ORIGINAL

Physical features of pediatric patients with lumbar spondylolysis and effectiveness of rehabilitation

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Abstract : The purpose of this study was to evaluate the physical features of pediatric patients with lumbar spondylolysis (LS), factors that increase the load during compensatory movements at the lumbar spine, and the outcomes of rehabilitation. Twenty patients were included. Fifteen items were used : fingertip-to-floor distance (FFD), straight leg raising (SLR), heel-to-buttock distance (HBD), tightness of the rectus femoris, the lateral and medial rotator muscles, iliopsoas, tensor fascia lata, adductor muscles, soleus muscle, and latissimus dorsi, and trunk rotation, sit-ups and endurance of the abdominal and back muscles. Initial findings were judged as positive or negative using previously reported cut-off values and were re-evaluated 2 or 3 months later. Positive tests were found for HBD and tightness of the rectus femoris in 85% of the patients, for endurance of the abdominal muscles in 75%, SLR and sit-ups in 70%, and FFD and tightness of the external rotator muscles in 60%. The physical features varied according to the type of sport played, and some patients were refractory to rehabilitation. Only 17.6%, 33.3%, and 40.0% of patients with initially positive findings for HBD, tightness of the external rotator muscles, and endurance of the abdominal muscles, respectively, achieved improvements after rehabilitation. J. Med. Invest. 65 : 177-183, August, 2018

Keywords : *spondylolysis, lumbar spine, pediatric, low back pain, rehabilitation*

INTRODUCTION

Lumbar spondylolysis (LS) is a disorder in which stress fractures occur at the lumbar spine and is frequently identified in adolescent athletes (1, 2). Early diagnosis and conservative treatment is essential for bone healing (3, 4). Recent advances in radiology and accumulation of clinical experience in the treatment of LS have improved the outcomes in pediatric patients with the condition (5-7).

Biomechanical studies have shown that extension and/or rotation of the lumbar spine concentrates stress on the pars interarticularis, which can lead to a stress fracture, that is, LS, at this site (8). Conservative treatment, including rest, cessation of physical activity, and use of a thoraco-lumbo-sacral brace, is recommended until the fracture has healed, and favorable outcomes have been reported (3, 4). However, some patients are refractory to conservative treatment and others develop further stress fractures when they resume physical activity (3). A possible reason for these unsatisfactory outcomes may be a lack of knowledge of the physical features that render certain individuals prone to LS. Furthermore, no optimal rehabilitation strategy has been established for patients with LS. If these patients return to their former level of sports activity with no change in their physical status, there is a high likelihood that LS will recur.

Many patients with LS are known to have tight hamstrings, quadriceps, and thoracic muscles (9), which may lead to compensatory movements and increased load at the lumbar spine. The aims of this study were to evaluate the physical features of pediatric patients with LS, to identify factors that increase their compensatory extension and/or rotation movements and loading at the lumbar spine, and to assess the effectiveness of rehabilitation in these patients.

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PATIENTS AND METHODS

Patients

Twenty consecutive pediatric patients (16 boys, 4 girls ; mean age 15.2± 1.82 years) with a diagnosis of LS were enrolled in the study. Eight patients were actively engaged in baseball, 4 in basketball, 4 in soccer, 2 in volleyball, 1 in sprinting, and 1 in javelin throw. LS was classified as early-stage in 5 patients, progressive-stage in 7, and terminal-stage in 8. In all cases, the LS was at L4 or L5. An institutional review board exemption was obtained for the retrospective review of clinical information, including imaging studies, for the present study.

Evaluation

Fifteen physical items were evaluated, of which 12 were for muscle tightness and 3 were for muscle strength and endurance (Table 1). The 12 muscle tightness items were as follows : (1) fingertip-to-floor distance (FFD), (2) straight leg raise (SLR), (3) heel-to-buttock distance (HBD), tightness of the (4) rectus femoris, (5) external and (6) internal rotator muscles, (7) iliopsoas, (8) tensor fasciae latae, (9) adductor muscles, (10) soleus muscle, and (11) latissimus dorsi, and (12) trunk rotation. All these items were evaluated before starting rehabilitation. The three muscle strength and endurance items were (13) ability to perform sit-ups and endurance of the (14) abdominal and (15) back muscles. These three items were evaluated 4 weeks after evaluation of the 12 muscle

