Characteristics of sports injuries and factors associated with injury in beginners of female artistic gymnastics

Características das lesões desportivas e fatores associados com lesão em iniciantes de ginástica artística do sexo feminino

Características de las lesiones deportivas y factores asociados con lesión en iniciantes de gimnasia artística del sexo femenino

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ABSTRACT | The artistic gymnastics is a modality that associates arts with biomechanical gestures, and it has been prominent among children and adolescents. Its practice can lead to sports injuries; therefore, it is important to know the factors inherent to trauma for the formulation of preventive models. Thus, the objective of this study was to characterize sports injuries and to verify factors associated with injury in people practicing artistic gymnastics with different levels of competitiveness. Forty-six gymnasts were interviewed with mean age of 10.1±2.0 years for female participants, who were classified in two competitive levels, i.e, initiation and training. We used the morbidity questionnaire adapted to sports characteristics to collect personal, training, and injury data. It was observed that injury risk was 0.3 injuries per athlete and 1.4 injuries per injured athlete, in which the gymnasts of the training category showed a higher frequency of the injury (83.3%; n=10) compared with the ones in the initiation category (10.5%; n=4). For both levels of competitiveness, training moment and light severity were the most reported variables. In the mechanism, contactless was more prevalent in the training category (90%; n=9) and the direct contact was more common at initiation category (75%; n=3). Anthropometric and training variables were considered as factors associated with injury to the gymnasts. It is concluded that gymnasts of the training category have higher injury frequency. Anthropometric and training variables were factors associated with injury. Characteristics of the injuries depend on the competitiveness level of the gymnasts.

Keywords | athletic injuries; morbidity surveys; epidemiology; cross-sectional studies; prevalence.

RESUMO | A ginástica artística é uma modalidade que combina arte a gestos biomecânicos e tem se destacado entre crianças e adolescentes. Sua prática pode conduzir a lesões desportivas, por isso é importante conhecer os fatores inerentes ao traumatismo para formulação de modelos preventivos. Desse modo, objetivou-se caracterizar as lesões desportivas e verificar os fatores associados com lesão em praticantes de ginástica artística de diferentes níveis de competitividade. Foram entrevistadas 46 ginastas, com média de idade de 10,1±2,0 anos do sexo feminino, classificadas em dois níveis competitivos: iniciação e treinamento. Utilizou-se o inquérito de morbidade referida adaptado com as características da modalidade para reunir dados pessoais, de treinamento e da lesão. Foram observadas 0,3 lesões por atleta e 1,4 lesões por atleta lesionado, em que ginastas da categoria de treinamento apresentaram maior frequência de lesão (83,3%; n=10) do que as de iniciação (10,5%; n=4). Para ambos os níveis, o momento treinamento e a gravidade leve foram os mais relatados. No mecanismo, o sem contato foi mais prevalente na categoria de treinamento (90%; n=9) e o contato direto foi o mais frequente na iniciação (75%; n=3). As variáveis antropométricas e de treinamento foram consideradas fatores associados com lesão para as ginastas. Conclui-se que ginastas da categoria de treinamento possuem maior frequência de lesão. As variáveis antropométricas e de treinamento foram fatores associados com lesão. As características das lesões dependem do nível de competitividade das ginastas.

Descritores | traumatismos em atletas; inquéritos de morbidade; epidemiologia; estudos transversais; prevalência.

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RESUMEN | La gimnasia artística es una modalidad que combina arte y gestos biomecánicos, y es destacada entre niños y adolescentes. Su práctica puede conducir a lesiones deportivas, por eso es importante conocer los factores inherentes al traumatismo para la formulación de modelos preventivos. De ese modo, el objetivo de este estudio es caracterizar las lesiones deportivas y verificar los factores asociados con lesión en practicantes de gimnasia artística de diferentes niveles de competitividad. Fueron entrevistadas 46 gimnastas, con edad media de 10,1±2,0 años de sexo femenino, clasificadas en dos niveles competitivos: iniciación y entrenamiento. Se utilizó la encuesta de morbilidad adaptada a las características de este deporte para recabar datos personales, de entrenamiento y de lesión. Fueron observadas 0,3 lesiones por atleta y 1,4 lesiones por atleta lesionado, en que gimnastas de la categoría de entrenamiento presentaron mayor frecuencia de lesión (83,3%; n=10) comparadas con las de iniciación (10,5%, n=4). Para ambos niveles, el momento de entrenamiento y la gravedad leve fueron los más relatados. En cuanto al mecanismo, el sin contacto fue el más prevalente en la categoría de entrenamiento (90%; n=9) y de contacto directo fue el más frecuente en la iniciación (75%; n=3). Las variables antropométricas y de entrenamiento fueron consideradas factores asociados con lesión para las gimnastas. Se concluye que las gimnastas de la categoría de entrenamiento poseen mayor frecuencia de lesión. Las variables antropométricas y de entrenamiento fueron factores asociados con lesión. Las características de las lesiones dependen del nivel de competitividad de las gimnastas.

