Comparative study between symmetrical and asymmetrical sports by static structural analysis in adolescent athletes

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Summary

In pre-participative sports medical examinations, the analysis of the anatomical structures that are not directly related to the sport in question, is usually more superficial. A more detailed assessment of the locomotive system may reveal the existence of certain anomalies, which may occasionally go unnoticed.

The aim of this study is to describe the prevalence of structural disorders of the locomotive system among elite-level athletes from the Community of Madrid. To establish the relationship between alterations and practising symmetrical or asymmetrical sports.

Descriptive cross-sectional study Level of evidence II-III.

Our study sample includes athletes that are members of the Community of Madrid Sports Technification Plan. 102 athletes, 66 males and 36 females aged between 12 and 19 years. One control group comprises swimming athletes, a sport considered to be symmetrical, and the second group comprises athletes practising sports considered to be asymmetrical: fencing and badminton. The athletes were examined following a blind method by three different specialists using the same protocol.

Hypothesis contrasting has been used for qualitative variables, with a 95% confidence level ($p<0.05$).

Ninety-six athletes (94.1%) displayed some kind of structural and/or postural alteration in the pre-participative sports medical examinations. No significant correlation was found ($p<0.05$) between the different sports on alterations to the spine, knees, extremities and footprint, regardless of whether they were symmetrical or asymmetrical ($p<0.05$).

Conclusions: Our study revealed a high prevalence of structural variation in high-level adolescent athletes. No relationship was found between practising an asymmetrical sport and the prevalence of scoliosis or other muscular-skeletal alterations.

Key words:
Scoliosis. Sports medicine. Medical history taking. Musculoskeletal abnormalities. Foot deformities.

Estudio comparativo entre deportes simétricos y asimétricos mediante análisis estructural estático en deportistas adolescentes

Resumen

En los exámenes médicos preparticipación deportiva, el análisis de las estructuras anatómicas que no están directamente relacionadas con el deporte en cuestión, suele ser más superficial. Un examen más detallado del aparato locomotor podría revelar la existencia de ciertas anomalías que, en ocasiones pueden pasar desapercibidas.

El objetivo de este estudio es describir la prevalencia de trastornos estructurales del aparato locomotor en una población de deportistas adolescentes de élite de la Comunidad de Madrid. Establecer la relación de alteraciones con la práctica de deportes simétricos o asimétricos.

Estudio transversal descriptivo. Nivel de evidencia II-III.

Nuestra población de estudio incluye deportistas pertenecientes al plan de tecnificación de la Comunidad de Madrid: 102 deportistas, 66 hombres y 36 mujeres con edades comprendidas entre 12 y 19 años. Un grupo control está compuesto por deportistas de natación, deporte considerado simétrico y el segundo grupo por deportistas practicantes de deportes considerados asimétricos: esgrima y bádminton. Los deportistas fueron examinados siguiendo un método cegado por tres diferentes especialistas que utilizaron el mismo protocolo.

Se ha empleado el contraste de hipótesis para variables cualitativas, con un nivel de confianza del 95% ($p<0,05$).

Noventa y seis deportistas (94,1%) presentaron algún tipo de alteración estructural y /o postural en los exámenes médicos preparticipación deportiva. No encontramos correlación significativa ($p<0,05$) entre los diferentes deportes en las alteraciones en la columna vertebral, las rodillas, las extremidades y la huella plantar, independientemente fueran simétricos o asimétricos ($p<0,05$).

Conclusiones: Nuestro estudio muestra una alta prevalencia de variaciones estructurales en los adolescentes que practican deporte de alto nivel. No encontramos relación entre practicar un deporte asimétrico y la prevalencia de escoliosis u otra alteración músculo-esquelética.

Palabras clave:
Escoliosis. Medicina del deporte. Exploración clínica. Alteraciones musculoesqueléticas. Deformidades del pie.

