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Difference in kick motion of adolescent soccer players in presence and absence of low back pain

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ABSTRACT

Many adolescent soccer players experience low back pain (LBP). However, there are no reports studying the kick motion of adolescent soccer players experiencing LBP. This study aimed to clarify the kick motion of adolescent soccer players in the presence and absence of LBP. We recruited 42 adolescent soccer players and divided them into two groups according to the presence of LBP (LBP group, n = 22) and absence of LBP (NBP group, n = 20). We measured real-time kick motion using a three-dimensional motion analysis system. We placed 65 spherical markers on each anatomical landmark and calculated the angle of the lumbar spine, center of mass (COM) of the whole body, and displacement of the support foot. We used an unpaired *t*-test to compare the data between the groups. Compared with the NBP group, the LBP group showed a lateral shift in COM, which increased the duration of kick motion. The presence of LBP affected the posterior positioning of the support foot and restricted the player's lumbar spine from bending laterally. A lateral shift in COM and larger rotation of the lumbar spine could stress the lumbar spine during kick motion. Therefore, coaches and athletic trainers should pay attention to soccer players' lumbar spine rotation and the COM shift during kick motion. This would be important for preventing LBP in adolescent soccer players.

1. Introduction

Soccer-related injuries and disorders during adolescence have been reported [1–5]. Compared with early-maturing players, late-maturing players have a higher incidence of soccer-related injuries and disorders [1]. Low back pain (LBP) is the fourth most common disorder reported by soccer players [2], and compared with non-athletes, their odds ratio for LBP is 1.2 [3] to 1.8 [4]. There is a relationship between the presence of lumbar disk degeneration [3] and spondylolysis [5] and LBP among soccer players. LBP is caused by muscle tightness in the lower limb [6], instability of the trunk muscle [7], hip–spine incoordination during movement [8], and repetition of excessive lumbar extension and rotation [9].

When performing kick motion to rapidly shoot a ball, an adolescent soccer player will place the support foot near the ball [10] and rotate the trunk with a high speed [11]. However, the repetition of excessive lumbar extension and rotation causes LBP [9]. How the presence of LBP affects kick motion in adolescent soccer players remains unknown. In this study, we examined the kick motion of adolescent soccer players in the presence and absence of LBP to clarify the difference of kick motion between the groups. If there was a difference between the groups, we could determine the predictive factor of LBP and help prevent LBP in adolescent soccer players. Our hypothesis was that, the LBP group would show more lumbar extension and rotation, and the difference in kick motion would cause a shift in the center of mass (COM) of the whole body.

2. Materials and methods

2.1. Subjects

This study was approved by the Office of Research Ethics, Waseda University [#2013-167(1)]. All participants from a soccer club team provided informed consent. We recruited 42 adolescent soccer players from the town recreation league team: age, 13.9 ± 0.6 years; height, 164.5 ± 7.1 cm; body mass, 54.0 ± 7.1 kg; body mass index, 19.9 ± 1.6 kg/m^2. Inclusion criteria were as follows: no history of spine/lower limb surgeries as well as no lower extremity joint pain. These participants attended regular soccer practice after school and on the weekends. Their training was supervised by coaches in the club team. All participants who developed LBP were assessed by an orthopedist with 30 years of experience immediately before or after the

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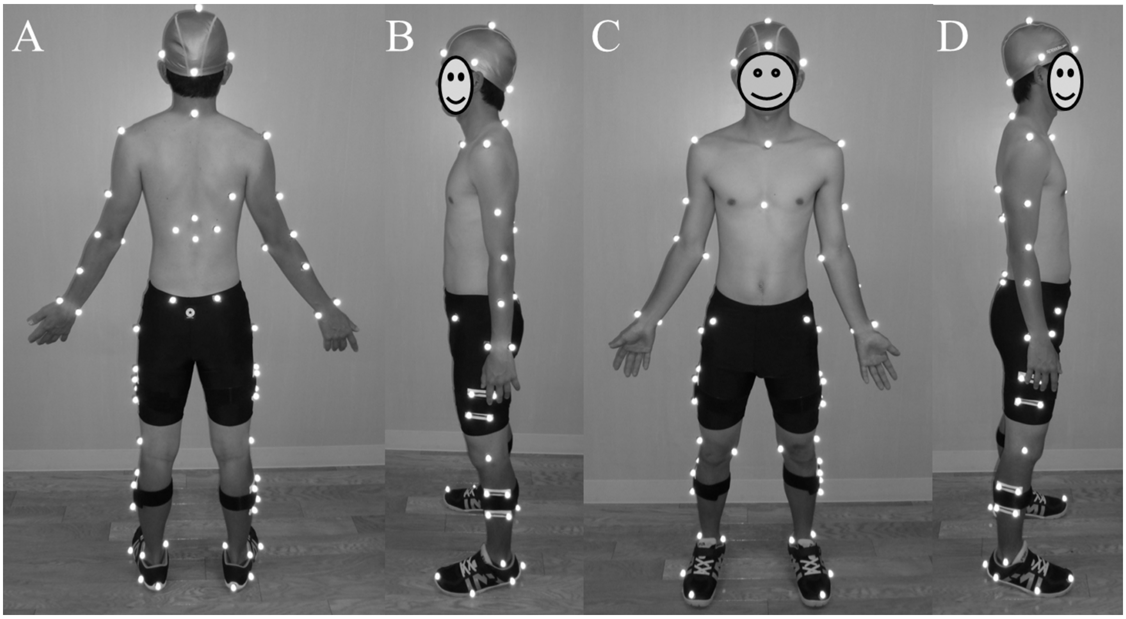

