

ORIGINAL ARTICLE

Sports injuries, types and causes in Turkish elite artistic gymnasts

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ABSTRACT

Background and aim. The risk of injury for gymnasts, especially competitive gymnasts, is quite high. It has been observed that most gymnasts do not go through years of training and competition without injury. The aim of the study is to investigate the body injury parts, causes, types and rates of Turkish elite female and male artistic gymnasts.

Material and Methods. A total of 34 artistic gymnasts, 12 female (35.3%) and 22 male (64.7%) participated in this research. Among the participants, 21 gymnasts (61.8%) are Turkish National Team athletes and 2 gymnasts (5.9%) competed in the Olympic Games held in Tokyo 2021 / Japan. A questionnaire was applied to female and male gymnasts. The data collection tool of the research was prepared by the researchers using Google Forms. The survey consists of 30 questions and each participant is evaluated according to their own knowledge. Data were analyzed using descriptive and frequency analyses. SPSS 24.0 program (SPSS Inc., Chicago, IL) was used for statistical analyzes.

Results. According to the findings of this study, it was determined that 79.4% of the gymnasts were injured and 20.6% were not injured during the one-year period determined for the study. It was found that artistic gymnasts with a mean age of 17.0 ± 2.83 years and training for an average of 24.91 ± 5.96 hours per week experienced an average of 2.06 ± 1.48 injuries during the research period (in the last 1 year). The average duration of interruption from training due to injury was 27.91 ± 37.45 days/year, while 47.1% (16 gymnasts) of the gymnasts were injured during training and 2.9% (1 gymnast) were injured during the competition. In this study, the highest injury rates in the head and trunk locations of both female and male were found in the waist-back section. The highest injury rates in the upper extremities were found in the shoulder and wrist sections. In the lower extremities, the highest injury rate was in the hip section.

Conclusions. It was determined that the gymnasts (male and female) suffered the most injuries in the waist-back, shoulder, wrist, hip, groin, knee and toes according to their body parts. It is thought that similar and more detailed studies with more gymnasts will benefit gymnasts, trainers and sports experts.

Keywords: artistic gymnastic, injury causes, injury types

INTRODUCTION

Gymnastics, whose institutionalization started in Europe in 1881, is one of the oldest and basic sports branches. Today, there are 8 gymnastics disciplines under the roof of International Gymnastics Federation (FIG), according to their application forms (men's artistic, women artistic, rhythmic, gymnastics for all, trampoline, aerobic, acrobatic and parkour) [1]. In the oldest Olympic discipline, artistic gymnastics, both men and women compete. In artistic gymnastics, there are 6 competition apparatuses for men (floor exercise, vault, high bar, pommel horse, rings, and parallel bars), and 4 competition apparatuses for women (vault, uneven bars, balance beam, and floor exercise) [2].

Desai et al. (2019) emphasized that all of the men's competitions rely heavily on upper body strength and upper extremity weight bearing and double leg landings, while women's competitions require more skills than men, requiring flexibility and more one-single landings. They also noted that both male and female gymnasts performed a significant amount of roll-off, which included both upper and lower extremity rebounds, somersaults, twists, and hard landings [3]. Kruse & Lemmen (2009) stated that gymnastics involves high levels of proprioceptive control, extremity impact, hyper lordotic positioning, and highly dynamic dismounts that can be taxing and difficult on young developing bodies on young developing bodies [4]. In artistic gymnastics routines, technique, composition (general expectations for exercise construction), aesthetics and execution, correct construction of

necessary movement patterns, and increasing the variety of movement in the construction of an exercise, in addition to the gymnast's personal inclinations and technical abilities, are important. In order to meet these criteria, it is necessary to start gymnastics at a young age and long training periods. The volume or intensity of training required to be competitive, combined with the increased involvement and difficulty of skills practiced at an early age and continued through the growing years, raises concerns about the risk, severity and long-term effects of injury [5]. It is known that training times in artistic gymnastics are related to the level of the gymnast. For example, it is emphasized that amateur gymnasts may train between 1 and 4 hours per week, while higher level and elite gymnasts may train between 20 and 40 hours per week [6].

These factors suggest that the risk of injury for gymnasts, especially competitive gymnasts, is quite high. It has been observed that most gymnasts do not go through years of training and competition without injury [7]. Therefore, the aim of the study is to investigate the body injury locations, causes, types and rates of Turkish elite female and male artistic gymnasts.

MATERIAL AND METHODS

Participants

A total of 34 artistic gymnasts, 12 female (35.3%) and 22 male (64.7%) participated in this research. Among the participants, 21 gymnasts (61.8%) are Turkish National Team athletes and

2 gymnasts (5.9%) competed in the Olympic Games held in Tokyo 2021 / Japan.

