ORIGINAL ARTICLE

SPONDYLOLYSIS AND SPONDYLOLISTHESIS IN YOUNG GYMNASTS

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ABSTRACT

Objective: To determine the incidence of spondylolysis and spondylolisthesis among female gymnasts, and to correlate these with lumbar pain, history of trauma and training load. Method: Eighteen competitive-level Olympic-style gymnasts aged 8-17 years, with an average age of 11.3 years, were evaluated on a voluntary basis. The gymnasts answered a questionnaire about their sports activities and underwent a clinical examination and lumbar spine radiography. Results: The radiographs were analyzed by orthopedists specializing in surgery of the vertebral column. The prevalence of spondylolysis was 5.56%, while no cases of spondylolisthesis were found. Conclusion: The incidence of the radiographic abnormalities identified was similar to what has been reported in the literature for non-athletic individuals, and the lumbalgia reported by these athletes did not show any direct relationship with spondylolysis and spondylolisthesis.

Keywords – *Gymnastics; Spine; Lumbalgia; Spondylolysis; Spondylolisthesis*

INTRODUCTION

Olympic-style gymnastics is a sport that brings together the art of dance, the speed of action sports, the agility of ornamental jumps and the flexibility of ballet[(1)]. Official Olympic gymnastic (artistic) contests differ according to sex. For men, there are six events (jumping on pommel horse, floor exercises, horse with hoops, rings, parallel bars and fixed bar), while for women there are four events (jumping on pommel horse, balance beam, floor exercises and uneven bars).

The risk of injury in performing this sport is twice as great as in any other female sport, if the severity of the incident is not considered[(2-4)]. Spinal injuries account for 17.2% of all injuries in Olympic gymnastics, and are the second most common site for such accidents[(3-7)]. Spondylolysis affects 11% of female gymnasts, and the most frequent location is the fifth lumbar vertebra. It is characterized by the presence of lumbar pain that worsens with running and falling and improves with rest and trunk flexion[(1,8-10)]. In physical examinations on such patients, lumbar hyperlordosis and shortening of the posterior musculature of the thigh is found[(1,9)].

The most common injury mechanism is general hyperextension, caused by the impact against the ground when coming off the apparatus, or torsion during the exercises, such as twisting movements[(9,10)]. Other predisposing factors for lumbar pain are hyperlordosis and muscle imbalance[(10)]. Among the causes of lumbalgia in athletes, spondylolysis and spondylolisthesis are common. Among adolescent athletes, spondylolysis accounts for 47% of lumbar pain, while it accounts for 5% among adults[(11)]. On the other hand, lumbalgia is the main symptom of spondylolysis, although in many cases, it is diagnosed as an occasional finding from imaging examinations[(1,4,9,12)].

Among competitive athletes, the incidence of lumbalgia may reach 100%[(9)]. Among Olympic athletes, 63% of gymnasts present observable abnormalities in magnetic resonance examinations[(4)], and it has been proven that the longer and more exhaustive the training

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is, the greater the overload on the spine will be, which will result in injury to this segment[4,6-9,12,13].

The aim of the present study was to determine the incidence of spondylolysis and spondylolisthesis among female athletes performing artistic gymnastics, and the correlations with lumbar pain, history of trauma and training load.

METHODS

This was an evaluation on a voluntary basis, on 18 female athletes aged eight to seventeen years who were involved in competitive-level Olympic gymnastics. They were members of the team at the Olympic Training and Research Center. The inclusion criteria were that the individuals needed to:

- Have been regularly practicing Olympic gymnastics for at least one year.
- Present good physical and mental health.
- Be between eight and seventeen years of age at the time of the study.
- Be volunteers.

Furthermore, an adult responsible for these gymnasts needed to have been informed about the study and to have read, agreed and signed the free and informed consent statement.

The exclusion criteria were as follows:

- Presentation of an infectious or acute tumor process at the time of the examination.
- History of recent surgery.
- History of uncontrolled systemic arterial hypertension.
- History of systemic neurological disorders and/or convulsions.
- Presentation, on the day of the examination, of heart rate greater than 100 beats per minute or blood pressure higher than 160 x 100 mmHg, at rest.

