

## Correlation between elite male Iranian gymnast's wrist injuries and their anthropometric characteristics

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### Abstract:

**Background:** In gymnastics, wrists are under considerable force that causes various injuries. The influences of various risk factors have not been studied sufficiently to date to reduce the wrist injuries of gymnasts. The aim of this research was to determine the relationship between anthropometric characteristics and the wrist injuries of elite male gymnasts who took part in the Iranian Premier League and Division One in 2012.

**Methods:** This was a cross-sectional correlation study concerning the injuries of 43 elite male gymnasts. The extent of their wrist injuries was determined by a questionnaire and interviews. Also, their anthropometric characteristics were collected according to the criteria established by the International Society for the Advancement of Kinanthropometry. Event tree analysis and the Spearman rho correlation coefficient were used for statistical analysis.

**Results:** Among the gymnasts, 53.5% experienced wrist injuries over the past year, and the rate of wrist injuries was three per gymnast for one year. The incidents of skin and muscular injuries were the most prevalent type of injuries followed by Injuries to ligaments and bones respectively. Body weight was the only anthropometric characteristic of the participants that was found to have a significant positive relationship with wrist injuries ( $P < 0.05$ ).

**Conclusion:** Gymnasts and their coaches should pay special attention to gymnasts' weight as an intrinsic risk factor and take the required actions to prevent wrist injuries.

**Keywords:** risk factors, wrist injuries, anthropometry, gymnastics

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### 1. Introduction

It has been suggested that a gymnast's physique has a crucial role in injuries because biomechanical efficacy may be enhanced if the gymnast has certain special anthropometric characteristics. For instance, gymnasts who are shorter and weigh less have greater ratios of strength to weight, greater stability, and reduced moments of inertia. Body fat increases the gymnast's mass, but it is considered to be highly disadvantageous because it does not improve the gymnast's power (1). Other researchers also have noted the relationship between injuries and physique. For

example, in 1986, Steele and White (2) observed that weight, height, age, mesomorphy, and standing lumbar curvature were common factors in almost 70% of elite female British gymnasts who sustained injuries. Similarly, other authors have reported that the physique of 156 immature elite gymnasts was related to the risk factor of ulnar variance. The results showed that elite young gymnasts who are more mature, taller, and leaner have been prone to experience positive ulnar variance in their wrists (3). Other researchers also have reported such results about gymnasts' injuries and their anthropometric characteristics (4, 5). Furthermore, many elements are engaged when a gymnast is supported only by the upper extremities in artistic gymnastics. This situation subjects the wrist to abnormally high forces that can cause several injuries (6-9).

Previous studies have addressed the epidemiology of gymnasts' wrist injuries of gymnasts and found that up to 13.8% of the injuries occurred in the upper extremities (10). Also, Nikro and colleagues indicated that almost 10% of the injuries suffered by elite male Iranian gymnasts were injuries to their wrists that were the main injury location in the upper extremities (11). However, to date, very little attention has been paid to risk factors, e.g., poor anthropometric characteristics (12-14). Attention has been focused mainly on gymnasts' wrists because of the severe and continual forces that are exerted on this anatomical part. However, the important relationship between injuries to male gymnasts and their anthropometric characteristics (as an intrinsic risk factor) has not been investigated sufficiently in Iran or in other part of the world, so that it has been a matter of concern in Olympic sports medicine literature (10). Therefore, in this study, our main aim was to determine the correlation between wrist injuries and the anthropometric characteristics of elite male gymnasts who competed in the Premier League and Division One in Iran.

## **2. Materials and Methods**

### **2.1. Research Design and Population**

The current study was a cross-sectional correlation study among elite male gymnasts who participated in the Iranian Male's Gymnastics Super League and Division One in 2012. There were approximately 60 gymnasts on 14 teams. The inclusion criteria were 1) a minimum of six years experience in gymnastics and 2) participation in the competition league that covered all active elite male gymnasts in Iran. The sample size included the 43 gymnasts who took part voluntarily in the survey. Since the total population of elite male gymnasts in Iran consisted of 60 gymnasts, no sampling methods were used, and researchers tried to persuade the gymnasts to participate in the study. However, 60 gymnasts declined the offer to participate, and only 43 gymnasts agreed to participate.

