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REVISIÓN

AEROBIC GYMNASTICS INJURIES. REVIEW ARTICLE

LAS LESIONES EN LA GIMNASIA AERÓBICA ARTÍCULO DE REVISIÓN

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ABSTRACT

The aim of the present article has been to analyze the literature on the epidemiology of injuries in two aspects of aerobic gymnastics: as a physical leisure activity and a regulated sport to determine which are the most frequent injuries when practising this gymnastics modality.

In December 2011 a search was made in the databases: Teseo, CSIC, Scopus, Medline, Sport Discus, Wos, Pubmed, Enfispo and Pedro. The descriptors used were: "aerobic dance injury", "aerobic gymnastic injury" and "gymnastic injury."

Ten studies on competition Aerobic Gymnastics and fourteen on traditional aerobics were found. The studies show that in both activities the most frequent injuries are to the extremities and those affecting the muscles.

The search revealed that the scientific production on this sport is scarce and in the competitive area it centres on Spain.

KEY WORDS: Epidemiology, athletic injuries, aerobic gymnastics, sport prevention.

RESUMEN

El objetivo del presente artículo ha sido revisar la bibliografía relacionada con la epidemiología de las lesiones en la gimnasia aeróbica en sus dos vertientes: como actividad física y como deporte reglado, con el fin de poder enunciar cuáles han sido las lesiones más frecuentes durante la práctica de esta modalidad gimnástica.

La búsqueda se realizó en diciembre de 2011 en las bases de datos: Teseo, CSIC, Scopus, Medline, Sport Discus, Wos, Pubmed, Enfispo y Pedro. Se utilizaron los descriptores: “aerobic dance injury”, “aerobic gymnastic injury” y “gymnastic injury”.

En la vertiente competitiva se encontraron diez trabajos mientras que en el aerobic tradicional catorce. Estos estudios ponen de manifiesto que en ambas actividades las lesiones más frecuentes son en las extremidades y de tipo muscular.

Se constata que la producción científica respecto a esta actividad deportiva es escasa y en el ámbito competitivo se centra en España.

PALABRAS CLAVE: Epidemiología, lesiones, gimnasia aeróbica, deporte, prevención.

INTRODUCTION

Aerobic Gymnastics has two different forms which are understood in its two concepts; one as a sport for everyone and included within fitness, and the other as a competitive sport.

Aerobic Gymnastics as a physical activity was defined by Porta⁽¹⁾ as a “method of gymnastics with musical accompaniment for the maintenance and development of the general physical form of the individual with fundamentally aerobic exercises”. For Diéguez⁽²⁾, it is a moderate to highly intense (but not exhausting) physical exercise of prolonged duration, logically structured to the rhythm of music and with the purpose of attaining a general bodily and cardio respiratory improvement. This exercise is generally done in group session programmes and under the supervision of a qualified professional. It respects the postulates of aerobic training and adds the specific use of technical movements whose speed, range and general execution depend on the musical base used.

As a regulated sport, Vernetta⁽³⁾ defines it as an “institutionalised, competitive discipline with a specific technical regulation which aims to measure the general ability of all competitors.” This sports discipline is included in the FIG and is different from other gymnastics specialties in that the ages of the competitors in the senior category occasionally exceed 25 years. As in any other high performance test, it has to do with making the most of artistic, technical and physical qualities. Therefore, while performing the exercise (between 1 minute and 30-45 seconds \pm 5 seconds), depending on the disciplines, the gymnast must demonstrate the highest level of strength, resistance and flexibility. All of this is in a choreography (use of a series of basic steps from traditional aerobics) with high coordination difficulty in which transitions and links are integrated with the speed of the music used, which must be in the range of 150-160 BPM.

Both aspects of the sport have different characteristics as regards the injury problems. On the one hand, the characteristics of aerobics as a physical activity result with greater regularity in injuries to the lower limbs, in part due to the footwear used and the training surface. On the other hand, authors such as Navarro⁽⁴⁾ and Navarro, et al.⁽⁵⁾ point out that injuries due to “excessive training” and mainly those associated with jumps have greater consequences in the competitive realm.

