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REVIEW ARTICLE

Spondylolysis and spondylolisthesis in children and adolescents☆

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KEYWORDS
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Abstract Low back pain is a common cause of lost playing time in young athletes, and spondylolysis is its most common identifiable cause. Despite technological advances in radiology, which can lead to an early diagnosis with better prognosis, progression to spondylolisthesis is sometimes asymptomatic and may not be detected until late stages. There are wide variations, suggesting lack of consensus as regards the objective of treatment, which consists of clinical, radiological, biomechanical or functional improvement. There is also a lack of agreement regarding the ideal conservative treatment, surgical indications and need of slip reduction, and most of the established recommendations are not evidence based. We present a review of literature, which summarizes the current knowledge of spondylolysis and spondylolisthesis in children and adolescents.

PALABRAS CLAVE
Dolor lumbar;
Espondilolisis;
Espondilolistesis;
Balance sagital;
Reducción;
Fusión *in situ*

Espondilolisis y espondilolistesis en niños y adolescentes

Resumen El dolor lumbar es causa frecuente de cese de actividades deportivas en atletas jóvenes, y la espondilolisis es su causa identificable más común. Aunque los avances en las técnicas radiológicas permiten su diagnóstico en fases precoces, en algunos casos la progresión a espondilolistesis es asintomática y no se detecta hasta fases avanzadas. No hay consenso en el objetivo del tratamiento, que consiste en la resolución clínica, radiológica, biomecánica o funcional, según autores. También hay falta de acuerdo en el tratamiento conservador ideal, en las indicaciones quirúrgicas y en la necesidad de reducción de la espondilolistesis, y muchas recomendaciones establecidas no están avaladas por la evidencia. Presentamos una revisión de la bibliografía que resume el conocimiento actual de la espondilolisis y espondilolistesis en niños y adolescentes.

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Introduction

The term spondylolysis (from the Greek *spondylo* = vertebra, *lisis* = separation) refers to a unilateral or bilateral defect of the *pars interarticularis*, an isthmus of the posterior arch of the vertebral body between the superior and inferior joint facets. Spondylolisthesis (*olisthesis* = sliding) describes the ventral migration of a vertebral segment over another, usually preceded by spondylolysis, and identified as a clinical entity by obstetrician Herbiniaux in 1782.[1] Both have been frequently described as causes of lumbar and radicular pain in all age groups.

Epidemiology

The incidence in the general population varies depending on the reports and is difficult to determine, as it is normally only investigated in patients who suffer symptoms. In a classic dissection study, Roche and Rowe[2] found a 4.2% overall prevalence of spondylolysis. More recently, random groups of computed tomography (CT) scans obtained in adults due to reasons unrelated to lumbar pain (aortic, abdominal and urological pathology) have been studied and a defect of the *pars* has been observed in 9–11% of cases, nearly doubling the figure detected through simple radiographs and with no significant association to the presence of lumbar pain.[3,4] There is considerable ethnic variability, with a distribution of frequency from highest to lowest among Eskimos (around 40%), Caucasians (5–12%) and African–Americans (1–3%).[5] In general, a higher incidence has been reported among males, but this statement is controversial. It seems true that the progression to spondylolisthesis, which takes place in 25% of cases,[6] is more likely among females.[3–5] Both genders require surgical treatment with similar frequencies.[7]

Lumbar pain is a frequent cause of temporary interruption of sports activities among professional athletes, and spondylolysis is the most common identifiable cause.[8] Soler and Calderón[9] carried out a study among 3152 professional athletes in Spain and registered a prevalence of spondylolysis of 8.02% (not much higher than among the general population with a similar age), with no significant differences observed between genders but with great variability among disciplines. From higher to lower frequency, it was identified in throwing sports, artistic gymnastics, rowing, weightlifting, combat sports, swimming (breaststroke and butterfly stroke), volleyball, rhythmic gymnastics and synchronized swimming. In athletes with lumbar pain, the prevalence of spondylolisthesis was higher among adolescents (47%) than adults (5%).[8–10]

There is a strong association between defects of the *pars* and the presence of *spina bifida occulta*, which is only found in 5% of the general population but in up to one-third of patients with isthmic spondylolisthesis. It is advisable to investigate the coexistence of spinal dysrhaphism prior to a possible posterior approach, in order to prevent accidentally damaging the elements of the dural sac and to assess if repair of the *pars* is feasible.[11]

Pathogenesis

The exact etiology of the condition is not known, although it is likely that elongation of the *pars* has a multifactorial origin due to *predisposing factors* (hereditary, vertebral dysplasia–*spina bifida*, elongation of the facets, anomalies of the soft tissues or the physis, and sacropelvic morphology) and *environmental factors* (straight posture, gait and repeated load of the lumbosacral spine).

Although there is a genetic predisposition towards spondylolysis, it is not a congenital pathology and there have been no cases described among newborns. Neither are there any patients in age groups which have not learned to walk. This indicates that the increase in load generated by bipedal posture plays a significant role in the development of the condition.[12] The incidence increases after the start of walking until 18 years, and then remains stable until adulthood. Its development at the end of the period of spinal growth is not frequent.[2,6]

In children and adolescents, the posterior arch is not completely ossified and the intervertebral disk is very elastic, making the *pars* more susceptible to failure due to fatigue caused by tension and shearing forces, especially among those who practice sports involving repeated hyperextension of the thorax.

Unlike degenerative spondylolisthesis, which is 5–6 times more frequent in L4–L5, children and adolescents are more likely to suffer in L5–S1 (71–95%), followed by L4–L5 (5–15%), L3–L2 (less than 5%) and L2–L1 (less than 1%).[5,7]

The prevalence in the lumbosacral joint among young patients is explained because the sacrum is relatively immobile, whereas the lumbar spine is the segment with greatest mobility. The *anterior elements* (the disk and the vertebral body) resist compression, whilst the *posterior elements* (bone) represent the support of the shearing forces. Under normal conditions, stability of the joint is achieved through a series of *static stabilizers* (orientation of the interfacet joint surface of L5–S1, integrity of the discs and the ligamentous complex), and *dynamic stabilizers* (neuromuscular system). Generally, these elements are able to maintain the alignment of the affected vertebra.

The *pars interarticularis* of L5, particularly its isthmic and lateral portions, represents the weakest bone link between these elements, and that is where the maximum mechanical stress is found, as it must resist both axial and shearing forces.

Spondylolysis has a biomechanical and anatomical explanation. On the one hand, the load on the posterior bone arch increases considerably from L1 to L5 during extension. These shearing forces are greater in patients with high pelvic incidence and lumbar lordosis (parameters which will be defined in the radiographic analysis of pelvic morphology), which explains why high-grade spondylolisthesis is observed more frequently among these patients.

Another hypothesis postulates that an adequate separation between the adjacent joint facets enables a superposition of the posterior elements during hyperextension. A recent anatomical study demonstrated that individuals who did not have sufficient interfacet distance in a craniocaudal direction were more likely to develop a spondylolytic defect by entrapment of the *pars* of L5