Palabras clave | traumatismos en atletas; encuestas de morbilidad; epidemiologia; estudios transversales; prevalencia.

INTRODUCTION

Participation in physical activities as well as in sports has become more frequent, especially in the last decades[1]. Among the modalities of sports, artistic gymnastics has been famous for associating arts with high complexity biomechanical gestures in several events[2].

The practice of artistic gymnastics provides benefits for the cardiorespiratory and musculoskeletal systems. It also improves motor abilities and acquires skills regarding techniques[3-5]. However, Benetti, Schneider e Meyer[1]. stated that training dynamics, which include the type of activity, frequency, intensity, and duration, must be compatible to growth and development of the person, mainly in children.

Despite the fact that this sport does not have physical contact between the athletes, it has high impact due to the floor landings[6]. Caine and Nasser[7] described that for gymnasts aged 0-18 years and of recreational and schools levels, age, weight, and height are the main intrinsic factors responsible for the occurrence of injury. According to the authors, higher values of height and weight induce more risks of injuries, because they provide more impact to the integrity of the body structures, such as tendons and articulations[7].

Many researchers, coaches, and athletes are aware of how important it is to map the characteristics of musculoskeletal injuries about artistic gymnastics and to identify the frequency and ways of acquiring several injuries that the gymnasts are subjected to, both in trainings and in competitions[7].

Although one of the Brazilian studies covers findings of injuries in the elite artistic gymnastics[2], it has not yet been found in the published literature studies approaching its beginning in Brazil, condition in which children and adolescents, who are still under the maturation phase, are exposed to the possible casual factors. Therefore, we understand the relevance of the need of knowing the factors that are associated with injuries in artistic gymnasts of different competitive levels to create preventive and training models. Thus, the objective of this study was to characterize sports injuries and to verify the factors associated with injury in female artistic gymnasts of different levels of competitiveness.

METHODS

Subjects

Forty-six female artistic gymnasts from the Secretaria Municipal de Esportes de Presidente Prudente (SEMEPP), Brazil, participated in this study. It was a convenience sample with only the female gender.

Participants were divided into the following two groups according to the level of competitiveness: Initiation Category (n=38), gymnasts who received their first lessons in one year and could participate in internal competitions; and Training Category (n=08), gymnasts who participated in competitions whether they were regional and/or federal. This research was approved by the Research Ethics Committee of Faculdade de Ciências e Tecnologia (FCT/UNESP), under protocol 08/2010.

Study design and field procedures

This is a cross-sectional and retrospective study. Data were collected by individualized interviews that covered occurrence of injury and its characteristics for the last 12 months of practices and/or competitions. The interviews were carried out before or after the trainings, with the aim of not interfering in the ordinary sport dynamics and routine.

For data collection, the reported morbidity questionnaire (RMQ) was applied, which is an instrument to collect information about the general health state of a specific population, mainly because it is very easy to apply and its questions are very objective[2,8]. A pilot study was carried out to test its applicability in the target population of the research, which improved the questionnaire and provided more contact of the interviewer with the method under use, avoiding possible failures in data collections.

One interviewer, who was familiar with the instrument, performed data collection, and the participants answered the questions conducted by the investigator, who also had the responsibility of making notes in the questionnaire[8]. The information could be provided not only by the participant, but also by her coach, legal keeper or both, as suggested by Pereira[9].