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Introduction

The main aims of a pre-participation sports medical examination include, on the one hand, the ruling out of any pathology that may condition or impede incorporation into a specific sport, and on the other hand, an assessment of physical capacity at that specific time. This information allows us to establish a customised training plan, that is adapted to the physical and technical characteristics of the athlete, and appropriate for the needs of the sport practised[1]. In the majority of cases, the analysis of the anatomical structures that are not directly related to the specific sport is more superficial and on many occasions certain structural variations can be observed that may condition performance or increase the injury rate[2]. On the one hand, high intensity sport undertaken during periods of growth and adolescence may contribute to muscular-skeletal asymmetries[3], and on the other hand, poor joint alignment may condition the presence of injuries[4-8] and constitute an osteoarthritis risk factor[9,10]. A more detailed assessment of the locomotive system may reveal the existence of certain alterations, which upon correction may improve both aspects. Its detection may be more significant during the accelerated growth period, during adolescence (10-11 to 17 years in girls and 12 to 19 years in boys)[11]. During this period, the muscular-skeletal system may be particularly sensitive to traction forces that are performed[12-16]. Secondly, traditionally asymmetrical sports have been discouraged among young athletes that present some structural alteration to the spine in the frontal plane, as it is considered that these sports worsen these alterations by overloading one side of the body[15,17-19]. The aim of our study is to describe the prevalence of structural alterations of the elite athlete Madrid population aged between 11 and 19 years, and to study a possible relationship with the practice of an asymmetrical sport with the practice of an asymmetrical sport.

Study design: cross-cutting descriptive study. Level of evidence II-III.

Material and method

The study sample comprised 102 athletes, 66 males and 36 females aged between 12 and 19 years (average 15.58±2.14), from three sports: swimming, fencing and badminton. The control group was composed of athletes that practised swimming, considered to be a symmetrical sport. The choice of asymmetrical sports was carried out randomly from all the sports considered asymmetrical with athletes that had been technified by the Community of Madrid (handball, tennis, throwing, fencing and badminton) (Flow Chart. Figure 1). All the athletes were part of the Community of Madrid (CM) Sports Technification Plan (Spain), had over three years practice in the specific sport, and performed a minimum of two hours training a day. They were referred to the CM Sports Medicine Centre by the different sporting federations over the past three years for sporting-medical follow-up. Table 1 contains the total number of athletes classified by sex and by sport, with their anthropometric characteristics.

All the subjects and their legal guardians were informed about the nature and characteristics of the study, and prior to the start they signed the informed consent form, in accordance with the principles in the Helsinki declaration for research on humans[20].

Figure 1. Flow Chart.

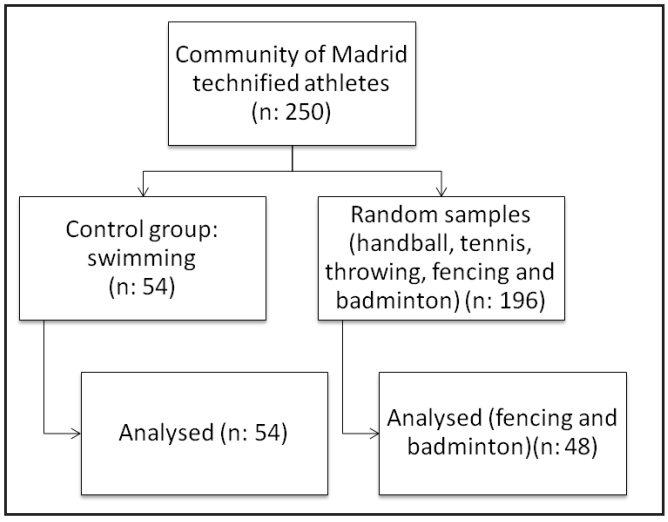

Table 1. Distribution of the sample by sex.

	n	Age	Height	Weight
Females				
Swimming	23	14 ± 1.9	1.64 ± 0.07	54.8 ± 8.46
Badminton	7	16 ± 1.29	1.63 ± 0.02	57.5 ± 3.60
Fencing	6	18.5 ± 0.83	1.60 ± 0.05	56.4 ± 4.41
Total	36	15.19 ± 2.33	1.64 ± 0.06	55.6 ± 7.17
Males				
Swimming	31	14.5 ± 1.7	1.69 ± 0.09	58.3 ± 11.5
Badminton	16	16.6 ± 1.8	1.70 ± 0.15	65.5 ± 10.61
Fencing	19	17.15 ± 1.2	1.75 ± 0.06	59.4 ± 7.25
Total	66	15.78 ± 2.0	1.71 ± 0.10	60.7 ± 11.35

Each athlete was assessed by three sports medicine specialist doctors, using a blind method, following the same work methodology as with previously consensual works.

