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Ankle injuries of elite male Iranian gymnasts and anthropometric characteristics

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Abstract

In men's gymnastics, the ankle is the most frequently injured part of the body. However, very few studies have been conducted to determine the roles of various risk factors so that the rate of these injuries can be reduced. The aim of this study was to determine the relationship between anthropometric factors (intrinsic risk factors) and the ankle injuries incurred by elite male gymnasts in the Iranian Premier League and Division One. This research was cross sectional correlation study in its nature. The injuries of 43 elite male gymnasts were recorded for the past year based on a questionnaire and interviews. Also their anthropometric characteristics, including weight, height, body mass index, percentage of fat, somatotype, size of the body, girth of the ankle, length of the lower extremities, and girth of the calf, were collected according to criteria established by the International Society for the Advancement of Kinanthropometry. The correlation method of non-parametric tests (Spearman) and event tree analysis (ETA) were used to identify the relationships between the variables. Seventy-nine percent of gymnasts experienced ankle injuries over the past year, mostly on the floor (58%) and vault (29%), and joint and ligamentous injuries occurred most frequently. Body size had a positive relationship with the injuries ($p < 0.05$), and no meaningful correlation was identified between number of injuries and other anthropometric characteristics ($p < 0.05$). Gymnasts and coaches should pay special attention to body size as an intrinsic risk factor and take preventive measures to decrease ankle injuries.

Keywords: Risk factor, ankle injuries, anthropometry, gymnastics.

INTRODUCTION

Studies have shown that aspects of a person's physique may have a crucial role in preventing the occurrence of injuries, because biomechanical efficacy may be enhanced by certain anthropometric characteristics. For instance, people who are shorter and weigh less generally have a greater ratio of strength to weight, greater stability, and a reduced moment of inertia. Body fat, which contributes to mass without enhancing a person's capability of creating power, is a distinct disadvantage for a gymnast (14). In addition to, other researchers have noted this relationship to greater and lesser extents. For instance, in a study on preventing sports injuries in children and adolescents, it was stated that heavier gymnasts are more susceptible to injuries (2). In 2010, Kolt and Caine (20) reviewed the intrinsic risk factors in gymnastics and stated that increased body size (height and weight), age, and body fat resulted in greater risk that a gymnast will be injured. Also, other researchers have reported that increases in any factors related to body size, such as height, weight, lean muscle mass, body fat content, BMI, and mass moment of inertia lead to proportional increases in the forces that articular, ligamentous, and muscular structures must be able to withstand; however, the researchers also stated that the relationship between body size and injury required additional investigation (27). Furthermore, epidemiological studies of injuries associated with gymnastics have shown that the lower extremity is the major anatomical location of injuries for men (35.9 - 70.2% of injuries). A more specific assessment of this region of the body indicated that ankle injuries are the most frequent injuries incurred by gymnasts (20). Moreover, a study in Iran on the injuries of elite male gymnasts confirmed that ankle injuries were the most frequent injuries to the lower extremities (28). Thus, while satisfactory numbers of research efforts regarding epidemiology of gymnastic injuries have been conducted, only a few of them have addressed risk factors. For instance, poor anthropometric characteristics, which increase

the probability of injuries significantly, have not been studied adequately to date (6,18).

Due to the crucial role of the ankle in gymnastics and the high incidence of injuries to the ankle, this study was focused exclusively on this component of the gymnasts' anatomy. Clearly, there has been inadequate investigation of the injuries of male gymnastics and their anthropometric characteristics (as an intrinsic risk factor) in Iran and other parts of the world so that it has been a matter of concern in Olympic sports medicine literature (20). Thus, our focus was on clarifying this correlation based on the data we acquired and our observations. So, the main aim of this study was to determine the correlation between the rate of ankle injuries and the anthropometric characteristics of the elite male gymnasts who compete in the Premier League and Division one in Iran.

MATERIALS AND METHODS

The current research was a cross sectional correlation study among 60 gymnasts who participated in the Iranian Male's Gymnastics Super League and Division one. Forty-three gymnasts voluntarily took part in the survey. The inclusion criteria were that 1) the gymnasts must be competing in the League and 2) the gymnasts must have had a minimum of six years' experience in gymnastics that covered all of the gymnasts in that competition. Sports injury specialists conducted a direct interview of the athletes in order to complete the questionnaires that referred to injuries in the past year. The first part of the questionnaire was concerned with the demographic data of participants, and it consisted of eight questions; the second part of the questionnaire included six tables of frequency, type, and severity of ankle injuries on six apparatuses used in gymnastics. The validity of the questionnaire was verified by specialists in sports medicine and experienced coaches of gymnastics; its reliability was determined to be around 75% to 85% by Cronbach's alpha method.

