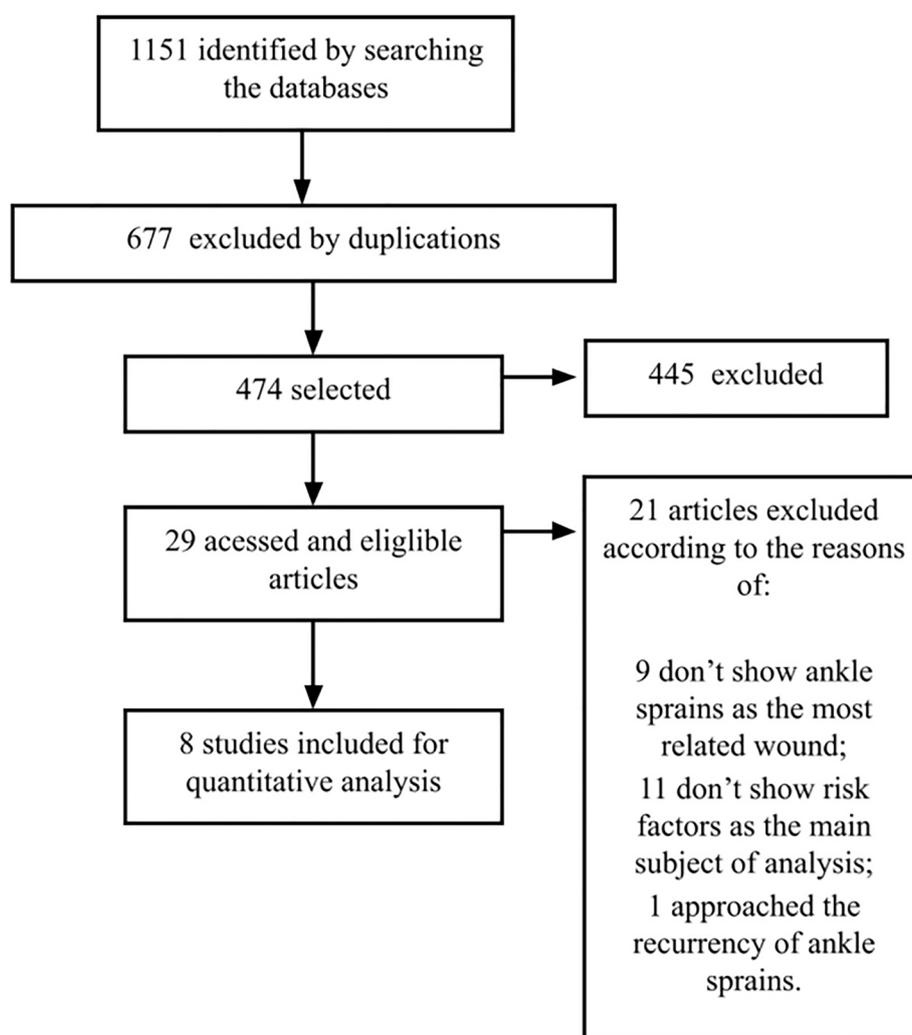


Figure 1. Flowchart, according to PRISMA, for studies selection, Alfenas, MG, Brazil, 2022.

The other risk factors described below were cited only once among the articles reviewed. Concerning anatomical aspects, athletes with *genu recurvatum* and navicular drop were at higher risk for ankle sprains. Elevated BMI was observed as a risk factor for American football athletes. Regarding soccer, the greater risk was observed for practitioners who use cleats, play on grass, and in defensive positions. On the subject of age, it was evidenced that the group of older athletes (16 to 18 years old) was more affected than the group of younger athletes (11 to 15 years old). In addition, more than six years of handball practice was associated with a higher risk of injury compared to three or fewer years of practice.

Regarding gender, it was observed in one of the publications that young female athletes have a broader range of motion in the ankle joint, a vast history of sprains, and three times more risk of suffering them than male athletes of the same age.

Regarding strength, the highest one-repetition maximum (1RM) in the leg press was observed as a risk factor in both sexes. In men, greater maximum isokinetic quadriceps strength was associated with a higher incidence of injuries. In women, this association was observed with the difference in hip abduction strength between the legs. About hip extension, smaller ones were identified as a risk factor for male outdoor soccer players.

The principal information from the studies selected for analysis in this integrative review is summarized in Table 1.

