



The association between pain, balance, fall, and disability in patients with lumbar spinal stenosis with vascular claudication

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Background: The effect of lumbar spinal stenosis (LSS) and peripheral vascular disease (PVD), which occurs with similar degenerative conditions, when seen together, has not been studied. The aim of this study is to examine and compare the relationship between pain, balance, disability, fear of falling, and kinesiophobia in LSS patients with intermittent vascular claudication (IVC).

Methods: Seventy-two patients diagnosed with LSS using magnetic resonance imaging participated in this study. Thirty-five patients with IVC symptoms and showing vascular lesions by lower extremity venous and arterial Doppler ultrasonography imaging were included in the IVC-LSS group. The pain, static balance, dynamic balance, disability, fear of falling, and kinesiophobia were evaluated using the numeric rating scale, single leg stance test, Time Up and Go (TUG), the Oswestry Disability Index (ODI), Fall Efficacy Scale-International (FES-I), and Tampa Scale for Kinesiophobia (TSK), respectively.

Results: Age and female sex were found to be higher in the IVC-LSS group ($P = 0.024$; $P = 0.012$). The IVC-LSS group had a shorter single leg stance time and TUG test duration, pain intensity, ODI, FES-I, and TSK scores were higher than patients with LSS ($P = 0.001$). Pain, fear of falling, and kinesiophobia were moderately correlated with disability in the IVC-LSS group. No relationship was found between pain and dynamic balance. Also, the pain was not related to kinesiophobia.

Conclusions: The findings indicated that IVC causes loss of balance and an increase in pain, disability, fear of falling, and kinesiophobia in patients with LSS.

Key Words: Accidental Falls; Catastrophization; Disability Evaluation; Fear; Intermittent Claudication; Low Back Pain; Peripheral Vascular Diseases; Postural Balance; Spinal Stenosis; Ultrasonography, Doppler.

INTRODUCTION

The primary symptom of lumbar spinal stenosis (LSS), a problem of narrowing of the spinal canal that occurs with aging, is intermittent claudication in the lower extremities [1]. Intermittent vascular claudication (IVC), which can be seen due to venous insufficiency [2] and peripheral arterial

diseases (PAD) [3], increases with walking and decreases when resting [4,5]. On the other hand, intermittent neurogenic claudication (INC) is aggravated by ambulation and standing, and is relieved by trunk flexion and sitting [6]. The effects of LSS and PAD, which cause intermittent claudication with similar degenerative conditions, can be seen simultaneously [7]. Therefore, LSS and peripheral vascular

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Table 1. Comparison of vascular versus neurogenic claudication

Outcomes	Vascular	Neurogenic
Pain location	Calves	Back, buttock, thighs
Exacerbating factors	Activity, walking	Walking/standing erect, spinal extension
Alleviating factors	Rest	Spinal flexion
Onset of relief	Immediate	Within minutes
Walking uphill	Painful	Painless
Imaging	Doppler ultrasonography	Magnetic resonance imaging of lumbar spine

diseases (PVD) occurring together in advanced ages should be distinguished from each other [8].

Pain and claudication are primary symptoms of the LSS [9]. Pain affects the daily life activities of individuals and leads to severe disability and a decrease in functional level [10,11]. Pain and disability result in kinesiophobia in individuals with LSS [12]. Intermittent claudication [9,13] and problems such as flexed posture, motor deficit, and a decrease in spinal proprioception lead to a decrease in functional mobility and poorer balance [14,15]. In previous studies, the loss of balance has been identified in about half of individuals with LSS [15,16].

In IVC, leg pain that is aggravated by walking is more severe than low back pain and reduces the functional capacity of individuals by restricting their mobility and physical activity [6]. Impaired peripheral circulation in individuals with PVD with IVC is associated with sensory and motor nerve dysfunction in the lower extremities [17]. This causes poorer balance function [17-19], and an increase in the risk of falling [20]. It is also known that individuals with IVC have more history of falls and stumbles [17,18]. These individuals have a fear of falling as a result of weak physical, social, and psychological functions [21].

