Relationship Between Hip Extensor Strength and Back Extensor Length in Patients With Low Back Pain: A Cross-Sectional Study

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Abstract

Objective: The purpose of this study was to examine the relationship between hip extensor strength and back extensor length in patients with low back pain (LBP) and healthy controls.

Methods: In 266 patients with LBP and 215 matched controls, back extensor length and hip extensor strength were measured and compared in the 2 groups using an independent *t* test. The Pearson correlation coefficient was used to determine correlation between these 2 variables. Multivariate logistic regression was used to test the risk of sustaining LBP with having these muscle insufficiencies.

Results: A significant difference in hip extensor strength was found between patients with LBP and controls ($P < .001$). Back extensor length was different in healthy men compared with the patients with LBP ($P < .001$) but was not significant between women with and without LBP ($P = .34$). The results showed a significant relationship between back extensor length and hip extensor strength in men with LBP ($r = 0.6$, $P = .01$). Multivariate logistic regression revealed that having a weak hip extensor ($P = .001$) or shortened back extensor ($P = .01$) could increase the risk of LBP occurrence.

Conclusion: The findings support the assumptions of the presence of muscle imbalance of hip extensor weakness and back extensor tightness in male patients with LBP and that each muscle impairment may contribute to LBP.
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Key Indexing Terms: *Low Back Pain; Spine; Posture*

Introduction

In modern society, low back pain (LBP) is a common musculoskeletal complaint and is a multifactorial disorder.[1] Increased lumbar lordosis and muscle impairments, such as decreased flexibility or strength in lumbopelvic region muscles, are thought to be related to development of LBP.[2-7]

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Some previous studies have been directed to the cross pattern of lumbopelvic muscle imbalance (pelvic cross syndrome or lower crossed syndrome) in patients with LBP.[2-6] However, it seems that investigating the association between adjacent muscles like hip and back extensor muscles should be taken into consideration in patients with LBP.[7] This group muscle has a significant role in spinal stability. Hip extensors act as a pelvis stabilizer and force transducer from the lower limb up toward the spine during upright activities. It also has been shown that there is load sharing between these muscles.[4]

This interaction between hip and back extensor muscles is approved by the anatomic coupling between back extensor muscles via the thoracolumbar fascia, which contributes to load transfer from the lumbar spine to the lower extremities and dynamic trunk stability.[8] Poor endurance of the hip extensors (gluteus maximus)[6,9-12] and decreased flexibility of back extensors[3,4,12,13] has been noted previously in individuals with LBP. These muscle malfunctions can lead to hyperlordosis and a changed pattern of muscular activation.[14,15] This altered movement pattern is uneconomical and produces mechanically induced pain by loading the joints incorrectly.[16]

It has been hypothesized that hip extensor muscle weakness and back extensor muscle tightness is a common muscle imbalance pattern in lumbar, pelvic, and hip disorders. Based on this assumption, clinicians have claimed that strengthening of weak and stretching of short muscles could be a beneficial way to treat patient with pain and dysfunction in the lumbopelvic girdle.[6,7,17] Clinicians, based on these assumptions, have advocated strengthening of weak and stretching of short muscles in the lumbopelvic area to correct the changes in the degree of lumbar lordosis and to treat patients with LBP.[14,18]

Although some research indicates an association between LBP and extensor muscle impairments, in our literature review no clinical scientific evidence examined the relationship between the hip extensor strength and back extensor length.

Considering the questioned relationship between shortened back extensors and weak hip extensors in participants with LBP, the main purposes of this study were to evaluate 1) whether there is any significant difference in hip extensor strength and back extensor length between patients with LBP and healthy controls; 2) whether these differences could increase the risk of sustaining LBP; and 3) whether there is a relationship between hip extensor strength and back extensor length in patients with LBP.

Methods

Participants

Among the patients in orthopedic and physical therapy departments who were recruited from 5 different hospitals in Tehran, Iran, 266 patients with nonspecific LBP based on inclusion criteria were selected in this cross-sectional nonexperimental study.

The inclusion criteria was history of LBP for more than 6 weeks before the study or at least 3 episodes of intermittent LBP, each one lasting more than 1 week during the year before the time of the study. Patients with LBP were excluded if they had history of spinal surgery; fracture the of spine, pelvis, or lower extremities; hospitalization for severe trauma; any obvious structural abnormality in the lower extremities; or any systemic disease, such as arthritis. Two hundred fifteen healthy participants matched in age, weight, and height were also selected as the control group.

The control group was selected among individuals who either accompanied a patient or were referred to the hospital owing to nonmusculoskeletal problems. They were assessed to have no pain; dysfunction in the lumbar, thoracic, and neck area; or any radicular pain in lower extremities during the 1-year period before the study.