Protocol

The static structural study included the anterior, lateral and posterior inspection of the spine, thorax and lower extremities facing a clear millimetre ruler, including a plumb line test and an anterior bending test, with the aim of assessing various postural or structural alterations of the spine (scoliosis, lumbar hyperlordosis and hyperkyphosis). The foot print was assessed using a podoscope, to establish the print type (cavus or flat). Measurement of the patello-femoral angle with a goniometer. Measurements of the intermalleolar and intercondylea distances and the knee extension angle, with the aim of assessing the *genu varo*, *valgo* or *recurvatum*. Measurement of the length of the lower extremities from the anterior-superior iliac spine to the medial malleolus, to assess possible dissymmetries. Normal limits were established for the different alterations found. It was considered *genu valgo* when the patello-femoral angle >6º and the intermalleolar distance >8 cm, *genu varo* if the intercondylea distance >3 cm and the patello-femoral angle >3º[21-23].

Genu recurvatum if the knee-joint angle was greater than 180º[24]. The assessment of flat and cavus foot was carried out by non-quantitative visual inspection[8,25,26]. Assessment of the lumbar curve was carried out by establishing the distance between the plumb line and the furthest point away from it, with the values classed as hyperlordosis if greater than 35 mm, normal if between 20 and 35 mm, and hypolordosis if less than 20 mm[27]. The kyphotic curve was assessed by measuring the distance of the plumb line to the spinous process of C7, with hyperkyphosis considered to be when the distance was greater than 30 mm and a flat dorsum lower than 15 mm[28]. The study of the frontal plane spinal deviations was carried out using the anterior bending test (Adam's test) and the measurements of the angles using a Scoliometer[29,30].

The total percentages of the structural deviations found in the feet, spine, and lower extremities, were established using the total study sample, while the analysis of each specific alteration was carried out on the partial sample group that presented some kind of anomaly in this area of the body.

The total rate of structural deviations among the athletes was compared to that obtained in each individual sport, with the aim of establishing a possible relationship between practising a specific sport and the development of some kind of structural alteration. Likewise, the cases were studied by sex and by sport, assessing the possible significant differences in each group. For the statistical handling of the data, SPSS 20 computing packages were used. EpiInfo 6.0 and Statgrafics version 6.0. Hypothesis contrasting has been used for qualitative variables, with a 95% confidence level ($p < 0.05$).

Results

In ninety-six athletes (94.1%), some kind of poor structural and/or postural alignment was detected during the examination. The examiners found that only six athletes (5.9%) did not present any alterations. Furthermore, no athlete presented secondary scoliosis (congenital, neurological, metabolic, etc.) according to the criteria from the *Scoliosis Research Society* (SRS)[31].

The alterations discovered were the following (Tables 2 and 3):

- *Feet:* In sixty-one athletes, alterations were detected in the footprint (59.8%). Six of them presented Grade I flat foot (5.9%), three had Grade II flat foot (2.9%), and two had Grade III flat foot (2%). Nineteen presented pre-cavus foot (18.6%), thirteen had Grade I cavus foot (12.7%), and eighteen had Grade II cavus foot (17.6%). Forty-one athletes did not present alterations in the footprint (40.2%).
- *Lower extremities: Knee:* alterations were discovered in the joints of twenty-seven athletes (26.5%). Nine with valgus knee (8.8%), six with varus knee (5.9%), and twelve with *genu recurvatum* (11.8%). Seventy-five athletes did not display any alterations in the knee joints (73.5%).
- *Dissymmetry:* Twenty-one athletes displayed leg-length difference (20.6%). Thirteen with Left Lower Limb (LLL) predominance (12.7%) and eight with Right Lower Limb (RLL) predominance (7.8%). Eighty-one athletes did not present dysmetria in lower-limbs (79.4%).

Table 2. Structural deviation by sport.

Sport	Spine	Knees	Dissymmetries	Footprint
Badminton	6 (18.2%)	4 (14.8%)	2 (9.5%)	16 (26.2%)
Fencing	10 (30.3%)	5 (18.5%)	6 (28.6%)	13 (21.3%)
Swimming	17 (51.5%)	18 (66.7%)	13 (61.9%)	32 (52.5%)
Total	33 (100%)	27 (100%)	21 (100%)	61 (100%)

Table 3. Structural deviations by symmetrical and asymmetrical sports.