Anamnesis and directed physical examinations were performed for all the athletes, with investigations on lumbar complaints and abnormalities of this segment that were presented on clinical examination. Following this, they filled out a questionnaire on their sports activities and any injuries that they had had as a result of their training. The athletes then underwent radiographic evaluation, using posteroanterior and lateral views of the thoracic, lumbar and sacral spinal segments, in the orthostatic position, using Siemens® radiography equipment adjusted to a power of 70 kV. The radiological examinations were initially evaluated by orthopedists specializing in spinal surgery who had not had any contact with the athletes. The findings were then compared with each athlete's historical clinical data.

RESULTS

The athletes' mean age was 11.38 years (range: eight to seventeen years) and their mean body mass index (BMI) was 16.84.

Investigation of the limb dominance pattern showed that 14 of the athletes were right-handed (77.77%), three were ambidextrous (16.6%) and one was left-handed (5.5%) (Table 1).

Table 1 – Body composition of the athletes in the sample

Athlete	Age	Weight	Height	BMI	Dominance
1	14	35	1.5	15.55	R
2	13	42	1.53	17.94	R
3	8	35	1.45	16.64	R
4	10	26	1.3	15.38	R
5	13	35	1.42	17.35	A
6	10	27	1.32	15.49	R
7	9	26	1.28	15.86	R
8	13	36	1.6	14.06	R
9	11	30	1.31	17.48	R
10	17	32	1.39	16.56	R
11	12	27	1.21	18.44	R
12	8	34	1.34	18.93	A
13	10	26	1.33	14.69	R
14	11	27	1.3	15.97	R
15	12	45	1.54	18.97	A
16	11	47	1.54	19.81	L
17	14	23	1.21	15.71	R
18	9	42	1.51	18.42	R

Age in years; weight in kilograms; height in meters; BMI = body mass index; dominance: A = ambidextrous, D = right-handed, L = left-handed

With regard to the intensity of the training, the gymnasts were training for an average of 27.77 hours per week; 13 athletes (72.22%) dedicated themselves to all four types of gymnastic event; three (16.66%) limited their training to floor, bar and beam exercises; one (5.5%) only did uneven bar and balance beam exercises;

and one (5.5%) focused only on floor exercises. The athletes who were training for fewer hours per week were doing so because of injuries and physiotherapy treatments that they were doing during training hours within the same sports complex.

The length of time for which the athletes had dedicated themselves to competitive sports ranged from one to eight years, with a mean of 4.27 years (Table 2).

Table 2 – Structure of the training undertaken by the gymnasts

Training structure		Athletes
Hours/week	10h	1
	20-25h	3
	30h	14
Apparatus	Floor	1
	Bar and beam	1
	Floor, bar and beam	3
	All	13
Length of time competing	Up to 2 years	4
	2-5 years	9
	More than 5 years	5

Hours/week: number of hours per week dedicated to training. Length of time competing: length of time in years for which the gymnasts had been participating in official competitions.

The general health of 14 (77.77%) of the athletes in the sample was excellent. One athlete (5.5%) presented a condition of allergic sinusitis that was controlled with general measures. The remaining three gymnasts (16.6%) presented health problems that required continuous use of medications. Nonetheless, using these medications did not interfere with these athletes' quality of life.

Investigation of personal antecedents of morbid conditions indicated that 15 athletes (83.33%) were free from previous surgical procedures. Two athletes (11.1%) had undergone umbilical herniorrhaphy during early childhood and one athlete (5.5%) had suffered a closed fracture of the elbow in 2005 that required a surgical procedure.

In the specific questionnaire on physical conditions relating to training, 15 athletes reported the presence of limiting pain in different locations, at different frequencies and intensities.

