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Original Article

Relationship between Lower Extremity Tightness and Star Excursion Balance Test Performance in Junior High School Baseball Players

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Abstract. [Purpose] The purpose of this study was to examine the relationship between lower extremity tightness and lower extremity balance, measured by the Star Excursion Balance Test (SEBT), in junior high school baseball players. [Subjects] Thirty-three male students belonging to baseball clubs in 2 junior high schools participated in this study. [Methods] For the SEBT, we chose to examine the anterior (ANT), posterior (POS), lateral (LAT), and medial (MED) directions. Regarding muscle tightness measurement, the angle of each joint of the bilateral iliopsoas, quadriceps, hamstring, gastrocnemius, hip internal rotator, and hip external rotator was measured. [Results] The ANT direction of the SEBT was significantly negatively correlated with gastrocnemius tightness. The MED direction of the SEBT was significantly positively correlated with hip internal rotator tightness and hamstrings tightness and significantly negatively correlated with gastrocnemius tightness. The LAT direction of the SEBT was significantly negatively correlated with iliopsoas tightness and gastrocnemius tightness. [Conclusion] Since the rate of upper extremity injury is high in these subjects and this could be due to tightness and instability of the lower extremity from a kinetic viewpoint, the SEBT could be used as a standard evaluation test when examining upper extremity injuries in young baseball players.
Key words: Growth phase, Standing balance, Flexibility

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INTRODUCTION

Various studies have shown the risk factors for elbow and shoulder injuries among young baseball players[1, 2)]. The incidence of elbow and shoulder pain increases with increasing age, increasing weight, decreasing height, weight lifting, pitching with arm fatigue, and increasing number of pitches thrown per season[1, 2)]. In addition, the lower extremity motion of adolescent baseball players is important to understanding the pitching motion and the implications of the lower extremity technique in upper extremity loads, injury, and performance.

The Star Excursion Balance Test (SEBT) is a functional performance test of the lower extremity and is used to assess chronic ankle instability and anterior cruciate ligament injury[3–5)]. The SEBT has been used to assess dynamic postural control. It has been proposed to challenge dynamic postural control because the subject must maintain balance on a single limb, whilst the other limb carries out a series of reaching tasks. Moreover, the SEBT reach distance is correlated with hip range of motion (ROM) and strength[6, 7)].

However, little is known about the relationship between lower extremity balance and tightness in young athletes. Therefore, the purpose of this study was to examine the relationship between lower extremity tightness and lower extremity balance as measured by the SEBT in junior high school baseball players.

SUBJECTS AND METHODS

Thirty-three male students belonging to baseball clubs in 2 junior high schools (mean age, 13.4 ± 0.5 years; height, 158.9 ± 5.9 cm; weight, 49.8 ± 5.5 kg) participated in this study. None of the subjects had suffered an injury in the past 6 months or had a self-reported disability in a lower extremity. Before enrollment in the study, all subjects provided written informed consent. The study conformed to the Declaration of Helsinki and was approved by the Gunma University Ethics Committee.

The SEBT, a multidirectional test of dynamic postural control, involves balancing on 1 leg and using the other leg to reach the maximum distance in 8 different directions: 3 anterior, 2 lateral, and 3 posterior directions. For the SEBT, we chose to examine the anterior (ANT), posterior (POS), lateral (LAT), and medial (MED) directions. The SEBT was performed based on the recommendations of Hertel[8)].

Participants underwent the testing barefoot, with the foot

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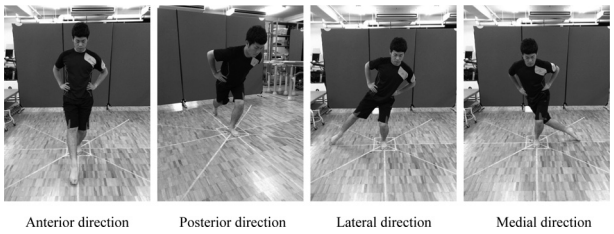

Fig. 1. Star Excursion Balance Test (SEBT)

Table 1. Star Excursion Balance Test (SEBT) results

Direction of SEBT	Step-leg stance	Axis-leg stance
Anterior (%)	91.9 ± 6.9	91.1 ± 5.9
Posterior (%)	88.8 ± 6.8	87.1 ± 6.6
Lateral (%)	92.5 ± 5.7	91.5 ± 5.8
Medial (%)	77.0 ± 10.0	78.3 ± 8.6

Data are expressed as mean ± SD.

