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Original Paper

Relationship between Nonspecific Low Back Pain and Physical Function among Japanese High School Long-distance Runners

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Abstract

Background: *For long-distance runners, low back pain as well as lower extremity disorders are becoming more common. This study analyzed the relationship between regular physical assessment results and nonspecific low back pain among long-distance runners.*

Methods: *Subjects included 105 high school long-distance runners, who were divided into the low back pain group (n = 20; LP) and non-pain group (n = 85; NP). All subjects underwent regular chronic pain and physical assessments every six months. Differences in each measurement between both groups were analyzed using an unpaired t-test for comparison.*

Results: *The LP had a shorter history of athletics (LP=3.2 years, NP=4.6 years, 95% confidence interval (95%CI): -2.55, -0.28, r=0.45), a greater hip extension angle (LP=32.7°, NP=28.4°, 95% CI: 2.85, 5.61, r=0.67), a lower hip extension muscle strength (LP=3.1 kgf/kg, NP=4.0 kgf/kg, 95% CI; 0.19, 0.61, r=0.45), and a greater number of times during the stand-up test (LP=11.1, NP=8.1, 95% CI; 0.40, 5.56, r=0.45) than the NP.*

Conclusion: *An excessive hip extension angle and insufficient hip extension muscle strength were considered as risk factors. It is possible that the excessive movement of the hip joint and the biarticular muscles may have caused the low back pain in the inexperienced runners.*

Keywords

Track and field, Adolescent, Prevention, Physical check, Muscle force

1. Introduction

The running motion is one of many basic movements utilized when playing sports. Given that running can be used not only for training athletes but also as an easy everyday exercise, it has become very popular. Although running promotes positive psychological and physical effects, repetitive motions and other factors are often cause musculoskeletal disorders. These disorders are more pronounced among track and field athletes who consistently run at high levels. Moreover, reports have shown that chronic disorders were strongly associated with the running motion (van der Worp et al., 2015).

Long-distance runners, in particular, often suffer from chronic pain in the lower limbs and other areas (Tschopp & Brunner, 2017). Many previous studies have reported that athletes are more likely to develop low back pain (Schmidt & Kohlmann, 2005), and it is not only a problem in adults, but also in growing athletes (Sato et al., 2011). Physical problems in long-distance runners include a wide range of disorders of the lower extremities, and low back pain has also been reported as a problem (Lewis et al., 2000).

Possible causes of low back pain include decreased lumbar spine stability, imbalance and weakness of trunk muscle strength including deep muscles, altered (increased or decreased) motor segment control of the lumbar spine, and dysfunction of compensatory strategies influenced by movement or fatigue (Bruno & Bagust 2007). Although there are some negative reports regarding whether running motion is a factor in low back pain (Maselli et al., 2020), possible mechanisms of low back pain caused by running motion include reduced muscle-tendon flexibility, repetitive microdamage of the lumbar region associated with excessive lumbar pelvic motion, damage to the sacroiliac joint, and more (Lewis et al., 2000).

Focusing on age differences, young athletes have been found to develop several problems due to their immature body. When engaging in sports during adolescence, regular physical assessments are imperative for preventing injuries (DiFiori, 2010). In addition, lower back pain is caused by lower limb function as well as other physical functions such as muscle strength and range of motion (de Sousa et al., 2019). Thus, it is meaningful to examine the results of regular physical checkups from the viewpoint of preventing lower back pain and to utilize these findings for prevention.

The present study aimed to determine the relationship between regular physical assessments, which are regularly conducted (Nakagawa et al., 2020), and low back pain among high school long-distance runners. These results may serve as a guide for identifying factors related to low back injury prevention.

2. Method

2.1 Subjects

The target population was long-distance runners who belonged to a high school track and field team. In this study, the results of physical assessments (occurring about once every six months) and a disability survey (almost everyday written in a daily practice diary) were examined retrospectively.

