Strength and Flexibility of the Quadriceps Muscle in Adolescent Athletes with Osgood-Schlatter Disease

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Abstract: In order to investigate the prevention of Osgood-Schlatter disease (OSD) in adolescent athletes, the strength and flexibility of the quadriceps muscles were examined in 30 adolescent athletes with unilateral OSD and 20 adolescent soccer players as a control. The following three factors were examined: 1) quadriceps strength in concentric and eccentric contraction, 2) quadriceps flexibility, and 3) the laterality of the involved knee. There was no significant difference in quadriceps muscle strength between athletes with OSD and soccer players, while quadriceps muscle flexibility in athletes with OSD was significantly low in comparison with soccer players. Although there was no significant difference in quadriceps muscle strength between the uninvolved and involved sides in our patients with unilateral OSD, the left knee was more prone to be affected than the right knee in adolescent athletes. In the great majority of adolescent athletes, the left knee had a tendency to be a dominant leg which was defined as the take-off leg. Since the dominant leg is susceptible to eccentric quadriceps contraction during rapid deceleration while jumping, landing or running when playing sport, we consider that these factors may play a role in the decrease of the quadriceps muscle flexibility in adolescent athletes with OSD. With regard to the prevention of OSD, stretching exercises to relieve the decrease of the quadriceps muscle flexibility and training to reduce the load on the dominant leg are recommended in adolescent athletes. (Jpn J Rehabil Med 2001; 38: 827-831)

Key words: Osgood-Schlatter disease (Osgood-Schlatter病), adolescent athletes (若年スポーツ選手), quadriceps muscle (大腿四頭筋), isokinetic muscle strength (等速筋力)
Introduction

Repeated traction of the quadriceps muscles on the tibial tuberosity and abnormal quadriceps tightness have been suggested to contribute to the development of Osgood-Schlatter disease (OSD). Avulsion of the patellar tendon with a small flake of the bone from the tibial tuberosity sometimes occurs in this condition, which particularly affects teenagers involved in vigorous sporting activities. Boys are more frequently affected than girls. The symptoms include local pain, tenderness, and swelling around the tibial tuberosity and the site of patellar tendon insertion. The discomfort is aggravated by exercise, especially while the knee is flexing with eccentric contraction of the quadriceps, such as when jumping, landing or stopping. In this study the strength and flexibility of the quadriceps muscle were measured to investigate the way of prevention of OSD in adolescent athletes.

Materials and Methods

A group of 30 adolescent athletes with unilateral OSD (OSD group) was enrolled in this study. They were involved in some after-school sporting activities for 4 days or more per week. They ranged from 11 to 18 years in age (mean: 13.7 years). OSD was diagnosed radiographically by a soft-tissue bulge anterior to the tibial tuberosity or fragmentation of the tuberosity in addition to the clinical symptoms and signs. All the patients had pain, tenderness, and swelling of the tibial tuberosity. Patients with patellar tendinitis, patello-femoral malalignment, or a history of significant injury suggesting meniscal and/or ligamentous tears were excluded. Among the patients with unilateral OSD, those having any symptoms or abnormalities in the contralateral knee joint were also excluded. Twenty soccer players aged 13 years old who had no history of knee injury were used as the control (S group).

The following three factors were examined in each group.

1) Quadriceps strength: A BIODEX (BIODEX, New York) muscle testing machine was used to measure the torque of the quadriceps during isokinetic contraction in OSD and S groups. The involved side was only tested after pain had completely subsided following conservative treatment involving rest and stretching exercises for quadriceps muscle. The angular velocity was set at 30 and 90 degrees per second and the knee motion was ranged from 100° to 0°. Each subject was positioned according to BIODEX testing manual. The peak torque (PT) relative to body weight (BW) \( \frac{PT}{BW} \) (ft-lbs/lbs × 100) of the quadriceps muscle was measured during concentric and eccentric contractions. The maximal effort in 3 trials was taken on both knees for data analysis. The data obtained were statistically analyzed by t-test.

2) Quadriceps flexibility: This was examined in OSD and S groups. The flexibility of the quadriceps muscle was measured goniometrically. Quadriceps flexibility was defined as being present when the flexion angle of the knee joint was over 130°, when the knee joint was passively flexed with the patient lying on the belly.

3) Laterality of the involved knee and the dominant leg which was defined as a take-off leg were assessed in OSD group.

Results

1. Quadriceps strength

1) PT/BW of the quadriceps in OSD group (mean ±SD)

With concentric contraction, the average PT/BW at 30 degrees per second of the uninvolved and involved sides was 66 ± 14 (ft-lbs/lbs × 100) and 65 ± 14, respectively. The average PT/BW at 90 degrees was 57 ± 13 and 57 ± 13, respectively. There was no significant difference between the uninvolved and involved knees. The torque of the concentric contraction was in inverse proportion to the angular velocity (Fig. 1).