Table 1. Scientific production regarding authors, study design, level of evidence, sample characteristics, studied sport and main results, according to studies included in the integrative review, Alfenas, MG, Brazil, 2022.

Authors	Study design	Evidence level	Sample	Sport	Risk factor
De Ridder et al. (2016) ³⁴	Prospective cohort	4	N=133; Men aged 10-16	Soccer	Hip extension strength decrease.
Gribble et al. (2016) ¹⁸	Prospective cohort	4	N=539; Men and women aged 17.33 +/- 2.28	Football	Low score SEBT; High BMI.
Hietamo et al. (2021) ²	Prospective cohort	4	N=362; Men aged 16.0 +/- 1.6 and women aged 15.4 +/- 2.0	Basketball and Floorball	Men: greater 1 RM in the leg press and maximum quadriceps isokinetic strength. Women: greater 1 RM in the leg press and difference between the abduction strength of hip between legs.
O'Kane et al. (2016) ³⁸	Nested case control	4	N =351; Women aged 11-15	Soccer	Training: use of cleat boots, play on grass surface. Playing: defensive positions.
Onate et al. (2016) ²⁵	Systematic review	1	N=759; Men and women aged 13-19	Several	Poor balance.
Owoeye et al. (2018) ¹⁷	Non-systematic review	4	N=2,265; Men and women aged 14.95 +/- 1.45	Basketball and Soccer	Older age (16-18 vs. 11-15 years old); Basketball compared to soccer; previous ankle sprains or lower limb injuries.
Saki et al. (2021) ⁸	Prospective cohort	4	N=152; Men aged 14.45 +/- 2.96	Soccer, Volleyball, Basketball and Handball	Previous ankle sprain, <i>genu recurvatum</i> and increased navicular drop.
Sugimoto et al. (2017) ⁹	Transversal	6	N=452; Women aged 13.6 +/- 2.3; Men aged 13.3 +/- 2.5;	Several	Women.
Higashi et al. (2015) ²⁸	Transversal	6	N=220; Women aged 14.7 +/- 1.53	Handball	Playtime greater than 6 years.

SEBT: Star Excursion Balance Test; BMI: Body mass index; 1RM: One-repetition maximum.

DISCUSSION

Among the risk factors for ankle sprains in children and adolescent athletes, the previous history of ankle sprain was identified in the studies by Owwoye et al. (2018)¹⁷ and Saki et al. (2021)⁸. In contrast, Gribble et al. (2016)¹⁸ did not find a statistically significant association between a previous history of ankle sprains and the occurrence of a new ankle sprain in football competitions. The discussion for this question suggests that the definition of the previous history of an ankle sprain may be influenced by the time of exposure to games, which is probably low in the group of children and adolescents analyzed by Gribble et al. (2016)¹⁸. Several studies in the literature address previous ankle sprain as a predictor of a new sprain in athletes^{11,19-23}. This relationship is supported by the restoration of joint health. An ankle sprain involves the tearing or stretching of the stabilizing ligaments in the ankle joint. Faced with an inadequate wound healing process, the ligaments may not recover their anatomy and functional capacity. Mechanical stability related to healing may not occur for up to six weeks to three months. Returning to activities before this period can lead to sprain recurrence^{11,24}.

In the literature, there is no consensus on the relationship between balance and the incidence of ankle sprains. For example, for McHugh et al. (2006)²² balance was not a significant risk factor for ankle sprains in high school athletes. However, among the reviewed studies, Gribble et al. (2016)¹⁸ and Onate et al. (2016)²⁵ were associated with a balance deficit with a higher risk of an ankle sprain. According to Gribble et al. (2016)¹⁸, athletes who suffered ankle sprains obtained a lower score on the balance test Star Excursion Balance Test (SEBT) in anterior reach than non-injured athletes. The SEBT is a widely used test for balance assessment, which consists of a sequence of movements in eight directions with one of the lower limbs while balancing on the contralateral limb²⁶. Onate et al. (2016)²⁵, as in the aforementioned study, reported the relationship between poor performance on the SEBT and increased risk of ankle sprains. Furthermore, he also mentioned that higher levels of postural sway are associated with higher incidences of ankle sprains. However, they described that poor performance in the frontal plane excursion test from an elevated platform cannot be used as a predictor for ankle sprains. Thus, it is evident that the methodology used in the balance tests can have an importance in the variation of the results. According to Rivera et al. (2017)²⁷, proprioception training programs were effective in reducing the incidence of ankle sprains, providing further evidence that contributes to the relationship between balance and ankle sprains.