Procedure

The research was designed to determine the body injury locations, causes, types and rates (%) of Turkish elite artistic gymnasts in the last year (January 2022-January 2023). In this direction, a questionnaire was applied to female and male gymnasts in order to determine the injury locations in the head-trunk, upper and lower extremities of their bodies, the types of injuries, the reasons for the injuries, the apparatuses they experienced according to the body locations, and the practices related to the treatment. The data collection tool of the research was prepared by the researchers using Google Forms. The questionnaire consisted of 30 questions and each participant was

evaluated according to their own knowledge. This study was approved by the Non-Invasive Ethics Committee of Dokuz Eylül University (File number 8230-GOA).

Statistical Analysis

SPSS 24.0 program (SPSS Inc., Chicago, IL) was used for statistical analyses. Descriptive statistical analyzes were performed to determine the mean \pm standard deviation values of gymnasts' age, body height, body weight, training and vacation times and interruption time from training due to injury times. The head-trunk, upper and lower extremities of the body, injury types, causes of injury, apparatus used by body locations, and rates of treatment-related practices of female and male elite artistic gymnasts were analyzed by frequency analysis.

Table 1. Descriptive analysis data of artistic gymnasts.

(N=34)	Min Value	Max Value	Mean \pm SD
Age (years)	14.00	27.00	17.0 \pm 2.83
Body weight (kg)	32.00	75.00	57.35 \pm 9.83
Body height (cm)	143.00	182.00	165.26 \pm 9.50
Weekly training volume (hours/week)	15.00	40.00	24.91 \pm 5.96
Number of unit training per week	5.00	9.00	6.06 \pm 0.60
Vacation duration per year (days)	3.00	14.00	8.44 \pm 2.77
Number of injuries per year	0.00	5.00	2.06 \pm 1.48
Interruption time from training due to injury (days)	0.00	150.00	27.91 \pm 37.45

N; Number of gymnast, *Min*; Minimum, *Max*; Maximum, *SD*; Standard Deviation.

Table 2. Analysis data on injury and treatment statuses of artistic gymnasts.

(N=34)	Yes	No
Injuries	27 (%79.4)	7 (%20.6)
Applying to the emergency department due to injury	19 (%55.9)	15 (%44.1)
Hospitalization for injury	8 (%23.5)	26 (%76.5)
Undergoing surgery for injury	5 (%14.7)	29 (%85.3)

N; Number of gymnast.

RESULTS

Descriptive statistics data regarding the physical characteristics and training information of the participants are shown in Table 1.

The analysis data regarding the injury and treatment status of artistic gymnasts are given in Table 2.

The analysis data regarding the injury status of male and female artistic gymnasts by body locations are shown in Table 3.

Analysis of data on injury types by body locations of artistic gymnasts is shown in Table 4 and the analysis data on the causes of injury according to the body positions of the artistic gymnasts are shown in Table 5.

It was determined that 47.1% (16 gymnasts) of the gymnasts were injured in the training, and 2.9% (1 gymnast) in the competition. It was found that 55.9% (19 gymnasts) of the upper extremities injuries occurred in training, 2.9% (1 gymnast) occurred in competition, and 38.2% (13 gymnasts) of the lower extremities injuries occurred in training and 2.9% (1 gymnast) in competition. The data

analysis results on which apparatuses gymnasts experienced injuries are shown in Table 6.

DISCUSSION

In this study, which was conducted to determine the injury locations, causes and types of female and male elite artistic gymnasts, it was determined that 79.4% (27 gymnasts) of the gymnasts were injured and 20.6% (7 gymnasts) were not injured in the one-year period determined for the research (Table 2). It was found that artistic gymnasts with a mean age of 17.0 ± 2.83 and training for an average of 24.91 ± 5.96 hours per week experienced an average of 2.06 ± 1.48 injuries during the research period (in the last 1 year). The average duration of interruption from training due to injury was 27.91 ± 37.45 days/year, while 47.1% (16 gymnasts) of the gymnasts were injured during training and 2.9% (1 gymnast) were injured during the competition (Table 1).