Since symptoms in LSS depend on the position of the spine, conservative approaches focus more on the lumbar region [22], while treatment of IVC involves the lower extremities [23]. The vascular problems accompanying LSS should be detected and their effects should be examined. A biopsychosocial approach to pain perception and determination of related factors are necessary for an individualized rehabilitation program [24].

In the literature, it has been reported that loss of balance and the risk of falling, disability, and fear of movement increase in IVC and LSS. However, to the authors' knowledge, there is no study investigating the effects of these factors on individuals with coexisting IVC and LSS (IVC-LSS). The author's hypothesis is that IVC may cause more pain, loss of balance, disability, fear of falling, and kinesiophobia in individuals with LSS. It is also thought that there is a relationship between pain, balance, and other psychosocial functions. This study aimed to compare and examine the relationship between pain, balance, disabil-

ity, fear of falling, and kinesiophobia in the individuals with LSS with and without IVC.

MATERIALS AND METHODS

1. Participants and settings

This study is a descriptive and cross-sectional study evaluating the IVC status of individuals with LSS who were admitted to the neurosurgery outpatient clinic from September 2020 to January 2021. Seventy-five individuals aged 35-80 years, diagnosed with LSS by magnetic resonance imaging, and able to walk independently participated in the study. The presence of intermittent claudication, factors increasing and decreasing pain, cardiovascular disease, and additional pathologies were questioned in the participants (Table 1) [5].

During the evaluation, one patient with severe pain and two patients with poor communication due to old age were excluded from the study. Of the 72 patients with LSS included in the study, lower extremity bilateral venous and arterial Doppler ultrasonography was requested for further imaging. Individuals who had a vascular lesion in the leg according to imaging results, and whose clinical symptoms met the definition of IVC by a neurosurgeon, were included in the IVC-LSS group as a result of the consultation of the vascular surgeon [25]. Arterial and venous calcification, occlusion, and narrowing ranged from minimum flow disturbances to maximum flow disturbances. No classification was used for rating. Individuals suffering from severe limb ischemia (*e.g.*, gangrenous tissue, ulcerated limb), a neurological disease that may affect balance (hemiplegia, multiple sclerosis, Parkinson, *etc.*), visual or vestibular system impairment, lower extremity joint disease, or surgical history in the past year, malignancy in the spine, and those with severe lung and cardiovascular disease were excluded. The patients were evaluated after the examination of the neurosurgeon. This study was approved by the Karabuk University ethics committee (2020/349). Written consent was obtained from all patients.

2. Data collection instruments

Demographic and physical characteristics of the patients such as age, sex, weight, height, smoking, chronic diseases, duration of symptoms, pain localization were recorded. Pain intensity was evaluated using the numerical rating scale (NRS) during activity and rest, both back and leg (0-10, 10 = worst imaginable pain) [26].

The static balance of the participants was measured with the single leg stance test (SLST) with eyes open (for a maximum of 30 seconds) [27]. Three tests were allowed on the affected side and the best result was used. The dynamic balance and mobility were assessed by the Time Up and Go (TUG) test. TUG is the measurement of the walking performance of the patient to get up from a standard chair, walk 3 meter, and come back and sit again. The time was recorded in seconds [28].

The disability level of individuals was assessed by the Oswestry Disability Index (ODI). The ODI revised form, developed to evaluate functional disability in low back pain, has 10 items (pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, traveling, and changing the degree of pain). Pain-related disability ranges from 0 to 100 points (100 = worst) [29].

Fear of falling was assessed using the Fall Efficacy Scale-International (FES-I). The FES-I is a self-reported questionnaire that evaluates the level of anxiety about falls during activities of daily living. The questionnaire contains 16 items scored on a four-point scale (1 = not at all concerned to 4 = very concerned) providing a total score ranging from 16 (absence of concern) to 64 (extreme concern) [30].