In answer to the questions on the presence of pain, independent of location, nine athletes (50%) reported that they were in pain in all training sessions; four (22.22%) were frequently in pain; two (11.11%) were occasionally in pain; and three (16.66%) said that their training was not impaired by pain (Table 3). We took the word "always" to mean periodicity of four or five episodes of pain per week; "frequent" to mean painful episodes appearing two or three times a week; "occasional" or "sometimes" to mean pain appearing around once a week; "rarely" to mean pain reported once a month; and "negligibly" to mean scattered episodes of pain.

Considering only the lumbar region as the site of limiting pain, three gymnasts (16.66%) reported the presence of pain in all training sessions, three (16.66%) reported frequent pain, five (27.77%) reported occasional pain, four (22.22%) reported pain on rare occasions and three (16.66%) did not indicate the spine as an important site for pain (Table 3).

Table 3 – Pain relating to the treatment

	Athletes with pain during training	Athletes with lumbar pain
Always	9	3
Frequently	4	3
Sometimes	2	5
Rarely	0	4
Negligibly	3	3

In correlating the appearance of the pain with the duration of training, 13 patients (72.22%) said that the peak pain occurred during the training, two (11.1%) said that they felt pain just after the training and three (16.66%) did not correlate the appearance of pain with the immediate training (Table 4).

Pain intensity is a very subjective parameter. The number of sports competitions that the athletes had failed to participate in because of pain was used for comparison purposes. The results from this showed that 12 gymnasts (66.66%) had never failed to compete because of pain and injuries resulting from training. On the other hand, three athletes (16.66%) had failed to participate in an important championship because of pain. One (5.5%) had failed to make a presentation on two occasions because of a painful condition, another (5.5%) had failed to participate in five competitions and, finally, one (5.5%) had been absent from sports events on many occasions because of pain relating to training and low-complexity sports injuries (Table 4).

Table 4 – Intensity and appearance of pain

		Athletes
Failed to compete	Never	12
	Once	3
	Twice	1
	5 times	1
	Many times	1
Training versus pain	During training	14
	After training	2
	No relationship	2

Failed to compete: number of times that gymnasts failed to participate in official events for which they had been classified but did not compete because of medical restrictions. Training versus pain: time relationship between training and appearance of pain.

Following this, radiograph evaluations were performed on the athletes, with emphasis on determining anatomical and pathological parameters, which are summarized in Table 5. The lordosis angle in the radiographic examination ranged from 10° to 40°, with a mean of 23°83' using Cobb's method (using a line tangential to the upper plateau of L1 and a lower line from the joint surface of L5; the lordosis angle was thus the angle formed by the intersection of perpendiculars from these lines). The sacral angle was between 20° and 55°, with a mean of 37°33'. The sacral incidence was between 5° and 32° (mean: 22°50'). This measurement was obtained as the intersection between a line tangential to the lower edge of the sacrum and a line perpendicular to the ground. Another important anatomical result identified from the radiographs was the incidence rate of spina bifida. In total, eight cases (44.45%) were identified radiographically, of which seven (38.88%) were at S1 and one (44.4%) at L5.

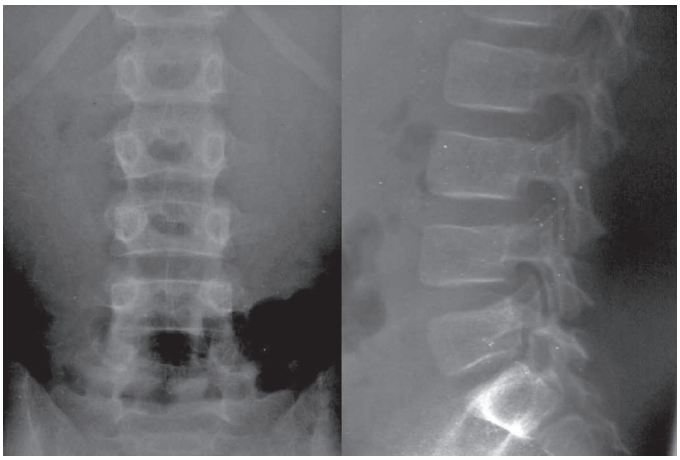

Figure 1 – Anterior and lateral radiographs on the lumbar-sacral spine, showing spondylolysis in L5

Investigation of spondylolysis resulted in finding one case (5.5%) at the fifth lumbar vertebra (Figure 1). No cases of spondylolisthesis were identified in this study sample. The athlete who presented signs of spondylolysis was eight years old, had been competing in the four events for one year and did not present any clinical abnormalities. She was training for around hours per week without restrictions. Among the group, she was one of the athletes with fewest complaints regarding pain during training, in relation to either the lumbar region or other regions of the body (Table 5).