With this work, the purpose is to know in general about the studies carried out with respect to the incidence and type of injuries in aerobic gymnastics in its two sport expressions. Therefore practitioners, gymnasts, coaches and trainers can take into account a series of recommendations in order to prevent the appearance of injuries.

MATERIAL AND METHOD

A literature review was performed on the topic of study through the following databases. Also, a manual search was done at the Pontevedra Campus Central Library, belonging to the University of Vigo (Spain).

The descriptors used were along the lines of “*aerobic dance injury*”, “*aerobic gymnastic injury*” and “*gymnastic injury*” even though they may have varied depending on the database’s thesaurus.

The research was carried out in December of 2011 and the search was limited neither by years of publication nor by languages because it was suspected that few publications would be found due to the short trajectory of gymnastics in sports.

Due to performing such an extensive search, the following inclusion criteria were established:

- *General studies of injuries in gymnastics.*

Attention was focused on the gymnastics disciplines with an independently assessed artistic component such as: rhythmic gymnastics and acrobatic gymnastics as a result of their similarity to aerobic gymnastics in this specific component.

- *Specific studies of injuries in aerobic gymnastics AG from the leisure-health and sports aspect.*
- *Have access to the complete text and at least, the abstract.*

The exclusion criteria were:

- *Studies of low quality or with little in common with our investigation.*
- *Studies that were repeated in various sources and even in the same source.*

RESULTS

At the beginning, a total of 2,013 articles were found in the databases using the aforementioned descriptors (Table 1). While in the manual search 146 results of original articles in different sources were found (monographs, magazines, etc.).

Table 1. Sources of information

Sources of information	Number	%
Teseo	27	1,34
CSIC	148	7,35
Scopus	158	7,84
Medline	277	13,76
Sport Discus	479	23,79
Wos	45	2,23
Pubmed	785	38,99
Enfispo	90	4,47
Pedro	6	0,30

Out of the total results found and based on the inclusion and exclusion criteria, 2,095 articles were excluded from the investigation. Therefore, the work was developed analysing 64 documents.

First, a general description was made of the material found during the search in regards to the type of documents (Table 2).

Table 2. Types of references

	Number	%
Monographs	6	9,38
Articles	47	73,44
Conference Proceedings	6	9,38
Thesis	5	7,81
Total	64	100

It was observed that the most substantial results are found in the section of articles in magazines, with the *American Journal of Sports Medicine* being the greatest source of references.

The information from the epidemiological studies of gymnasts' injuries in the different areas is compiled in the following table. Only the works which provided some of the information are shown (Table 3).

AUTHOR	YEAR	DESIGN	DATA COLLECTION	n	NUMBER OF INJURIES	SOURCE
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Table 3. Most relevant research in Gymnastics

