

## INJURY FREQUENCY IN ARTISTIC GYMNASTICS – A SYSTEMATIC REVIEW

UDC 796.41.012: 616-001; 796:612.7:001.814

**Miloš Paunović, Dušan Đorđević, Saša Veličković, Marko Đurović,  
Aleksandar Paunović, Petar Veličković**

Faculty of Sport and Physical Education, University of Niš, Serbia

**Abstract.** *A higher frequency of sports injuries occurs due to the intense and physically challenging training, especially in artistic gymnastics. Hence, the aim of this study was to summarize the relevant literature on the incidence of injuries in artistic gymnasts. The following index databases were used to collect adequate literature: Google Scholar, PubMed, and MEDLINE, with the pre-defined inclusion criteria: studies on the given topic written in English language, published until December 2022, the participants sample consisted of competitive professional, semi-professional, elite and junior gymnasts, as well as national teams were taken into consideration. A total of 15 studies have met the pre-defined criteria and were included in the systematic review. According to the localization, the most common injuries are the lower extremities, with a 30-60% frequency. Regarding the upper extremities, 14 of 15 studies have reported approximately 20% injury frequency. Other injuries, such as shoulder, head, torso, and back, have a frequency of 3-15%. Furthermore, according to the mechanisms of injury, the most common causes were contact with the apparatus surface. Authors can conclude that the training process, which is not reflected in technical preparation but in the purpose of injury prevention, is crucial in this sport.*

**Key words:** *gymnastics, injuries, incidence*

### 1. INTRODUCTION

Artistic gymnastics is a sport that places high physical and mental demands on strength, flexibility, endurance, coordination, etc. It is stated that gymnasts have an average of 7 to 36 hours of training, i.e., preparation, depending on their competitive level. Top-level gymnasts typically train twice daily, 5 to 6 days a week, and up to 12 months a year (Caine, Russell, &

---

Received October 22, 2023/Accepted November 08, 2023

**Corresponding author:** Dušan Đorđević

Faculty of Sport and Physical Education, University of Niš, Čarojevića 10a, 18000 Niš, Serbia

Phone: +381 18 510 900 • E-mail: [dusandjordjevic1995@gmail.com](mailto:dusandjordjevic1995@gmail.com)

Lim, 2013). Over the years, the difficulty of gymnastic routines and the range of skills required to compete successfully have increased significantly. Hence, sports demands and increased practice, starting early, likely increase the risk of injury. Most gymnasts (both male and female), especially those who progress to the elite level, usually have at least one injury during their sporting career (Wadley & Albright, 1993).

Many children join and stay in artistic gymnastics; over the years, they can reach a high level of sport, i.e., elite rank. Consequently, performing heavy elements in early ages may be associated with an increased risk of injury (Meeuwisse, 1994). Most top gymnasts did not go through childhood or adolescence without injury, where the risk of injury increases with the length of training and the difficulty of the elements performed (Tofler, Stryer, Micheli, & Herman, 1996). Some authors consider artistic gymnastics a sport with a high risk of injury (Kolt & Kirkby, 1995), and this higher frequency of sports injuries probably occurs due to intense and physically challenging training (Daly, Bass, & Finch, 2001). In this regard, the high demands of this sport can lead to an injury if the gymnast's body is pushed beyond the physiological and physical limits and does not respond with corrective treatment at the right time. As the level of skills increases, so does the workload and, thus, the frequency of acute injuries (Ashwell & Richardson, 2019).

An essential part of the prevention of gymnastic injuries is the identification and analysis of risk factors, which could be both internal and external (Fu & Stone, 1994). Internal risk factors include physical characteristics, particularly anthropometric characteristics. Factors associated with an increased risk of injury include larger body size, age, body fat, and periods of rapid growth. The most crucial external risk factor is inadequate training, whereas 43.9% of traumas in artistic gymnastics are the result of inadequate training methods, 17.4% - of specific performance, 9.6% - of training conditions, and 8.4% - gymnasts' condition (Daly et al., 2001).

Although sports injuries are an indispensable part of any other sport, including sports such as artistic gymnastics, the authors consider it necessary to summarize the relevant literature on this topic. Therefore, the aim of this study was to collect and analyze research from available sources dealing with injuries in artistic gymnastics.

## 2. METHODS

### 2.1. Literature identification

An electronic search of studies was performed in databases such as Google Scholar, PubMed, and MEDLINE, which were published until December 2022. Also, keywords or their combination were used during the search of relevant literature, such as *gymnastics, injuries, and incidence*.

A descriptive method was used to analyze the obtained data, and all titles and abstracts were reviewed for potential studies to be included in the systematic review. Also, lists of references of previous reviews and original research were reviewed. Relevant studies were obtained after a detailed review if they met the pre-defined inclusion criteria.