Table 1 Fifteen items for evaluation of physical features

Evaluation for tightness	*Evaluation for muscle strength and endurance*
1. Fingertip-to-floor distance	13. Sit-ups
2. Straight leg raising	14. Endurance of abdominal muscles
3. Heel-to-buttock distance	15. Endurance of back muscles
4. Rectus femoris	
5. External rotator muscle	
6. Internal rotator muscle	
7. Iliopsoas	
8. Tensor fasciae latae	
9. Adductor muscles	
10. Soleus muscle	
11. Latissimus dorsi	
12. Trunk rotation	

tightness items, so as not to interfere with healing of the fracture, and 2 or 3 months later. Findings for all items were judged as positive or negative using the cut-off values reported in the literature (Figure 1).

Rehabilitation

The rehabilitation program consisted of self-stretching exercises and training in range of motion at the hip joints and thorax. All patients were instructed on how to perform daily active self-stretching exercises at home (Figure 2, 3). They also attended the outpatient clinic once or twice weekly for 40-min rehabilitation sessions consisting of 2–3 20-s sets of passive stretching, 15 min of exercycle training, and 15 minutes of trunk muscle training. The exercycle training was started 4 weeks after the initial evaluation and trunk muscle training after 6 weeks to allow healing of the fracture.

RESULTS

Initial evaluation

Seventeen (85%) of the 20 patients had positive findings for HBD and the rectus femoris, 15 (75%) for abdominal muscle endurance, 14 (70%) for SLR and sit-ups, and 12 (60%) for FFD and the external rotator muscles (Figure 4).