Each athlete was measured five to six times during the three-year high school competition period. In this study, the period from September to March in the second year of high school was the target period since it is relatively less affected by the schedule of student life and competitions. The measurements obtained before and after this period were compared. Of all the athletes who were enrolled in the school for the past six years (2014-2019), those for whom measurement results were obtained before and after the above period, and the results of the disability survey for that period were available were selected as the subjects.

All subjects were informed of the purpose and procedures of the study, and provided written informed consent prior to participation. Those who were under the age of 16, parental consent was also obtained in addition to consent by the student himself or herself. This study was approved by the Takasaki Health and Welfare University Ethics Review Committee (No. 2723).

2.2 Methods

All subjects underwent regular assessments for chronic pain caused by repetitive running movement or training intensity. In this study, we focused on disorders and pain in the lumbar region. Back pain was defined as any pain that caused a person to miss at least one day of practice or competitions, and could be treating with reconditioning by physical therapists in the field. Those who required medical attention for back pain were excluded. Subjects were divided into the low back pain (LP) and non-pain (NP) groups, which comprised subjects with and without low back pain between the six-month physical assessments, respectively.

2.3 Measurements

Physical assessments, which were conducted every six months, consisted of basic information, muscle flexibility and joint mobility, and muscular force. Basic information included age, athletic history, height, weight, body mass index, and body fat percentage. Muscle flexibility and joint mobility were determined using the straight leg raising test, knee flexion angle in the prone position (prone knee bend), lower leg inclination angle, hip joint (extension and rotation) and ankle joint (planter flexion) range of motion (ROM) tests, and sole arch efficiency, which was calculated by dividing the height of the arch in the standing position (the height from the floor surface to the scaphoid) by the foot length. Muscular force was assessed by measuring the hip abductor and extensor forces using a hand-held dynamometer (μ-tas F1, Anima), trunk muscle strength using the sit-up test (i.e., the number of times subjects could perform a sit-up from the floor in 30 s), and total lower extremity strength using the stand-up test (i.e., the maximum number of times subjects could stand from a 20-cm-tall chair with one leg in 30s). All measurements for muscle flexibility, joint mobility, and the sit-up and stand-up test were measured once. Moreover, all measurements using a hand-held dynamometer were measured twice, with the larger value being used for analysis. For those assessments requiring left- and right-side measurements, the average values of the left and right sides were used for analysis. All physical checks were performed at the high school athletic field and measured by the physical therapy staff.

2.4 Analysis

All measurements were confirmed to be normally distributed, and paired t-tests and the 95% confidence interval (95% CI) were used to evaluate differences in each measurement between groups. All statistical analyses were conducted using SPSS 24.0J for Windows, with the significance level set at 5%. And effect size (r) was calculated as η2 (eta squared) (Hatch & Lazaraton, 1991), and the power of the test ("Power (1-β err prob)") was also calculated using G*Power 3.1 (Faul et al., 2009).

3. Result

A total of 20 subjects were included in the LP group, and 85 subjects were in the NP group.

The LP group had a shorter history of athletics (LP = 3.2 years, NP = 4.6 years, 95% CI: [-2.55, -0.28], r = 0.45), a significantly greater hip extension ROM (LP = 32.7°, NP = 28.4°, 95% CI: [2.85, 5.61], r = 0.67), a significantly lower hip extension muscle strength (LP = 3.1 kgf/kg, NP = 4.0 kgf/kg, 95% CI: [0.19, 0.61], r = 0.45), and a significantly greater number of times during the stand-up test (LP = 11.1, NP = 8.1, 95% CI: [0.40, 5.56], r = 0.45) than the NP group. No significant differences were found in the other items. All results are presented in Table 1.