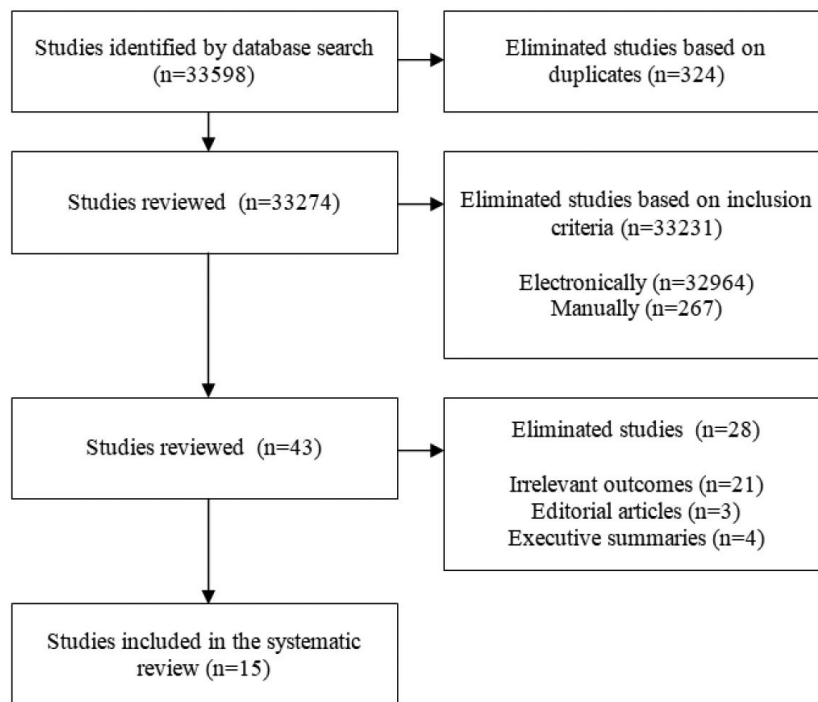
### 2.2. Inclusion criteria

The literature for analysis is research on the given topic written and published in English. Also, only published studies in the period until December 2022 were taken into

consideration. We have included a sample of competitive gymnasts (professional, semi-professional, elite, junior categories, and national teams were considered). Likewise, studies included in this review had to include data on the type of injury and its frequency. Studies were not included if the participants were recreationists or studies that did not determine the injury localization, only the incidence.

### 3. RESULTS

After a general database search, 33 598 potential studies were identified. At the very beginning, 324 studies were eliminated based on duplicates. Furthermore, a total of 33 231 studies were eliminated based on the inclusion criteria, with an additional 28 studies eliminated based on irrelevant outcomes, editorials, and executive summaries. In the end, 15 studies met the pre-defined criteria and were included in the systematic review. Figure 1 represents a detailed presentation of the study identification and selection process.



**Fig. 1** Process of collecting adequate studies based on pre-defined criteria

Table 1 presents a detailed description of the studies included in the systematic review.

**Table 1** Overview of included studies

Authors and year of publication	Participants sample	Study aim	Injury localization	Conclusion
Snook (1979)	n = 70 (F) 14-21 years	They examined the frequency of injuries among F gymnasts	UE 20%, LE 35%, trunk injuries 11%, and traumatic acute injuries were the most common	The increased number of hours of training before the competition caused most of the injuries
Garrick & Requa (1980)	n = 3 049 (F) 11-29 years	Determining the incidence of injuries in semi-professional and professional gymnasts	36% of LE injuries (ankle – 10%, 8% foot, 8% groin), 21% of UE injuries (2.1% head, 11.3% shoulder, 7.6% wrist)	95% of injuries occurred during training
Bak, Kalms, Olesen, & Jargensen, (1994)	n = 117 65 (M) 52 (F) 8-25 years	They examined the frequency of injuries in gymnasts of different ages	Injuries of the LE 64%, with equal frequency in the knee, ankle joint, and wrist injuries were the most frequent injuries of the UE	Artistic gymnastics is a sport with a high injury rate
Caine et al. (2003)	n = 79 (F) 7-18 years	They determined the frequency of injuries among elite F gymnasts	Knee 34%, lower back 17%, ankle, and foot (both 14.5%). 114 injuries (59.4%) were acute, while 78 (40.6%) were due to overexertion syndrome	The frequency of injuries was higher during competition than during training
O'Kane, Levy, Pietila, Caine, & Schiff (2011)	n = 126 (96 have completed entirely the quest) (F) 7-17 years	Assessing the frequency of injuries in gymnasts of different levels of competition	LE 59.6%, UE 21.6%, spine 10.1%, head 8.8%. The most common type of injury was sprain/strain 39.6%, bruise/swelling 30.3%, fracture 22.6%	The highest number of injuries occurred during training (proportionally due to hours spent in training compared to competition)
Bolling & Leite (2012)	n = 33 26 (F) 7 (M) 11-22 years	Determining differences in injury rates between sport and artistic gymnastics (a sample of sport gymnastics is shown here)	22.6% of UE injuries, 33.67% of LE injuries, 22.3% wrist injuries and 12.1% shoulder injuries. The most common cause is a sprain (25.9%)	The injury rate is higher with gymnasts in proportion to the competition rank
Westermann, Giblin, Vaske, Grosso, & Wolf (2015)	n = 119 64 (M) 55 (F)	Determining the differences between the mechanism and the frequency of injuries of M and F gymnasts	24.4% of injuries required surgery in F, versus 9.2% in M, 55% UE injury in F, 62.6% UE injury in M, 31% of LE injuries in F, 27% of LE injuries in M	The authors concluded that the frequency and localization of injuries were similar in M and F but that F suffered more serious injuries than M