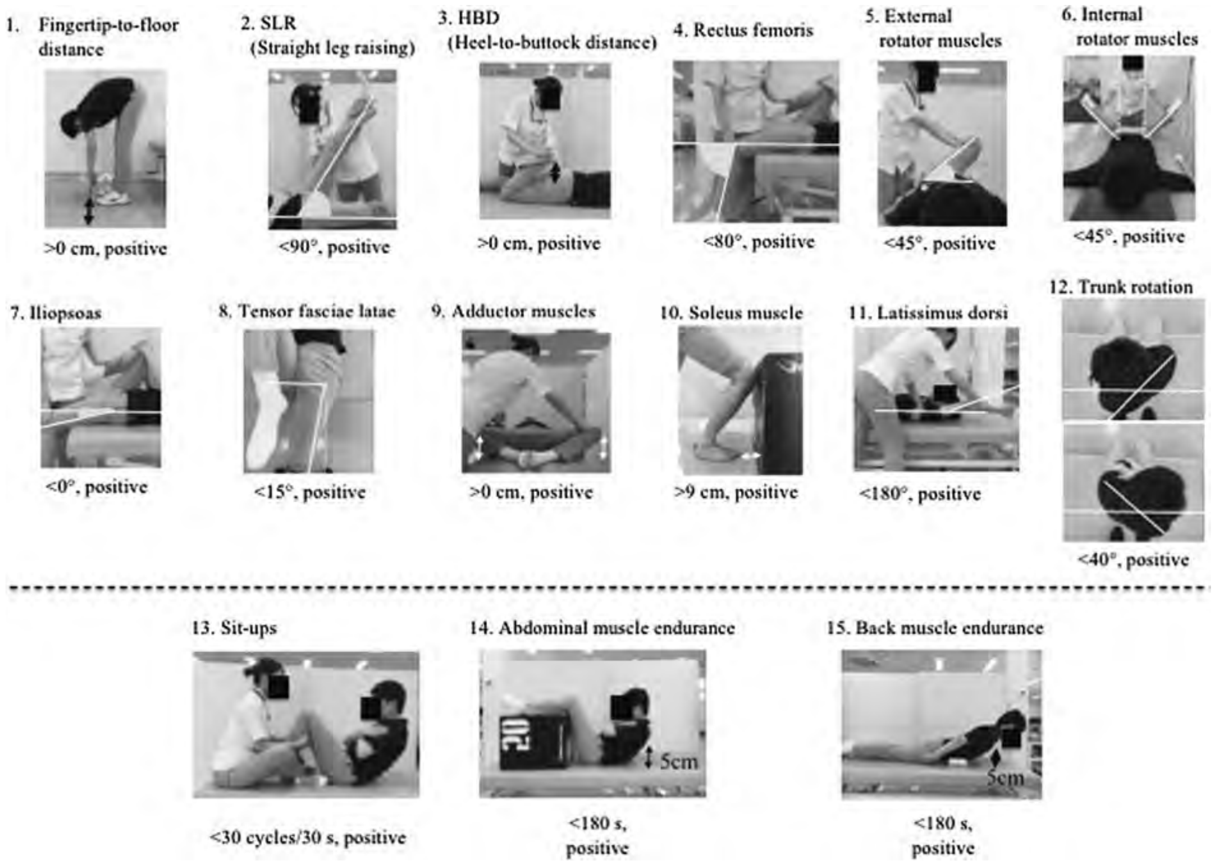

Figure 1
Twelve tightness and three muscle strength and endurance items. Tightness : (1) Fingertip-to-floor distance (FFD ; cutoff, 0 cm of FFD) ; (2) straight leg raising (SLR ; cutoff, 90 degrees of hip flexion) ; (3) heel-to-buttock distance (HBD ; cutoff, 0 cm of HBD) ; (4) rectusfemoris (cutoff, 80 degrees of knee flexion) ; (5) external rotator muscles (cutoff, 45 degrees of hip adduction) ; (6) internal rotator muscles (cutoff, 45 degrees of internal hip rotation) (7) iliopsoas (cutoff, 0 degrees of hip extension) ; (8) tensor fasciae latae (cutoff, 15 degrees of hip adduction) ; (9) adductor muscles (cutoff, 0 cm of the knee to floor distance) (10) soleus muscle (cutoff, 9 cm of the first toe to wall distance) ; (11) latissimus dorsi (cutoff, 180 degrees of shoulder flexion with no movement of the thorax) ; (12) trunk rotation (cutoff, 40 degrees of trunk rotation). Muscle strength and endurance : (13) sit-ups (cutoff, 30 times/30s) ; (14) endurance of abdominal muscles (cutoff, 180 s of holding the spine of the scapula 5 cm above the floor) ; endurance of back muscles (cutoff, 180 s of holding the acromion 5 cm above the floor).

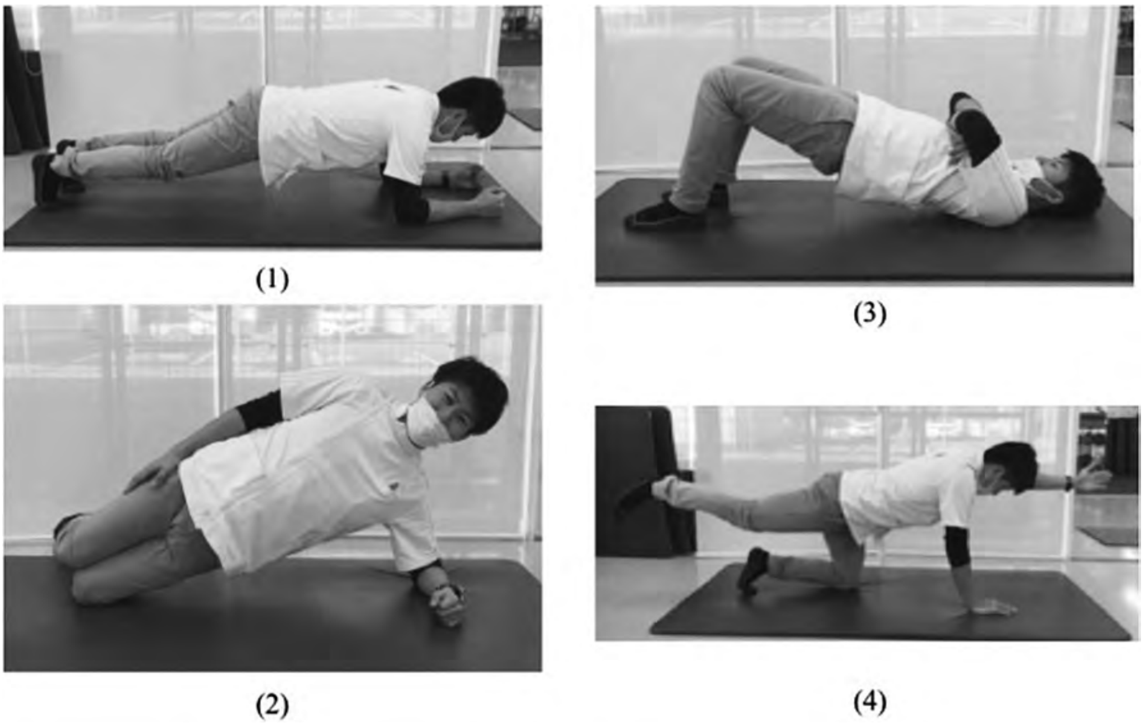

Figure 2
Four core stability and endurance training items (40 seconds-1 minutes of trunk muscle training, 2-3sets) : (1) anterior plank, (2) side plank, (3) bridge exercise, (4) bird dog exercise.