### **2.2. Measurement tool**

Sports injury specialists conducted a direct interview of the athletes in order to complete the questionnaires. The first part of the questionnaire had eight questions about the demographic data of the participants, and the second part included six tables of the frequency and types of wrist injuries on six gymnastic apparatuses for one year. The validity of the questionnaire was verified and approved by sports medicine specialists and experienced gymnastics coaches, and its reliability was evaluated to be between 76 and 85% by Cronbach's alpha method. Since there were different apparatuses in gymnastics in which gymnasts worked out even when they are injured, the injury was defined as "any damaged body part (in our study we only refer to wrist) that required medical attention or prevented or restricted the gymnasts from training or competing in any activity/apparatus in any way and/or any length of time" (1). The anthropometric characteristics of the gymnasts that were measured were weight, height, body mass index (BMI), fat percentage, somatotype, body size, wrist girth, and forearm girth. Measurements were made with various devices, including a tape measure (Mabis Model), an analog scale (Seca Model), caliper (Slim Guide), small digit caliper, and the Excel program of level one Performance; all measurements were performed according to the criteria established by the International Society for the Advancement of Kinanthropometry (ISAK) (15). The body size was determined by a person's wrist circumference. A wrist girth of less than 17 cm was grouped in small body size, the range of 17–to 18.5 cm was grouped in medium body size, and more than 18.5 cm was grouped in the large body size category (16).

### **2.3. Data collection**

First, the researchers took the Gymnastics Federation of Iran agreement for collecting data in dormitories of the competitors. Then, we arranged a meeting with coaches and representatives of the gymnasts and informed them regarding the aims and advantages of our research for gymnasts. We asked them to transform the data for their gymnasts and allowed them to come in a measurement room between 8:00 A.M. and 1:00 P.M. the day after their competitions. In the room, the gymnasts were asked to complete the injury questionnaire while a sports specialist

was available to answer any questions they might have. After that, an anthropometrist measured their body characteristics and wrote them in special forms.

#### 2.4. Ethical consideration

In their first meeting with the researchers, the gymnasts read and signed a consent letter. It showed their complete agreement to participate in the study, reassured them their raw data with their names would be kept secret by the researchers, and reminded them that only the results that supported our scientific aims would be published.

#### 2.5. Statistical methods

For gathering information related to injuries and anthropometric features, quantitative variables used a ratio scale and qualitative variables used an ordinary scale. SPSS Version 15 (SPSS, Inc. Chicago, Illinois, United States of America) was used to identify the variables' relationships according to data scale and level. Therefore, the distribution of data was examined by the Kolmogorov-Smirnov (K-S) test and showed that they were not normal. Consequently, Spearman and ETA methods were used to define the correlation coefficient ( $P < 0.05$ ).

### 3. Results

The age range of gymnasts was 16 to 28 years with a mean age of 20.47 years; their mean years of experience was 13 years; the mean age of starting gymnastics was 7 years old, the mean number of training sessions in the week was 5.25, and the time of each session was 2.66 hours. In general, they devoted 24 minutes to warm up and 13 minutes to cool down each session, and 81% of the participants used wrist bandages during training. The results indicated that 53.5% of the gymnasts had experienced wrist injuries over one year and the average rate of wrist injuries was three per year for each gymnast. Sixteen percent of the injury incidents occurred in competition, and 84% occurred during training. The incidents of skin and muscular injuries were the most frequent at 56%, and this was followed by joint and ligamentous injuries and bone injuries.

**Table 1.** Type of wrist injuries in elite male gymnasts (n = 43)

Injury type	Frequency	%
sprain	8	6.5
Dislocation	3	2
Inflammation	19	15
Wrist ganglia	19	15
Strain	11	9
wound	60	47
Closed fracture	5	4
Hairline fracture	2	1.5
Total wrist injuries	127	100

**Table 2.** Anthropometric characteristics of elite male gymnasts (n = 43)

Variable	Mean	Standard deviation	Max	Min
Weight (kg)	64.33	7.2	79	45
Height (cm)	170	0.05	1/80	1.58
BMI (kg/m <sup>2</sup> )	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
Upper Extremity Length (cm)	74.23	13.2	79	67
Wrist girth (cm)	17.9	0.7	19.5	15.7
Forearm girth (cm)	27.23	1.2	30.5	24.8

Thirty-three gymnasts were meso-ectomorph, five gymnasts were ecto-mesomorph, and four gymnasts were meso-endorph. Other anthropometric characteristics of elite male gymnasts are presented in Table 2. In addition, the correlation of the number of wrist injuries and anthropometric characteristics were investigated. Table 3 shows that only weight was positively related to wrist injuries ( $P = 0.02$ ,  $r = 0.34$ ), and no significant relationship was found between wrist injury epidemiology and other anthropometric characteristics ( $P < 0.05$ ).

