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Prolonged low-back pain in young athletes: a prospective case series study of findings and prognosis

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Abstract We investigated the prognosis of low-back pain and the association of clinical symptoms and anatomic findings among young athletes. Consecutive patients, aged between 12 and 18 years, who had low-back pain that had interfered with their training for at least 4 weeks were included in the case series. All the patients participated in a standardized interview and clinical examination, and plain radiographs and magnetic resonance images were also obtained. Most patients also participated in technetium bone scan examination. In 15 out of 19 subjects there were anatomic abnormalities that corresponded with the location and type of clinical symptoms. Twelve subjects had changes in the disk-vertebral end plate complex and eight had a positive bone scan indicative of posterior vertebral arch stress reaction. Six out of eight boys and two out of 11 girls had stress re-

action ($P = 0.043$). Restriction of painful activities was recommended to all subjects, restriction of activities and the use of a dynamic low-back brace for the first 3 months was recommended to patients with posterior vertebral arch stress reaction. The self-reported intensity of low-back pain (scale 0–100) among all the patients was 69 ± 16 (mean $\pm$ SD) at baseline and 18 ± 21 at the 1-year follow-up ($P < 0.0001$). In conclusion, the reasons for prolonged back pain among young athletes are usually established by imaging studies. A knowledge of anatomic abnormalities may help in tailoring training programmes and avoiding the progression of changes during growth. Simple restriction of painful activities usually leads to good recovery.

Key words Bone scan · Growth · Intervertebral disk · MRI · Spondylolysis

Introduction

Among young athletes, low-back pain (LBP) may result from acute macrotrauma, repetitive microtrauma (stress), or from a combination of these two mechanisms, and many anatomic abnormalities may underlie chronic LBP [3]. Among top-level athletes before the adolescent growth spurt anatomic abnormalities of the thoracolumbar spine are rather uncommon, but after the growth spurt they are a frequent finding [4, 6, 8, 13, 14], and the anatomic changes appear to correlate with the symptoms

[8, 13]. Unlike the situation in adults, spondylolysis stress fracture has been reported to be a common cause of LBP in young athletes [10].

In the growing individual, especially during the rapid growth phase, the skeleton (mainly the growth zones and apophyses) is more vulnerable to acute trauma and injuries stemming from overuse than is the adult skeleton [1, 8]. Injuries affecting the intervertebral disks, end plates, or ring apophyses may contribute to the degenerative process [5, 9, 12], although degeneration of intervertebral disks in the non-athletic population may also start early [15].

It has been reported that, in particular among adults, there are commonly anatomic abnormalities among non-symptomatic subjects as well [2, 7, 11]. Thus, the use of imaging methods in subjects with back pain has been questioned. Young athletes usually do not have as many degenerative changes as adult or older patients and their motivation to go in for sports is high. We hypothesized that psychogenic pain would be uncommon among athletes and the association of symptoms and existing anatomic abnormalities would be more apparent among young athletes than among the adult population. We therefore investigated in this prospective case series study the association of clinical symptoms and anatomic findings among young athletes with prolonged LBP to evaluate the clinical value of diagnostic imaging, and to study the prognosis of LBP associated with the changes.

Materials and methods

Selection of subjects

All consecutive athletically active patients and dancers who were treated by the authors (U.M.K., P.H., S.O.) at a private outpatient sports clinic (of the Finnish Foundation of Sports Medicine working in co-operation with the Unit for Sports and Exercise Medicine, University of Helsinki), aged from 12 to 18 years, with LBP that had interfered with their training for at least 4 weeks volunteered to be included in the case series. The patients visited the clinic between April 1 1995 and December 31 1997.