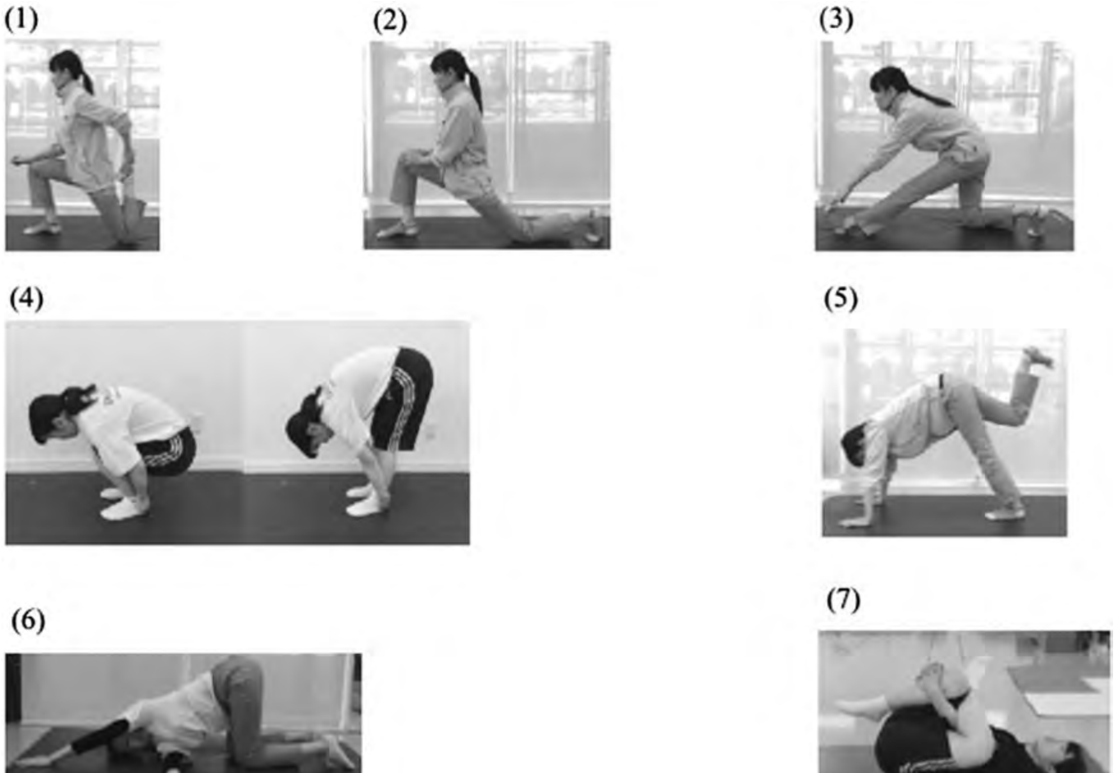

Figure 3
Methods of stretching (20-s sets of passive stretching, 2-3 set) against tightness muscles : (1) quadriceps muscle, (2) iliopsoas, (3) hamstrings-1, (4) hamstrings-2, (5) lower leg triceps, (6) latissimus dorsi, (7) glut muscle.