According to the United State of America Gymnastics Safety Course Handbook, a gymnastics injury is defined as "any injury during gymnastic participation that causes a

Table 3. Analysis data on injury status of artistic gymnasts by body locations.

	n	Female	Male
Head and Trunk			
Face	1 (%2.9)	1 (%100.0)	0 (%0.0)
Neck	4 (%11.8)	1 (%25.0)	3 (%75.0)
Spine	4 (%11.8)	1 (%25.0)	3 (%75.0)
Sternum / Costae	2 (%5.9)	1 (%50.0)	1 (%50.0)
Waist / Back	9 (%26.5)	2 (%22.2)	7 (%77.8)
Stomach	1 (%2.9)	0 (%0.0)	1 (%100.0)
Pelvic	1 (%2.9)	0 (%0.0)	1 (%100.0)
I did not experience any injuries in the head and trunk area.	11 (%32.4)	6 (%54.5)	5 (%45.5)
I have not suffered any injury to any part of my body.	7 (%20.6)	1(%14.3)	6 (%85.7)
Upper Extremities			
Shoulder	10 (%29.4)	3 (%30.0)	7 (%70.0)
Upper arm	2 (%5.9)	2 (%100.0)	0 (%0.0)
Elbow	4 (%11.8)	2 (%50.0)	2 (%50.0)
Wrist	8 (%23.5)	3 (%37.5)	5 (%62.5)
I did not experience any injuries in the upper area.	5 (%14.7)	5 (%100.0)	0 (%0.0)
I have not suffered any injury to any part of my body.	7 (%20.6)	1(%14.3)	6 (%85.7)
Lower Extremities			
Hip	3 (%8.8)	3(%100.0)	0 (%0.0)
Pubic	3 (%8.8)	1 (%33.3)	2 (%66.7)
Knee	3 (%8.8)	1 (%33.3)	2 (%66.7)
Lower leg	2 (%5.9)	1 (%50.0)	1 (%50.0)
Ankle	2 (%5.9)	2 (%100.0)	0 (%0.0)
Foot	3 (%8.8)	2 (%66.7)	1 (%33.3)
Toes	4 (%11.8)	2 (%50.0)	2 (%50.0)
I did not experience any injuries in the lower area.	11 (%32.4)	2 (%18.2)	9 (%81.8)
I have not suffered any injury to any part of my body.	7 (%20.6)	1(%14.3)	6 (%85.7)

N; Number of gymnast.

gymnast to miss any part of a workout or competitive event" [8]. It has been reported that elite level gymnasts tend to specialize by age 12, with peak training intensity occurring at age 18 [3]. It is emphasized that competitive gymnasts have a high risk of injury [7]. There is information in the literature that the injury rates for artistic gymnasts range from 1.5 to 9.2 injuries per 1000 athletic exposures [5, 9, 10, 11]. Previous studies and reviews of gymnastics have found higher injury rates during competitions involving higher-risk situations [6, 9, 12, 13]. A 10-year retrospective study at the Australian Institute of Sport found that both female and male gymnasts experience an average of two injuries per year during the observation period, consistent with this study [14]. In this study, in which 79.4% of artistic gymnasts were injured, the injury rates of high-level competitive gymnasts were also found to be high, in line with the literature [7]. However, unlike the literature [6, 9, 12, 13] it was determined that the participants of this study, which were at the elite level, experienced more injuries during training.

In this study, the highest injury rates in the head and trunk locations of both female and male were found in the waist-back section. A total of 9 gymnasts (2 female and 7 male gymnasts) suffered injuries in the waist-back section. The injury rates of female and male gymnasts belonging to this division were 22.2% and 77.8%, respectively (Table 3). It is emphasized that intense and repetitive training programs required by the nature of gymnastics can create great stress on the spine [4]. Many studies have reported the incidence of low back injuries in gymnastics [4, 14-17]. Caine and

Nassar (2005) in their study in which they published a summary of the epidemiology of gymnastic injuries, reported the rates of lumbar injuries to be between 5.2% and 20%. They also reported that chronic low back injuries may be more common than actually reported [15]. Overlin et al. (2011) argued that gymnasts tend to train by becoming chronic instead of stopping training when injury occurs, which may lead to low back pain and underreporting of injuries [18]. In a comprehensive study by Sward et al. (1990) conducted with 26 male gymnasts and 26 female gymnasts, approximately 85% of male gymnasts and 65% of female gymnasts complained of back pain. Of the 52 gymnasts examined, 42% had spondylolysis, decreased disc height, and radiological changes in the thoracolumbar spine, including Schmorl's nodes [19]. In this study, the highest rates of injuries related to the waist and back in the head and trunk section were found in men and women, which is similar to the literature [4, 14-17, 19]. Striking or falling from the apparatus is thought to be the cause of head and trunk injuries in both male and female gymnasts. Kruse and Lemmen (2009) emphasized that low back pain is a common problem in gymnasts, that the branch of gymnastics exerts tremendous force along the spine in gymnasts, and as a result, it predisposes the gymnast to various injuries due to overuse of the spine [4].