Since there are different apparatuses in gymnastics on which gymnasts work out even when they are injured, an injury was defined as "any damaged body part (in our study, only the ankle) that requires medical attention or prevents or restrict the gymnast from training or competing in any activity/apparatus in any way and/or any length of time" (1). Generally, the duration of restriction from training and competition was the basis for defining the severity of the injury. Moreover, according to the definition of injury, the time until the gymnast could return to his customary activity in training or competition used as a basis for reporting the severity of the injury. Therefore, severity of an injury was graded as slight (1-3 days), minor (4-7 days), moderate (8-28 days), and major (more than 28 days) (8).

The anthropometric characteristics of the gymnasts that were measured consisted of weight, height, body mass index (BMI), percentage of fat, somatotype, size of the body, girth of the ankle, girth of the calf, and length of the lower extremity. The tools used for the measurements were tape measure (Mabis Model), an analogue scale (Seca Model), a caliper (Slim Guide), a small digital caliper, Excel program of level one Performance and the manual of the International Society for the Advancement of Kinanthropometry (ISAK) (33). Body size was determined by measuring the circumference of the wrist; a wrist girth less than 17 cm was grouped in the small body size, 17 to 18.5 cm was grouped in the medium body size, and greater than 18.5 cm was grouped in the large body size (9). For gathering information related to injuries and anthropometry, the ratio scale was used for the quantitative variables, and the ordinary scale was used for the qualitative variables. Then, by using SPSS Version 15 (SPSS, Inc., Chicago, Illinois, United States of America), the correlation method of non-parametric tests was used to identify the relationships between the variables according to data scale and level. Therefore, after using the K-S test to verify that the distribution of the data was not a normal distribution, the Spearman and ETA methods were used to determine the correlations ($P < 0.05$).

RESULTS

The age range of gymnasts was 16 to 28 years with a mean age of 20.47 years; their mean time as gymnasts was 13 years, and the mean age at which they started gymnastics was 7 years old. The mean number of training sessions in a week was 5.25, and the mean time of the sessions was 2.66 hours. In general, they devoted 24 minutes to warm up and 13 minutes to cool down for each session, and 42% of the participants used ankle bandages during training. Thirty-three gymnasts were meso-ectomorph, five gymnasts were ecto-mesomorph, and four gymnasts were meso-endomorph. The other anthropometric characteristics of the elite male gymnasts are presented in Table 1. The results

indicated that 79% of the gymnasts had experienced ankle injuries over the past year and 29% of them occurred during competition, while 71% occurred in the practice phase. Seventy-six percent of the injuries reported in landing, and 24% while executing the routine, excluding the landing. Table 2 shows that joint and ligamentous injuries occurred with the greatest frequency. Floor (58%) and vault (29%) were the apparatuses that were involved in the majority of ankle injuries, and they were followed by the pommel horse and the parallel bars in that order. According to the definitions of the severities of injuries, 34% of the injuries were classified into the slight intensity group, while minor, moderate, and major injuries were 50%, 13%, and 3%, respectively. In addition, the correlation between ankle injuries and anthropometric characteristics was investigated. Table 3 shows that only body size had a positive relationship with ankle injuries ($P = 0.002$, $r = 0.524$), and no significant relationships were found between the presence of the ankle injuries and other anthropometric characteristics ($P < 0.05$).

Table 1. Anthropometric characteristics of elite male gymnasts (n = 43).

Variable	Mean	SD	Max	Min
Weight (kg)	64.33	7.2	79	45
Height (cm)	170	0.05	1/80	1.58
BMI (kg/m^2)	22.15	2	26.53	17.25
Fat percentage	7.31	1.4	12.02	5.44
Endomorphy	1.43	0.5	3.30	0.7
Mesomorphy	4.79	1	6.80	2.50
Ectomorphy	2.68	0.9	4.70	0.80
Body size	2.09	0.4	3	1
Lower Extremity Length (cm)	87.33	3.3	93	77.6
Ankle girth (cm)	21.62	1.2	24.2	19
Calf girth (cm)	35.59	2.6	45.2	30.5

Table 2. Type of ankle injuries in elite male gymnasts (n = 43).