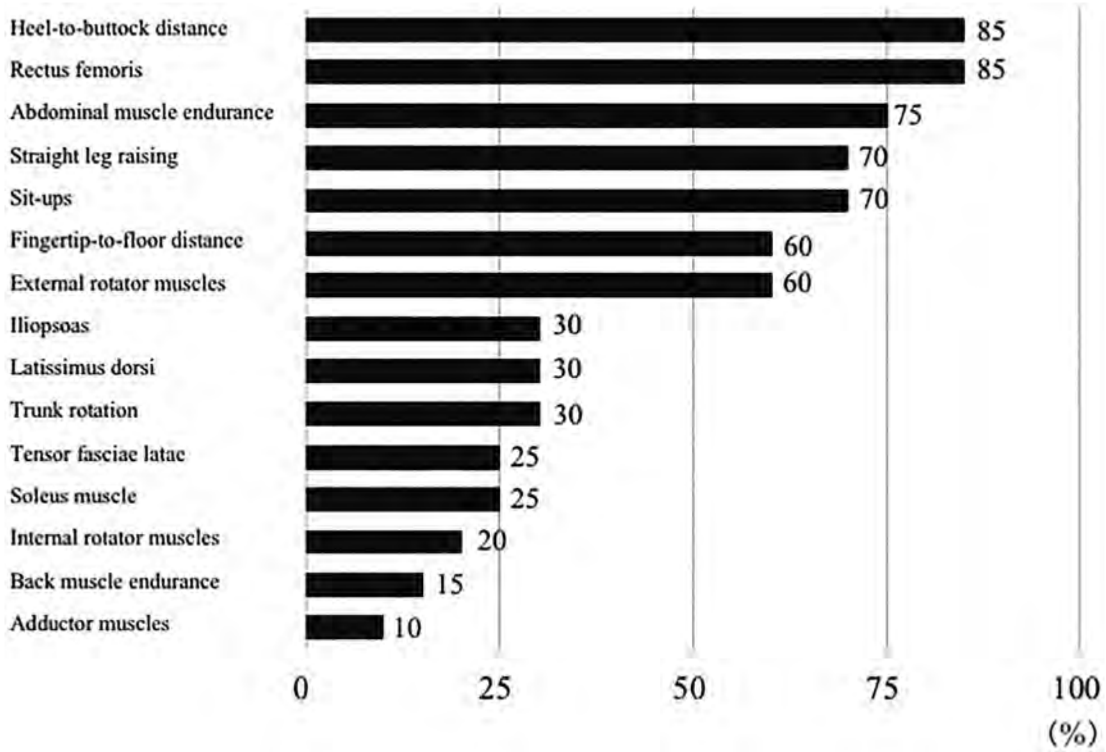

Figure 4
Graph showing the results at the initial evaluation for all 20 patients. Positive tests were found for heel-to-buttock distance and tightness of the rectus femoris in 85% of the patients, for endurance of the abdominal muscles in 75%, straight leg raise and sit-ups in 70%, and fingertip-to-floor distance and tightness of the external rotator muscles in 60%.

Baseball players

Of the 8 patients who played baseball, 7 (87.5%) had positive findings for FFD, SLR, HBD, and the rectus femoris, 6 (75%) for endurance of the abdominal muscles, and 5 (62.5%) for sit-ups (Figure 5). Four patients (50%) had positive findings for trunk rotation and tightness of the latissimus dorsi, and accounted for 75% of all patients who had positive results for these items. These patients showed loss of flexibility at the trunk and hip joints, which was particularly difficult to improve in the trunk.

Basketball players

All (100%) of the 4 patients engaged in basketball had positive findings for sit-ups and endurance of the abdominal muscles (Figure 6). The main feature in these patients was loss of strength in the trunk.

Soccer players

All of the 4 patients who played soccer had positive findings for FFD, SLR, and HBD, and for the rectus femoris and the external rotator muscles (Figure 7). The main physical feature in these patients was loss of flexibility at the hip joints.

Effect of rehabilitation

The improvement rate for each item is shown in Table 2. The least improvement was found for HBD (17.6%), followed by the external rotator muscles (33.3%), rectus femoris (35.3%), and endurance of the abdominal muscles (40.0%).

DISCUSSION

Positive tests were found for HBD and tightness of the rectus femoris in 85% of the patients, for endurance of the abdominal muscles in 75%, SLR and sit-ups in 70%, and FTD and tightness of the external rotator muscles in 60%. We found that these physical features varied according to the sport played. Furthermore, some of these items were refractory to rehabilitation. Only 17.6%, 33.3%, and 40.0% of patients with initially positive findings for HBD, tightness of the external rotator muscles, and endurance of the abdominal muscles, respectively, were found to be improved after rehabilitation.