**Table 3.** The correlation of the number of elite male gymnasts' wrist injuries in one year with their anthropometric characteristics (n= 43)

Anthropometric Variables	Spearman/ Eta Correlation	
	Correlation Coefficient	P-value
Weight	0.34	0.02
Height	0.15	0.32
BMI	0.27	0.07
Endomorphy	0.08	0.57
Mesomorphy	0.09	0.55
Ectomorphy	-0.18	0.23
Fat Percentage	0.06	0.70
Upper Extremity Length	-0.12	0.42
Wrist Girth	0.11	0.45
Forearm girth	0.17	0.25
Small Body size	0.16	0.23
Medium Body size	0.23	0.36
Large Body size	0.15	0.31
Total body size	0.24	0.21

#### 4. Discussion

Male gymnasts work out their elements while in four out of six apparatuses the whole body weight is supported merely by an upper extremity, which changes the wrist into a weight-bearing joint. Undoubtedly, body weight is the minimum force that is tolerated by wrists because this force could increase considerably during take-offs and landings on the hands. These situations are even more complex because gymnastics skills require wrist extensions of 90° or greater, while the normal wrist extension is about 60-75° (7). High volume repetitions, weight bearing positions, more range of motion and usually starting gymnastics from a young age, several years before skeletal maturity, make the wrist one of the most commonly injured body parts, with up to 13.8% of injuries (4, 7, 10, 17). Although different studies have mentioned the wide range of wrist injuries in gymnasts (from 46% to 79%), all of them highlighted the high frequency of this problem, especially among elite male gymnasts (18-20). In our study, we did not compare the frequency of wrist injuries with other anatomical locations, but the high rate of wrist injuries is supported by the mentioned investigations. The authors generally did not mention the specific types of injuries to the wrists of male gymnasts. However, in 1993-1994, the National Collegiate Athletic Association's (NCAA) Injury Surveillance System Report for Gymnastics, the top injury types were sprain (22-35%), strain (12-26%), contusion (7-17%), and fracture (7-12%) (21). We focused on wrist injuries in our study, and have been shown that the wounds were the most reported injury in male gymnasts (47%). Since gymnasts usually support their wrists by leather and other kinds of bandages, the friction between skin and the bandages during gymnastic activities can lead to wounds that sometimes limit the workout of gymnasts.

Regarding anthropometric characteristics, our gymnasts were slightly lighter (around 2 kg) and taller (around 2 cm) in comparison with research has been done by Cuk and colleagues in 2012 among elite gymnasts (22). As we discovered in our research, just weight among anthropometric characteristics had a positive correlation with wrist injury epidemiology in elite male gymnasts (Table 3). In specific, the four main wrist injury mechanisms mentioned including throwing, weight bearing, twisting, and impact (23). All four mechanisms may cause wrist injuries by doing gymnastics elements on six apparatuses. During gymnastics activity, the wrists are under continual stress as they are training different elements and support themselves just by the upper extremity. Consequently, the weight mechanism has a more important role on the onset of injuries. According to the aforementioned facts, heavier

gymnasts can expect more injuries based on what our results showed. For instance, Difiori and colleagues particularly investigated wrist pain risk factors in 52 gymnasts in 1996 (24). They clarified that 73% of gymnasts experienced wrist pain during the last six months. They also pointed that gymnasts with wrist pain were noticeably heavier, older, higher level, and did more training in a day. In addition, these results are supported by another researcher who did a review about ulnar variance and its related risk factors in gymnasts (25). Other authors who focused on risk factors of gymnastic injuries in general also have noted the relationship between weight and injuries from a different perspective. Hume, in 2005, mentioned physical characteristics as an intrinsic risk factor and stated that decreasing some factors, such as weight and height, led to increased mechanical proficiency and eventually to decreases in injuries (1). Also Emery studied sports injury prevention in children and adolescents in 2005 and mentioned that heavier gymnasts are more susceptible to injuries (4). Furthermore, the injury epidemiology of collegiate female gymnasts since 1988 to 2004 was perused. It explained that the gymnast's weight reaches to 5 to 17.5 times more than their original body weight, especially in taking off and landing during tumbling, which may raise their injury rate and severity (21). Overall, it seems that added weight enhances the force on the joints to several times the original body weight, making gymnasts ultimately prone to more injuries.

