CHANGES OF LUMBOPELVIC RHYTHM DURING TRUNK EXTENSION IN ADOLESCENT SOCCER PLAYERS

Michio Tojima[1] and Suguru Torii[1]
Faculty of Sport Sciences, Waseda University, Saitama, Japan[1]

Hip–spine coordination (or lumbopelvic rhythm) can be used to assess the lower-limb and spine functions. We measured low-back pain (LBP) in adolescent soccer players before and after a 6-month period and divided them into four groups: no LBP both before and after the period, LBP before but not after (PN), LBP after but not before (NP), and LBP both before and after. We used 3D motion analysis during trunk extension to measure the lumbar spine and hip ranges of motion (ROMs). During the 6-month follow-up, lumbar spine ROM decreased in the NP group. This group extended their lumbar spine excessively compared with the hip before the period, which could cause LBP, but decreased the extension after the period. Lumbar extension relative to hip extension decreased in the PN group, which could decrease the excessive load on the lumbar spine and eliminate LBP.

KEY WORDS: lumbar spine, hip, low-back pain, longitudinal research, range of motion.

INTRODUCTION: Many adolescent athletes experience low-back pain (LBP) caused by lumbar spondylolysis/intervertebral disk disorder. LBP is the seventh most common sports-related and the fourth most common soccer-related disorder (Le Gall et al., 2006). Causative factors of LBP include lower-limb muscle tightness (Kujala et al., 1992) and hip–spine incoordination (Offierski & Macnab, 1983).

Hip–spine coordination, known as lumbopelvic rhythm (LPR), can be used to assess the lower-limb and spine functions. LPR is represented graphically by plotting the lumbar spine range of motion (ROM) (y-axis) against hip ROM (x-axis). During trunk extension in adults, when the hip is extended by 1°, the lumbar spine extends by 1.9° (Tojima et al., 2013). However, there are no studies on LPR among adolescents with LBP.

There are many reports on lumbar spine ROM during trunk extension in the standing position. Lumbar spine ROM is reported as 15.5° (Wong & Lee, 2004) and 30.1° (Tojima et al., 2016) for adults and 30° for adolescents (Kujala et al., 1992). Hip ROM is reported as 15.7° (Wong & Lee, 2004) and 17.1° (Tojima et al., 2016) for adults, with no reports for adolescents.

We investigated changes of LPR in the presence/absence of LBP among adolescent soccer players. The medical benefits of a better understanding of LPR include its usefulness for assessing lower-limb and spinal malfunctions in terms of deviation from the normal ranges.

METHODS: This study was approved by the Office of Research Ethics, Waseda University

(#2013-167(1)), and all participants provided informed consent. We included 63 adolescent male soccer players (town recreation league team; age, 13 ± 1 years; height, 158 ± 10 cm; body mass, 46 ± 7 kg; body mass index, 18 ± 2) who undertook regular soccer practice after school and at weekends over a 6-month period. Their training was supervised by coaches in the club team. The inclusion criteria were no prior spine/lower-limb surgery and no painful joint in the lower extremities.

LBP was assessed for each participant before and after the 6-month period. For LBP assessment, a doctor asked the participants to extend their trunk while in the standing position and if LBP had persisted for over a week. The participants were divided into four groups according to the presence/absence of LBP: no LBP both before and after the 6-month period (NBP group, $n = 23$); LBP before but not after the period (PN group, $n = 9$); LBP after but not before the period (NP group, $n = 14$); and LBP both before and after the period (LBP group, $n = 17$).

To assess LPR, we placed 13 spherical markers, 14 mm in diameter, on the following anatomical landmarks: the thoracolumbar spine [right and left paravertebral muscles at the 11th thoracic vertebra (T11), T10, and T12], pelvis [right and left posterior superior iliac spines and the third sacral vertebra (S3)], and femur (greater trochanter and medial and lateral epicondyles). Subjects were asked to perform trunk extension three times at their own speed. We used a 3D motion analysis system (Qualysis Track Manager, Qualysis AB., Sweden) with six cameras at 60 Hz to measure the position of the spherical markers. Noise was filtered from the raw data using a 6-Hz low-pass filter.