Authors and year of publication	Participants sample	Study aim	Injury localization	Conclusion
Saluan, Styron, Ackley, Prinzbach, & Billow (2015)	n = 823 13-26 years	They examined the frequency of injuries over 21 years	833 (22.53%) UE injuries and 2242 (60.91%) LE injuries, shoulder 4%, back 11%, head/neck 1.2%	A greater number of injuries were present in gymnasts of a higher competitive level and vice versa
Rodríguez-Camacho, Correa-Mesa, Camargo-Rojas, & Correa-Morales (2016)	n = 14 (F) 14-22 years	They determined the frequency of injuries among F gymnasts from Bogotá during 1 season	Elbow 24%, wrist 19.5%, ankle 21%. Sprains (31.6%) were the most common mechanism of injury	Women's gymnastics is a sport with a high injury rate
Goulart et al. (2016)	n = 20 (M) 23.1±6.5 years	They investigated the incidence of injuries in M elite gymnastics	Forearm 36%, ankle 16.2%, hand and fingers 14.4%, shoulders 12.6%, lower back 9%, wrist 8.1%, and knee 5.4%	Most injuries in men's gymnastics are caused by overtraining on floor, pommel horse, and rings
Paxinos et al. (2019)	n = 156 116 (F) 40 (M) 14-36 years	They investigated the frequency of injuries in elite gymnasts over 10 years	Hip 18.5%, ankle 16.5%, lumbar spine 16% and foot 16%. The most common diagnosis was tendinitis 32%, followed by lower back pain 20% and sprains 12%. 9% of injuries required surgery	Musculoskeletal injuries are common in this sport
Chandran et al. (2021)	n = 1 200 742 (F) 458 (M) 13-31 years	They investigated the frequency of injuries among national-level gymnasts from 2014 to 2019	Knee 13.1%, ankle 12.6%, and foot 12.1% were more common in F, while in M, lower leg injuries 11.6% and head and face injuries 10.4% were more common	Injuries were more common during competition (35.7%) than during training
Kruse, Nobe, & Billimek (2021)	n = 2 102	Assessing the incidence of mid-competition injuries in gymnasts over ten years (2008-2018)	50% LE injuries and 24% UE injuries, 17% head injuries. The most significant cause of injuries was contact with the surface (66%)	The frequency of injuries is higher proportionally with the rank of the competition. Motivation for achievement is cited as a risk factor of injury caused by performing elements beyond the technical reach of the competitor

Authors and year of publication	Participants sample	Study aim	Injury localization	Conclusion
Tisano, Zynda, Ellis, & Wilson (2022)	n = 34000 > 7 years old	The authors collected data from the "National Electronic Injury Surveillance System" and determined injury rates among M and F gymnasts	12.19% ankle, 8.33% wrist, knee 11.5%, 3.88% fingers, 3.01% neck, 9.08% shoulder	In the period of adolescence, M had a higher rate of injuries compared to F (ankle and wrist), while F had a higher rate of UE injuries
Sastre-Munar, Pades-Jiménez, García-Coll, Molina-Mula, & Romero-Franco (2022)	n = 160 89 (F) 51 (M)	The authors determined injury rates in gymnasts of different competitive ranks	Ankle (25.5% of all injuries), knee (14.2% of all injuries) and lower back (10.4% of all injuries)	The frequency of injuries was increased with a higher level of competition

Legend: n – number of participants, M – male, F – female, LE – lower extremities, UE – upper extremities

This study includes 15 original scientific studies. All papers have dealt with the same problem, and all presented studies have evaluated the frequency (rate) of gymnasts injuries with data presented on percentage and numerical frequency, localization, and mechanism of gymnasts' injuries.