Morbidity questionnaire description and injury definition

The questionnaire included questions about age, weight, height, time of training in years, and weekly hours of the participants' sports practice. Body weight was obtained using a Filizola scale and a portable stadiometer was applied to identify the height. Furthermore, the survey had questions about sports injuries that occurred in the last 12 months of training and/or competitions, such as troubled anatomical place, injury mechanism, injury moment, injury severity, return to normal activities, and relapses.

For the anatomical localization, an illustrative picture of the human body was shown to the participant for easier identification. The injury mechanism, which consisted of the participant's perception about the contact or gesture performed when the typical signs and symptoms of an acute episode appeared and/or type of activity in which these manifestations were more pronounced, was divided into direct contact, no contact, and overload[10,11]. The occurrence of the injury during the trainings or competitions was also verified. The injury severity was classified based on the National Athletic Injury Reporting System (NAIRS), according to the athlete's restraining period for recovery[10]. Return to normal physical activities was aimed at observing if returning back to sports practice without any changes in the normal training occurred with or without the presence of signs and/or symptoms, or if it did not occur only. Finally, the relapse was investigated to detect if such an occurrence had already been manifested at other occasions and at the same anatomical place[10,12].

For effectiveness of this study, any physical complaint from training and/or competition that limited a subject's participation for at least one day was considered an injury from sports, regardless of the requirement of the medical care[13].

Organization and description of categories of variables

To make the analysis and presentation of results easier, the variables were subdivided into categories from groupings to represent more expressive blocks of results.

As to the anatomical place, the following segments were selected: upper limbs, lower limbs, and trunk. Three injury mechanisms were considered as follows: i) injury through direct contact caused by one traumatic incident like falls[10,11]; ii) injuries without contact inherent to the sport itself, such as short distance runs, fast movement changes, leaps, landings, etc.[10,11]; and iii) injuries due to overload presented as chronic ones, which occur because of the repetitive effort of the musculoskeletal system[10,11].

The injury severity was divided into the following: light (one to seven restraining days), moderate (8 to 21 restraining days), and severe (above 21 restraining days or with permanent injuries)[10,12].

Statistical analysis

Initially, for the comparison of the anthropometric and training variables between injured and non-injured participants, Shapiro-Wilk's test was used to test data normality. When the normal distribution was accepted, the Student's *t*-test for independent samples was applied and in the non-normal distribution, Mann-Whitney's test was used.

To calculate the injury risk, the following formula was used: total number of injuries divided by the total amount of participants in the study. The risk of injury per injured athlete was calculated as follows: total number of injuries divided by the total amount of injured athletes.

The study of the association between anatomical place, mechanism, moment, severity, return to normal activities, and relapses according to the studied populations was carried out using Goodman's test for contrasts between and inside multinomial populations, according to the characteristics of the groups of variables under analysis. A 5% significance level was also adopted.

RESULTS

Subjects from this study presented a mean age of 10.1±2.0 years, body mass of 33.5±6.9 kg, height of 1.4±0.1 m, practice time of 1.6±1.1 years, and weekly hours of sports practice of 5.0±3.1 hours. Among the 46 interviewed gymnasts, in the last 12 months, 10 athletes reported 14 injuries; therefore, one of them presented more than one injury. The injury risk was of 0.30 and per injured athlete was of 1.40. Table 1 shows the difference between injured and non-injured gymnasts, according to intrinsic and extrinsic variables. They presented the intrinsic (age, weight, and height) and extrinsic (practice time and weekly hours of sports practice) characteristics as factors associated with the settling of injuries, in which gymnasts with higher mean or median scores for these variables were more injured that the non-injured athletes.

Table 2 presents the association between injury occurrence and level of competitiveness. The injury presence was statistically different in the training category when compared with the initiation category, while in the injury absence the initiation category was statistically different from the training category.

For the causal mechanism, there was a significant difference between the levels of competitiveness (Table 3). Athletes from the initiation category presented higher injury index due to the direct contact (75%; n=3) compared with those of the training category, who presented as the main causal injury factor for the mechanism without contact. For the injury moment, gymnasts from both the categories were more injured in the training period (Table 3). Regarding the injury relapse, the initiation category had more recurrent injuries (100%; n=4) compared with the training category, which presented a higher frequency of non-recurrent injuries (80%; n=8).