Some investigators have not reported any direct and meaningful correlation between body weight and gymnasts' wrist injuries. For instance, in 2006 Difiori and colleagues (17) perused the distal epiphysis injury of radial, wrist pain and ulnar variance in the young gymnast, which is common in gymnasts. He mentioned very soft mats, over training in growth years, more training hours during the week, and doing elements at higher level as the risk factors that may make them susceptible to injuries. Also, there are other studies that did not mention weight as a risk factor in gymnastics injuries (3, 26). Dissimilarities of groups under survey and their body characteristics (which comes along mostly by different gender), the training situation of the gymnasts, the equipment used in Iran, and studies of the relation between body characteristics and whole body injuries rather than a specific anatomical part could explain these discrepancies.

As we surveyed in our study, between the number of gymnasts' wrist injuries and other body characteristics including height, mesomorphy, ectomorphy, endomorphy, fat percentage, wrist girth, forearm girth, body size and BMI did not confirm any significant correlation, which is in agreement with other research. For instance, Wright and De Cree in 1998 (5) divided 15 gymnasts who were 8 to 18 years old into two groups based on low and high rates of injuries. They found no meaningful variations between the two groups' body types. Although the studies on the relationship between injuries and male gymnasts' physique are rather scarce, these kinds of studies have been conducted more among female gymnasts and other athletes. For instance, Jackson and colleagues investigated the prediction of young athletes' injuries in 1978 (27) and did not point to any important correlation between injuries and physique (28, 29).

However, another group of researchers, i.e., Steel and White in 1986 (2), after a survey about the injuries of female gymnasts, declared that body characteristics, such as height, mesomorphy, and lumbar curvature, increased the elite female gymnasts' injuries. Also, some other authors have argued that factors related to physique, for example, height and somatotype, can increase an individual's predisposition to injuries separately (30, 31). Gender and related variety in physique, different apparatuses for men in comparison with women that each one can influence on injuries separately can be the reason of differences between mentioned studies and our study.

Our study has had some limitations that made it difficult to generalize our results. The first limitation was the small number of subjects, because we were limited to 43 gymnasts. Although it was difficult to get 43 elite male gymnasts to participate in our research study, this small population was insufficient for generalizing our results from a statistical perspective. The second limitation of our study is related to gathering injuries data by retrospective view. While we did our best to obtain the gymnasts' memories about their wrist injuries during one year, we could not be sure that we received information about all of the wrist injuries that occurred. This lack of confidence could influence the final results of this research and their generalization. The last factor that could have had considerable effect on the results and that was not discovered in our study was the time that gymnasts devote to working out on special apparatuses. For instance, a heavy gymnast may plan the majority of his workout time on the horizontal bar and rings that impose less pressure on wrists, resulting in his reporting fewer wrist injuries. However, a gymnast who is not heavy may work out mostly on the pommel horse that forces significant stress on the wrists and subsequently report more injuries in spite of his lighter weight.

## 5. Conclusion

The findings of this research showed that just one out of eleven body characteristics (i.e., weight) has any correlation with wrist injuries. As many elements and movements are done on the hands in gymnastics and sometimes the weight on them is several times more than body weight, it can be concluded that heavier gymnasts are more subject to wrist injuries. According to the gymnastics situation, we suggest to coaches and gymnasts that they pay special attention to this factor and other factors that could be related to it, such as body size. If a gymnast's physical characteristics are out of the normal elite gymnasts' characteristics, he should predict the possibility of injury and take special preventive training and the required action especially for weight-bearing body parts. Looking carefully, anthropometric characteristics could have different influences on injuries according to field of sport, body part, age, and gender because these factors lead to meaningful change in anthropometric characteristics. Therefore, looking for a correlation of injuries and anthropometric characteristics in general could be basically irrational without paying 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 to which to compare our results. Consequently, we suggest more study on anthropometric characteristics of senior male gymnasts and their injuries to separate anatomical parts, especially the parts with higher risk of injury, such as the wrists, ankles, shoulders, and lower back.

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## Conflict of Interest:

There is no conflict of interest to be declared.

## Authors' contributions:

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

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