MEDICAL SCIENCE MONITOR

CLINICAL RESEARCH

e-ISSN 1643-3750
© Med Sci Monit, 2023; 29: e939657
DOI: 10.12659/MSM.939657

Received: 2023.02.01
Accepted: 2023.02.27
Available online: 2023.03.03
Published: 2023.03.23

Association Between Hamstring Shortness and Asymmetry, Pain Intensity, Disability Index, and Compensatory Lumbar Movement in 60 Patients with Nonspecific Chronic Low Back Pain

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Financial support: None declared
Conflict of interest: None declared

Background: The correlation between hamstring muscle shortening and nonspecific low back pain and compensatory lumbar movements is still controversial. The purpose of this study was to evaluate the association between hamstring shortness and asymmetry, pain intensity, the disability index, and compensatory lumbar movement in 60 patients with nonspecific chronic low back pain.

Material/Methods: Sixty patients with nonspecific low back pain participated in this study. The hamstring shortness and asymmetry, pain intensity, the disability index, and compensatory lumbar movement of the patients were assessed. The pain intensity was evaluated using a numeric pain rating scale (NPRS), active knee extension testing was performed to measure the length of the hamstring, and compensatory lumbar movement was assessed using a digital dual inclinometer. Correlation analysis was used for analysis of the obtained data.

Results: The hamstring length showed a negative correlation with hamstring length asymmetry, NPRS, and disability index ($P<0.05$). The asymmetry of the hamstring length was positively correlated with NPRS, disability index, and compensatory lumbar rotation ($P<0.05$). Lumbar flexion was positively correlated with the hamstring muscle length ($P<0.05$). However, there was a negative correlation between the hamstring length asymmetry, NPRS, and disability index ($P<0.05$). There was no correlation between the compensatory lumbar rotation, hamstring length, or disability index.

Conclusions: Compensatory flexion movements, NPRS, and disability index in patients with nonspecific chronic low back pain were associated with hamstring shortness and asymmetry. These factors should be considered when planning physical therapy for patients with nonspecific low back pain.

Keywords: Back • Correlation of Data • Hamstring Muscles • Low Back Pain • Movement Disorders

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/939657

2743 2 3 34

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Background

Low back pain is caused by anatomical pathologies such as in the nucleus pulposus, osteoporosis, infection, rheumatoid arthritis, fractures, tumors, inflammatory disorders, and neuromuscular compression [1]. Approximately 80% of the population worldwide suffers from low back pain [2]. It is a major health problem and severely affects quality of life, leading to disability and absenteeism [3].

Nonspecific chronic low back pain persists for more than 3 months without patho-anatomical causes such as epidural abscess, compression fractures, caudate syndrome, spondyloarthropathies, malignant tumors, spinal canal stenosis, radiating pain, facet joint syndrome, and disc herniation [4]. Nonspecific chronic low back pain accounts for 90% of back pain with functional limitations and affects the ability to perform activities of daily living [5]. Nonspecific chronic low back pain is characterized by abnormal joint movement and muscle dysfunction [6]. Hypermobility and unstable lumbar movement cause mechanical micro-injury and soft tissue damage, resulting in nonspecific chronic low back pain [7].

There are many factors that influence nonspecific low back pain. Kim and Shin reported that asymmetry of the hip extension range of motion of both hip joints was more related to nonspecific low back pain than to the simple amount of hip extension range of motion, and found that limitation of hip extension was correlated with compensatory rotational movements of the lumbar spine [8]. Decreased rotation of the pelvis and spine during walking is correlated with nonspecific chronic low back pain by stiffening of the trunk [9]. Dysfunction of the core muscles that maintain trunk stability while moving the extremities, abnormal activation of hip muscles, and limited flexibility of hip muscles are typical muscle dysfunction problems [10].

Although there are several studies on risk factors for nonspecific chronic low back pain, there have been few recent studies on shortening of the hamstring muscle and nonspecific chronic low back pain [11]. The hamstring muscle attaches to the pelvic bone and participates in pelvic movement; additionally, the lumbar vertebra is adjacent to the pelvis and cooperates to move in a functional manner. However, when the hamstring muscle is shortened, it can limit the movement of the pelvis and lower back during functional movements, changing the mechanical force and causing excessive stress, which can cause pain [12]. Shortening of the hamstrings creates nonideal movements in the lower back and pelvis, which affects nonspecific chronic low back pain [13].