Regarding the association between BMI and increased risk of ankle sprain, only the study by Gribble et al. (2016)¹⁸ showed this association among football players. In contrast, studies by Owwoye et al. (2018)¹⁷ and Higashi et al. (2015)²⁸ do not show that BMI is a risk factor for ankle sprain.

Owwoye et al. (2018)¹⁷ argue that this relationship may be specific to the sport, being that a high BMI is not a risk factor for ankle sprains in field soccer and basketball players, according to their findings.

Previous studies demonstrate the increased risk of the occurrence of ankle sprains in children and adolescent athletes with a high BMI^{22,23}. In the study by Tyler et al. (2006)²³, the incidence of ankle sprains increased about four times in overweight athletes. High body mass indexes may be associated with physical inactivity and lack of activities that promote weight support. In addition, in heavier players, the force applied to the ankle ligaments in the support phase is greater. Thus, there is a greater moment of inertia around the ankle axis, which promotes lesions in the ankle¹⁰.

According to Saki et al. (2020)⁸, the anatomical aspects related to a higher incidence of ankle sprains were the recurvated knee and accentuated navicular drop. The recurvated knee or *genu recurvatum* is a hyperextension that exceeds the normal knee extension by 5 degrees, the angle of knee extension can be measured with a goniometer exactly in the sagittal plane between the femur and the tibia^{29,30}. According to Yazdani et al. (2020)³¹, deformities in the lower limb, specifically the recurvated knee, deviate the axis of the lower limb, generating deficits in proprioception, balance and, thus, increasing the risk of lower limb injuries. Navicular fall, on the other hand, is the vertical displacement of the navicular when a load is applied under the subtalar joint. Displacement of the navicular makes it possible to assess subtalar pronation³². The drop of the navicular can be measured with a ruler by comparing the height of the navicular with the individual sitting, without load, with the height of the navicular with the individual standing, with a load³⁰. Increased navicular fall is considered in the literature as a risk factor for lower limb injuries, but there are few studies directly correlating navicular fall with the incidence of ankle sprains. On the other hand, there is evidence that a decrease in navicular fall may be a protective factor against foot injuries for running athletes³³.

Two reviewed papers, Hietamo et al. (2021)² and De Ridder et al. (2016)³⁴, analyzed the relationship between muscle strength and ankle injuries, especially ankle sprains. While Hietamo et al. (2021)² found an association between greater muscle strength in the lower limbs and the occurrence of ankle injuries, De Ridder et al. (2016)³⁴ associated greater risk of ankle sprain with decreased strength of the extensor muscles of the hip.

The association described by De Ridder et al. (2016)³⁴ can be justified by the important contribution that the hip extensor muscles have in decelerating the center of body mass and in postural control. Inappropriate foot positions can be corrected by the joint action of the hip and foot muscles. Athletes who have less hip muscle strength tend to be less able to cushion the impact of a high-speed maneuver and maintain balance. Thus, the stabilizing elements of the ankle joint, such as the ligaments, are subjected to greater load and are more susceptible to injury³⁵.

Other studies associate the occurrence of ankle sprains and decreased hip abductor strength, although Hietamo et al. (2021)² and De Ridder et al. (2016)³⁴ have not found this association among young male athletes^{36,37}.

Although Hietamo et al. (2021)² established the hypothesis that lower muscle strength in lower limbs would be associated with a higher risk of injury, their findings demonstrated the opposite. Possibly, young athletes with greater muscle strength have greater chances of ligament injury by submitting their joints to greater mechanical forces, as they run and change position quickly¹⁰.

O'Kane et al. (2016)³⁸, in their study, mentions aspects of soccer that can be risk factors for ankle sprains. The use of boots with cleats was one of the identified risk factors. The direct proportion between the size of the cleats and the risk of injury was also identified, as it is assumed that the friction generated between the cleats and the grass can generate an overload on the ankle joint. Playing on natural or artificial grass also appears as a risk factor, as most injured players played on grass and with spiked boots. It was also observed that players from defensive positions are more prone to ankle sprains, an event whose most likely cause is the greater number of contact plays required by the defensive position. Similar findings were found by Junge e Dvorak (2013)³⁹ in adult professional athletes, in which 80% of injuries were caused by contacts between players, and the most injured body part was the ankle.