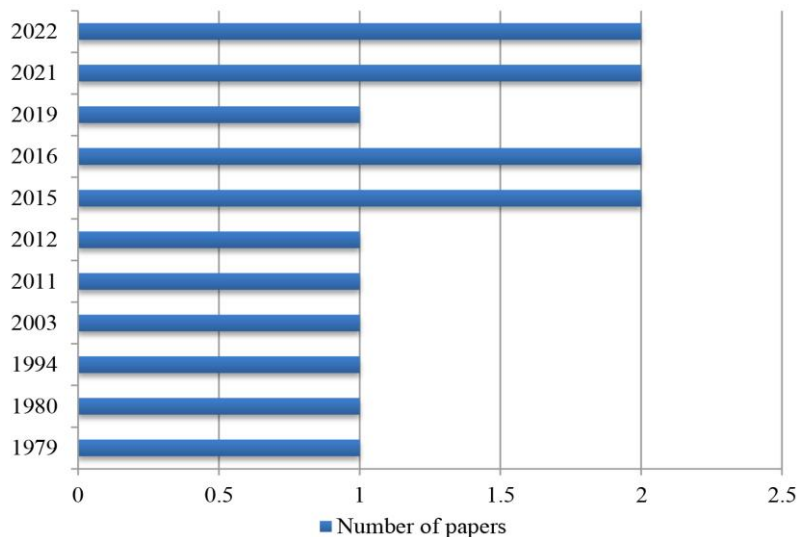
All studies contained the basic characteristics of the participants and complete data on injuries, mechanisms, and localization. Some studies have examined the frequency of injuries during 1 season (Bak et al., 1994; Bolling & Leite, 2012; O'Kane et al., 2011; Rodríguez-Camacho et al., 2016; Sastre-Munar et al., 2022; Westermann et al., 2015), during 3-5 seasons (Caine et al., 2003; Garrick & Requa, 1980; Snook, 1979; Westermann et al., 2015), but also during ten seasons (Kruse et al., 2021; Paxinos et al., 2019; Tisano et al., 2022). The sample size varied from study to study, with the lowest number of participants being 14 (Rodríguez-Camacho et al., 2016), while the highest was 34000 (Tisano et al., 2022). The total number of participants was 42 068, 22 482 female gymnasts and 19586 male gymnasts. Also, the participants ranged from 11-36 years old, which shows that this problem of injuries is present in gymnasts of different ages.

#### 4. DISCUSSION

The aim of this study was to collect and analyze research from available sources dealing with injuries in artistic gymnastics. The primary study findings are that 15 studies have met the pre-defined criteria and are included in the systematic review. According to the localization, the most common injuries are the lower extremities, with a 30-60% frequency. Regarding the upper extremities, 14 of 15 studies have reported approximately 20% injury frequency. Other injuries, such as shoulder, head, torso, and back, have a frequency of 3-15%. Furthermore, according to the mechanisms of injury, the most common causes were contact with the apparatus surface.

#### 4.1. Systematization of research based on the quantity

Starting with the oldest published studies, three of them were in the past decade (Bak et al., 1994; Garrick & Requa, 1980; Snook, 1979). The following study from the table was published in 2003 (Caine et al., 2003). Furthermore, one published paper was recorded in 2011 (O'Kane et al., 2011) and 2012 (Bolling & Leite, 2012). Two studies were published in 2015 (Saluan et al., 2015; Westermann et al., 2015) and 2016 (Goulart et al., 2016; Rodríguez-Camacho et al., 2016). In 2019, only one study was published (Paxinos et al., 2019), while two studies were published in 2021 (Chandran et al., 2021; Kruse et al., 2021) and 2022 (Sastre-Munar et al., 2022; Tisano et al., 2022).



**Fig. 2** Number of studies by year

#### 4.2. Systematization of research based on a sample size

The number of participants varied from study to study, with the smallest number of competitors being 14, as seen in the work of Rodríguez-Camacho et al. (2016), while the largest was 34000 in the study of Tisano et al. (2022). The participants' ranged from 11-36 years old, which shows that this problem of injuries is common among gymnasts of different ages. In the ten presented studies, there was a mixed sample size (Garrick & Requa, 1980; Bak et al., 1994; Bolling & Leite, 2012; Westermann et al., 2015; Saluan et al., 2015; Paxinos et al., 2019; Chandran et al., 2021; Tisano et al., 2022; Kruse, Nobe & Billimek, 2021; Sastre-Munar et al., 2022), in four studies the participants were only female (Snook, 1979; Caine et al., 2003; O'Kane et al., 2011; Rodríguez-Camacho et al., 2016), while in one study (Goulart et al., 2016) the participants were only male.

#### 4.3. Systematization of research based on localization of injuries

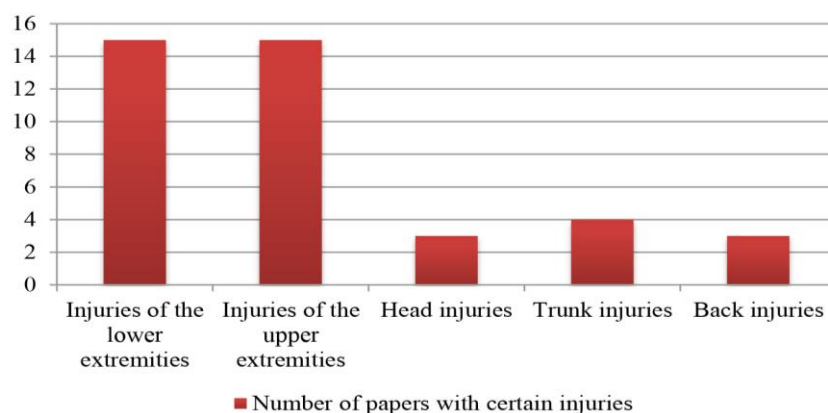
When we explore the results of the presented studies, it can be seen that most of the studies reported the highest rate of injuries of lower extremities, respectively: Garrick &