Demographic characteristics for the participants are shown in Table 1. Details of the study were explained to the participants, and they filled in the written informed consent form approved by the human subject ethics committee at the University of Social Welfare and Rehabilitation Sciences.

Procedures

For each participant, extensibility of back extensors and strength of hip extensor were measured as follows.

Extensibility of Back Extensors. The maximum range of lumbar flexion indirectly was related to the back extensor length.[12,15,19-22] Also, some other factors such as joint and soft tissue stiffness can affect this movement. During this maneuver, back extensor muscles are elongated in a direction opposite to their action. It has been projected that muscle length and soft tissue extensibility would be consistent with available joint range of motion.[23] In this study, based on the mentioned assumption, the maximum degree of lumbar flexion was assumed to represent the length of back extensor muscles. We used a flexible ruler and followed the procedure described by others[12,15,19-22] to measure the participants' maximum lumbar flexion in the sitting position. The participant sat on the front edge of a chair with feet flat on the floor and spread to shoulder width. Each participant was instructed to bend the trunk forward and to attempt to place the head between the knees while keeping both arms lateral to the knees. At the end of the test procedure, the participants who had pain as a limiting factor for flexion movement were excluded from the study. The quantitative method described by others[12,15,19-22] was used to obtain the amount of maximum lumbar flexion in degrees. The reliability of this procedure has been established.[9,12,21,22]

Strength of Hip Extensors. A pressure meter, which is an objective and quantitative method, was used to measure muscle strength in the current study.[12,19,24-26] Its reliability and validity has previously been established.[12,25] The unit used in this study first was calibrated and had 99% measurement accuracy.

The standard position for testing hip extensor muscle strength as described by Kendall et al and the detailed instruction for standard contact points of the pressure meter as introduced by others was assumed to measure muscle strength[9-12,27] to selected standard contact points to measure the muscle strength. The pelvis was fixed, and the inflated bag of the pressure meter was placed between the examiner's hand and the specified contact point on the participant's limb (lower part of the posterior thigh). To obtain the maximal value, the participant was familiarized with the test and procedure. All measurements of muscle strength were performed by 1 therapist, and the same size inflated bag was used during all measurements to assure the reliability of measurements.

After ending the test, participants questioned about if pain or lack of strength were limiting factors for applying maximum muscle force. Those who had pain during the test, as a limiting factor, were excluded from the study.

Table 1. *Mean Age, Height, Weight, and BMI of Control Participants and Those With LBP*

	Controls (N = 215)		LBP Participants (N = 266)	
Variables	Male (N = 133)	Female (N = 82)	Male (N = 139)	Female (N = 127)
Age (y)	42.20 ± 15.01	45.35 ± 13.26	42.19 ± 14.38	44.40 ± 12.37
Height (cm)	170.62 ± 6.14	166.16 ± 7.53	172.48 ± 6.98	165.95 ± 6.32
Weight (kg)	72.36 ± 10.24	69.64 ± 12.46	74.42 ± 10.92	68.09 ± 10.36
BMI (kg/m^2)	24.87 ± 3.40	27.06 ± 4.81	24.92 ± 2.60	28.61 ± 12.98

BMI, body mass index; *LBP*, low back pain.
Values are mean ± standard deviation.

Table 2. *The Result of ROC Curve Analysis Used for Differentiating Participants With and Without Weak Hip Extensor and Short Back Extensor: Cutoff, Sensitivity, Specificity, and Area Under the ROC Curve*

Variable	Sex	Mean ± SD	Cutoff Score	Sensitivity	Specificity	Area Under Curve (%)
Hip extensor strength (kPa)	Male	30.5 ± 7.5	<28	80	78.7	87
	Female	21.7 ± 5.8	<20	70.7	78	82
Back extensor length (°)	Male	20.8 ± 8.1	<17.6	45.7	80.7	69
	Female	17.4 ± 6.8	<15.3	52.7	63.3	61

kPa, kilo Pascal; *ROC*, receiver operating characteristic; *SD*, standard deviation.

The average of the measurements obtained from the right and left side in kilo Pascal (kPa) was recorded as the strength of the hip extensors.

The order of measurements of extensibility of back extensors and strength of hip extensors was randomly selected and was not in specified order in participants. All tests were performed by the same person. Because the tests were performed by the same examiner, it might be thought the tester was not blind to the respective findings and might have bias for measurements, which might criticize the results. However, in this study a standard flexible ruler was used to measure the participant's maximum lumbar flexion for assessment of the back extensor length. To obtain the amount of maximum lumbar flexion, the curve of the flexible ruler, resembling the size of participant's lumbar curvature, first was graphed on a paper, and then the standard formula was used to calculate the degree of maximum lumbar flexion in degrees. Thus, the tester did not know the amount of back extensor length when measuring the other variable because the calculation procedure was done afterward.