There are studies reporting the association between hamstring shortness and low back pain, but there are also studies that show a lack of association between low back pain and hamstring shortness [14]. Also, in another study, the length of hamstring muscle was not associated with the occurrence of low back pain [10]. Although there are a number of studies on hamstring shortening in the patients with nonspecific chronic low back pain, these are insufficient, and studies on the compensatory movement of the lumbar spine due to hamstring shortening are scarce. Although there have been several studies on functional movement impairment due to the left-right asymmetry of the hamstring muscles, studies on nonspecific chronic low back pain patients are lacking. Therefore, the purpose of this study was to evaluate the association between hamstring shortness and asymmetry, pain intensity, the disability index, and compensatory lumbar movement in patients with nonspecific chronic low back pain. The hypothesis of this study was that nonspecific low back pain is correlated with hamstring length or hamstring length asymmetry.

Material and Methods

Subjects

The subjects were provided with a sufficient explanation of the procedure and purpose of this registered clinical study and signed the consent form. This study was approved by the Ethics Committee of Kyungnam University.

This cross-sectional study investigated the correlation between hamstring length, left-right asymmetry of hamstring length, pain intensity, disability index, lumbar flexion, and compensatory lumbar rotation in patients with nonspecific chronic low back pain.

A total of 64 subjects were recruited for this study, and a total of 4 subjects were excluded from this study, excluding 2 patients diagnosed with intervertebral disc herniation, 1 patient diagnosed with vertebral fracture, and 1 patient diagnosed with hamstring rupture according to the exclusion criteria. The participants were inpatients or outpatients in the physical therapy room of J Hospital located in XXX-si, and were recruited through notices on bulletin boards in the hospital.

The selection criteria of this study were as follows: 1) those aged 25 to 45 years who were diagnosed with nonspecific low back pain by a doctor and 2) those who experienced low back pain for at least 6 weeks in the past 12 weeks. The exclusion criteria were as follows: 1) patients with malignant tumors; 2) patients with spinal cord infections or fractures; 3) patients who have undergone orthopedic surgery on the lower back, pelvis, or hips; 4) patients with neurological symptoms such as radiating pain, paresthesia, and muscle paralysis; 5) patients with inflammatory diseases such as spinal tuberculosis or rheumatism; 6) muscle rupture; and 7) pregnant women.

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Procedure

The lengths of the left and right hamstrings of the subjects participating in this study were measured in the supine position. The difference in the length of the left/right hamstring was then calculated to measure the asymmetry in the length of the hamstrings. The lumbar flexion and compensatory lumbar rotation range of motion were measured using the trunk flexion motion in standing position. Subsequently, the pain intensity and disability index of the subjects were measured through questionnaires. The hamstring length, lumbar flexion, and compensatory lumbar rotation were measured in triplicate, and the average values were used. All evaluations were performed by physiotherapists with 7 years of clinical experience.

Hamstring Length

An active knee extension test was performed to measure the length of the hamstrings, and a smartphone goniometer app (G-Pro, 5FUF5 Co., USA) was used. The patient was placed in a supine position with 1 leg extended, and the leg to be tested had a hip joint angle of 90°; subsequently, the knee was straightened. The angle was measured on a flat surface immediately below the knee (**Figure 1**). The average value of 3 measurements was used, and the intra-rater reliability of this test was ICC=0.86-0.99 [15]. The test-retest reliability was ICC=0.76-0.89 [16].

Hamstring Length Asymmetry

The left and right hamstring length asymmetry was measured by calculating the difference in length between the left and right sides based on the data collected by measuring the hamstring length.

Numeric Pain Rating Scale

The pain was based on the pain felt on the day of the measurement and was measured using the numeric pain rating scale (NPRS), which is mainly used to evaluate the overall pain intensity, with 0 indicating no pain and 10 indicating extreme pain. Patients were asked to rate their pain level between 0 and 10. The test-reliability of the NPRS was ICC=0.61-0.77 and the validity was ICC=0.85 [17].

Oswestry Disability Index

The disability index was measured using the Oswestry disability index (ODI), which commonly used to identify perceived impairments in patients with low back pain. It consists of 8 items related to activities of daily living and 2 items related to pain, and each item is scored on a scale of 0 to 5 points. The total score is expressed as a percentage, and the higher the score, the higher the disability index. Among the 10 items, it was judged that the sex life-related questions were not suitable for people of Korean culture; therefore, a revised scale consisting of 9 items was used. The intra-rater reliability of this test was ICC=0.81-0.90, and the test-retest reliability was ICC=0.85-0.94 [18].

Figure 1. Measurement of hamstring muscle length in supine position.

Lumbar Flexion Movement

To measure lumbar flexion movement, the lumbar flexion was measured when the subject flexed the trunk in an upright posture. Patients were instructed not to bend the knee joint, while bending the torso as much as possible. Lumbar flexion was measured using a modified Schober test and a tape measure. After drawing a parallel line by making dots on both sides of the posterior superior iliac spine (PSIS), points were drawn 5 cm below and 10 cm above the PSIS, and the length between the lower and upper points when bending the trunk was measured (**Figure 2**). The intra-rater reliability of this test was ICC=0.89-0.97, and the test-retest reliability was ICC=0.83-0.96 [19].