GYMNASTICS	Garrick y Requa	1980	Prospective	Questionnaire Interview		141	Am J Sports Med
	Lowry y Leveau	1982	Retrospective	Questionnaire		786	Am J Sports Med
	Weiker	1985	Prospective	Questionnaire		105	Phys Sportsmed
	Steele y White	1986	Retrospective	Questionnaire	40		B J Sports Med
	Caine et al.	1989	Prospective	Interview	50	192	Am J Sports Med
	Lidner y Caine	1990	Prospective	Questionnaire Interview		90	Can J Sport Sci
	Dixon y Fricker	1993	Retrospective	Interview		325	Med Sci Sports Exerc
	Bak et al.	1994	Prospective	Questionnaire		41	Scand J Med Sci Sports
	Kolt y Kirkby	1995	Retrospective	Questionnaire	162	321	Sport Med Train Rehab
	Kolt y Kirkby	1996	Retrospective	Questionnaire		162	Aust J Physiother
	Kolt y Kirkby	1999	Prospective	Questionnaire	64	349	B J Sports Med
	Caine et al.	2003	Prospective	Interview	79	147	Phys Therap Sport
	Caine et al.	2003	Prospective				Am J Sports Med
	Marshall et al.	2007	Retrospective				J Athl Train
	Cupsisti et al.	2007	Retrospective	Questionnaire	49	70	J Sports Med Phys Fitness
Hoshi et al.	2008	Retrospective	Questionnaire		54	Rev Bras Med Esporte	
AEROBIC GYMNASTICS COMPETITION	Navarro	2003	Retrospective	Interview Questionnaire	60	156	Thesis
	Fetterplace	2004	Retrospective	Questionnaire	28	61	Dissertation
	Navarro et al.	2005	Retrospective	Interview Questionnaire	60	156	MD Revista Científica en Medicina del Deporte
	Abalo	2011	Retrospective	Interview Questionnaire Antropometric measurements	51	14	Thesis
AEROBIC GYMNASTICS LEISURE & HEALTH	Richie et al.	1985	Retrospective				Phys Sportsmed
	Vetter et al.	1985					Phys Sportsmed
	Garrick et al.	1986	Prospective Retrospective	Telephone Interview	411		Am J Sports Med
	Allen et al.	1986					Ann Sports Med
	Rothenberg et al.	1988					Am J Sports Med
	Cable et al.	1988	Retrospective		726		Am J Sports Med
	Mutoh et al.	1988					Phys Sportsmed
	Marchionni	1991		Questionnaire			Dissertation

DISCUSSION AND CONCLUSIONS

The bibliography related to Aerobic Gymnastics injuries firstly suggests a comparison of the results with other gymnastic sports that have an artistic component.

The epidemiological studies found in the diverse bibliography on injuries in gymnastics allow us to know and determine the potential areas of injury in the most comprehensive manner.

Characteristic examples are the studies presented by Caine⁽⁶⁾; Lindner and Caine⁽⁷⁾; Rozenblat⁽⁸⁾; Warnke and Marti⁽⁹⁾; Gremion et al.⁽¹⁰⁾; Grana and Weiker⁽¹¹⁾, Kolt and Kirkby⁽¹²⁾; Mendizábal⁽¹³⁾ and Caine⁽¹⁴⁾. In general, these works address the following aspects related to injuries: identify risk factors and practices, describe the most common injuries and design strategies to decrease vulnerability to this type of incidents.

In the first studies that were found on the incidence of injuries in gymnastics, the injuries mostly occurred in the lower extremities, followed by the upper extremities and lastly, in the spinal column^(15,16,17). However, the most current works point out the lower extremities^(18,19,20,21), in which the most affected area is the ankle^(18,19,20).

Other authors specifically address potential areas such as the wrist, elbows, shoulders, knee and lower back, among others^(7,22,23,24,25,26,27,28,29).

Other works on artistic gymnastics, such as the one by García⁽³⁰⁾ show the incidence of injuries by anatomical region, the ankle and the foot being the most injured, followed by the wrist and fingers and, in third place, the elbow and forearm. Other later studies, such as that by Durá et al.⁽³¹⁾, confirm that injuries occur in a gradual manner, mainly in the wrist, back and ankle. However, the affected areas vary according to the different works.

Based on the type of injuries as well as their location and causes, McAuley et al.⁽¹⁶⁾ carried out a review of all of the works done from 1974-1987. A large majority of the published studies tell us that sprains and strains are the most common injuries^(6,7,11,12,5,22,27,32) whereas other studies suggest wrist, toe and finger fractures are the most common ones^(16,17). Authors such as García⁽³⁰⁾ and Rozenblat⁽⁸⁾ refer to muscular injuries as the most frequent ones, as does Mendizábal⁽¹³⁾, who references painful contractures as the most common injuries in rhythmic gymnasts before belonging to the Spanish selection, while pain in the lumbar region becomes the most common once they belong to the selection or leave it.