Fig. 1. Location of 65 reflective markers on the whole body.

measurement of kick motion. We divided participants into two groups according to presence of LBP (LBP group, n = 22) and absence of LBP (NBP group, n = 20) based on the findings of pain during trunk flexion, trunk extension, and Kemp's test; tenderness of the fifth lumbar spinous process; as well as observations during soccer training.

2.2. Motion analysis

We used half the area of a basketball court in a gym and placed a regulation soccer ball (FIFA standard) at the center of a circle, which was set at the coordinate center. We placed motion analysis cameras 8.5 m away from the ball; the accuracy of calibration was 1.9 mm. We placed two plastic pylons, 70 cm in height, at a distance of 3.6 m from each other as the goal. The distance from the ball to the goal was 14 m.

The participants did a warm-up before the measurement and practiced kicking the soccer ball three to five times. We placed 65 spherical markers on each anatomical landmark (Fig. 1). We used a combination of three marker placements: Helen Hayes marker for the whole body [12], the Point Cluster Technique for the lower legs [13,14], and our previous technique for the spine [8,15]. To calculate the ball velocity, we attached the reflective tapes as markers to the ball. We measured real-time kick motion using a three-dimensional motion analysis system (Qualisys track manager; Qualisys AB., Sweden) with eight cameras at 240 Hz to measure the position of the spherical markers. In the measurement, we asked the participants to kick the ball into the goal, not over the goal height or by letting the ball roll on the floor. Participants kicked the ball two times, as forcefully as possible. We then analyzed data related to the second kick motion. Noise was filtered from the raw data using a 6 Hz low-pass filter.

We used biomechanics analysis software Visual3D v5 (C-Motion, Inc., MD, USA) to calculate the angle of the lumbar spine, COM from Helen Hayes marker, and maximum ball velocity. We defined support foot position as the average of all of the support foot marker locations: the top of the second toe, head of the fifth metatarsal, and posterior and lateral heel. We calculated the lumbar spine angle from the thoracolumbar segment with respect to the pelvic segment (i.e., the sum of L1–L5 vertebral movements, [8]). Previous studies have found that skin movement artifacts from pelvic [16] and spine markers [17] are not a major source of error in thin participants. The measurement of lumbar motion using this marker method is sufficiently repeatable and reliable [15]. Based on a previous report [18], we collected data related to the following six events: foot contact (FC), toe off (TO), maximum hip extension (HE), maximum knee flexion (KF), ball impact (BI), and maximum hip flexion (HF). We converted the obtained data into a percentage and averaged each participant's data in both the groups.

2.3. Statistical analysis

We performed statistical analysis using IBM SPSS Statistics ver. 19.0 (IBM Corp., Endicott, NY). We used unpaired *t*-test to compare the data between the groups. We calculated the effect size of *Cohen's d*. The level of significance was set at $p < 0.05$.

3. Results

In the LBP group (n = 22), the participants complained about pain during trunk flexion (n = 1), trunk extension (n = 19), Kemp's test to the right side (n = 20) and left side (n = 22), and soccer training (n = 9), as well as tenderness of the fifth lumbar spinous process (n = 22).

Except for two participants in the NBP group who kicked the ball with an instep kick, all participants in both groups kicked the ball with their inside foot. There was no difference in the maximum ball velocity between the groups [95% confidence interval (CI) for difference = −0.345 to 2.572, effect size = 0.47, Table 1]. The duration of kick motion between FC and HF in the LBP group was 61.6 ± 30.7 ms and had a tendency to be longer than that in the NBP group (95% CI for difference = −123.653 to 0.413, effect size = −0.61, Table 1). Compared with the NBP group, the LBP group tended to show a lateral shift in COM at FC (p = 0.065, 95% CI for difference = −0.231 to 0.007) and HF (p = 0.076, 95% CI for difference = −0.008 to 0.153, Fig. 2, Appendix A), and their support foot tended to be positioned posterior to the ball from HE (p = 0.078, 95% CI for difference = −0.020 to 0.355) to BI (p = 0.009, 95% CI for difference = 0.018 to 0.117) and tended to be positioned supporting side laterally at FC (p = 0.063, 95% CI for difference = −0.351 to 0.010, Fig. 3, Appendix A). During kick motion, there was no difference in lumbar extension between the groups (Fig. 4, Appendix A). Compared with the NBP group, the LBP group showed 5.9 ± 2.2° greater rotation of the lumbar spine at FC (p = 0.010, 95% CI for difference = 1.487 to 10.317) and tended to show 3.4 ± 1.8° lesser lateral bending of the lumbar spine at KF (p = 0.067, 95% CI for difference = −0.252 to 7.024, Fig. 4, Appendix