Compensatory Lumbar Rotation

The compensatory lumbar rotation was measured using a digital dual inclinometer during the maximum trunk flexion motion. The knee joint was not flexed, while the patient flexed the trunk as much as possible. A digital dual inclinometer was placed at the 12th spinous process of the thoracic vertebrae and center of both PSISs, and the range of rotational motion of the compensatory lumbar vertebrae was measured during maximum trunk bending (**Figure 3**).

Statistical Analysis

Statistical analysis was performed using SPSS 21.0. Descriptive statistics were used for general characteristics such as gender,

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Figure 2. Lumbar forward flexion measurement in the standing position.

Figure 3. Compensatory lumbar rotation measurement during lumbar forward flexion in the standing position.

height, and weight of the subjects. The Kolmogorov-Smirnov test was used for normality testing of all data. The Spearman's correlation coefficient was used to analyze the correlation between the hamstring length, left-right asymmetry of hamstring length, pain intensity, disability index, compensatory lumbar flexion, and compensatory lumbar rotation. The significance level was set at $P<0.05$.

Results

General Characteristics of Participants

We included 60 participants: 37 men (61%) and 23 women (39%). Mean age, height, weight, NPRS, ODI score, and duration of pain were 32.3 (±7.01) years, 167.35 (±12.34) cm, 71.53 (±12.54) kg, 5.04 (±1.62), 24.38 (±3.37), and 56.3 (±7.4) days, respectively (**Table 1**).

Table 1. Characteristics of participants (N=60).

Sex		
Male (%)	37	(61%)
Female (%)	23	(39%)
Age (years)	32.3	(7.01)
Height (cm)	170.35	(12.34)
Weight (kg)	71.53	(12.54)
NPRS (score)	5.04	(1.62)
ODI (score)	24.38	(3.37)
Duration of pain (days)	56.3	(7.4)

The values are presented as mean and standard deviation (SD). NPRS – numeric pain rating scale; ODI – Oswestry disability index.

Correlation with Hamstring Length and Hamstring Length Asymmetry

The hamstring length showed a negative correlation with hamstring length asymmetry, NPRS, and ODI ($P<0.05$). However, the hamstring length was positively correlated with lumbar flexion ($P<0.05$). The asymmetry of the hamstring length was positively correlated with NPRS, ODI, and compensatory lumbar rotation ($P<0.05$). However, there was a negative correlation with lumbar flexion ($P<0.05$) (**Table 2**).

Correlation with Lumbar Flexion and Compensatory Lumbar Rotation

Lumbar flexion was positively correlated with the hamstring muscle length ($P<0.05$), but there was a negative correlation between the hamstring length asymmetry, NPRS, and ODI ($P<0.05$). Compensatory lumbar rotation was positively correlated with hamstring length asymmetry and NPRS ($P<0.05$). There was no correlation between the compensatory lumbar rotation, hamstring length, or ODI (**Table 2**).

Discussion

We analyzed the correlations between the hamstring length, left-right asymmetry of hamstring length, NPRS, ODI, lumbar flexion, and compensatory lumbar rotation motion in subjects with nonspecific chronic low back pain. The hamstring length showed a negative correlation with hamstring length asymmetry, NPRS, and disability index. The asymmetry of the hamstring length was positively correlated with NPRS, disability index, and compensatory lumbar rotation. Lumbar flexion was positively correlated with the hamstring muscle length. However, there was a negative correlation between the hamstring length asymmetry, NPRS, and disability index.

Table 2. Correlation analysis of hamstring length and hamstring length asymmetry (N=60).

		Hamstring shortness	Hamstring asymmetry	NPRS	ODI	Lumbar flexion	Compensatory lumbar rotation
Hamstring shortness	P	.	–	–	–	–	–
	CC	1	–	–	–	–	–
Hamstring asymmetry	P	.002	.	–	–	–	–
	CC	-.394*	1	–	–	–	–
NPRS	P	.004	.000	.	–	–	–
	CC	-.369*	.893*	1	–	–	–
ODI	P	.003	.000	.000	.	–	–
	CC	-.383*	.757**	.842*	1	–	–
Lumbar flexion	P	.000	.004	.006	.027	.	–
	CC	.740*	-.368*	-.350*	-.286*	1	–
Compensatory lumbar rotation	P	.237	.000	.000	.051	.259	.
	CC	-.155	.476*	.444*	.253	-.148	1

* Correlation is significant at the 0.05 level; ** correlation is significant at the 0.01 level. NPRS – numeric pain rating scale; ODI – Oswestry disability index.