Arce⁽³³⁾ generally concludes that the most frequent pathologies in gymnastics sports are: injuries due to overstraining⁽²⁶⁾, fatigue of segments and injuries due to an immature locomotor system. More specifically, Rozenblat⁽⁸⁾ points out that, in both rhythmic and artistic gymnastics, microtraumas, osteochondrosis and Sever's disease⁽³⁴⁾ in the lower limbs are the most frequent injuries in these disciplines. He also mentions that due to repeated hyperextensions of the trunk,

lower back pain and spondylolysis (detected by clinical tests) have higher levels of incidence.

Mendizábal⁽³⁵⁾ indicates that the injuries which have affected gymnasts during their sports career have been lower back pain, contractures and sprains. When gymnasts no longer practise the sport, the injuries are lumbar, cervical and dorsal pain. Currently, it is the 1st generation (1974-1981) which has more pains related to the spinal column. However, there is more hyperlordosis, spondylolysis, olisthy and dorsal pain in the 2nd generation gymnasts (1982-1992). The obtained results seem to indicate that the practice of high level rhythmic gymnastics does not cause as many injuries as it seems, in comparison to other sports. However, given the youth of the sample, it is possible that new pathologies may appear and/or the incidence of already existing ones may increase after a few years.

On the other hand, there are many studies^(6,14,30,31,33,36) which address the causes of traumas in the gymnastics disciplines, alluding to the type of material used, environmental characteristics, states of anxiety, the nature of the sport itself and excessive repetitions of difficult elements^(37,38) as the causes of the injuries. Other works^(14,39) allude to the theme of injuries and their impact on growth among gymnasts.

A study on injuries in rhythmic gymnastics was found, which refers to those suffered in dance⁽²⁴⁾.

The incidence of injuries to the gymnasts' locomotor system depends both on intrinsic factors, i.e., the anatomical-physiological characteristics of the athlete, and extrinsic factors such as the duration and type of sports practice, training conditions and material used⁽⁴⁰⁾. In regards to the former, two studies make reference to the frequency of injuries being related to the starting age of gymnasts. Daly et al.⁽⁴¹⁾ explain that young people have less coordination, structure and concentration. For Meeusen and Borms⁽²⁴⁾, the periods of intense training and growth provide the conditions for injuring oneself. However, Caine and Nassar⁽¹⁹⁾ describe that some high values of height and weight influence whether the gymnast will have injuries to the tendons and joints. Steele and White⁽⁴²⁾ add the age of the athlete to the previous causes.

Studies were also found on the materials used in gymnastics⁽³¹⁾, which analyse the mats used in rhythmic gymnastics and specifically the reception phase, coming to the conclusion that this can cause significant injuries, especially sprains and strains. Thus, between 54.1 and 70.2% of the injuries are to the lower extremities (knee/ankle), 18.1 - 25% to the upper extremities and up to 16.75% to the trunk-column (vertebral discs).

Following the same line of research, Pérez et al.⁽⁴³⁾ state that landings are mostly responsible for the lower extremities being the anatomical area in which the higher percentage of injuries (11 - 13%) are located, the percentage being higher in male gymnasts (54.1 - 70.1%) than in female gymnasts (34.4 - 43.1).

Between 15.1% and 2.5% of total injuries occur in the upper extremities, and between 7.5% and 16.5% in the spinal column.

Several authors end their review with an emphasis on the need to grant due regard to the facilities, work material and trainers' education as the keys for preventing gymnastics injuries⁽⁴¹⁾.

Others recommend using protective measures and integrating neuromuscular training⁽¹⁸⁾. However, for Kolt and Kirkby⁽³⁴⁾, stress is the best factor for predicting injuries.

In regards to aerobic gymnastics related injuries, we can point out that the bibliography related to competitive aerobics is short but current. In this field, the only references and investigations found on sports injuries are those by Navarro et al.^(5,44,45,46), Abalo et al.⁽⁴⁷⁾ and Fetterplace⁽⁴⁸⁾.