Table 2. Tightness test results

Muscle	Step-leg tightness (degrees)	Axis-leg tightness (degrees)
Hip internal rotator	41.4 ± 9.6	38.9 ± 7.9
Hip external rotator	48.9 ± 11.8	54.9 ± 10.7
Quadriceps	148.7 ± 8.6	147.0 ± 8.3
Hamstring	68.3 ± 9.9	68.1 ± 10.3
Iliopsoas	8.5 ± 2.1	8.5 ± 2.7
Gastrocnemius	51.9 ± 6.2	50.8 ± 6.3

Data are expressed as mean ± SD.

position controlled by aligning the heel with the center of the grid and the great toe with the anteriorly projected line. This position was marked with a piece of tape to ensure accurate repositioning between trials. Subjects were instructed to perform maximal reach with the opposite lower extremity followed by a single, light toe touch on the tape (Fig. 1). Errors were recorded if the hands did not remain on the hips, the position of the stance foot was not maintained, the heel did not remain in contact with the floor, or the subject lost balance during the trial. The participants completed 3 test trials in each of the 4 reach directions. Leg length was used to normalize excursion distances by dividing the distance reached by leg length and then multiplying by 100. Leg length was measured from the anterior superior iliac spine to the distal tip of the medial malleolus using a standard tape measure while the participants lay in a supine position. In this study, we classified the leg on either side as the axis leg and step leg at the time of pitching.

Regarding muscle tightness measurement, the angle of each joint of the bilateral iliopsoas, quadriceps, hamstring, and gastrocnemius was measured, referring to the measurement method reported by Tolii[9]. Additionally, bilateral hip external rotator and internal rotator tightness was measured in the supine position, with the hip flexed at 90 degrees. Muscle tightness was passively measured by a physical therapist.

Using Spearman's rank correlation, we calculated bivariate correlations between the SEBT score and the muscle tightness of the stance leg during the SEBT. Statistical analysis was performed using SPSS version 20 for Windows, and a $p < 0.05$ was considered statistically significant in all analyses.

RESULTS

All lower extremity tightness and SEBT scores are presented in Tables 1 and 2. The ANT direction of the step-leg stance was significantly negatively correlated with gastrocnemius tightness ($r = -0.470$, $p = 0.006$). The MED direction of the step-leg stance was significantly positively correlated with hip internal rotator tightness ($r = 0.572$, $p = 0.001$) and hamstring tightness ($r = 0.457$, $p = 0.007$). The ANT direction of the axis-leg stance was significantly negatively correlated with gastrocnemius tightness ($r = -0.420$, $p = 0.015$). The LAT direction of the axis-leg stance was significantly negatively correlated with iliopsoas tightness ($r = -0.394$, $p = 0.023$) and gastrocnemius tightness ($r = -0.416$, $p = 0.016$). The MED direction of the axis-leg stance was significantly negatively correlated with gastrocnemius tightness ($r = -0.371$, $p = 0.033$) .

DISCUSSION

In this study, we observed a significant correlation between lower extremity tightness and reach direction in the SEBT. Gastrocnemius tightness was negatively correlated with the ANT direction in the SEBT. As gastrocnemius tightness increases, ANT reach distance decreases. A previous study reported that the ankle dorsiflexion ROM was significantly correlated with the ANT reach distance in the SEBT[10]. The present study supports this. In addition, in the results of this study, it became clear that gastrocnemius tightness is also correlated with the MED and LAT reach distance. Similarly, as gastrocnemius tightness increases, the MED and LAT reach distances also decreases. Therefore, the role of ankle dorsiflexion movement is also important when reaching in the MED and LAT direction. Moreover, iliopsoas tightness is correlated with LAT reach. The tightness of the hip internal rotator and hamstring is negatively correlated with MED reach. As each muscle's tightness increases, MED and LAT reach decrease. A re-

cent investigation exploring kinematic predictors of SEBT performance reported that the sagittal plane motion of the knee and hip account for approximately 90% of the variance in MED and LAT reach[6]. Therefore, in MED and LAT reach, movement of the knee and hip joint is considered important, and the influences of iliopsoas tightness and hamstring tightness were significant.

Therefore, the ANT reach direction in the SEBT may be a useful clinical indicator of lower extremity function for individuals with gastrocnemius tightness, and the MED and LAT reach directions in the SEBT may be useful for assessing individuals with tightness in the iliopsoas, quadriceps, and hamstring.

The SEBT is a functional performance test of the lower extremity and is used to assess chronic ankle instability and anterior cruciate ligament injury[3–5]. In young baseball players, the rates of elbow and shoulder injuries are high. It is thought that the muscle tightness and instability due to muscle weakness of the lower extremity results in breakdown of the kinetic chain, causing early trunk rotation, an increase in elbow valgus, or shoulder rotation, and it is thought that the load of the upper extremity is increased. In other words, tightness and instability of the lower extremity may induce injury in the upper extremity. Therefore, by including assessment of the tightness of the lower extremity, the SEBT could be used as a standard evaluation test when examining upper extremity injuries in young baseball players. In the future, the relationship between throwing-related injuries and dynamic postural control measured by the SEBT should be considered.

From our results, we concluded that lower extremity tightness and balance were significantly correlated. Since the rate of upper extremity injury is high in these subjects and this could be due to tightness and instability of the lower extremity from a kinetic viewpoint, the SEBT could be used as a standard evaluation test when examining upper extremity injuries in young baseball players.

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