Table 1. Results of Measurement

	LP (n=20)	NP (n=85)	P value	95% CI	P Power	Effect size (r)
Athletic history (years)	3.2 ±2.3	4.6 ±1.9	0.007*	[-2.55, -0.28]	0.43	0.45
Height (cm)	162.9 ±10.8	163.4 ±6.8	0.827	[-5.80, 4.69]	0.05	0.05
Weight (kg)	53.4 ±8.9	53.3 ±4.9	0.979	[-4.12, 4.23]	0.05	0.01
Body mass index ($kg*^2/m$)	20.0 ±0.8	20.0 ±1.6	0.902	[-0.55, 0.48]	0.05	0.02
Body fat (%)	15.3 ±4.2	16.4 ±5.2	0.357	[-3.23, 1.20]	0.10	0.16
Straight leg raising test (deg)	65.1 ±7.5	66.5 ±8.7	0.451	[-5.36, 2.43]	0.05	0.01
Prone knee flexion angle (deg)	139.2 ±4.5	139.0 ±6.7	0.886	[-2.34, 2.70]	0.05	0.02
Lower leg inclination angle (deg)	40.3 ±8.8	41.4 ±7.5	0.604	[-5.50, 3.26]	0.07	0.10
Hip extension angle (deg)	32.7 ±2.4	28.4 ±3.9	>0.001*	[2.86, 5.61]	0.76	0.67
Hip internal rotation angle (deg)	41.8 ±8.5	43.5 ±11.4	0.450	[-6.32, 2.86]	0.07	0.12
Hip external rotation angle (deg)	48.7 ±9.4	45.2 ±10.3	0.160	[-1.43, 8.24]	0.17	0.25
Ankle planter flexion angle (deg)	50.4 ±7.0	49.1 ±10.8	0.539	[-2.72, 5.15]	0.06	0.09
Sole arch efficiency (%)	16.8 ±2.4	16.8 ±2.1	0.538	[-1.17, 1.26]	0.05	0.02
Gluteus medius muscle force (kgf/kg)	3.8 ±1.3	3.6 ±1.2	0.603	[-0.49, 0.82]	0.07	0.10
Gluteus maximus muscle force (kgf/kg)	3.1 ±0.8	4.0 ±0.8	0.028*	[0.19, 0.61]	0.43	0.45
Sit-up test (number)	27.7 ±5.8	29.3 ±4.1	0.248	[-4.45, 1.21]	0.42	0.44
Stand-up test (number)	11.1 ±5.3	8.1 ±3.5	0.025*	[0.41, 5.56]	0.43	0.45

* = $p < 0.05$, LP=low back pain group, NP=no pain group, CI=confidence interval

4. Discussion

LP reportedly occurs in approximately 15% of student athletes (Schmidt, & Kohlmann, 2005). Lewis et al. (2000) reported that the lifetime prevalence of LP in runners was as high as 47%. The presence of pain was independent of age, experience, and training volume (Teixeira et al., 2016). In this study, 20 out of 105 subjects (19%) experienced LP, which is similar in frequency, but we were unable to draw conclusions about the degree of frequency since only minor cases were included in analysis. Pain is also affected by age, experience, and amount of practice (Teixeira et al., 2016), and there is a gender difference in pelvic stability. It has been reported that research on LP should be limited by gender (Cynn et al., 2006). In the present study, differences in LP were observed depending on the number of years of running experience. However, it is necessary to examine the characteristics that would be observed if the number of years of competition experience were standardized, and to investigate any gender differences.