In the first work, Navarro et al.⁽⁴⁴⁾ descriptively set out an analysis of the Code of Points for competitive aerobics and the possibility of modifying it as a prevention of possible sports injuries in this discipline. According to the authors, the prevention of injuries in this sport fundamentally lies in the execution of a more structured and systematised training programme with good knowledge of the technique and methodology for teaching it, as well as the correct use of safety equipment while learning about the injuries and possible readjustments to the Code of Points in its requirements, some of which were revised and put into force in the previous edition from 2001 - 2004.

Navarro⁽⁴⁾ did the first epidemiological study on sports injuries associated with competitive aerobics, the theme of his doctoral thesis. The application of the principles of epidemiology to this sports discipline has contributed to shedding light on the determination of the risk factors in this relatively new sport.

The following year, a work published in Australia⁽⁴⁸⁾ analysed the injuries of gymnasts in the senior category over the course of the season before participating in the FISAF (Federation of International Sports, Aerobics and Fitness). A questionnaire was used to gather all of the information, with which 61 injuries were found. More injuries were caused in the lower extremities (52.4%), especially in the ankle/foot (29.5%), followed by the wrist (13.1%) and the lower part of the thigh (13.1%).

Navarro et al.⁽⁴⁵⁾ focused their research on the influence of the flooring used by gymnasts and injuries in sports aerobics. Their results show a high percentage of injury to these athletes (88%) due to not using a statutory floor, which reflects a problem of poor adaptation of the area to training as well as a lack of awareness of how important this aspect is. Likewise, this injury percentage is higher for those who do not use adequate flooring during the specific technique (including jumps) and doing jumps involving a fall with bending the arms and the splits due to the aggressive nature of these elements. Therefore, the authors

conclude that a hard and slightly flexible floor at the landing of the difficult elements affects the used joints as a result of this type of material. Based on this, we should emphasize the importance of using adequate flooring, a surface which allows the energy of impact to be absorbed and reversed, i.e., an elastic surface.

Later, Navarro et al.⁽⁵⁾ also set up a descriptive study with the purpose of discovering the incidence of acute and chronic injuries due to the practice and training of sports aerobics, and determining the type of injuries and their most frequent location. The results show a high injury rate in this sport, mostly in the adductors, hamstrings and upper body, specifically in the wrist area, due to the great demand of these structures by specific movements. On the other hand, muscular injuries are the most frequent, followed by joint injuries, and then bone injuries, which have a lower percentage. Chronic injuries are less common than acute ones even though there are more chronic injuries in the upper extremities, compared to a greater number of acute injuries in the lower extremities.

Navarro et al.⁽⁴⁶⁾ did an in-depth study on the differences of injuries between traditional aerobics trainers and competitive AG athletes. Likewise, they indicate that the specific predictive factor of injuries in the senior categories has been the trainer's work association of traditional aerobics with his/her competitive sports life.

Abalo et al.⁽⁴⁷⁾ did a comprehensive review on sports injuries and prevention related to sports with an expressive component and musical accompaniment such as AG, rhythmic gymnastics, dance, artistic roller and ice skating and synchronised swimming. The main purpose was to gather information on all of these disciplines in order to establish injury prevention programmes which improve the athletes' performance in these specialties.

There are two works, one by Vernetta et al.⁽⁴⁸⁾, which suggest the use of logistic regression equations as predictors of sports injuries that affect the lower limbs in sports such as athletics or basketball, and propose the application of these methods in the artistic gymnasts as a possible, valid way to be able to differentiate certain anthropometric parameters related to their sports injuries in the lower limbs, since there is proof in previous studies that it is one of the most affected areas. The other study, by Abalo and Gutiérrez⁽⁴⁹⁾, analyses the habits of use of protective material in the different categories and their relation to the appearance of injuries in the artistic gymnasts by means of a questionnaire. They came to the conclusion that the use of protective material is not very popular among athletes and its use may reduce the occurrence of some of the injuries.