We used the biomechanics analysis software Visual3D v5 (C-Motion, Inc., MD, USA) to calculate the lumbar spine angle from the thoracolumbar segment with respect to the pelvic segment (i.e., the sum of L1–5 vertebral movements) and to calculate the hip angle from the femur segment with respect to the pelvic segment. Previous studies have found that skin-movement artifacts from pelvic (Drerup & Hierholzer, 1987) and spine markers (Gracovetsky et al., 1995) are not a major source of error in thin participants. Measuring lumbar motion with this marker method is sufficiently repeatable and reliable (Tojima et al., 2013). We used hip ROM to define trunk extension, defining the start of extension as the point when hip ROM was ≥1° and the end as the point at which the ROM was at its maximum.

Statistical analysis was performed using IBM SPSS Statistics ver. 19.0 (IBM Corp., Endicott, NY). Paired *t*-tests were used to compare the joint ROM before and after the period, and linear prediction was used to describe LPR. The level of significance was set at $p < 0.05$.

RESULTS: Comparing the results obtained before and after the 6-month period, lumbar spine ROM decreased in the NP group and hip ROM increased in the LBP group (Table 1); LPR decreased in all four groups (Figure 1). From before to after, the linear prediction indicated that when the hip extends by 1°, the lumbar spine extends by 3.1° to 2.8° for the NBP group, 3.5° to 3.2° for the PN group, 3.4° to 2.8° for the NP group, and 2.8° to 2.3° for the LBP group.

Table 1: Change in Joint Range of Motion

	Group	before mean	±	SD	after mean ±	SD	p
Lumbar spine ROM (°)	NBP	34.5	±	12.1	33.0 ±	9.1	0.492
	PN	30.8	±	9.7	31.7 ±	7.6	0.842
	NP	39.6	±	10.5	35.4 ±	11.2	0.047
	LBP	30.0	±	11.9	26.9 ±	9.3	0.149
Hip ROM (°)	NBP	11.1	±	4.4	12.2 ±	3.6	0.112
	PN	9.5	±	2.9	11.0 ±	2.3	0.190
	NP	12.2	±	5.5	14.6 ±	4.6	0.104
	LBP	10.7	±	5.5	12.9 ±	3.5	0.036

NBP group, no LBP both before and after the period; PN group, LBP before but not after; NP group, LBP at after but not before; LBP group, LBP both before and after. ROM, range of motion

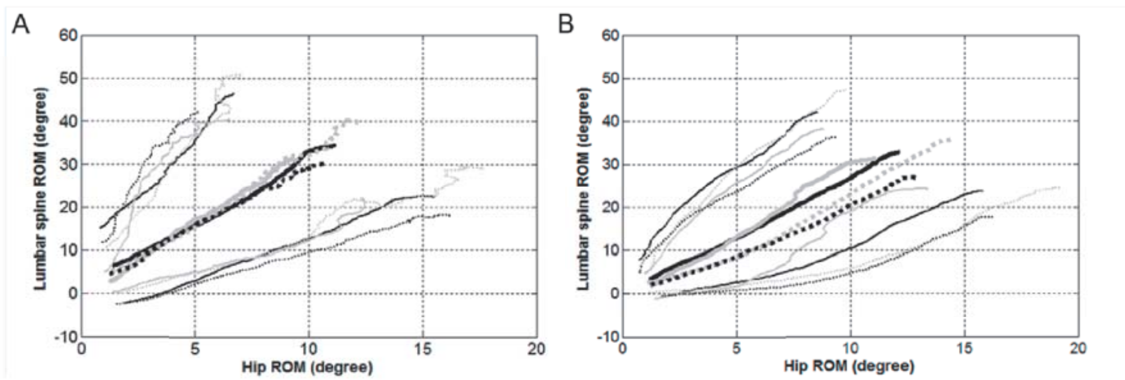

Figure 1: The mean (thick lines) and standard deviation (thin lines) for the hip and lumbar spine ranges of motion during trunk extension before (A) and after (B) the 6-month period.

Black unbroken lines, NBP group; gray unbroken lines, PN group; gray broken lines, NP group; and black broken lines, LBP group. ROM, range of motion

NBP group: before, $y = 3.1x + 0.6$ ($R^2 = 0.991$, $p < 0.001$); after, $y = 2.8x - 0.5$ ($R^2 = 0.998$, $p < 0.001$).

