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Association between reduced trunk flexibility in children and lumbar stress fractures

Masahiko Kemmochi[a,*], Shigeru Sasaki[b,c], Shoichi Ichimura[b]

[a] Kenmochi Orthopedic Surgery Sports Clinic, KOSSMOS Medical Corporation, 42-1 Higashi-honcho Ota City, Gunma, 373-0026, Japan
[b] Department of Orthopaedic Surgery, Kyorin University, 5-4-1 Mitaka, Shimorenjaku, 181-8612, Tokyo, Japan
[c] Japan Community Health Care Organization, Yamanashi Hospital, 3 Chome-11-16 Asahi, Kofu, Yamanashi Prefecture, 400-0025, Japan

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ABSTRACT

Background: We noticed that most of active sports children with low back pain (LBP) have muscle tightness around the pelvis and reduced trunk flexibility. Abnormalities in short-time inversion recovery (STIR) images on magnetic resonance imaging (MRI) can show stress fracture. Therefore, we investigated the associations among LBP, trunk flexibility, and lumbar stress fractures.

Methods: A total of 130 patients under the age of 18 years complained of LBP were investigated in STIR MRI images. Among these 130 patients, 65 cases of lumbar stress fracture were diagnosed and 65 cases were not diagnosed as a lumbar stress fracture. We compared between a group suspected of stress fracture (suspected group) and a group of stress fracture(stress fracture group)about their trunk flexibility. These groups were investigated about their initial trunk flexibility about below items; Finger floor distance (FFD), Heel to buttock distance (HBD), straight leg raising (SLR).

Results: Significant differences were observed between suspected group and stress fracture group about every items; SLR ($P < 0.001$), FFD ($P < 0.01$), HBD ($P < 0.002$). Most cases of stress fracture group had reduced trunk flexibility, and low flexibility in pelvic area muscles was observed in 93.8% (61/65) of cases at the initial examination. Otherwise, that of suspected group was 73.8%(48/65).

Conclusions: Most patients of lumbar stress fracture had reduced trunk flexibility, and their reduced trunk flexibility might not be caused by LBP. In the early diagnosis of lumbar stress fractures using STIR MRI images, there were indicated that reduced trunk flexibility was one of helpful item for lumbar stress fracture.

1. Introduction

We noticed that most of active sports children with low back pain (LBP) have muscle tightness around the pelvis and their reduced trunk flexibility. If they continue vigorous exercise while having muscle tension around the pelvis, we may be doubted that the possibility that repeated stress accumulates somewhere in their body. If no abnormal sign is identified on radiography or on clinical assessment in these children, we tend to diagnose them with unknown lumbar pain. However, we believe that the diagnosis depends on the cause of LBP. According to a previous report, on magnetic resonance imaging (MRI), abnormal findings in short-time inversion recovery (STIR) and T1 images indicate the stage before the occurrence of a stress fracture.[1] We applied this principle to the lumbar vertebrae and found abnormalities in STIR MRI images. In addition, some previous studies have reported a relationship between LBP and hip flexibility.[2–6] We doubted that stress fracture might have occurred as a result of repeated stress to the lumbar vertebrae. Perhaps reduced trunk flexibility might be compensated by changes in the lumbar vertebrae. Hence, we generally performed MRI examination in active sports children with flexion or extension lumbar pain or reduced trunk flexibility, despite the absence of a fracture sign on radiography, to confirm the existence of a stress fracture.

The present study aimed to investigate the associations among reduced trunk flexibility, and lumbar stress fracture. Additionally, we considered detail of trunk flexibility item about stress fracture group, and the prevention and treatment of stress fracture during the growth period is discussed.

2. Materials and methods

2.1. Patients

This is a case control study. Eligibility criteria were patients with low back pain during the growth period under the age of 18 years

* Corresponding author.
E-mail address: kossmos@rainbow.plala.or.jp (M. Kemmochi).

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between June 2007 and November 2016. 65 cases which diagnosed as a stress fracture and 65cases which suspected stress fracture. 65 cases which were diagnosed lumbar stress fracture (55 cases in boys and 10 cases in girls; mean patient age, 14.0 + − 1.60 years [range, 8–17 years]) were defined as a stress fracture group. 65 cases which were not diagnosed lumbar stress fracture (31 cases in boys and 34 cases in girls; mean patient age, 14.0 + −1.84 years [range, 10–18 years]) were defined as a suspected group.

This study was approved by the institutional review boards of the concerned institutions. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from the parents/guardian of the children included in the study.

2.2. Study protocol

Patients who complained of LBP at the first medical examination and fulfilled any of the following criteria underwent MRI: 1) aggravation of LBP during standing (anteflexion) or during the one-leg extension test;[7–10] 2) reduction in trunk and lower limb flexibility indicated with reduced results in a straight-leg-raising angle (SLR), finger-to-floor distance (FFD), or heel-to-buttock distance (HBD) test; and 3) bone sclerosis or bone resorption in the pars interarticularis in oblique radiographs.

Coronal and transverse T1-weighted images and STIR images were obtained using a 0.3T AIRIS Vento open MRI system (Hitachi Medical Corporation, Chiyoda, Tokyo). All MRI images from the initial examination to the final examination were assessed by the same doctor.