Hamstring length was negatively correlated with hamstring length asymmetry, NPRS, and ODI. However, the hamstring muscle length was positively correlated with lumbar flexion. A previous study established a strong correlation with the shortening of the hamstring muscle in patients with nonspecific chronic low back pain compared to the normal group [20]. However, another study reported a lack of correlation between hamstring length and low back pain [10], but it seems that the correlation between hamstring length and low back pain was insufficient because the study was conducted without distinguishing between specific and nonspecific low back pain. Because this study targeted nonspecific low back pain, the hamstring length may have had a correlation with low back pain.

Patients with nonspecific chronic low back pain with weakened core muscle endurance tend to have excessive shortening of the hamstrings [21]. The hamstrings move in cooperation with the anatomically connected hip joint and lumbar vertebrae, and shortening of the hamstring length reduces the relative flexibility and causes low back pain [22].

In particular, shortening of the hamstrings directly affects the sacroiliac ligament, causing pain [23]. Additionally, mechanical stress on the lower back increases by limiting the forward tilting movement of the pelvis and indirectly increases tension in the lower back muscles and ligaments [24]. In addition, shortening of the hamstring muscle increases tension of the hip joint capsule and the iliopsoas muscle, causing nonspecific chronic low back pain [25]. Additionally, hamstring length is correlated with functional movement of the lower back and pelvis by limiting pelvic anterior tilt [26]. In particular, there is a correlation between the abnormal movements of the lower back and pelvis during functional movements such as walking and bending of the trunk [27]. In patients with low back pain, the more severe the hamstring shortening, the lesser the pelvic movement during trunk flexion and the greater the lumbar flexion movement to compensate for the decreased pelvic movement [28], suggesting that hamstring length is associated with excessive lumbar flexion movement, causing excessive stress on the lumbar region [22]. We found that hamstring length was correlated with pain intensity, disability index, and lumbar flexion.

In this study, hamstring length asymmetry was positively correlated with NPRS, ODI, and compensatory rotation of the lumbar vertebrae and negatively correlated with lumbar flexion. In patients with nonspecific chronic low back pain, bending movements in the lower back and pelvis decreased during trunk bending, and rotation occurred in the lower back and pelvis in a compensatory manner [29]. In addition, the left-right asymmetry of hamstring shortening was strongly correlated with low back and pelvic pain [30]. Compensation for the asymmetry of the hamstrings length causes left/right imbalance of the lumbar vertebrae [31], and this left/right imbalance of the lumbar vertebrae is a major factor causing back pain [32]. Moreover, in a study comparing patients with nonspecific chronic low back pain with flexion syndrome and rotation syndrome during trunk

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flexion and a control group, left-right asymmetry of the hamstring shortening was more common in patients with nonspecific chronic low back pain [33]. It has been reported that this compensatory lumbar rotation can induce low back pain by exerting increased mechanical stress in the lumbar pelvic region [34].

In the subjects of this study, a clear negative correlation was established between hamstring length, pain intensity, and disability index, and a strong positive correlation was established between hamstring length and lumbar flexion. However, there was no statistically significant correlation between the hamstring length and compensatory lumbar rotation. A clear positive correlation was established between the left and right asymmetry of the hamstring length and pain intensity, and a strong positive correlation was established with the disability index. A clear negative correlation was established between left-right asymmetry of the hamstring length and lumbar flexion, and a clear positive correlation was established with compensatory lumbar rotation. The results of this study indicate that during functional movements that require trunk flexion, the shortening of the hamstring muscle decreases pelvic movement and increases lumbar flexion. In addition, the greater the left-right asymmetry of hamstring shortening, the greater the compensatory lumbar rotation. The compensatory movements of lumbar flexion and rotation due to shortening of the hamstrings are thought to be the result of induced mechanical stress and micro-damage in the lumbar region.

The limitation of this study is that it cannot be generalized to all age groups because the age of the study subjects was set at 25-45 years. In addition, the number of participants was insufficient to prove the correlation between low back pain and related factors. In this study, hamstring length and compensatory lumbar rotational movement that affect lumbar flexion in a standing posture were studied, but the correlation between dynamic functional movements such as walking and running and low back pain was not investigated.

The clinical significance of this study is that the hamstring length strongly contributes to the pain intensity, disability index, and lumbar flexion movement. Additionally, the degree of left-right asymmetry in the hamstring length is related to pain, disability index, lumbar flexion, and compensatory lumbar rotation. It is correlated with movement, and the left-right asymmetry of hamstring shortening is correlated with compensatory lumbar rotation. These results suggest that when treating patients with nonspecific chronic low back pain, functional low back pain management can be considered by adding a program that improves flexibility of the hamstrings and resolves the left-right asymmetry.

Conclusions

The findings from this study showed that compensatory flexion movements, pain intensity, and degree of disability in patients with nonspecific chronic low back pain were associated with hamstring shortness and asymmetry. These factors should be considered when planning physical therapy for patients with nonspecific low back pain.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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