Injury type	Frequency	%
Torsion	81	55.2%
Dislocation	25	17%
Inflammation	10	6.8%
Total joint/ligamentous injuries	116	79%
Strain	25	17%
rupture	1	0.7%
Total muscular injuries	26	17.7%
Simple fracture	5	3.4%
Total bone injuries	5	3.4%
Total ankle injuries	147	100%

Table 3. Correlation of the number of ankle injuries among elite male gymnasts in one year with their anthropometric characteristics.

Anthropometric Variables	Spearman	
	Correlation Coefficient	P-value
Weight	-0.061	0.696
Height	-0.146	0.351
BMI	-0.022	0.890
Endomorphy	-0.015	0.925
Mesomorphy	-0.061	0.698
Ectomorphy	-0.029	0.852
Fat Percentage	-0.007	0.967
Lower Extremity Length	0.080	0.610
Ankle Girth	-0.140	0.369
Calf girth	-0.218	0.160
Body size	0.524 (Eta)	0.002*

* Significantly different at $P < 0.05$.

DISCUSSIONS

To our knowledge, this is the first research in Iran that has paid special attention to the ankle injuries of elite male gymnasts and their anthropometric characteristics. In the last decade, gymnasts have been developed more complicated skills that have led to landing from greater heights unto an unstable surface, often with rotation. These situations have caused more ankle injuries, and several studies have indicated that the ankle is the location where most injuries occur in lower extremities among male gymnasts (4-19). In our study, we did not compare the frequency of ankle injuries with other anatomical locations, but the high rate of ankle injuries is supported several investigations that have been mentioned. Regarding the types of injuries, sprains were the most frequently reported type of injury among gymnasts and athletes in general (8). A significant number of these sprains occurred in the ankle (8, 13, 11), and others mentioned sprains for injuries in general (18, 20, 30), which are in agreement with our results. The severity of a sports injury basically depends on three factors, i.e., 1) the level of tissue damage, 2) the type of structure that was injured, and 3) the nature of the injury itself (8). However, generally in the investigations of sports injuries, and particularly in gymnastics, injuries are assessed on the basis of "time loss" to show the severity of the injuries. Accordingly, in one study, it was reported that 76.6% of injuries among female gymnasts were minor because they resulted in restricted activity for less than 7 days. In turn, they mentioned 10.9% and 12.5% of the injuries were moderate (8-21 days of time loss) and major injuries (more than 21 days time loss), respectively (3). In 2002, Kirialanis and colleagues observed the injuries of 100 male and 87 female gymnasts weekly for a year (19). They indicated that minor, moderate, and major injuries in male gymnasts were 26.8%, 44%, and 29%, respectively. This inconsistency may be due to the fact that we defined the severities of injuries specifically, and this led to a clear understanding of minor injuries. Moreover, we focused only on ankle injuries, instead of injuries in general and difference in gender and the mean age of the population that we studied in compare with other studies could be the reason of discrepancy in the results.

Male gymnastics have six apparatuses, and each one requires special skills. Consequently, the injuries and risk factors that each apparatus causes are rather different. In one research effort, injuries to senior, elite, male gymnasts associated with each apparatus were studied. The researchers found that the most of the injuries to the lower extremities occurred on the floor and in the vault, while, in another research project, ankle injuries were found to be the most common injuries in these two apparatuses (3). Other researcher (5) evaluated each of these apparatuses separately and reported that the floor was the main site for injuries to male gymnasts, followed by rings and horizontal bars. Kirialanis and colleagues (18) highlighted particularly the role of the apparatus in the injuries to the lower extremities of male gymnasts in 2003. While they mentioned the floor as the main event for ankle injuries, they referred to parallel bars, the vault, and horizontal bars after that. Although other studies have supported the observation that the floor is the main apparatus for ankle injuries, the vault has not been mentioned as the second apparatus for ankle injuries. The difference between these other results and our results may be due to the facts that gymnasts of different ages have different skills and anthropometric characteristics and that they conducted overall assessments of injuries rather than focusing on one anatomical location, as we did.

Our results indicated that 76% of ankle injuries occur in the landing phase. Generally, a gymnast tries to present a perfect landing after doing a routine, usually when his fatigue is at its maximum level. This is to be expected because the final score is usually better if the gymnast shows great skill and perfection in executing a difficult landing. All of these factors create a difficult and risky situation for a gymnast in the landing phase, leading to many ankle injuries. In fact, the landing phase is the main source of injuries in general and specifically ankle injuries among gymnasts, as has been proved by several researchers (13, 11, 29, 24). Regarding anthropometric characteristics, our gymnasts were slightly lighter (by about 2 kg) and taller (by about 2 cm) than the gymnasts who were involved in the research done by Cuk and colleagues in 2012 among elite male gymnasts (5).