The Tampa Scale for Kinesiophobia (TSK) is a 17-item scale used to measure individuals' fear of movement/re-injury. All items are rated on a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree). Four out of 17 items (the 4th, 8th, 12th, and 16th item) are scored inversely (1 = strongly agree, 4 = strongly disagree). The total sum has a minimum score of 17 (low fear) and a maximum of 68 (high fear) [12].

3. Sample size

The sample size was calculated using G*Power 3.1 software (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). The sample size of the study [31] was calculated with 80% power, an effect size of 0.68, and a significance level of $\alpha = 0.05$ based on two independent groups and two-way hypothesis. Accordingly, it was found that it was necessary to work with 70 individuals, including at least 35 individuals in both groups.

4. Statistical analysis

The IBM SPSS Statistics 21.0 (IBM Co., Armonk, NY) program was used for the statistical analysis of the data. The relevance of data to a normal distribution was evaluated using the Kolmogorov-Smirnov test. Descriptive analyses were presented using mean and standard deviation for the normally distributed variables, and tables of frequencies, median, and minimum and maximum values for the non-normally distributed and ordinal variables. The independent *t*-test and Mann-Whitney *U*-test were used for comparisons between the two groups, and the chi-square test was used to compare qualitative data. Spearman's rank-order correlation analysis was used to determine the correlations between the variables. For the correlation coefficients, $r > 0.7$ was considered a strong correlation, those between 0.3 and 0.7 a moderate correlation, and those between 0 and 0.3 a weak correlation [32]. The level of statistical significance was set at $P < 0.05$ and $P < 0.01$.

RESULTS

A total of 72 patients with LSS (48 females and 24 males) were included in the study. The demographic characteristics of the 37 LSS and 35 IVC-LSS patients with are shown in Table 2. The mean age of the IVC-LSS group (60.9 ± 7.9 years) was higher than the LSS group (56.4 ± 8.4) ($P =$

Table 2. Demographic characteristics of the patients (n = 72)

Variable	IVC-LSS (n = 35)	LSS (n = 37)	P value
Age (yr)	60.9 ± 7.9	56.4 ± 8.4	0.024*
BMI (kg/m ²)	33.8 ± 4.8	30.9 ± 4.5	0.012*
Sex			
Female	29 (82.9)	19 (51.4)	0.006**
Male	6 (17.1)	18 (48.6)	
Smoking			
Never	18 (51.4)	16 (43.2)	0.547
Former	12 (34.3)	12 (32.4)	
Current	5 (14.3)	9 (24.3)	
Diabetes mellitus	15 (42.9)	2 (5.4)	0.001**
Hypertension	23 (65.7)	10 (27.0)	0.002**
Cardiovascular disease	13 (37.1)	5 (13.5)	0.029*
Affected leg side			
Unilateral	24 (68.6)	23 (62.2)	0.568
Bilateral	11 (31.4)	14 (37.8)	
Positive history of falls	24 (68.6)	8 (21.6)	0.001**
Duration of symptoms (mo)	48 (18-240)	36 (3-216)	0.022*

Values are presented as mean ± standard deviation, number (%), or median (minimum-maximum).

LSS: lumbar spinal stenosis, IVC-LSS: intermittent vascular claudication with lumbar spinal stenosis, BMI: body mass index.

* $P < 0.05$, ** $P < 0.01$.

0.024). In the IVC-LSS group, body mass index, female sex, diabetes, hypertension, and cardiovascular disease were significantly higher than the LSS group ($P = 0.012$; $P = 0.006$; $P = 0.001$; $P = 0.002$; $P = 0.029$). A history of smoking, which is known as a risk factor for vascular diseases, was not different between the groups ($P = 0.547$). The IVC-LSS group had higher fall history in the last 6 months ($P < 0.001$) and longer duration painful symptoms ($P = 0.022$).