With regard to the anatomical place, no statistical differences were observed in both the categories (Table 4). For the injury severity, in both the categories, the most frequent was the light grade injury. In the initiation category, the symptomatic return to normal activities was more frequent (100%; n=4). For the training category, both the symptomatic (five injuries) and asymptomatic (five injuries) return presented higher frequency of injuries compared with the initiation category (zero and four injuries, respectively).

DISCUSSION

After analyzing factors associated with injuries in gymnasts, it was verified that a difference in the mean from both intrinsic and extrinsic factors between injured and non-injured gymnasts, was is in agreement with the findings observed by Caine and Nassar[7], who classified older athletes with higher values in the anthropometric and training variables, as likely to have an injury. However, Hoshi et al.[2] found homogeneous values of

Table 1. Distribution of the anthropometric measures and training variables of gymnasts according to injury occurrence

Variable	Injury		
	Absent	Present	p-value
Age[1]	9.4±1.3 (10.0) [8.9-9.9]	12.8±2.1 (14.0) [11.5-14.0]	0.001*
Weight[1]	31.7±4.9 (30.5) [30.1-33.4]	40.8±9.0 (43.5) [35.6-46.0]	0.003*
Height[2]	1.4±0.1 (1.4) [1.3-1.4]	1.5±0.1 (1.6) [1.4-1.6]	0.0011*
Training time[2]	1.4±0.5 (1.0) [1.2-1.6]	2.9±2.2 (2.5) [1.7-4.2]	0.0001*
Weekly hours[1]	3.9±1.5 (4.0) [3.4-4.4]	9.7±3.7 (12.0) [7.5-11.9]	0.001*

[1]Student's *t*-test; [2]Mann-Whitney's test; *Significant difference between injured and noninjured athletes (p<0.05)

Table 2. Distribution of the absolute and relative (%) frequencies, presence or absence of the injury, according to the competitiveness category of the gymnasts

Categories	Injury		
	Presence	Absence	Total
Initiation	4 (10.5)	34 (89.5)*	38 (100)
Training	10 (83.3)**	2 (16.7)	12 (100)

Goodman's test for contrasts between and inside multinomial populations
*Difference regarding the training category (p<0.05) and Difference regarding the presence of injury (p<0.05); **Difference regarding the initiation category (p<0.05) and Difference regarding the absence of injury (p<0.05)

Table 3. Distribution of absolute (n) and relative (%) frequencies, of the variables mechanism, moment and relapse of injury according to the competitiveness category of the gymnasts

Level	Injury mechanism			
	Direct contact	No Contact	Overload	Total
Initiation	3 (75)#‡	1 (25)	0 (0)	4 (100)
Training	0 (0)	9 (90)†•	1 (10)	10 (100)
Level	**Injury moment**			
	Training	**Competition**		**Total**
Initiation	4 (100)*	0 (0)		4 (100)
Training	9 (90)*	1 (10)		10 (100)
Level	**Injury Relapse**			
	Yes	**No**		**Total**
Initiation	4 (100)#¥	0 (0,0)		4 (100)
Training	2 (20)	8 (80)†Δ		10 (100)

Goodman's test for contrasts between and inside multinomial populations
#Difference regarding training category (p<0.05); †Difference regarding initiation category (p<0.05); ‡Difference regarding overload mechanism (p<0.05); •Difference regarding the direct contact mechanism and overload (p<0.05); *Difference regarding the competition moment (p<0.05); ¥Difference regarding the absence of relapse (p<0.05); ΔDifference regarding the presence of relapse (p<0.05)

Table 4. Distribution of absolute (n) and relative (%) frequencies, of the anatomical place, severity and return to normal activities variables according to the category of competitiveness of the gymnasts

Level	Anatomical place		
	Upper limbs	Lower limbs	Total
Initiation	3 (75)	1 (25)	4 (100)
Training	3 (30)	7 (70)	10 (100)
Level	**Injury severity**		
	Light	**Moderate**	**Total**
Initiation	4 (100)*	0 (0)	4 (100)
Training	9 (90)*	1 (10)	10 (100)
Level	**Return to normal activities**		
	Asymptomatic	**Symptomatic**	**Total**
Initiation	0 (0)	4 (100)	4 (100)
Training	5 (50)†#	5 (50)†	10 (100)

Goodman's test for contrasts between and inside multinomial populations
*Difference regarding moderate severity (p<0.05); #Difference regarding asymptomatic return (p<0.05); †Difference regarding the initiation category (p<0.05)

age, weight, height, and training time between injured and non-injured gymnasts, which resulted in the non-verification of factors associated with the injury.