PN group: before, $y = 3.5x - 1.0$ ($R^2 = 0.997$, $p < 0.001$); after, $y = 3.2x + 2.6$ ($R^2 = 0.991$, $p < 0.001$)

NP group: before, $y = 3.4x - 0.4$ ($R^2 = 0.989$, $p < 0.001$); after, $y = 2.8x - 4.0$ ($R^2 = 0.989$, $p < 0.001$)

LBP group: before, $y = 2.8x + 1.2$ ($R^2 = 0.996$, $p < 0.001$); after, $y = 2.3x - 2.4$ ($R^2 = 0.994$, $p < 0.001$)

DISCUSSION: Previous studies have reported the lumbar spine and hip ROMs for adults during trunk extension. Wong and Lee (2004) reported a lumbar spine ROM of 16° and hip ROM of 16°. Tojima et al., (2016) reported a lumbar spine ROM of 30° and hip ROM of 17°. Our results for lumbar spine ROM in adolescents are comparable to the previous results for lumbar spine ROM in adults (Tojima et al., 2016); however, our results for hip ROM in adolescents are smaller compared with previous results for hip ROM in adolescents (Tojima et al., 2016; Wong & Lee, 2004). In comparison with adults, the adolescent soccer players show tightness in the quadriceps femoris muscle (Kujala et al., 1992), which could restrict hip motion during trunk extension.

From before to after the 6-month period, lumbar spine ROM decreased in the NP group. This was because these participants extended their lumbar spine excessively relative to the hip before the period, which could load the lumbar spine and result in LBP, but decreased the extension after the period. Hip ROM had increased after the period in the LBP group. This was because LBP restricted their lumbar extension relative to the hip; therefore, they could extend the hip as a compensatory motion. The PN group decreased their relative lumbar spine extension, which could reduce the load on the lumbar spine and thus eliminate LBP after the period. These findings suggest that to prevent LBP in adolescent soccer players, it is important to restrict the lumbar spine extension relative to the hip extension.

The limitation of this study was that we did not assess the relationship between LBP and soccer motions such as kicking and heading in adolescent soccer players. Further studies on other joint and muscle functions are needed to explain the relationship between LBP and LPR during soccer motion.

CONCLUSION: Adolescent soccer players with LBP extended their lumbar spine relative to their hip to a greater degree than those without LBP. Thus, it is important to restrict lumbar extension relative to hip extension to prevent LBP in adolescent soccer players.

REFERENCES:

Drerup, B. & Hierholzer, E., (1987). Movement of the human pelvis and displacement of related anatomical landmarks on the body surface. *J. Biomech.* 20, 971-977.

Gracovetsky, S., Newman, N., Pawlowsky, M., Lanzo, V., Davey, B. & Robinson, L., (1995). A database for estimating normal spinal motion derived from noninvasive measurements. *Spine (Phila Pa 1976)* 20, 1036-1046.

Kujala, U.M., Salminen, J.J., Taimela, S., Oksanen, A. & Jaakkola, L., (1992). Subject characteristics and low back pain in young athletes and nonathletes. *Med. Sci. Sports Exerc.* 24, 627-632.

Le Gall, F., Carling, C., Reilly, T., Vandewalle, H., Church, J. & Rochcongar, P., (2006). Incidence of injuries in elite French youth soccer players: a 10-season study. *Am. J. Sports Med.* 34, 928-938.

Offierski, C.M. & Macnab, I., (1983). Hip Spine syndrome. *Spine (Phila Pa 1976)* 8, 316-321.

Tojima, M., Ogata, N., Nakahara, Y. & Haga, N., (2016). Three-Dimensional Motion Analysis of Lumbopelvic Rhythm During Trunk Extension. *Journal of Human Kinetics* 50, 7 - 20.

Tojima, M., Ogata, N., Yozu, A., Sumitani, M. & Haga, N., (2013). Novel 3-dimensional motion analysis method for measuring the lumbar spine range of motion: repeatability and reliability compared with an electrogoniometer. *Spine (Phila Pa 1976)* 38, E1327-1333.

Wong, T.K.T. & Lee, R.Y.W., (2004). Effects of low back pain on the relationship between the movements of the lumbar spine and hip. *Hum. Mov. Sci* 23, 21-34.

Acknowledgement: All authors have no conflicts of interest to disclose.

This study was supported in part by research grants from JSPS KAKENHI (Grant No. 15K16492) and Waseda University grant for special research projects (2014S-149 and 2015K-289).