Sport	Spine	Knees	Dissymmetries	Footprint
Asymmetric	16 (48.5%)	9 (33.3%)	8 (38.1%)	29 (47.5%)
Symmetrical	17 (51.5%)	18 (66.7%)	13 (61.9%)	32 (52.5%)
Total	33 (100%)	27(100%)	21(100%)	61(100%)

- *Spine:* Thirty-three athletes (32.4%) presented static postural and/or structural alterations in an anterior and posterior vision of the spine, the anterior bending test and measurement with the Scoliometer. Alterations to the frontal plane were: ten cases of right dorsal scoliosis (9.8%), eleven left dorsal scoliosis (10.8%), one right lumbar scoliosis (1%), one left lumbar scoliosis (1%) and two double thoracic curve (2%). The alterations found in the sagittal plane were: five athletes with hyperlordosis (4.9%), one hyperkyphosis (1%), and two cases of hyperkyphosis with hyperlordosis (2%). Seventy-nine athletes did not display any postural or structural alterations to the spine (67.6%). All the athletes had slight structural alterations to the spine[32,33], none of them presented scoliotic curves above 10º following measurement with the Scoliometer. In two athletes (8%), a left-thoracic curve was measured of over 15º, assessed with a radiographic study, presenting curves of 18º and 20º Coob for both cases. No significant correlation was found ($p < 0.05$) between the different sports and alterations to the spine, knees, extremities and footprint.

Discussion

An athlete's lack of progress and a higher injury rate may be associated with structural or postural alterations that have not diagnosed or corrected early. A detailed and thorough structural study of the muscular-skeletal system identifies some of these alterations, which a routine sports medical examination may not assess. In some cases it is necessary to carry out complementary tests such as radiological studies in order to assess them more thoroughly and appropriately[34].

In this study, structural variations were found in 94.1% of the study sample, similar results to a previous study in fencing[35]. Despite the majority of these deviations being considered variations of normality, given that in many cases there is no consensual agreement with strict clinical or radiological criteria for the definition of a flat foot[36]. Regarding lower limb dissymmetry, we consider it to be a difference of 5mm or more between the limbs, though the majority of authors do not consi-

der dissymmetries lower than one centimetre to constitute structural anomalies, nor do we know the long-term evolution in adolescents that practise high-intensity sport, nor the possible consequences on injury rates. However, the high deviation rate found implies that a more thorough study of the muscular-skeletal system would reveal anomalies, that despite not appearing in a superficial examination, may condition performance and increase the injury rate, which is why is would be advisable to carry out long-term prospective studies. In any case, it would be recommendable to diagnose and try to correct these issues early, before the athlete reaches high-level competition. The discoveries made, as well a previous studies[35,37], lead us to consider the need to carry out a more exhaustive structural study of children that are starting their sporting careers.

The practice of sports in general does not appear to be associated with the appearance or evolution of scoliosis[38], though there are studies that suggest that practising an elite sport from an early age presents a higher prevalence of scoliosis[17,39-42]. This information coincides with that found in this study, in which the percentage of structural alterations of the spine among the sample studies was 32.4%. This figure is higher than the general population[43-45] and is higher than the percentage found in the previous study[37]. In this study, no scoliotic curves were found of over 20º, which may suggest that scoliosis of over 20º may be a limiting factor for practising sports at an elite level. However, the structural alterations found require the establishment of special attention by medical staff that perform medical examinations on children and adolescents, in particular among high-level athletes. Furthermore, it is important to highlight the differential diagnosis of a structural scoliosis, in particular for left thoracic curves[46]. In these cases, a complementary radiographic or topographic study is recommended, given that the examination may not be enough to assess these curves[34].

Classically, a higher incidence of scoliosis and asymmetrical muscular-skeletal adaptations has been related to athletes that mainly use one part of their bodies, considered asymmetrical[15,17-19], though other authors have not found these same results from fencing[47]. In this study, we did not find a relationship between structural alterations and the practise of a specific sport, whether symmetrical or asymmetrical.

Till now, no strong scientific evidence has been produced proving that a compensatory exercise plan may prevent the progress of a scoliosis[48], likewise, the practise of an asymmetrical sport, as shown in this study, does not seem to increase the risk of scoliosis, even if carried out to a competitive level.

All the athletes examined filled out a questionnaire about the type of physical exercise performed, and all of them carried out compensatory exercises on the non-dominant side as part of training. It is not known if this may be the reason for not finding differences between symmetrical and asymmetrical sports. However, the results obtained lead us to insist upon the need to carry out compensatory exercises as part of training.

Study limitations: this work is a pilot study with an elite-level adolescent sporting population from a specific region in Spain. We therefore recommend studies with large study groups. We have not used a control group from the general public, which may be considered a study limitation. However, the aim of this study was to describe the alterations in high-level athletes and to alert them of the possible consequences of them on performance.

Conclusions

This study reveals a high prevalence of structural variations among adolescents that practise high-level sport, which is why the importance of a thorough physical examination in pre-participative sports examinations should be highlighted. No relationship was found between practising an asymmetrical sport and the prevalence of scoliosis or other muscular-skeletal alterations.

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