Lastly, Abalo's thesis⁽⁵⁰⁾ analyses the injuries of Valencian gymnasts in the 2009 - 2010 season and tries to discover their relation to determined anthropometric and morpho-constitutional parameters through logistic regression equations to be able to prevent future injuries. Fourteen injuries that equally affected the

extremities and were mainly muscular injuries were found. One of the significant morpho-constitutional parameters in regards to lower-limb injuries of gymnasts was the average Q-angles for the left and right knees, as well as the support weight on the lower left limb.

In regards to traditional aerobics, the references found on injuries follow the same line of work by gathering information through surveys and questionnaires given to the participants^(52,53,54,55).

The results of the different studies are similar, showing a higher incidence of injuries to the lower extremities, repeated impacts on inadequate floors and overstress of the studied anatomical structures⁽⁵⁶⁾.

Cable et al.⁽⁵⁷⁾ conducted a study to find out what are the prevalence and types of injury in aerobics. With a sample of 726 gymnasts, the following locations of injuries were found: 24.5% in the shin and 12.9% in the lower part of the back, while 12.2% were in the ankle. Following the same line⁽⁵⁴⁾, a study was done to identify injuries in aerobics, doing a telephone follow-up involving 351 students and 60 instructors for 16 weeks. The most affected areas are the shinbone/leg, foot and ankle and their cause is related to previous orthopaedic problems, students' lack of physical activity and the type of session, while the type of shoe or floor had no effect.

Marchionni⁽⁵⁸⁾ found, by means of surveys, that 42% of the polled gymnasts had suffered an injury, the majority in the lower extremities (sprains and tibial stress syndrome), but a decrease of 70-75% in injuries compared to previous studies was shown, which means that injuries can be prevented.

In a study performed in Japan⁽⁵⁹⁾, a rate of injury of 72.4% for the coaches and 22.8% for the students was found with the lower part of the leg and foot affected the most. The cause of injuries seems to be excessive use, which means that a moderation of frequency, duration of participation and personalised programmes could reduce the number of injuries.

Other authors directed their works related to aerobics and the corresponding injuries to different topics of study, such as the advantages and disadvantages of its disciplines⁽⁶⁰⁾, the forces of impact that are produced^(61, 62), the surfaces on which it is practised⁽⁵⁶⁾ and the shoes used⁽⁶³⁾.

For Belt⁽⁶⁴⁾, the most common injuries are those due to overstress and are generally related to training errors, shoes, an inadequate work surface and biomechanical factors.

It can be concluded that the publication of works on injuries in aerobic gymnastics both from the leisure-health and performance aspect is lacking if we compare it with those existing on other gymnastics disciplines. In general, the majority of the studies correspond to references related to traditional aerobic

gymnastics, which is very limited in its competitive aspect. This could be due to it being a very young sports discipline, integrated into the International Gymnastics Federation in 1994.

A predominance of articles in English related to the leisure-health aspect was observed, with the *American Journal of Sports Medicine* being the greatest source of references. It should be highlighted that the scientific production of the competitive aspect has been concentrated in Spain in the last decade.

However, the need has developed to increase scientific production in this area of study, where necessarily the research in Spain should be promoted and be as visible as possible at the international level. This is especially true because Spanish gymnasts are in some of the first place positions in the international ranking. To do so, it is necessary to set new research challenges on this topic which span different areas (rehabilitation, prevention programmes, rehabilitation programmes, etc.), research designs (descriptive, correlational, experimental, validation of instruments, regression analysis, etc.) and that show the object of the study (confirmed athletes, young athletes, students, adults, etc.). It will be then, at the root of the obtained results, when intervention strategies may be created in order to reduce these injuries and risk factors in the gymnasts practising this discipline.

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