The highest injury rates in the upper extremities were found in the shoulder and wrist sections. A total of 10 gymnasts, 3 female (30.0%) and 7 male (70.0%), suffered injuries in the shoulder section. In the wrist section, 8 gymnasts, 3 female (37.5%) and 5 male (62.5%), suffered injuries (Table 3). In artistic

gymnastics, the upper extremities are largely responsible for a successful performance in men's and women's routines. Gymnastics involves a multitude of skills that result in significant forces and torques applied to the upper extremity [6]. The most common location of injuries of the upper extremity in men's gymnastics is the shoulder, followed by the wrist. Among female gymnasts, the wrist is the most commonly affected structure of the upper extremity, followed by the elbow [18]. In parallel with the literature [13], in this study, injuries were found in the upper extremity of male gymnasts, most frequently in the shoulder and wrist sections, respectively. Wrist and shoulder injuries were the most common among female gymnasts. In men, the increase in shoulder injuries may be attributed to the additional apparatuses on which they perform, such as the rings, parallel bars, and high bar, which places increased stress on the male gymnast's shoulder. The wrists of both men and women gymnasts seem to be particularly vulnerable to injury [18]. It has been determined that the type of injury in the upper extremity is tendon tear in female gymnasts and fracture in male gymnasts. The causes of injury are thought to be overloading in both male and female gymnasts.

In the lower extremities, the highest injury rate was in the hip section (3 female gymnasts, %100.0), while in 2 male gymnasts (%66.7) were injured in the pubic, 2 male gymnast's knee (%66.7) and 2 male gymnast's toes sections (%50.0) (Table 3). Although there is not much research on hip injuries in the literature, it was found in this study that female gymnasts had the most injuries in the lower

extremities of the hip. It is thought that this situation is due to the fact that the use of the lower extremities of the body of female gymnasts is quite intense and excessive. In addition, striking or falling from the apparatus was the most common cause of injury in the lower extremities of female gymnasts. The knee is reported as the second most common body part injured in gymnastics [16, 18]. Kerr et al. (2015) found that the knee had the largest proportion of severe injuries (30.2%-47.1%) when compared to all other gymnastics injuries [9]. Consistent with the literature [9, 16, 18], knee injuries in male gymnasts were also found at a high rate in this study. In addition, fractures were found to be the most common type of injury in the lower extremities in male gymnasts. Toes and pubic injuries are thought to occur due to overload in male gymnasts.

CONCLUSIONS

In this study, which was conducted to determine the injury areas, causes and types of Turkish elite artistic gymnasts, it was determined that the gymnasts (male and female) suffered the most injuries in the waist-back, shoulder, wrist, hip, groin, knee and toes according to their body parts. Gymnastics is a sport that starts at an early age and continues with heavy training loads. The number of gymnasts who can continue this process without getting injured is almost non-existent. However, when preparing and applying training programs, injuries can be made more harmless by correct loading. In this study, we investigated the injury rates, locations and causes of Turkish elite artistic gymnasts. It is

thought that similar and more detailed studies with more gymnasts will benefit gymnasts, trainers and sports experts.

Acknowledgments

I would like to thank all gymnasts who contributed to this research. Also, endless thanks to Mr. İsmail Göktekin, President of Şavkar Sports Club, Vice President of Turkish Gymnastics

Federation and Vice-President of Mediterranean Countries Gymnastics Confederation (COMEGYM), who contributed greatly to the realization of this research.

Conflicts of Interests

The authors declare no conflicts of interest.

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Table 4. Analysis data on injury types of artistic gymnasts by body locations.