Range of motion (ROM) is the angle of the total displacement of a joint, the most common method of measuring it is with a goniometer⁴⁰. Increased ROM in dorsiflexion, plantar flexion, foot inversion, and eversion movements have been generally reported in the literature as one of the predictors for ankle sprains, but there are studies where this finding is not observed, as can be seen in Kobayashi's meta-analysis⁴¹. Sugimoto et al. (2017)⁹ reported that women have a greater range of motion, in plantar flexion and inversion, than men, but ROM was not identified as a risk factor for ankle sprains in young athletes. In the study by Saki et al. (2021)⁸ increased ROM was identified as a potential risk factor for ankle sprain, but it was not identified as a significant risk factor.

Although De Ridder et al. (2016)³⁴ did not identify an association between age and the occurrence of ankle sprains in their studied populations, it was reported a higher incidence of ankle sprains in older athletes. On the other hand, Owoeye et al. (2018)¹⁷ identifies, through univariate regression, the variable age as a predictor of ankle sprain, with basketball and soccer players aged 16 to 18 years being more likely than with 11 to 15 years of suffering an ankle sprain. A longer time of sports practice is investigated in the study by Higashi et al. (2015)²⁸, in which a statistically significant association was demonstrated between experience with handball over six years and musculoskeletal injuries, especially sprains located in the ankle. Possibly the characteristics of older players with more experience in sports, such as greater competitiveness and willingness to take risks, influence a higher rate of ankle sprains.

In addition, more experienced athletes are involved in more games and tend to have more injuries⁴².

Sugimoto et al. (2017)⁹ identified a greater chance of female athletes, compared to male ones, to present a history of an ankle sprain. Owoeye et al. (2018)¹⁷ also investigate sex as a risk factor but does not identify this association between children and adolescents who practice soccer and basketball. The investigation in the literature about the incidence of ankle sprains related to sex demonstrates a higher rate in female athletes^{4,43}. In the epidemiological study by Swenson et al. (2013)⁴, girls were more likely than boys to suffer an ankle sprain in football, baseball, and athletics.

In general, the studies showed methodological heterogeneity, which may have contributed to the varied results. Variations between studies regarding definitions of a number of participants, gender, mean age, length of follow-up in prospective cohort studies, the concept of reportable injury, mode of data collection (measurement or self-report), and sports practice determined the various risks factors gathered in this review. The type of sport practiced by children and adolescent athletes was one of the main elements that explain this diversity. Each sport has particularities in its practice and injury mechanisms. Women's and men's basketball, which among other sports present the greatest risk for ankle sprains, have contact with the player as the main injury mechanism. On the other hand, women's gymnastics presents a higher proportion of cases of ankle sprains due to contact with the surface^{4,44}. Further reviews could limit the analysis of risk factors for ankle sprains among children and adolescents who practice a specific sport, in order to synthesize the conditions that can be focuses for preventing this type of injury in sports practices.

CONCLUSION

Determining risk factors for injuries is fundamental to understanding the conditions that generate the mechanics that cause injuries and, therefore, promoting preventive measures to avoid or control them. In the present study, from the integrative literature review, the following risk factors for ankle sprains in children and adolescent athletes were observed: muscle strength, such as deficit in hip extension strength, higher maximum repetition in the leg press, higher strength quadriceps isokinetic, and the difference between legs about hip abduction strength; poor balance; previous ankle sprain; women; high BMI; older age; practice time greater than 6 years; basketball game compared football game; anatomical changes such as bent knee and increased navicular drop.

However, the scarcity of studies on risk factors for ankle sprains in child and adolescent athletes was evident, especially studies that specifically addressed ankle sprains. Therefore, the need for more studies on the subject is identified to promote greater results in the findings.

AUTHOR'S CONTRIBUTION

The authors' contributions are structured in according to the taxonomy (CRediT) described below: Conceptualization, Data curation, Formal analysis, Research, Methodology, Resources, Visualization, Writing - original draft: Victor Hugo Morais Ruela and Gabriela Silva Bochi. Conceptualization, Formal analysis, Research, Methodology, Project Management, Supervision, Validation, Writing - review and editing: Eli Ávila Souza Junior.

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