Competitive Sports and the Progression of Spondylolisthesis

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Summary: To consider the effects of several years of competitive sports training on children and adolescents with spondylolisthesis, we carried out a retrospective radiologic and clinical study of 86 young athletes with spondylolisthesis or spondyloysis (24 girls and 62 boys between the ages of 6 and 20 years). The mean degree of displacement was 10.1% at the beginning of the observation. The radiologic tests showed an increase in displacement over time in 33 athletes. The average progression of spondylolisthesis in this group was 10.5%. For 36 athletes, spondylolisthesis did not progress during the period of athletic training. In seven athletes, a decrease in the displacement was observed, from 17.9 to 8.9% on average. For 10 athletes, the course of spondylolisthesis could not be determined, because only one lateral radiograph was available. In spite of intensive daily training, the athletes had no symptoms during the entire period of observation, which lasted an average of 4.8 years. In light of our experiments, there is no justification for generally advising children and adolescents with limited spondylolysis spondylolisthesis not to take part in competitive sports. Key Words: Spondylolisthesis—Spondyloysis—Sports.

The most frequent cause of displacement of the vertebrae in children and adolescents is spondylolisthesis of the pars interarticularis, or less frequently, a dysplasia of the fifth lumbar vertebral arch or the upper sacrum (1,10,23,25-28).

As the cause of spondylolisthesis, it has been suggested that, at a genetically predispositioned weak point in the pars interarticularis, even the weight of a normal upright gait leads to stress fracture (7,10,25). Probably for this reason, spondylolisthesis is not observed in newborns or in patients who have never walked (6,19). Various authors have reported a 15-50% higher incidence of spondylolisthesis with increased weight on the pars interarticularis from repeated hyperextensions and rotations, as is common in many sports (5,8-12,15,22).

Spondylolisthesis is rarer than spondylolisthesis, and its natural course is often clinically unremarkable (20), so that children and adolescents without symptoms are not advised to limit their normal activity (6). They require observation rather than treatment (28).

The participation of patients with spondylolisthesis in competitive sports has been discussed in various ways. Because of the danger of progression, patients are generally advised against competitive sports. On the other hand, it is possible that a well-conditioned musculature could hinder the progression of spondylolisthesis and compensate for the displacement of the vertebra without symptoms (2,18). The performance of athletes with displaced vertebrae is not noticeably affected; in general, they are asymptomatic (2,12,18,22).

In this study, our goal was to test the influence of several years of intensive sports training on the progression of spondylolisthesis in children and adolescents.

MATERIAL AND METHODS

Our patients were drawn from a special school for competitive athletes, in which the pupils participated in an unusually intensive (20 h/week) training program for many years. The purpose of the school was to prepare young athletes for international competition. All athletes in that school were regularly checked by school medical staff, including regular monitoring by a doctor.

Radiologic examination of the thorax and the lumbar spine was routinely performed for every pupil on enrollment in the school. Thus athletes with asymptomatic spondylolysis or spondylolisthesis were identified and subsequently monitored.
This study thus describes a group of children and adolescents with spondylolysis or spondylolisthesis who participated in an intensive and lengthy sports training program between 1970 and 1990 and whose athletic performance was consistently exceptional. We evaluated retrospectively the patient files and the radiographs of the lumbosacral joint of 86 children and adolescents with spondylolysis (n = 22) or spondylolisthesis (n = 64).

There were 24 girls and 62 boys between the ages of 6 and 20. The average age at the beginning of the observation was 11.9 ± 3.1 years (girls, 12.3 ± 3.2; boys, 11.8 ± 3.0 years).

The radiographs document a period of observation during active training, which lasted between 2 and 18 years. The average period was 4.8 years. A total of 611 radiographs of the lumbosacral region were evaluated: 295 lateral, 120 anteroposterior (AP), and 196 oblique. The radiologic examinations were done with subjects in a standing position. For determining the progression of vertebral displacement, an average of 3.4 lateral radiographs were evaluated.

In the AP radiographs, we examined the vertebral arch to determine the frequency and localization of spina bifida occulta. In the oblique views, we looked for the presence of lysis or an elongation of the pars interarticularis. In the lateral views, we determined the form of the sacral plateau and categorized it as normal, S-shaped, or domed (17). We determined the degree of displacement according to Meyerding (14) and measured the percentile degree of displacement, the displacement angle, and the sacral inclination according to Bradford (3; Figs. 1–3).