Requa (1980) - 36% injuries of lower extremities (ankle – 10%, 8% foot, 8% groin); Snook (1979) reported a lower extremity injury rate of 35% of all recorded injuries; Caine et al. (2003) reported 48.5% lower extremity injuries; Bak et al. (1994) reported a 64% frequency of lower extremity injuries (with equal frequency in the knee and ankle joint); O'Kane et al. (2011) reported a 59% incidence of lower extremity injuries; while Bolling & Leite (2012) reported a slightly lower rate of injuries than some previously presented research (33.68%), but again this rate of injuries of the lower extremities is at a statistically significant level. All these results indicate that artistic gymnastics is a sport with frequent injuries of the lower extremities, which has already been seen in previously published studies (Gram, Clarsen, & Bø, 2021; Jakše, Jakše, Čuk, & Šajber, 2021; Saluan et al., 2015). All the studies presented and listed in this paragraph agreed on the exact localization of the injury and showed that the ankle and the knee were the most frequently injured body parts.

Therefore, it is logical to conclude that artistic gymnastics is a sport with a high frequency of injuries of lower extremities. Mechanical stress arising from technical elements requiring landings explains these results (Campbell, Bradshaw, Ball, Pease, & Spratford, 2019). These physical demands are similar in all disciplines of artistic gymnastics, so the study by Chandran et al. (2021) did not observe any differences in the mechanism and anatomical location of injuries based on the discipline (floor, pommel horse, rings, etc).

When talking about the second most common place of injury, it can be seen that the upper extremities are also often injured, and the presented studies found the following: the authors of two studies (Garrick & Requa, 1980; Snook, 1979) reported 20-21% of upper extremity injuries; consistent with studies (Caine et al., 2003; Bak et al., 1994; O'Kane et al., 2011; Bolling & Leite, 2012) that reported a similar rate ranging from 19.63% to 23% of upper extremity injury, as well as studies (Goulart et al., 2016; Kruse et al., 2021; Paxinos et al., 2019; Rodríguez-Camacho et al., 2016; Saluan et al., 2015; Tisano et al., 2022) who reported upper extremity injury rates ranging from 20-24%. Namely, only one study by Westermann et al. (2015) reported an upper extremity injury frequency of 55% of all injuries occurring, and this can be attributed to the fact that the sample did not consist of gymnasts with long experience in training or competition.

When looking at other injuries in artistic gymnastics, the researches presented showed the following: Garrick & Requa (1980) recorded 2.1% of head injuries in the tested sample, and O'Kane et al. (2011) recorded 10.01% of head injuries, while Caine et al. (2003)



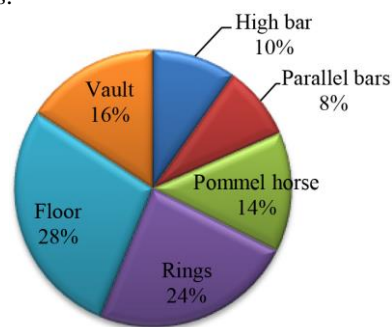
**Fig. 3** Number of papers showing injuries in a specific part of the body



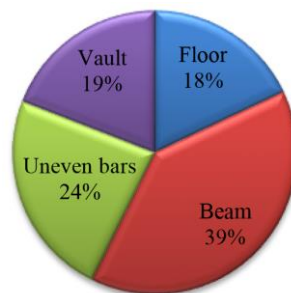
recorded 17.86%-21% of spinal injuries. The studies of Kruse et al. (2021) reported 17% of head injuries of all injuries, and the study of Tisano et al. (2022) reported 3.01% of head injuries. Finally, a study by Sastre-Munar et al. (2022) reported 10.04% of lumbar back injuries.

#### 4.4. Study systematization based on the place of injury – apparatus on which the injury occurred

The following two figures show the results (percentage) about the place – apparatus where the injury occurred. The data were obtained by extracting data from all the analyzed studies, where there was information on injuries systematized by discipline, i.e., apparatus for males and females.



**Fig. 4** Frequency of injuries by apparatus – male



**Fig. 5** Frequency of injuries by apparatus – female

#### 4.5. Study systematization based on the period of occurrence of the injury

When talking about how the volume and frequency of training affect injuries, the following can be seen: Caine et al. (2003) reported an overall rate of 2.5 injuries per 1000 hours of training/competition; O'Kane et al. (2011) reported a rate of 1.9 injuries per 1000 hours of training/competition; while the study by Chandran et al. (2021) reported a staggering 8 injuries per 1000 hours of competition/training in a sample of elite gymnasts. A wide range of other studies have reported similar injury rates per 1000 hours of training or competition.