Although the pathophysiologic mechanism of LS is still unclear, biomechanics studies using finite element modeling suggest that these stress fractures are caused mainly by combined extension and rotation movements of the lumbar spine (1, 8). Several causes of low back pain in adolescents, including those with LS, have been reported (2, 10). One factor is tightness of the leg muscles, including the hamstrings and quadriceps, which may increase compensatory movements and loading at the lumbar spine. According to the joint-by-joint theory proposed by Cook, the lumbar spine provides stability whereas the hip and thorax across the lumbar spine allow mobility (11, 12). Therefore, mobilization of the hip joint and thorax in addition to stabilization of the lumbar spine are considered important components in conditioning regimens for patients with disorders that affect the lumbar spine (13).

Recently, Sato *et al.* speculated that tightness of muscles in the region of the mobility joints, particularly the hip and ankle, may be the underlying pathology in pediatric patients with LS, and reported that active stretching with reciprocal inhibition was very effective for improving the flexibility of these joints (9). In the present study, we found that HBD was the item least likely to be

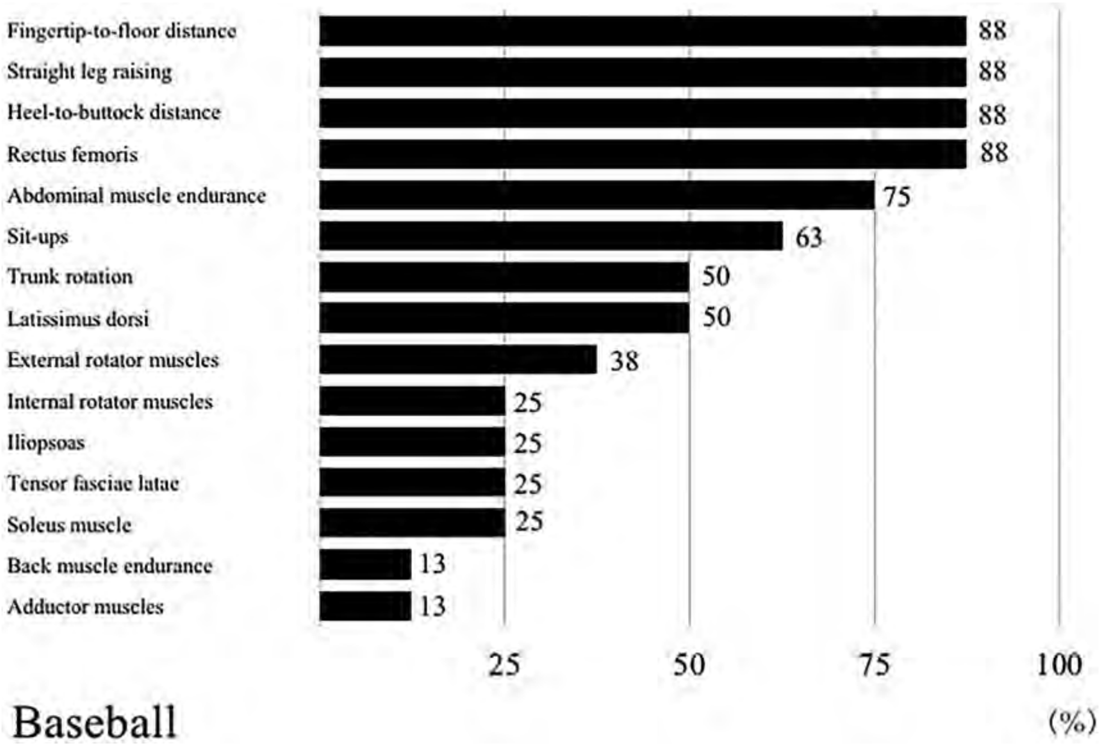

Figure 5
Graph showing the results at the initial evaluation for 8 patients who played baseball, in whom tests were positive for fingertip-to-floor distance, straight leg raise, heel-to-buttock distance, and rectus femoris in 88%, endurance of the abdominal muscles in 75%, and sit-ups in 63%. Note 4 patients (50%) had positive tests for shoulder flexion and trunk rotation, and accounted for 75% of all patients who had positive findings for those two items.