In the literature, the progression of vertebral displacement is defined in different ways (4,17,21,24). We set a minimum of 5% change in the span of displacement as our definition of progression of spondylolisthesis.

The athletes trained in a variety of sports: 39 played ball sports (hand-, basket-, and volleyball), 24 were gymnasts, 10 trained in track events (long distance, springs, hurdles), seven athletes were involved in multiple field events, four were shot putters, and two were javelin throwers.

Statistical methods
To test the differences for significance we used t tests. As the sample sizes of some of the groups were small, distributions were checked for normality before t tests were performed. For very small groups, the Wilcoxon test was used.

RESULTS
Spondylolysis or spondylolisthesis or both was the criterion for including athletes in study.

In 78 (91%) of the 86 athletes we found spondylolisthesis in L5 to be already present in the first radiograph. The spondylolisthesis was observed on both sides in 69 (80%) cases and on one side in nine (10%) cases. In four (5%) others, we found an elongated uninterrupted isthmus. In four (5%) athletes, the initial examination showed no change in the pars interarticularis. In the course of observation, however, they developed an isthmic spondylolisthesis with a mean displacement length of 8.5 ± 3.4%. They were between 8 and 13 years old, three boys and one girl, two of whom played ball sports and two of whom were runners.

At the beginning of the observation period, 64 (74%) children and adolescents already showed a spondylolisthesis in L5 in addition to the pathologic change in the pars interarticularis. The mean degree of displacement at the beginning of observation was 10.1 ± 12.1%. In 22 cases, we observed no displacement; in 54 cases, a Meyerding displacement stage 1 (<25%); in eight cases, displacement stage 2 (<50%); and in two cases, displacement stage 3 (<75%).

The two athletes with a spondylolisthesis of Meyerding stage 3 had trained in ball sports (handball and volleyball) for >5 or 7 years. A 10-year-old boy had a degree of displacement of 69% at the beginning of observation. A second radiograph taken at the age of 16 showed a displacement degree of 66%. The second boy was 13 years old. Only a lateral radiograph that showed a degree of 52% was available.

Progression analysis of spondylolisthesis

In the analysis of the progression of spondylolisthesis or spondylolyis, 76 of the 86 athletes were followed up in two to 10 lateral radiographs; for 10 athletes, only one lateral radiograph was available.

Thirty-six (47%) children and adolescents showed no progression during the whole observation period (change in displacement <5%; Fig. 4). Of this group, 14 were girls, and 22 were boys, and their average age was 11.4 ± 2.7 years. The degree of displacement at the beginning of observation was 12.6 ± 13.5%. By the end, it was 12.5 ± 13.3%; the difference is not significant.

In seven (9%) athletes, we found a partial reversal of the displacement process. We defined a reversal as a >5% decrease in the span of displacement. In this group (one girl and six boys, with an average age of 10.3 ± 2.2 years), we found an initial degree of displacement that was above average, 17.9 ± 7.7%. The average time of spontaneous repositioning, as measured in terms of the intervals between radiographs, was 18 months, and led to a significant (p < 0.05) reduction in the spondylolisthesis to 8.9 ± 7.0%. These were all cases of isthmic spondylolisthesis.

In 33 (44%) of the 76 athletes, we found progressive spondylolisthesis (change of slip >5%) in the course of observation. In this group, there were five girls and 28 boys, and the average age at the beginning of observation was 12.6 ± 3.2 years. The mean degree of displacement at the beginning of observation was 5.8 ± 7.6%. Spondylolisthesis increased an average of 10.3 ± 4.7%, and at the end of observation was 16.3 ± 7.8% (p < 0.01).

If only spondylolistheses with an increase in displacement of >10% are defined as progressive (24), only 10 athletes in our study displayed a progressive spondylolisthesis (three girls and seven boys with a median age of 12.1 ± 3.4 years). These spondylolistheses had a displacement of 2.6 ± 2.8% at the beginning of the study, which increased to 19.4 ± 5.7% (p < 0.01) at the conclusion of the study period. Only one athlete displayed an increase in spondylolisthesis of >20%; an 11-year-old girl gymnast who had a 7% displacement at the beginning and 31% displacement at the end of the observation period.