Zetaruk (2000) found that injury rates among female gymnasts ranged from 65 to 200 per 100 gymnasts per year or less than 1 to 3.66 per 1000 hours of training or competition. Cupisti et al. (2007) reported an injury rate of 1.08 injuries per 1000 hours of training or competition,

which shows that the research presented in the table is consistent with the previous literature. When looking at these injury rates per 1000 hours of competition or training, there is evidence that most injuries occur during training (Garrick & Requa, 1980; O'Kane et al., 2011), but also some evidence shows that most injuries occur during competition (Caine et al., 2003; Bolling & Leite, 2012; Chandran et al., 2021; Sastre-Munar et al., 2022).

A study by O'Kane et al. (2011) explained this higher frequency of training injuries as a proportional number between hours of training and competition. Namely, the number of hours spent in training is much greater than in the competition, and this results in a more significant number of injuries during training, while the authors Kruse et al. (2021) state that the frequency of injuries is proportionally higher with the rank of the competition. They emphasize motivation for achievement as a risk factor of injury caused by performing elements beyond the technical reach of the competitor and thus justify the more significant number of injuries caused during the competition compared to training. Although the evidence is mixed, it can be seen that artistic gymnastics is undoubtedly a sport with a high incidence of injuries, regardless of competition.

Furthermore, the studies shown (Bak et al., 1994; Bolling & Leite, 2012; Saluan et al., 2015; Paxinos et al., 2019; Kruse et al., 2021; Sastre-Munar et al., 2022) in addition to the issue of the frequency of injuries in gymnastics, dealt with determining the rate of injuries based on the competition rank. Namely, all studies agreed and determined that a higher number of injuries was associated with a higher competition rank (the frequency of injuries was directly proportional to a higher competition rank and vice versa). When we delve into the gender differences in the frequency of injuries, the following can be observed: Tisano et al. (2022) determined that in the period of adolescence, the male population has a higher rate of injuries in general compared to the female population (in the ankle and wrist), while in the same period, the female population has a higher rate of injuries of the upper extremities, and these are data that have already been seen in previous literature (Singh, Smith, Fields, & McKenzie, 2008), which indicates that the difference in the frequency of injuries based on gender has not changed with age, or with different requirements of artistic gymnastics. Several studies presented in the paper suggest that there are no gender differences in the frequency of injuries between male and female gymnasts but that these differences add to the level of competition. Namely, injuries are more frequent in higher competition ranks, and competition rank is an essential factor in increasing the frequency of injuries concerning gender (Orces & Orces, 2020; Pettrone & Ricciardelli, 1987), as the abovementioned studies have shown.

Our study's strength is reflected in the fact that it indicates which injuries are the most common in artistic gymnastics and the localization of injuries. This study can be beneficial for the athletes themselves, but also for the coaches, and knowing which apparatus most often causes injuries, which parts of the body are most often injured, as well as in which period injuries occur, can be of great benefit to coaches in designing training in order to prevent injury.

## 5. CONCLUSION

Considering all the information presented in this paper, we can conclude that the highest frequency of injuries occurs in the lower extremities, where studies have shown a frequency range of 30-60% of injuries of the lower extremities. Regarding the upper extremities, 14 out

of 15 studies reported results of approximately 20% incidence of upper extremity injuries. Other injuries, with a low frequency of 3-15%, were shoulder, head, trunk and back injuries.

Speaking about the mechanisms of injury, the most common causes of injury were contact with the surface of the apparatus. The majority of injuries did not require hospitalization (given that the injuries were of an acute type), but it was noted that a more significant number of women's injuries required hospitalization compared to men's. With this, it can also be concluded that the training process, which is not reflected in technical preparation but in injury prevention, is vital in this sport, given that it has been proven that artistic gymnastics is a sport with a high frequency of injuries.