One trial was done for the measurements.

Data Analysis

Statistical Package for the Social Sciences (SPSS) for Windows (version 17, SPSS Inc, Chicago, Illinois) was used for statistical analysis. An independent *t* test was used to compare age, weight, height, and body mass index, hip extensor strength, and back extensor length in patients with LBP and matched controls. The Pearson correlation coefficient was used to assess the correlation between the hip extensor strength and back extensor length in each group.

Then, participants with and without shortness or weakness were identified based on the cutoff values for back extensor length and hip extensor strength obtained from the receiver operating characteristic curve analysis[28] performed by MedCalc statistical software (MedCalc, Mariakerke, Belgium). Owing to inherent sex differences in muscle strength and extensibility, separate cutoff values were obtained for men and women. Upon identifying men and women with and without muscle impairment, participants were coded as having weak hip extensors or having short back extensor muscle impairments. Logistic regression in a multivariate model was used to test the increased risk of sustaining LBP with having these muscle insufficiencies. The level of significance was set at $P < .05$.

Results

There was no statistically significant difference in participants' age, height, weight, and body mass index among the groups ($P > .05$). The results of receiver operating characteristic curve analysis are shown in Table 2. Table 3 shows results of an independent *t* test comparing hip extensor strength and back extensor length between groups of control participants and

Table 3. *Hip Extensor Strength and Back Extensor Length Between Groups of Controls and LBP Participants*

Variable	Sex	Group	Mean ± SD	95% CI of Difference	*P* Value
Hip extensor strength (kPa)	Male	Healthy	33.82 ± 6.39	4.64-7.97	.001
		LBP	27.51 ± 7.50		
	Female	Healthy	23.90 ± 5.44	3.60-6.56	.001
		LBP	18.82 ± 5.20		
Back extensor length (°)	Male	Healthy	23.56 ± 7.59	3.24-6.96	.001
		LBP	18.46 ± 7.96		
	Female	Healthy	17.91 ± 7.25	0.16-4.07	.34
		LBP	15.79 ± 6.82		

CI, confidence interval; *kPa*, kilo Pascal; *LBP*, low back pain; *SD*, standard deviation.
Values are mean ± SD.

Table 4. *Logistic Regression Results to Investigate the Association of Having a Weak Hip Extensor or Shortened Back Extensor and LBP*

Factor	Exp (β)	95% CI	*P* Value
Weak hip extensor	5.21	4.32-6.55	.001
Shortened back extensor	2.30	1.87-3.49	.01
Constant	2.02	-	.17

CI, confidence interval; *Exp,* exponentiation of the coefficients; *LBP*, low back pain.

patients with LBP. Hip strength was greater in controls compared with patients with LBP ($P < .001$). Moreover, there was a significant difference in back extensor length between male controls and patients ($P < .001$), but this difference was not significant between women ($P = .34$). The Pearson correlation coefficient showed a significant correlation between hip extensor strength and back extensor length in men with LBP ($r = 0.6$, $P = .01$). However, no significant correlation was found between these parameters in women with LBP. Our data also revealed no correlation between hip extensor strength and back extensor length in healthy men ($r = 0.12$, $P = .14$) or women ($r = 0.05$, $P = .72$) without LBP. Multivariate logistic regression results suggested that a weak hip extensor or shortened back extensor could increase the risk of being classified in the LBP group (Table 4).

Discussion

The results of this study indicated a significant difference in hip extensor strength and back extensor length between patients with LBP and healthy controls. The results also suggested that having weak hip extensor or a shortened back extensor might increase the susceptibility of LBP occurrence. Moreover, there was a significant correlation between hip extensor strength and back extensor length in symptomatic men.

As mentioned before, some investigators have postulated a common muscle imbalance of weakness and tightness of some synergistic muscles in chronic musculoskeletal disorders of the lumbar, pelvic, and hip complex such as LBP.[2-6] The results of the current study showed that patients with LBP had lower levels of hip extensor strength than their matched controls. In agreement with the results of the present study, Kankaanpaa et al[29] postulated poor endurance of these muscles in participants with LBP and showed that hip extensors fatigued faster in patients with LBP than in control participants during an endurance task. Low back pain may cause a change in strength or inhibition of the hip muscles.[13] The association between the hip extensor weakness and LBP may be important because this musculature plays a significant role in transferring forces from the lower limb up toward the spine during upright activities.[13] Johnson[30] suggested that individuals with poor hip muscular control may be at a greater risk for LBP secondary to alterations in the transference of forces.