The age distribution for the athletes with progressive spondylolisthesis, the relation of these athletes to the total number of athletes in each age group and the increase in displacement in each respective age group are shown in Fig. 5. The age at the beginning of observation had no influence on the extent of vertebral displacement. The increase in displacement tended to be higher when the progression phase began at age 6 or 7 years.

If one considers the spondylolisthesis of all the 76 athletes, the progression is minimal overall. An initial degree of displacement of 10.1 ± 11.6% can be
FIG. 5. Number of athletes (total athletes, n = 86) in each age group, the number of athletes with progressive spondylolisthesis (athletes with progression; n = 33) in each age group, and the average increase in displacement in percentage progression. The number of athletes with progressive spondylolisthesis as a fraction of the total number of athletes in each age group is shown, as well as the progression of the degree of displacement.

Spina bifida occulta

For 65 of 86 of the athletes, clear AP radiographs of the lumbar spine were available. In 41 (63%) cases, we observed spina bifida occulta. In 34 of these cases, the dorsal arch split was found in S1. Infrequently, it was found in L5, or in L5 and S1 (2 and 5 times, respectively). In 24 of the athletes, no spina bifida occulta was found.

We divided the athletes into groups with and without spina bifida occulta and examined them with respect to the course of spondylolisthesis. The 28 athletes for whom a progression analysis was not possible because of the lack of lateral radiographs, or for whom no AP radiographs were available, and the seven athletes with regressive spondylolisthesis were not included, leaving a group of 51.

The four groups were as follows (Table 1):

- Group A: athletes with displacement progression and with spina bifida (n = 20)
- Group B: athletes with displacement progression and without spina bifida (n = 10)
- Group C: athletes without displacement progression but with spina bifida (n = 14)
- Group D: athletes without displacement progression and without spina bifida (n = 7)

The presence or absence of spina bifida had no significant influence on the extent of vertebral displacement at the beginning or the end of the observation period on athletes either with progression of spondylolisthesis (groups A and B) or without progression of spondylolisthesis (groups C and D).

The extent of the observed progression of the vertebral displacement was just as high in athletes with spina bifida occulta (group A) as it was in those without (group B). The difference was not significant. A high number of particular sports types in any of the four groups was not observed.

Degree of displacement, slip angle, sacral inclination and the form of the sacral plateau

There was a high correlation between both the degree of displacement and the slip angle, as well as between the degree of displacement and sacral inclination ($r = 0.86$ and 0.74, respectively). An increase in the degree of displacement was correlated to a decrease in the slip angle (kyphosis) and a decrease in the sacral inclination (steepening of the sacrum).

In the evaluation of displacement angle according to Meyering, the slip angle and the form of the sacral plateau yielded the relation shown in Fig. 6 (for the measurements, only the first lateral radiograph was used in each case).

Twenty-two athletes had no spondylolisthesis (degree of displacement = 0%). The mean displac-

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The differences between group A and B, as well as group C and D, in the initial and final degree of displacement were not significant.

x, mean; s, standard deviation; NS, no significance.

A: athletes with progressive spondylolisthesis and spina bifida occulta.
B: athletes with only spondylolisthesis.
C: athletes with only spina bifida occulta.
D: athletes with neither.
ment angle was $-18.1 \pm 6.0\%$. The sacral plateau was normal (no S-shape or dome shape).

Fifty-four children and adolescents had Meyerding stage 1 spondylolisthesis; 41 of these displacements showed a normal sacral plateau. The mean slip angle was $-15.9 \pm 7.2\%$. In 12 spondylolistheses in this group, we observed an S-shaped sacral plateau, and the mean slip angle was $-13.9 \pm 4.7\%$.

Eight athletes had a Meyerding stage 2 spondylolisthesis. The sacral plateau was S-shaped in six cases and domed in two cases. In the group of S-shaped sacral plateaus, we observed a mean displacement angle of $-6.3 \pm 4.4\%$. The two domed sacral plateaus showed a positive displacement angle of $12 \pm 4\%$.

In two young people with Meyerding stage 3 spondylolisthesis, we observed domed sacral plateaus with a displacement angle of $14.5 \pm 2.5\%$.