In the present study, regarding the association of injury presence with competitiveness level, the training category had more frequency of injuries compared with the initiation category. Therefore, the injury risk may be intimately associated with the category, i.e., once the injury risk is higher, there will be more existence of exposure to musculoskeletal efforts in training and/or competitions[13]. According to Kolt and Kirkby[13], elite gymnasts present a 4.19 injury risk in a 12-month period, while the sub-elite gymnasts have a 3.30 risk for the same period. According to the authors, these findings are associated with the difficulties of movements performed by different performance levels[13].

The anatomical place did not present a statistical difference for both the initiation and training categories. Thus, the studies emphasize that the most compromised anatomical places in artistic gymnasts are lower limbs, mainly the knee and the ankle. According to findings by Harringe, Lindblad and Werner[11], the ankle is the most injured place. However, other studies about the same topic have noticed more frequency of injuries in the upper limbs[14,15].

Data of this study showed that for both the initiation and training categories, injuries occurred more frequently in the moment of training. Such fact may be associated with extended permanence time in an equipment and loss of concentration due to awareness of the practiced ability during the practice. Another explanation would be that muscle fatigue and decrease of neuromuscular coordination at the end of practices could provide higher risks of injury[11].

About the injury mechanism, it was observed that the training category presented the mechanism without contact as the most frequent one. The equipment used to practice artistic gymnastics, like parallel bars and rings, have the execution of leaps and acrobatics skills as their main characteristic, which provide loads that can reach 5 to 17.5 times the body weight of the athlete, when he/she reaches the floor, being inclined to injuries[6]. On the other hand, the initiation category presented the direct contact mechanism as the most frequent one. This can be explained by the inexperience of the gymnasts to perform acrobatics skills, without enough preparation; therefore, they did not perform an appropriate landing, due to which the favoring fell[2].

Gymnasts from the initiation category reported more relapses when compared with the training category. Studies have shown that when the competitiveness level of the athletes was higher, the recurrence of an injury in the same anatomical place may be increased[11,12], which was not in accordance with the findings of the present study. Kolt and Kirkby[13] showed that gymnasts with increased technical quality and competitive level change and return to practice without a complete recovery, because of the pressure suffered by the team members and to avoid a potential lack of physical activities, which is more feasible to injury recurrence.

Both the categories presented symptomatic return to the sport. Harring et al.[12] reported that 58% of the gymnasts stated that they competed in the presence of symptoms created by new or recurrent injuries, therefore these findings had an important clinical implication for the coaches and professionals of the Sports Sciences to establish appropriate protocols of rehabilitation and safe return to the sport after an injury[16].

With respect to the severity of the injuries, the light injury was the most predominant for both the categories. After searching in the relevant published literature, no articles were found that approach the relation between injury severity and artistic gymnastics. However, we believe that most occurrences of the light injuries occur due to the characteristic of the sample of the present study, formed in its majority by the initiation category, in which the intensity of practices is lower if compared with the training category.

The RMQ does not present a validation, which poses a limitation to this study. However, the use of RMQ is justified by the requirement of an instrument able to collect information about LD in the sports environment. Furthermore, the frequency of injuries was not collected per 1,000 practiced hours, which could have enriched the discussion of the study.

It is expected that the results obtained in this study will contribute to better understanding of injuries in children and adolescents, who practice artistic gymnastics, including a better planning, training adjustment, and injury prevention for them. Future studies should carry out a prospective follow-up of these injuries in this specific population.

CONCLUSION

It can be concluded that gymnasts from the training category are injured more frequently than those from the initiation category. In the direct contact mechanism, the relapse presence and the symptomatic return were more frequent in the initiation category, while in the mechanism without contact, the absence of relapse injuries and the asymptomatic return were predominant in the training category. Finally, a statistical difference of the anthropometric and training variables was noticed between the injured and non-injured gymnasts.

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