#### REFERENCES

- Ashwell, Z. R., & Richardson, M. L. (2019). Gymnast's wrist in a 12-year-old female with MRI correlation. *Radiology Case Reports*, *14*(3), 360–364. <https://doi.org/10.1016/j.radcr.2018.09.010>
- Bak, K., Kalms, S. B., Olesen, S., & Jargensen, U. (1994). Epidemiology of injuries in gymnastics. *Scandinavian Journal of Medicine & Science in Sports*, *4*(2), 148–154. <https://doi.org/10.1111/j.1600-0838.1994.tb00419.x>
- Bolling, C., & Leite, M. (2012). Difference in injury profile in Trampoline and Artistic Gymnastics. *Journal of Science and Medicine in Sport*, *15*(1), 127–128. <https://doi.org/10.1016/j.jsams.2012.11.307>
- Caine, D. J., Russell, K., & Lim, L. (2013). *Handbook of sports medicine and science: gymnastics*. John Wiley & Sons.
- Caine, D., Knutzen, K., Howe, W., Keeler, L., Sheppard, L., Henrichs, D., & Fast, J. (2003). A three-year epidemiological study of injuries affecting young female gymnasts. *Physical Therapy in Sport*, *4*(1), 10–23. [https://doi.org/10.1016/S1466-853X\(02\)00070-6](https://doi.org/10.1016/S1466-853X(02)00070-6)
- Campbell, R. A., Bradshaw, E. J., Ball, N. B., Pease, D. L., & Spratford, W. (2019). Injury epidemiology and risk factors in competitive artistic gymnasts: a systematic review. *British Journal of Sports Medicine*, *53*(17), 1056–1069. <https://doi.org/10.1136/bjsports-2018-099547>
- Chandran, A., Roby, P. R., Boltz, A. J., Robison, H. J., Morris, S. N., & Collins, C. L. (2021). Epidemiology of Injuries in National Collegiate Athletic Association Women's Gymnastics: 2014–2015 Through 2018–2019. *Journal of Athletic Training*, *56*(7), 688–694. <https://doi.org/10.4085/1062-6050-635-20>
- Cupisti, A., D'Alessandro, C., Evangelisti, I., Umbri, C., Rossi, M., Galetta, F., ... Piazza, M. (2007). Injury survey in competitive sub-elite rhythmic gymnasts: results from a prospective controlled study. *Journal of Sports Medicine and Physical Fitness*, *47*(2), 203.
- Daly, R. M., Bass, S. L., & Finch, C. F. (2001). Balancing the risk of injury to gymnasts: how effective are the counter measures? *British Journal of Sports Medicine*, *35*(1), 8–19. <https://doi.org/10.1136/bjism.35.1.8>
- Fu, F., & Stone, D. (1994). *Sports injuries: Mechanisms, prevention, treatment Gymnastics, 2nd edition*. Lippincott Williams & Wilkins; 2nd edition (August 15, 2001).
- Garrick, J. G., & Requa, R. K. (1980). Epidemiology of women's gymnastics injuries. *The American Journal of Sports Medicine*, *8*(4), 261–264. <https://doi.org/10.1177/036354658000800409>
- Goulart, N. B. A., Lunardi, M., Waltrick, J. F., Link, A., Garcias, L., Melo, M. de O., ... Vaz, M. A. (2016). Injuries prevalence in elite male artistic gymnasts. *Revista Brasileira de Educação Física e Esporte*, *30*, 79–85. <https://doi.org/10.1590/1807-55092016000100079>
- Gram, M. C. D., Clarsen, B., & Bø, K. (2021). Injuries and illnesses among competitive Norwegian rhythmic gymnasts during preseason: a prospective cohort study of prevalence, incidence and risk factors. *British Journal of Sports Medicine*, *55*(4), 231–236. <https://doi.org/10.1136/bjsports-2020-102315>
- Jakše, B., Jakše, B., Čuk, I., & Šajber, D. (2021). Body Composition, Training Volume/Pattern and Injury Status of Slovenian Adolescent Female High-Performance Gymnasts. *International Journal of Environmental Research and Public Health*, *18*(4), 2019–2030. <https://doi.org/10.3390/ijerph18042019>
- Kolt, G. S., & Kirkby, R. J. (1995). Epidemiology of injury in Australian female gymnasts. *Research in Sports Medicine: An International Journal*, *6*(3), 223–231. <https://doi.org/10.1136/bjism.33.5.312>
- Kruse, D. W., Nobe, A. S., & Billimek, J. (2021). Injury incidence and characteristics for elite, male, artistic USA gymnastics competitions from 2008 to 2018. *British Journal of Sports Medicine*, *55*(3), 163–168. <http://dx.doi.org/10.1136/bjsports-2019-101297>
- Meeuwisse, W. H. (1994). Assessing causation in sport injury: a multifactorial model. *Clinical Journal of Sport Medicine*, Vol. 4, pp. 166–170. LWW. <http://dx.doi.org/10.1097/00042752-199407000-00004>