	Head – Trunk Location			Upper Extremities			Lower Extremities		
	N	Female	Male	n	Female	Male	n	Female	Male
Fracture	2 (%5.9)	1 (%50.0)	1 (%50.0)	5 (%14.7)	1 (%20.0)	4 (%80.0)	4 (%11.8)	1 (%25.0)	3 (%75.0)
Other bone injuries	0 (%0.0)	0 (%0.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)	2 (%5.9)	0 (%0.0)	2 (%100.0)
Dislocation	0 (%0.0)	0 (%0.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Stress fracture	1 (%2.9)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)
Sprain	3 (%8.8)	2 (%66.7)	1 (%33.3)	0 (%0.0)	0 (%0.0)	0 (%0.0)	3 (%8.8)	2 (%66.7)	1 (%33.3)
Crush-tissue hemorrhage-bruise	2 (%5.9)	1 (%50.0)	1 (%50.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)
Tendon rupture	0 (%0.0)	0 (%0.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)	1 (%2.9)	0 (%0.0)	1 (%100.0)
Tendon tear	0 (%0.0)	0 (%0.0)	0 (%0.0)	5 (%14.7)	2 (%40.0)	3 (%60.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)
Tendon degeneration	1 (%2.9)	0 (%0.0)	1 (%100.0)	2 (%5.9)	0 (%0.0)	2 (%100.0)	1 (%2.9)	0 (%0.0)	1 (%100.0)
Meniscus or cartilage lesion	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)
Jamming	1 (%2.9)	0 (%0.0)	1 (%100.0)	3 (%8.8)	1 (%33.3)	2 (%66.7)	1 (%2.9)	1 (%100.0)	0 (%0.0)
Tearing	2 (%5.9)	0 (%0.0)	2 (%100.0)	3 (%8.8)	1 (%33.3)	2 (%66.7)	3 (%8.8)	2 (%66.7)	1 (%33.3)
Nerve injury	2 (%5.9)	0 (%0.0)	2 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Muscle cramps and spasm	4(%11.8)	1 (%25.0)	3 (%75.0)	3 (%8.8)	1 (%33.3)	2 (%66.7)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Except those	3 (%8.8)	0 (%0.0)	3 (%100.0)	6 (%17.6)	1 (%16.7)	5 (%83.3)	2 (%5.9)	1 (%50.0)	1 (%50.0)
I don't know	1 (%2.9)	0 (%0.0)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	2 (%5.9)	1 (%50.0)	1 (%50.0)

N; Number of gymnast.

Table 5. Analysis data on injury causes of artistic gymnasts by body locations.

	Head – Trunk Location			Upper Extremities			Lower Extremities		
	n	Female	Male	N	Female	Male	n	Female	Male
Overuse (overload)	3 (%8.8)	1 (33.3)	2 (%66.7)	14 (%41.2)	4 (%28.6)	10 (%71.4)	6 (%17.6)	2 (%33.3)	4 (%66.7)
Sudden onset (inadequate warm-up)	1 (%2.9)	0 (%0.0)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Non-contact trauma	1 (%2.9)	0 (%0.0)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Repetition of previous injury	2 (%5.9)	1 (%50.0)	1 (%50.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	2 (%5.9)	1 (%50.0)	1 (%50.0)
Due to contact with another athlete	1 (%2.9)	0 (%0.0)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Striking or falling from the apparatus	5 (%14.7)	2 (%40.0)	3 (%60.0)	4 (%11.8)	1 (%25.0)	3 (%75.0)	6 (%17.6)	4 (%66.7)	2 (%33.3)
Don't try to move before you're ready	1 (%2.9)	0 (%0.0)	1 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Except those	1 (%2.9)	0 (%0.0)	1 (%100.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)	3 (%8.8)	2 (%66.7)	1 (%33.3)
I don't know	5 (%14.7)	2 (%40.0)	3 (%60.0)	3 (%8.8)	1 (%33.3)	2 (%66.7)	0 (%0.0)	0 (%0.0)	0 (%0.0)

N; Number of gymnast.

Table 6. Analysis data of artistic gymnasts' body locations of injuries on apparatuses.

Floor exercise	Head – Trunk Location			Upper Extremities			Lower Extremities		
	N	Female	Male	N	Female	Male	n	Female	Male
	6 (%17.6)	1 (%16.7)	5 (%83.3)	6 (%17.6)	3 (%50.0)	3 (%50.0)	10 (%29.4)	5 (%50.0)	5 (%50.0)
Pommel horse	2 (%5.9)	0 (%0.0)	2 (%100.0)	4 (%11.8)	0 (%0.0)	4 (%100.0)	1 (%2.9)	0 (%0.0)	1 (%100.0)
Rings	1 (%2.9)	0 (%0.0)	1 (%100.0)	5 (%14.7)	0 (%0.0)	5 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
High bar	2 (%5.9)	0 (%0.0)	2 (%100.0)	2 (%5.9)	0 (%0.0)	2 (%100.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)
Uneven bars	2 (%5.9)	2 (%100.0)	0 (%0.0)	2 (%5.9)	2 (%100.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)
Parallel bars	3 (%8.8)	0 (%0.0)	2 (%100.0)	4 (%11.8)	0 (%0.0)	4 (%100.0)	2 (%5.9)	0 (%0.0)	2 (%100.0)
Vault	2 (%5.9)	0 (%100.0)	2 (%100.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)	3 (%8.8)	2 (%66.7)	1 (%33.3)
Balance beam	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	0 (%0.0)	1 (%2.9)	1 (%100.0)	0 (%0.0)

N; Number of gymnast.