Study protocol

All the patients were interviewed about their training history and back-pain history as well as participating in a standardized interview and clinical examination by the same physician (U.M.K.). Thereafter, plain radiographs (antero-posterior and lateral) and magnetic resonance (MR) images were obtained. The patients were erect during the plain film examination. Usually the patients also underwent in a ^{99m}Tc methylenediphosphonate (MDP; Osteosol) bone scan. The few patients whose diagnoses were evident based on clinical examination, radiographs and MR images, did not receive a ^{99m}Tc -MDP bone scan, in order to avoid unnecessary exposure to radiation. Except for the first outpatient visit to a treating physician, the examinations were free of charge for the subjects. One year after the baseline examinations the subjects were interviewed by phone by the first author using standardized questions on the subjects' present physical activity as well as the continuation and severity of low-back pain. The study was approved by the local ethics committee.

MR imaging

MR imaging of the lumbar spine was performed with an open 0.23-T unit (Outlook; Picker Nordstar Inc., Vantaa, Finland). A phased-array solenoid saddle spine coil was used. The imaging protocol comprised conventional sagittal spin echo (SE) T1-weighted images (TR 380 ms, TE 23 ms, FA 90°, FOV 324 × 380 mm, slice thickness 5 mm with a 0.5 mm slice separation; an acquisition time of 6 min 29 s with three averages) and sagittal fast spin echo (FSE) T2-weighted images (TR 3900 ms, TE 120 ms, FA 90°, FOV 360 × 360 mm, slice thickness 5 mm with a 0.5 mm slice separation, an acquisition time of 6 min 14 s with one average).

The MR images were analyzed by a radiologist (J.K.). Disk intensity was categorized as abnormal, i.e. degenerated, when there was a decrease in the intensity of nucleus pulposus and inner annulus on T2-weighted images. Disk herniation was classified as a protrusion, extrusion or sequestration. In addition, ring apophysis injuries or other irregularities of the vertebral end plates were recorded. Subjects with one of these abnormalities (disk degeneration, protrusion/prolapse or vertebral end plate change) were classified as having MR imaging abnormality of the disk-vertebral end plate complex. The spatial resolution of the low-field MR images was not sufficient to demonstrate directly the inflammatory changes of annular tears.

^{99m}Tc -MDP bone scan

In the ^{99m}Tc MDP (Osteosol) bone scan, the images were obtained 2 h after administering the recommended age-adjusted dose. Whole body and lumbar anterior and posterior views were obtained using a Picker Prism 2000 gamma camera.

The ^{99m}Tc -MDP scans were analyzed by a radiologist (M.T.). Scans were read as positive if there was a focal increased uptake of the tracer. In these cases there was a definite asymmetry between the left and right sides or a definite difference in the level of activity between one vertebral arch and the adjacent vertebrae. Focal lesions of the vertebral arch and body could be differentiated.

Statistical analysis

Fisher's exact test and Student's *t*-test (two-tailed) as well as confidence interval (CI) analyses were used for statistical comparisons.

Results

One of the patients was diagnosed with pain related to kidney disease and was excluded from further analyses. Our results are based on the remaining 19 subjects: eight males and 11 females. The mean age of the subjects was 15.3 years (range 12–18 years). Eight of the subjects reported remembering the exact time when they first experienced the pain, which in these cases usually was associated with a minor trauma (Table 1).

Imaging studies

The individual main findings are shown in Table 1. In MR imaging only one subject showed typical disk extrusion, while protrusion and/or disk degeneration either with or without vertebral end plate changes was seen in a further nine subjects. In addition, two subjects had vertebral end plate irregularities without marked disc degeneration. Thus, altogether 12 subjects had changes in the disc-vertebral end plate complex. Eight subjects had a positive ^{99m}Tc -MDP bone scan, indicative of posterior vertebral arch stress reaction (Fig. 1). Two of these subjects showed spondylolysis on plain radiographs at baseline. Six of eight males (75%, 95% CI 35–97%) and two of 11 females (18%, 95% CI 2–52%) had a posterior vertebral