Table 5 – Radiographic data

Radiographic findings		Athletes
Spondylolysis	L5	1
	Absent	17
Spina bifida	L5	1
	S1	7
	Absent	10
L1-L5 lordosis	10-20º	8
	21-30º	6
	31-40º	4
Sacral angle	20-35º	6
	36-40º	6
	41-55º	6

Lordosis and sacral angle: for parameters, see text

DISCUSSION

Given that lumbalgia is the main complaint in consultations with general orthopedists, it is important to determine its etiology. Among these causes, spondylolysis and spondylolisthesis have significant prevalence[4,9,10,11].

The most prevalent symptom in both of these conditions is lumbar pain, and it is worsened by physical activities, lumbar hyperextension and staying in the same position for a long time. This pain may irradiate to the buttocks and the posterolateral region of the thighs, and paresthesia, claudication and radicular or even medullary compressive symptoms may occur[10].

Studies in the literature have shown prevalence of spondylolysis of 4.4% to 5% among school-age children, reaching 6% at around the age of 14 years, and

7.2% among adults[14,15]. Higher prevalence has also been found among males and among Alaskan Eskimos, and lower prevalence among black people[16]. Among the etiological factors, it is known that heredity is a determining factor, as is growth[2]. The presence of trauma is considered to be a causal factor, as are repeated microlesions[12]. As suggested in the literature, one possible cause of spondylolysis is stress fractures of the *pars interarticularis* caused by microtrauma, which would suggest that the prevalence of spondylolysis would be greater in certain sports that generate hyperextension and, consequently, contact between the caudal edge of the lower joint facet and the *pars*[9,11]. Among the sports in question, weight-lifting, soccer, diving, ballet and gymnastics have been cited[6,10].

The radiographic examinations were analyzed by orthopedists specializing in spinal surgery, and a prevalence of 5.56% was found for spondylolysis. No cases of spondylolisthesis were found.

Thus, no difference in prevalence was observed between gymnasts and the general population. Although this was a small sample, the result obtained suggests that there is no direct relationship between Olympic gymnastics and spondylolysis or spondylolisthesis. One of the possible causes of the absence of lysis and listhesis in gymnasts' spines is that despite the overload due to hyperextension, their above-average muscle conditioning with regard to stretching and flexibility would compensate for the stress experienced. In the specific case of listhesis, the muscle strengthening coming from the sport itself and the stretching sessions that the gymnasts undergo would prevent its occurrence. On the other hand, regarding spondylolysis, a balance between causal factors and prevention brings the prevalence closer to that of the non-sportive population.

In the light of this evidence, it can be supposed that Olympic gymnastics does not predispose towards lysis or listhesis of the thoracic, lumbar and sacral spinal segments. This gives rise to doubt regarding their occurrence in other sports that present hyperextension. This would provide a motive for conducting similar studies on athletes within other specialties, such as diving, weight-lifting, parachuting and American football.

It is clear that other causes of lumbalgia among athletes need to be sought. At the same time, the influence of physical preparation in relation to technical preparation cannot be neglected, given that physical preparation seems to be a decisive factor in preventing anatomical lesions in the lumbar spine.

CONCLUSIONS

We conclude that the incidence of spondylolysis and spondylolisthesis was small in the present sample, compared with the literature, and that it did not present any correlation with the presence of lumbar pain among these athletes practicing artistic gymnastics. The sacral angles, for sacral incidence and lumbar lordosis, did not present any correlation with the presence of symptoms of pain or spondylolisthesis. Although it should be emphasized that this study presented a small sample of athletes, the incidence of such lesions was close to the occurrence among non-athletic patients reported in the literature.

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