2.3. Assessment of trunk flexibility (muscle tightness)

The SLR, HBD, and FFD tests were used as indices of flexibility. The following standard values were set for these muscle tightness tests: SLR, 70°; FFD, 0 finger's breadth [fb]; and HBD, 0 cm. This standard was used as a criterion for pass of flexibility. Joint laxity was not assessed in the present study, as it can be influenced by sex and age.

2.4. Treatment methods and protocols

Physical therapy was continued until all patients achieved the standard values set for the SLR, FFD, and HBD tests. When hyperintensity was observed in STIR MRI images, patients were fitted with a Damen-type soft trunk corset, were instructed to rest, and were taught to stretch according to the methods described by Sairyo et al. [11] Radiographic changes were assessed every month to confirm whether a fracture was present near the hyperintense area. After 2–3 months, STIR MRI images were obtained, and patients were considered to be in a healing trend if the hyperintensity disappeared or decreased in the MRI images (Fig. 1).[1] In patients who were considered to be in a healing trend and who achieved the pass standard of trunk flexibility, the Damen-type soft trunk corset was removed, and these patients were permitted to start exercising carefully on the day of corset removal. The level of exercise was increased gradually to avoid LBP or discomfort, and if the patients did not experience any problems for approximately 2 weeks, medical follow-up was discontinued. Patients who did not achieve the standard values of the muscle tightness tests continued with stretching rehabilitation. Additionally, patients who did not show a decrease in hyperintensity in STIR MRI images were re-examined after 1 month (Fig. 2).

2.5. Outcome measures

In the stress fracture cases, we examined the treatment period; proportion of patients with reduced results in the SLR, HBD, and FFD tests at the initial examination; change in these test results at the final examination; time taken to achieve flexibility; rate of return to sports; and changes in the STIR MRI images.

2.6. Statistical analysis

We compared between a suspected group and a stress fracture group about their trunk flexibility. These groups were examined for their initial trunk flexibility about below items using the Welch's *t*-test; FFD, HBD, SLR. We used the Wilcoxon signed-rank test to determine whether changes in the SLR, HBD, and FFD test results (non-continuous and non-normally distributed data) were significant.

All statistical analyses were performed using SPSS, version 22.0 for Windows (IBM Corp., Armonk, NY). A P-value ≤ 0.05 was considered statistically significant.

3. Results

Significant differences were observed between suspected group and stress fracture group about every item; SLR ($P < 0.00001$), FFD ($P < 0.01$), HBD ($P < 0.002$) (Table 1). Most cases of stress fracture group had reduced trunk flexibility, and low flexibility in pelvic area muscles was observed in 93.8% (61/65) of cases at the initial examination. On the other hands, it was 73.8% (48/65) in the suspected group.

In the stress fracture group, five cases (7.7%) reached the pass level and 60 cases (92.3%) did not reach the pass level. 14 cases passed 2 out of the 3 items (SLR, FFD, HBD) [21.5%], 19 passed 1 out of 3 items [29.2%], and 27 did not pass any item [41.5%] at the initial medical examination (Fig. 3). At the final examination, 51 of the 65 cases (78.5%) reached the pass level of trunk flexibility and 14 did not reach the pass level (Fig. 3). In 14 cases which did not reach the pass level, 10 cases passed 2 out of 3 items (15.4%), 2 cases passed 1 out of 3 items (3.1%), 2 patients did not pass any item (3.1%) (Fig. 3).

The rates of improvement in the results of the SLR, HBD, and FFD tests at the final examination were 92.5% (49/53 cases), 88.1% (37/42), and 71.1% (27/38), respectively (Fig. 4).

The mean values in the SLR, HBD, and FFD tests improved from 53.0° to 70.6°, 2.8 fb to 0.7 fb, and 8.2 cm to 1.3 cm, respectively (Fig. 5). An improvement in flexibility was observed in 61 cases, while 4 cases did not exhibit improvement. The Wilcoxon signed-rank test showed that the SLR test value increased significantly between the initial and final examinations ($P < 0.001$), and that the HBD and FFD test values decreased significantly between the initial and final examinations ($P < 0.001$).

LBP disappeared approximately 21 days after instructing the patients to rest, and flexibility was achieved at a mean of 37.6 days. The median treatment period was 119 days (range, 53–1105 days), and all the patients returned to usual sporting activities. The rate of return to sports was 100%.

Hyperintensity in STIR MRI images disappeared in 51 of the 65 cases (78.5%), decreased in 8 cases (12.3%), and increased in 6 cases (9.2%). The onset site was bilateral, right, and left in 23, 25, and 17 cases, respectively.

4. Discussion

Repeated microtrauma and excessive stress at the lumbar vertebra have been reported to be involved in the onset of lumbar stress fractures,[12–14] although only few studies have examined the causes in detail. Some studies have reported the influence of trunk flexibility on LBP.[2–6] Hence, we considered that a reduction in trunk flexibility might be associated with repeated micro-trauma and excessive stress at the lumbar vertebra as a bone stress reaction.[15] We focused on a reduction in the flexibility of pelvic area muscle groups, as an essential aspect of compensation for a reduction in trunk flexibility.[8,9] Considering a