Clinical results

Based on the evaluation of the patient files, none of the athletes had to stop training because of complaints that could be related to spondylolysis or spondylolisthesis. Local or radiating pains in the lumbar spinal column leading to an interruption in training were not documented for any of the athletes.

DISCUSSION

A retrospective study of 86 child and adolescent athletes with spondylolysis or spondylolisthesis or both was carried out. The high number of boys is due to their greater participation in sports and results from the enrollment practices of sports schools.

We observed spondylolysis and spondylolisthesis exclusively in the fifth lumbar vertebra. The emergence of spondylolysis during the observation period is rarely described, and subsequent spondylolisthesis attains, as in our study, only a small degree of displacement (6,12,22). The extent of progression was minor overall. Most of the displacement (80%) had already occurred before the first radiologic examination, as Seitsalo et al. (21) reported.

The progression of displacement with symptom-producing spondylolisthesis has been repeatedly observed in young people (1,4,13,17,21). Pfir (17), for example, reported $>40\%$ progressive spondylolysis (defined as an increase in displacement of $5\%$). We found an almost identical number of $43\%$ (33) in the athletes observed (76). Only 10 (13\%) athletes in our study had an increase in displacement of $>10\%$. Seitsalo et al. (21) reported that in 62 (23\%) of 272 subjects with spondylolisthesis with clinical symptoms, a $>10\%$ displacement was observed. Blackburne and Velikas (1) found such a progression in $15\%$ of their patients. McPhee et al. (13) reported $24\%$ progressive spondylolistheses. A progression (defined as an increase of $20\%$) was seen by Danielson et al. (4) in nine (3\%) of 311 patients. In our study, we saw such a progression in only one of our patients.

Competitive sports, in other words, did not affect the progression of spondylolytic spondylolisthesis. The young athletes with spondylolisthesis in our study displayed a smaller progression in displacement than that found in studies of children and adolescents with clinically observable symptoms who did not engage in competitive sports (1,4,13,17,21). The additional strain on the lumbosacral joint from sports did not lead to an increased progression in the displacement. We also found a tendency toward a more frequent progression in the displacement during the growth spurt of early puberty (1,6,21,26, 28).

We found a high occurrence (63\%) of spina bifida occulta in the athletes with spondylolisthesis (1,4, 17,21,28). In the general population, this figure declines with age from 59\% in 6-year-olds to 20\% in adults (6). We ascribe the failure of ossification in the dorsal arch split to a mechanical osteochondrosis, which results from the particular instability of the spondylolisthetic segment (17). This instability has also been said to be the reason that spondylolisthesis with spina bifida leads to a greater displacement (1,17,28). A further cause of increased risk of displacement progression is said to be the reduced effect of the multifidus muscle, which lacks a part of its attachment, the processus spinosus, in the case of spina bifida (1). However, in our study, we could not find any significant differences in the progression of spondylolisthesis that could be related to the occurrence of spina bifida.

Regressive spondylolistheses have been rarely described (17,21) and indicate, in our opinion, the dynamic character of vertebral displacement.
Phases of stagnation, of progression, and also of spontaneous repositioning occur.

The measurements of sacral inclination and of the degree and slip angle confirm a known correlation, that an increasing degree of displacement is associated with an increasing kyphosis in the displaced segment (the slip angle is positive), and a compensatory steepening of the sacrum (the sacral inclination decreases (4,7,10,16,17,21).

CONCLUSIONS

In spite of regular intensive physical exertion, all 86 athletes with spondylolysis or spondylolisthesis remained asymptomatic. The increase in displacement was minor overall, with the average degree of displacement 10.1% at the beginning of observation and 13.8% at the end. Our observations offer renewed support for recognizing that spondylolisthesis is a spinal diagnosis with a good prognosis that should be monitored but that does not necessarily require treatment (28).

It is not appropriate to advise pupils with asymptomatic spondylolisthesis to avoid sports completely. From our study, there is also no reason to advise athletes with spondylolysis or limited spondylolisthesis against participation in competitive sports. In our view, participation in school and competitive sports is possible for children and adolescents with a spondylolisthesis when the following conditions are met: (a) limited spondylolytic spondylolisthesis; (b) lordosis in the displaced segment; (c) absence of symptoms; and (d) regular medical monitoring.

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