The results of the current study showed differences in back extensor length between asymptomatic men and those with LBP. In this study, measuring maximum lumbar spine flexion served to provide an indirect measurement of the length of back extensor muscles. A similar procedure has been used in previous studies.[12,15,19-22] This test is in accordance with Kendall et al[14] because low back muscles are elongated in a direction opposite to their action.

Our finding is consistent with Jull and Janda's classification,[7,17,31] which named back extensors as postural muscles that have a tendency to shorten with overstress and back pain. Other investigators also have shown decreased flexibility and back muscle tightness in participants with LBP.[3]

Decrease in muscle strength or length and joint range of motion has been associated with deconditioning syndrome. Adaptation to pain as suggested by Lund[32] could explain deconditioning syndrome leading to decreased muscle activation and strength. Mbada et al[33] stated that pain is the major impairment of long-term LBP and it results in deconditioning of the musculoskeletal system, leading to loss of motion, stiffness, cartilage degeneration, fear-avoidance behavior, iatrogenic muscular inhibition, and muscle atrophy. The increased stiffness of the pain area also could explain decreased joint range of motion in patient. Neuromuscular changes in trunk flexion, observed using flexion relaxation phenomena during lumbar spine flexion, could support the results of this study. Considering this, the lower length of the back muscle may be a consequence of increased muscle activity in the lower back spine. It seems that neuromuscular training improving patterns of activation and neuromuscular activation of the lumbopelvic muscles could be beneficial to clinicians when prescribing therapeutic exercise for patients with LBP, particularly those with back extensor muscle tightness. Ashmen et al,[2] however, have found no difference in the flexibility of back extensor muscles in athletes with and without LBP, which may be due to enhanced general flexibility in the athletic population. The differences of back extensor length between the women with and without LBP did not reach the significant level. One of the reasons for this finding could be fewer women in the control group. This issue also may exist because women are often more flexible than men in the lower back, even when they have LBP. Thus, the difference in back extensor length between women with and without LBP is smaller than the difference between men with and without LBP. Further studies might not have this limitation.

We found significant correlation between back extensor length and hip extensor strength in men with LBP. These reveal that there is a potential association between decreased back extensor length and weakened hip extensor strength with LBP. Moreover, having a weak hip extensor or shortened back extensor could increase the risk of sustaining LBP. As mentioned earlier, these musculatures play a significant role in spinal stability. These muscles contribute to dynamic trunk stability and help to transfer forces from the lower extremity via the thoracolumbar fascia up toward the spine during upright activities.[4] These muscle insufficiencies showed in the current study could change the normal pattern of hip extension.[14,15]

Limitations

As we wanted to have a more heterogenous population of patients with LBP, the intensity level of pain was not rated. This could be an issue because muscle dysfunction in LBP patients might be related to pain. Moreover, there were fewer women in the control group compared with the ones with LBP.

Another area of concern in our study is that the measurements of extensibility of back extensors and strength of hip extensors were done by the same person. It could be suggested that the tester was not blind to the respective findings and might know the finding of one test when doing the others, and this may compromise the results. However, in this study a standard flexible ruler was used to measure the participant's maximum lumbar flexion for assessment of the back extensor length. To obtain the amount of maximum lumbar flexion, the curve of the flexible ruler, resembling the size of participant's lumbar curvature, first was graphed on a paper, and then the standard formula was used to calculate the maximum lumbar flexion in degrees.[12,15,19-22] Thus, the tester did not know the amount of back extensor length when measuring the other variable because the calculation procedure was done afterward.

Another issue in our study is that the examiner performing measurements was aware of the health status of the participants. However, because the tester did not know the amount of back extensor length before the quantitative calculation method when measuring the other variable, the examiner tried to have no bias on test results. However, this must be considered as a limitation of the study.

Cross-sectional studies, including this one, cannot determine the pathophysiology of such association. The relationship between hip extensor strength and back extensor length still could be investigated in a longitudinal study.

Further studies are needed to fully explain the muscle imbalance of weakness and tightness of synergistic muscles and also the altered movement patterns in patients with LBP.

Conclusion

The findings support the assumptions of the presence of muscle imbalance of hip extensor weakness and back extensor tightness in male patients with LBP and that each muscle impairment may contribute to LBP.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): A.M.A., M.R.N.

Design (planned the methods to generate the results): M.S., A.M.A.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): A.M.A., M.R.N.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): M.S.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.M.A., M.S.
Literature search (performed the literature search): M.S.
Writing (responsible for writing a substantive part of the manuscript): A.M.A., M.R.N., M.S.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): A.M.A., M.R.N.

Practical Applications

- The results showed muscle impairments of hip extensor weakness and back extensor tightness in patients with LBP.
- These insufficiencies were correlated in men with LBP.
- Moreover, having these muscle impairments could increase the risk of sustaining LBP.

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