In our research, we analyzed the correlation of the number of ankle injuries with anthropometric characteristics, including weight, height, BMI, fat percentage, somatotype, length of the lower extremities, girth of the ankle, girth of the calf, and body size. Among these factors, only body size has a positive and meaningful correlation with the

epidemiology of ankle injuries in elite male gymnasts (Table 3). In studies of risk factors that affect injuries, body size has been analyzed in different ways, including height, weight, lean muscle mass, body fat content, BMI, and moment of inertia of the mass. An increase in any of these variables produces a relative increase in the forces that must be resisted by articular, ligamentous, and muscular structures; therefore, they have been considered as risk factors for injury (27). At the same time, any increase in height and weight proportionally increases the degree of inversion torque that the ligaments and muscles of the ankle complex must resist (1). Kolt and Caine (20) reviewed the intrinsic risk factors in gymnastics in 2010 and stated that body size (height and weight), age, and body fat were all greater in injured gymnasts and in gymnasts who were at high risk of injury. Also, Emery (12) studied the prevention of sports injuries in children and adolescents and stated that heavier gymnasts are more susceptible to injuries. Steel and White (32), after a survey about the injuries of female gymnasts, concluded that body characteristics, such as height, mesomorphy, and lumbar curvature, were associated with increased injuries in elite female gymnasts. Other researchers (23, 34) stated that factors related to physique, such as height and somatotype, can separately increase an individual's predisposition to injuries.

We did not find any reported research that specifically investigated the relationship between the ankle injuries of gymnasts and their anthropometric characteristics even though it has been done in other sports. Watson (36) investigated the ankle sprain of eight Gaelic football and hurling players over four years. He found that male soccer athletes who experienced ankle sprains were taller than those who did not. In 1991, Milgrom and colleagues (26) reported that, during basic training, male military recruits who were taller and heavier were at increased risk of suffering an ankle injury. It has been shown by other authors that, among professional soccer players, increased BMI and body weight increased the propensity for ankle sprains (10, 35).

In contrast, some researchers have indicated that is no relationship between anthropometric characteristics and injuries. For instance, Wright and De Cree (37) divided 15 gymnasts, who were 8 to 18 years old, into groups, i.e., those with a low rate of injuries and those with a high rate of injuries, and found no meaningful variations between the body types of the two groups. Jackson and colleagues (15) investigated the prediction of young athletes' injuries and did not point to any important correlation between injuries and physique, and this finding was supported by other authors (2, 22). Moreover, ankle sprains and predictive factors were investigated specifically in another study (1) in which the researchers stated that height and weight were not independent risk factors; this conclusion also was supported by the work of other researchers (2, 25, 31). In all of these different studies, there was no conformity concerning important variables, such as gender, age group, sport, and the anatomical location of injuries, so it should not be surprising that the studies produced conflicting results. Our study has had two limitations that made it difficult to generalize our results. The first limitation was the number of participants. We were only able to include 43 gymnasts in the study. While it was difficult to get these 43 elite male gymnasts to participate in our research, we realize that this small number of participants was not enough to allow us to generalize our results from a statistical perspective. The second limitation of our study is related to gathering data about injuries retrospectively. While we did our best in order to extract the gymnasts' memories of their ankle injuries during the past year, we are not completely sure that we were able to list all of the ankle injuries or elicit their details from the gymnasts. This lack of confidence could influence the final results of this research and our ability to generalize those findings.

In conclusion; the findings of this research showed that just one characteristic (i.e., body size) out of eleven body characteristics was correlated with ankle injuries. We suggest that coaches and gymnasts pay special attention to this factor and other factors that could be related to it, such as weight and height. If a gymnast's physical characteristics are different from the normal, elite gymnasts' characteristics, he should be aware of the data concerning the probability of an injury occurring and undergo special preventive training and action, especially for weight-bearing body parts, such as the ankle. Looking carefully, anthropometric characteristics could have different influences on injuries according to the sport, body part, age group, and gender, because these factors lead to meaningful changes in anthropometric characteristics. Therefore, looking for a correlation

of injuries and anthropometric characteristics in general could be basically irrational unless researchers are willing to pay attention to these factors. So, we tried to clarify them exactly in our study, although we could not find any published paper with complete similarity in these factors with which to compare our results. Consequently, we suggest additional study of the anthropometric characteristics of male gymnasts and their injuries to separate anatomical parts, especially the parts with higher injury rates, such as ankles, wrists, shoulders, and the lower back.

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Conflict of Interest

There is no conflict of interest to be declared.

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