- O'Kane, J. W., Levy, M. R., Pietila, K. E., Caine, D. J., & Schiff, M. A. (2011). Survey of injuries in Seattle area levels 4 to 10 female club gymnasts. *Clinical Journal of Sport Medicine*, 21(6), 486–492. <https://doi.org/10.1097/JSM.0b013e31822e89a8>
- Orces, C. H., & Orces, J. (2020). Trends in the US Childhood emergency department visits for fall-related fractures, 2001–2015. *Cureus*, 12(11), e11629. <https://doi.org/10.7759/cureus.11629>
- Paxinos, O., Mitrogiannis, L., Papavasiliou, A., Manolarakis, E., Siempenou, A., Alexelis, V., & Karavasili, A. (2019). Musculoskeletal injuries among elite artistic and rhythmic Greek gymnasts: A ten-year study of 156 elite athletes. *Acta Orthop. Belg*, 85(2), 145–149.
- Pettrone, F. A., & Ricciardelli, E. (1987). Gymnastic injuries: the Virginia experience 1982–1983. *The American Journal of Sports Medicine*, 15(1), 59–62. <https://doi.org/10.1177/036354658701500108>
- Rodríguez-Camacho, D. F., Correa-Mesa, J. F., Camargo-Rojas, D. A., & Correa-Morales, J. C. (2016). Prevalence of injuries in gymnasts from the Gymnastics League of Bogotá, DC. *Revista de La Facultad de Medicina*, 64(3), 85–91. <https://doi.org/10.15446/REVFACMED.V64N3SUPL.50829>
- Saluan, P., Styron, J., Ackley, J. F., Prinzbach, A., & Billow, D. (2015). Injury types and incidence rates in precollegiate female gymnasts: a 21-year experience at a single training facility. *Orthopaedic Journal of Sports Medicine*, 3(4), 2325967115577596. <https://doi.org/10.1177/2325967115577596>
- Sastre-Munar, A., Pades-Jiménez, A., García-Coll, N., Molina-Mula, J., & Romero-Franco, N. (2022). Injuries, Pain, and Catastrophizing Level in Gymnasts: A Retrospective Analysis of a Cohort of Spanish Athletes. *Healthcare*, 10(5), 890–901. MDPI. <https://doi.org/10.3390/healthcare10050890>
- Singh, S., Smith, G. A., Fields, S. K., & McKenzie, L. B. (2008). Gymnastics-related injuries to children treated in emergency departments in the United States, 1990–2005. *Pediatrics*, 121(4), 954–960. <https://doi.org/10.1542/peds.2007-0767>
- Snook, G. A. (1979). Injuries in women's gymnastics: a 5-year study. *The American Journal of Sports Medicine*, 7(4), 242–244. <https://doi.org/10.1177/036354659302100218>
- Tisano, B., Zynda, A. J., Ellis, H. B., & Wilson, P. L. (2022). Epidemiology of pediatric gymnastics injuries reported in US emergency departments: Sex-and age-based injury patterns. *Orthopaedic Journal of Sports Medicine*, 10(6), 23259671221102480. <https://doi.org/10.1177/23259671221102478>
- Tofler, I. R., Stryer, B. K., Micheli, L. J., & Herman, L. R. (1996). Physical and emotional problems of elite female gymnasts. *New England Journal of Medicine*, Vol. 335, pp. 281–283. Mass Medical Soc. <https://doi.org/10.1056/NEJM199607253350412>
- Wadley, G. H., & Albright, J. P. (1993). Women's intercollegiate gymnastics: Injury patterns and "permanent" medical disability. *The American Journal of Sports Medicine*, 21(2), 314–320. <https://doi.org/10.1177/036354659302100224>
- Westermann, R. W., Giblin, M., Vaske, A., Grosso, K., & Wolf, B. R. (2015). Evaluation of men's and women's gymnastics injuries: a 10-year observational study. *Sports Health*, 7(2), 161–165. <https://doi.org/10.1177/1941738114559705>
- Zetaruk, M. N. (2000). The young gymnast. *Clinics in Sports Medicine*, 19(4), 757–780. [https://doi.org/10.1016/s0278-5919\(05\)70236-2](https://doi.org/10.1016/s0278-5919(05)70236-2)

## UČESTALOST POVREDA U SPORTSKOJ GIMNASTICI – SISTEMATSKO PREGLEDNO ISTRAŽIVANJE

Veća učestalost sportskih povreda nastaje usled intenzivnog i fizički zahtevnog treninga, posebno kod gimnastičara. Stoga je cilj ovog istraživanja bio da sumira relevantnu literaturu o učestalosti povreda gimnastičara. Za prikupljanje adekvatne literature korišćene su sledeće indeksne baze podataka: Google Scholar, PubMed, MEDLINE, sa unapred definisanim kriterijumima uključivanja: studije na datu temu napisane na engleskom jeziku, objavljene do decembra 2022. godine, za uzorak ispitanika uzeti su u obzir poluprofesionalci, vrhunski gimnastičari, kao i juniori i reprezentativci. Ukupno je 15 studija ispunilo unapred definisane kriterijume i uključeno u sistematski pregled. Prema lokalizaciji, najčešće su povrede donjih ekstremiteta sa učestalošću od 30-60%. Što se tiče gornjih ekstremiteta, 14 od 15 studija izvestilo je o približno 20% učestalosti povreda. Ostale povrede, poput ramena, glave, trupa i leđa imaju učestalost od 3-15%. Takođe, prema mehanizmima povređivanja, najčešći uzroci su bili kontakt sa površinom sprave. Autori mogu zaključiti da je trenažni proces, koji se ne ogleda u tehničkoj pripremi, već u cilju prevencije povreda, ključan u ovom sportu.

Ključne reči: gimnastika, povrede, učestalost