With eccentric contraction, the average PT/BW at 30 degrees per second of the uninvolved and involved sides was 105 ± 27 and 102 ± 26, respectively, while the values at 90 degrees was 103 ± 25 and 106 ± 28. There was no significant difference between the uninvolved and involved knees. The torque did not change according to the angular velocity. The PT/BW was larger during eccentric contraction than that during concentric contraction (Fig. 1).
2) Comparison of the two groups using both knees data

With concentric contraction, the average PT/BW at an angular velocity of 30 degrees per second in OSD and S groups was 66±14 (ft-lbs/lbs×100) and 71±13, respectively, whereas the values at 90 degrees was 56±13 and 59±12. With concentric contraction, there was no significant difference in the average PT/BW among two groups (Fig. 2).

With eccentric contraction, the average PT/BW at 30 degrees per second in the above two groups was 104±27 and 101±21, respectively, whereas the values at 90 degrees was 105±28 and 94±18. With eccentric contraction, there was no significant difference in the average PT/BW among two groups (Fig. 2).

2. Quadriceps flexibility

Quadriceps flexibility was found in the uninvolved and involved sides in 93% and 43% of OSD group, while respective values were 100% in both sides of S group. Quadriceps flexibility was more common in the uninvolved side of OSD group and in S group.
than that in the involved side of OSD group.

3. Laterality of the involved knee and the dominant leg

In 30 patients with unilateral OSD, the left side was involved in 77%, the right side in 23%, so there was left-sided predominance. In this group, there was no right or left predominance in baseball players, while there was left-sided predominance in soccer players. The dominant leg which was defined as a take-off leg was involved in 83%.

Discussion

Osgood and Schlatter independently reported the entity that bears their names today and both concluded that the etiology was trauma. Ehrenborg reported that the cause of OSD was traumatic and the mechanism was avulsion of the patellar tendon associated with detachment of fragments from the tibial tuberosity. Lancourt and Cristini found patella infra in OSD prior to epiphyseal closure, and concluded that patella infra with shortening of the patellar tendon might lead to increased stress on the tibial tuberosity. Jacob et al found patella alta and a well-developed or even hypertrophic quadriceps muscle with decreased stretch-ability in OSD, and concluded that patella alta was related to contracture of the knee extensors, especially the rectus femoris. Willner found genu valgus, while Turner and Smillie found lateral tibial torsion in OSD. These conditions can increase the distance from origin to insertion of the quadriceps by increasing the Q angle, so that the tension on the tibial tuberosity might be magnified. Although many studies have investigated the etiologic factors of OSD, few authors have assessed quadriceps strength and tightness.

Since Hislop and Perrine proposed the concept of isokinetic contraction, various studies have been reported in the literature. However, clinical studies have mainly assessed concentric muscle strength and investigation of eccentric strength has been uncommon. Nevertheless, eccentric strength is as important as concentric strength, because instantaneous eccentric strength is often required in sporting activities. Eccentric strength is required, for instance, during rapid deceleration while running, jumping, or rapidly changing direction. Moreover, the symptoms of OSD are aggravated by exercise, especially while the knee is flexing with eccentric contraction of the quadriceps, such as when jumping, landing or stopping.

We suggested that eccentric strength of the quadriceps in athletic and non-athletic boys with OSD was significantly high in comparison with that in non-athletic boys without OSD, so that it might play important role in the development of OSD. In this study the strength and flexibility of the quadriceps muscle were measured to investigate the way of prevention of OSD in adolescent athletes. There was no significant difference in quadriceps strength between adolescent athletes with OSD and adolescent soccer players, while quadriceps flexibility in athletes with OSD was significantly low in comparison with that in soccer players. Eccentric quadriceps strength of adolescent athletes may be relatively high in comparison with that of non-athletes as a result of sporting practice such as jumping or landing.

Several cohort studies have examined the relationship of muscular flexibility and overuse injuries. Ekstrand et al found in their study of soccer players that muscular tightness was associated with tendinitis. These studies support the concept that decreased flexibility will lead to an increase in tendon strain with joint movements and therefore predispose athletes to tendon overload. In our patients with unilateral OSD, although there was no significant difference in quadriceps strength between the uninvolved and involved sides, the left knee was more prone to be affected than the right knee. In the great majority of adolescent athletes, the left knee had a tendency to be a dominant leg which was defined as the take-off leg. The dominant leg is susceptible to eccentric quadriceps contraction during rapid deceleration while jumping, landing or running when playing sport. The quadriceps flexibility in involved side of OSD was significantly low in comparison with that in uninvolved side in our results, so that we consider that the decreased quadriceps flexibility in involved side of OSD may be caused by fatigue of quadriceps muscle owing to overuse of sporting activities such as eccentric exercise.

As mentioned before, when eccentric quadriceps
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strength is exerted during rapid deceleration, quadriceps muscle force resist the reaction from the floor, which in turn acts on the bone-tendon junction of tibial tuberosity several times as much as during standing or walking. But quadriceps with tightness is not resilient enough to absorb the floor-reaction force, and the impact force may act directly on the bone-tendon junction of tibial tuberosity. With regard to the prevention of OSD, stretching exercises to relieve the decrease of the quadriceps flexibility and training to reduce the load on the dominant leg are recommended in adolescent athletes.

References