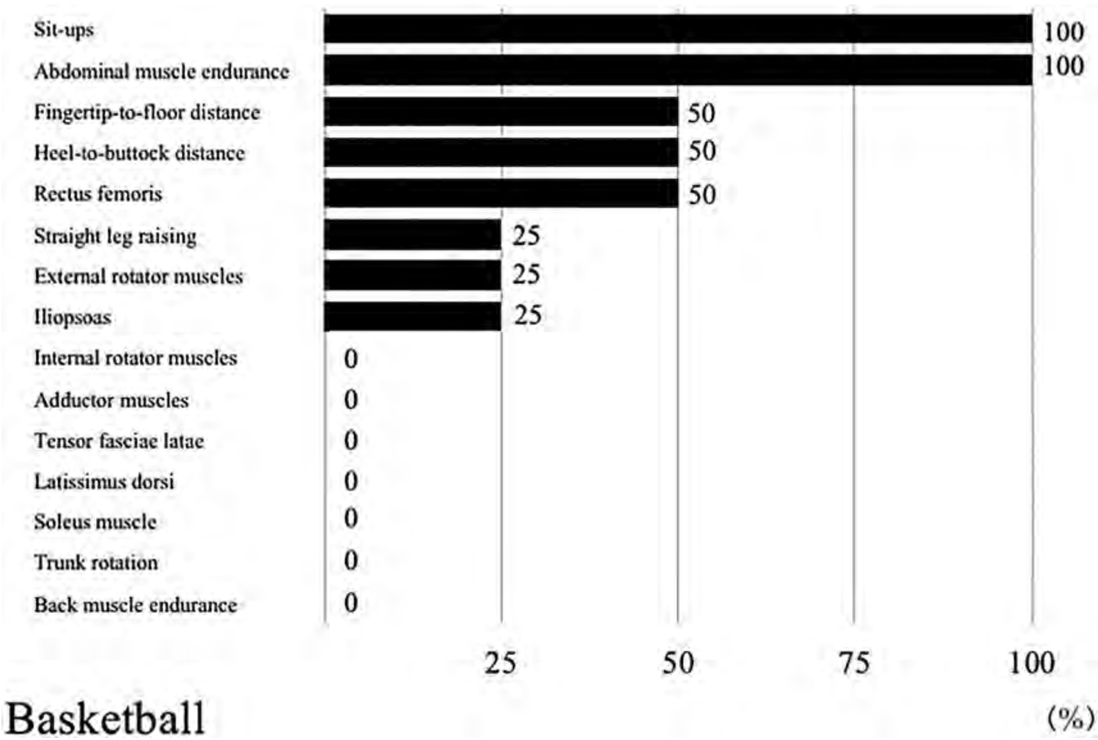

Figure 6
Graph showing the results at the initial evaluation for 4 patients who played in basketball, in whom tests were positive for sit-ups and endurance of the abdominal muscles in 100% of cases and for fingertip-to-floor distance, heel-to-buttock distance, and rectus femoris in 50% of case. Note that patients who played basketball tended to have loss of strength in the trunk.