The main result of this study was that the LP group had a larger hip extension ROM and reduced strength of the gluteus maximus muscle (hip extension muscle) compared to the NP group. The importance of hip function in LP has been reported from various viewpoints (Taylor-Haas et al., 2014), and there were many reports that limited hip extension ROM causes excessive pelvic anteversion and lumbar kyphosis, leading to LP (Roach et al., 2015). It was reported that a dysfunctional iliotibial band was a possible cause of LP in long-distance runners, and that stretching of the anterior hip joint reduced LP (Kasunich, 2003). Alternatively, Taylor-Haas et al. (2014) investigated the relationship between 3-dimensional hip motion, and hip extension and abduction muscle strength in young long-distance runners, and reported a negative association with the transverse plane and frontal plane hip motion. In addition, it was reported that the joint moment and total force of passive hip extensors were altered in subjects with LP compared to healthy subjects (Hines et al., 2018). Another report revealed that excessive movement of the lumbar spine during hip extension was associated with delayed activity of the gluteus maximus muscle in healthy subjects (Bruno et al., 2008). Based on these previous studies, we assumed that the LP group had a weak gluteus maximus muscle and compensated for their performance by hip extensor movements, which in turn caused repetitive stress on the low back. The fact that this tendency was strongly observed in the inexperienced runners supports the need to educate inexperienced runners about training the hip extensor muscles.

Furthermore, it was reported that runners with weak hip extensors adopt a more upright trunk posture, which leads to overly relying on knee extensors (Teng, & Powers, 2016). Shum et al. (2005) also reported that LP was associated with altered mobility and coordination of the lumbar spine and lower back during sit-to-stand and stand-to-sit movements, and those subjects with LP used various strategies to compensate for the limited mobility of the lower back and lumbar spine. In our study, the number of times moving between sit-to-stand positions was significantly higher in the LP group than the NP group. It is possible that the weakness of the hip extensors was compensated by the knee extensors, suggesting the need to consider the excessive burden on the knee joint.

Regarding muscle strength, the gluteus maximus muscle strength of the LP group was significantly lower than the NP group, which might be a factor of low back pain. This finding is similar to a previous report that observed atrophy of the gluteus maximus muscle in women with chronic LP (Amabile et al., 2017). In addition, previous studies have shown that stress on the lumbar spine due to weakness of the gluteus medius muscle might be a cause of LP (Bussey et al., 2016; Cooper et al., 2016; Penney et al., 2014), but the results were not statistically significant. Although there are few reports on the relationship between the gluteus medius muscle and LP in long-distance runners, it is likely that the relationship between the gluteus medius muscle and LP is not as strong as in other sports because runners tend to move less to the left and right.

In terms of flexibility and tightness, there were no characteristic differences between the groups other than the large hip extension ROM described above. Previous studies have reported on the relationship between limitation of ROM or muscle tightness and LP (Kim & Shin, 2020), and some reports focus on the left-right difference rather than the ROM itself, especially regarding the rotation movement (Lee & Kim, 2015). In long-distance runners, there is a reasonable possibility that the left-right difference in subtle turning movements may affect those with many linear movements.

This study was not originally designed and conducted, but is based on the results of backward-looking validation of results obtained from routine measurements. Therefore, the test power of the results obtained is not so strong, and the results and discussion obtained in this study are in the realm of speculation. Therefore, it is desirable to set up a research design including a necessary sample size to support the present results, and to verify them. And another limitation of this study is that the cause of LP was not clear, so we cannot speculate on the actual mechanism of occurrence. Collecting responses of physiotherapists in the field would provide robustness to our study findings. Further, since this study focused on pain related to movement, the relationship between pain and the characteristics of actual running movements need to be explored. In addition, it was reported that changes in body weight over time might impact LP (Kujala et al., 1997). We will continue to conduct regular physical checkups to verify the relationship between changes in each parameter over time and disabilities including LP, may be linked to injury or disorder prevention for athletes.

5. Conclusion

In inexperienced runners, excessive hip extension angle and insufficient hip extension muscle strength may be risk factors of LP. It is possible that excessive movement of the hip joint and the biarticular muscles may cause LP in inexperienced runners. Since it is not possible to determine whether the pain was caused by excessive forward tilt and lumbar kyphosis or by myofascial stretching stress on the muscles of the lumbar back, future research on this topic should include exploring the factors of LP and verifying the relationship with running movements, in addition to continuing condition checks of running athletes.

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