Table 1 Patient characteristics, main history and main imaging findings

Case no.	Sex	Age	Sports	Duration of symptoms prior to first visit, (months)	Acute trauma at onset of symptoms	Radiographic abnormalities	Abnormalities of intervertebral disks and vertebral end plates on MR imaging	Stress reactions in posterior vertebral arches seen by ^{99m}Tc bone scan
1	F	14	Women's gymnastics	3	No	Neg.	Neg.	Bilateral L5
2	M	17	Soccer	1	Sudden onset during game	Neg.	Neg.	Right L4
3	F	13	Rhythmic sport gymnastics	1	Sudden onset, hyperextension/distension	Neg.	Neg.	No scan
4	F	16	Basket ball	1	No	End plate irregularities	Protrusion L4-S1 and degeneration L3-S1	Neg.
5	F	18	Rhythmic sport gymnastics	1	Fall on back	L5 spondylolysis and -listhesis	Degeneration L5-S1	Left L5
6	F	18	Floorball	1	Sudden onset during game	Neg.	Neg.	Neg.
7	M	14	Ice hockey	1	Sudden onset at tackling	L5 spondylolysis l.a.	Degeneration L3-L4	Bilateral L5
8	M	15	Soccer	6	No	Neg.	Neg.	Left L5
9	F	16	Cheerleader	2.5	Sudden onset during performance	Neg.	Degeneration and protrusion L5-S1	Neg.
10	M	12	Soccer	2	No	Neg.	Neg.	Left L5
11	F	17	Ballet	1	No	Neg.	Neg.	Neg.
12	F	15	Ballet	12	No	End plate irregularities	Degeneration L3-L4 and L5-S1 Protrusion 1 L5-S	Neg.
13	M	18	Handball	2	No	Neg.	Degeneration L5-S1	Right L4
14	M	17	Gymnastics	1	Distension at landing	End plate irregularities	Degeneration T12-L1 L1-L2	Neg.
15	F	14	Soccer	2	No (pain onset in soccer tournament)	Neg.	Degeneration/protrusion L4-L5	Right L5
16	M	15	Snowboarding	6	Fall on buttocks	Neg.	End plate irregularities	Neg.
17	F	16	Figure skating	1	No	Neg.	Protrusion L4-L5	No symptoms after MRI, no scan
18	M	14	Ice hockey	1	Onset in ice-hockey tournament	Neg.	Degeneration L4-L5 and L5-S1 Extrusion L4-L5	No scan, typical disk extrusion
19	F	12	Gymnastics	3	No	Neg.	End plate irregularities L1-L3	No scan

arch stress reaction (P for sex difference = 0.043 by Fisher's exact test). Four of the subjects with posterior vertebral arch stress reaction also had disk degeneration, but none of them had disk extrusion or end plate changes. Three of the patients did not show marked anatomic abnormalities in imaging studies. One of these (case 6) had a pain in the sacro-iliac joint. Her ^{99m}Tc -MDP bone scan revealed a left-right asymmetry, however, this was not a sufficiently specific finding for sacroiliitis.

Anatomic abnormalities and clinical findings

Overall, in 15 out of 19 subjects there were anatomic abnormalities that corresponded with the location (level of

maximal pain) and type of clinical symptoms. Only one subject had referral pain to the calf, distal to the knee (case 18 with disk extrusion), the same subject had scoliosis while standing and, in particular, while forward bending. All eight subjects with a posterior vertebral arch stress reaction had pain associated with backward bending, while five of the other 11 patients were free of pain in this test (P for group difference = 0.08 by Fisher's exact test). Among the subjects with a posterior vertebral arch stress reaction, the pain was usually particularly strong when putting weight on the lower limb of the affected side and bending backward to the same side.

Fig. 1 Posterior ^{99m}Tc -MDP bone scan shows focal increased uptake of the tracer in the right arch of the fifth lumbar vertebra (*arrow*)

Fig. 2 Sagittal T2-weighted fast spin echo magnetic resonance (MR) image showing extrusion of L4/5 intervertebral disk (*arrow*)