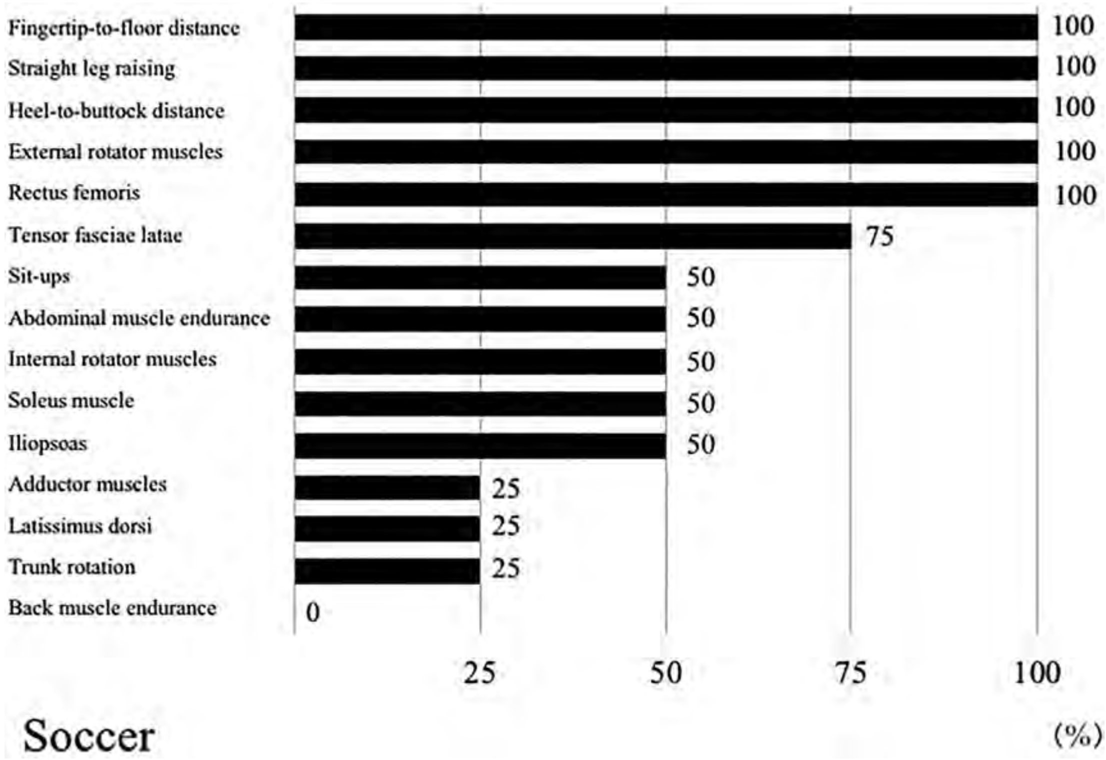

Figure 7
Graph showing the results at the initial evaluation for 4 patients engaged in soccer, all (100%) of whom had positive tests for fingertip-to-floor distance, straight leg raise, heel-to-buttock distance, rectus femoris, and the external rotator muscles. Note that patients who played soccer had loss of flexibility at the hip joints.

Table 2 Rate of improvement of each item

Evaluation for tightness	Patients with positive results before intervention (n)	Patients with negative results after intervention (n)	Improvement rate (%)
1. Fingertip-to-floor distance	12	11	91.7
2. Straight leg raising	14	9	64.3
3. Heel-to-buttock distance	17	3	17.6
4. Rectus femoris	17	6	35.3
5. External rotator muscles	12	4	33.3
6. Internal rotator muscles	4	1	25.0
7. Iliopsoas	6	3	50.0
8. Tensor fasciae latae	5	1	20.0
9. Adductor muscles	2	2	100.0
10. Soleus muscle	5	1	20.0
11. Latissimus dorsi	6	2	33.3
12. Trunk rotation	6	3	50.0
Evaluation for muscle strength and endurance			
13. Sit-ups	14	10	71.4
14. Endurance of abdominal muscles	15	6	40.0
15. Endurance of back muscles	3	2	66.7

improved by rehabilitation. The HBD is an indicator of flexibility not only in the quadriceps muscles but also in iliopsoas (14). For example, hyperextension of the lumbar spine with hyperextension of the hip and flexion of the knee is required when kicking a soccer ball set behind the body axis (15). If there is tightness in the muscles associated with these movements, excessive compensatory hyperextension of the lumbar spine is needed.

Half of the baseball players included in our study had positive findings for shoulder flexion and trunk rotation. Both these items indicate tightness of the thoracic muscles, which would increase the load at the lumbar spine and lead to compensatory hyperextension or hyperrotation. In a study of asymptomatic baseball players reported by Laudner *et al*., thoracolumbar movements, particularly extension and rotation, were found to be greater than those reported by the American Medical Association (16, 17).

We acknowledge that there are several limitations in this study. It is uncertain whether the methods we used for evaluation and rehabilitation were optimal. To simplify the evaluation, we classified our findings as positive or negative based on a cutoff value for each item, but whether our judgments were too strict or too loose is unclear. Furthermore, there was considerable variation in the staging of LS in our already small study sample. However, this research does have an important strength ; in other words, we were able to analyze data for consecutive patients with LS enrolled during a narrow time period in which a consistent rehabilitation protocol was used.

There is still no optimal evidence-based rehabilitation strategy for patients with LS that can be implemented during conservative treatment to reduce the risk of recurrence when they returning to playing sport (3). Identification of the physical features underlying the pathophysiologic mechanism of LS, which may involve increased mechanical stress from extension and rotation of the lumbar spine, would be an important first step in developing a rehabilitation program that can be used in primary care to avoid occurrence and recurrence of LS.

CONCLUSIONS

We have identified several physical features in pediatric patients with LS that tended to vary according to the type of sporting activity engaged in. Some of these physical features were refractory to rehabilitation. These findings represent an early step toward development of an optimal rehabilitation strategy for children with LS.

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DISCLOSURE

All authors confirm that there are no conflicts of interest with regard to persons or organizations that could have influenced our study findings.

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