Restriction of activities and outcome

We recommended that all of our patients should not participate in pain provoking training or sports during the 1st month, but we allowed totally painless physical activities. Subjects with posterior vertebral arch stress reaction were recommended not to participate in sports during the first 3 months and were prescribed an elastic low-back brace for use during physical activity during the first 3 months to restrict lumbar extension. Those with a posterior vertebral arch stress reaction reported at the 1-year follow-up that they had not participated in training for 13.0 ± 6.7 weeks (mean $\pm$ SD) after the recommendation, compared to 6.7 ± 7.0 weeks in the other 11 subjects. The self-reported intensity of LBP (scale 0–100) among all the patients was 69 ± 16 (mean $\pm$ SD) at baseline and 18 ± 21 at the 1-year follow-up (when it was worst during the month preceding the 1-year follow-up) (difference between baseline and follow-up by paired *t*-test, $P < 0.0001$). There was no difference between the subjects with posterior vertebral arch stress reaction and other subjects in the self-reported intensity of pain either at baseline [stress reaction group 75 ± 14 (mean $\pm$ SD) vs others 64 ± 17] or at follow-up (15 ± 20 vs 20 ± 22 , respectively). One subject with posterior vertebral arch stress reaction and four of the other subjects reported some restriction of training due to LBP at the 1-year follow-up.

Discussion

Our non-controlled case-series study has known limitations for drawing exact conclusions about the association between anatomic abnormalities found in imaging studies and LBP. However, our study provides further evidence that among young athletes with chronic LBP, it is often possible to specify the underlying injury using imaging studies. Also, the profile of reasons for LBP in young athletes differs from that seen among adults.

There are limits on how far it is possible to detect the exact role of acute injuries and cumulative stress in the etiology of prolonged LBP. Traumas originating in training maneuvers involving peak loads are not always reported as acute injuries. People experiencing chronic LBP may report it as an acute injury sooner or later as they become aware of the pain, for example when jumping. Minor traumas or cumulative microtrauma were the most common etiologies behind the LBP among our subjects.

Based on our and other studies [6, 8, 10] the most common anatomic changes causing chronic LBP among young athletes can be classified as posterior vertebral arch stress injuries and injuries to the intervertebral disk-vertebral end plate complex. The relationship between lumbar abnormalities and LBP is controversial. Even though among adults abnormalities on MR imaging have been shown to be common without LBP [2, 7, 11], in a 3-year

follow-up study of athletic adolescents [8] and non-athletic adolescents [15] an association between the early abnormalities and frequent LBP was seen. In our study the location and type of imaging findings were closely related to LBP. We did not have a non-symptomatic athletic control group to investigate the difference in abnormalities between symptomatic and non-symptomatic athletes. However, compared to our present study, abnormalities seen on MR images were less frequent in the non-symptomatic athletes in our previous study [8].

In accordance with earlier studies [6, 10], a positive ^{99m}Tc -MDP bone scan indicating posterior vertebral arch stress reaction (commonly termed "stress fracture") was common. However, these changes could not be demonstrated with conventional SE sequences on a low-field MR imaging unit. This may be possible using an MR imaging unit with higher field strength where the better homogeneity of the magnetic field allows for the use of more sensitive sequences, including with fat-suppression and the STIR techniques. Spondylolysis seen on radiographs in two cases at baseline may be indicative of old spondylolytic changes. We did not repeat our imaging studies, and in the other cases the only evidence of focal bone damage was the reaction shown by the bone scan. A

higher percentage of posterior vertebral arch stress reactions among boys may be due to more rotational stress to the low back in their modes of sports. Rotational stress may load the posterior vertebral arch of the lumbar spine due to the orientation of the facet (zygapophyseal) joints of lumbar vertebrae.

Our study gives data for the 1-year prognosis of LBP. Treatment of cases with stress reaction of posterior vertebral arch by activity restriction and an elastic brace gave good results at the 1-year follow-up. Development of diagnostic methods and randomized treatment studies are needed to confirm the superiority of this simple treatment method.

In conclusion, the reasons for prolonged LBP among young athletes can usually be established, and a knowledge of anatomic abnormalities may help in tailoring training programmes and avoiding progression of changes during growth. Thus, imaging studies in growing athletes with prolonged LBP seem to be indicated. However, in future we should be able to replace bone scans by appropriate MR imaging. According to the findings of this study, simple restriction of painful activities usually leads to good recovery. Thus, the prognosis of prolonged LBP usually is good with conservative therapy.

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