As shown in Table 3, the IVC-LSS groups had more severe pain. When the groups were compared, single leg stance time was shorter, TUG test time was longer, and ODI, FES-I, and TSK scores were higher in the IVC-LSS group ($P = 0.001$). In the IVC-LSS group, there was a moder-

ate correlation between the TUG test and TSK ($r = 0.525$, $P < 0.001$). No correlation was found between TUG and other tests ($P > 0.05$). A moderate negative correlation was found between SLST and NRS activity ($r = -0.344$, $P = 0.043$) and FES-I ($r = -0.488$, $P = 0.003$). Also, a moderate positive correlation was found between ODI and NRS activity ($r = 0.481$, $P = 0.003$), FES-I ($r = 0.558$, $P < 0.001$), and TSK ($r = 0.479$, $P = 0.004$). Table 4 shows the correlation between NRS, SLST, TUG, ODI, FES-I, and TSK in LSS and IVC-LSS groups.

DISCUSSION

To the authors' knowledge, the present study is the first examining balance, disability, fear of falling, and kinesophobia in patients with IVC-LSS. Patients with IVC-LSS had more severe pain, disability, and loss of balance compared to patients with LSS. In addition, fear of falling and kinesophobia levels were highly associated with impaired mobility and disability. The results of the combination of vascular and neurogenic intermittent claudication that affect individuals physically and psychologically are not surprising, but the detection of these results is important.

Chronic back pain occurs in LSS as a result of degenerative changes in the spine. INC, which occurs due to mechanical compression or ischemia in the nerve roots, causes pain aggravated by walking in the leg [6]. Studies have shown that individuals with LSS have severe pain in the back and legs [10,11]. In this study, the pain severity of individuals with LSS was found to be higher and consistent with previous studies. IVC is characterized by pain and cramping of muscle groups [23]. The pain was observed in

Table 3. Comparison of outcomes between IVC-LSS and LSS groups (n = 72)

Variable	IVC-LSS (n = 35)	LSS (n = 37)	P value
NRS			
Activity	9 (7-10)	8 (5-10)	0.001**
Rest	3 (1-5)	2 (0-6)	0.015*
SLST (sec)	4.02 (1.98-17.42)	12.32 (2.68-27.19)	0.001**
TUG (sec)	15.59 ± 2.24	11.78 ± 1.53	0.001**
ODI	69.37 ± 8.01	52.11 ± 10.45	0.001**
FES-I	36.20 ± 7.23	27.49 ± 5.23	0.001**
TSK	50.89 ± 3.68	45.86 ± 3.55	0.001**

Values are presented as median (minimum-maximum) or mean ± standard deviation.

LSS: lumbar spinal stenosis, IVC-LSS: intermitant vascular claudication with lumbar spinal stenosis, NRS: numeric rating scale, SLST: single leg stance test, TUG: Time Up and Go, ODI: Oswestry Disability Index, FES-I: Falls Efficacy Scale-International, TSK: Tampa Scale for Kinesiophobia.

* $P < 0.05$, ** $P < 0.01$.

Table 4. Spearman's rank-order correlation coefficients values between all outcome measures in IVC-LSS and LSS groups (n = 72)

Group	TUG	SLST	NRS activity	NRS rest	ODI	FES-I
IVC-LSS	TUG					
	SLST	-0.29				
	NRS activity	0.10	-0.34*			
	NRS rest	0.02	-0.26	0.38*		
	ODI	0.16	-0.31	0.48**	0.29	
	FES-I	-0.17	-0.49**	0.31	0.21	0.56**
	TSK	0.52**	-0.25	0.31	-0.02	0.48**
LSS	TUG					
	SLST	-0.55**				
	NRS activity	0.21	-0.12			
	NRS rest	0.55**	-0.40*	0.50**		
	ODI	0.64**	-0.41*	0.53**	0.65**	
	FES-I	0.53**	-0.51**	0.38*	0.49**	0.67**
	TSK	0.39*	-0.23	0.49**	0.45**	0.68**

LSS: lumbar spinal stenosis, IVC-LSS: intermitant vascular claudication with lumbar spinal stenosis, TUG: Time Up and Go, SLST: single leg stance test, NRS: numerical rating scale, ODI: Oswestry Disability Index, FES-I: Falls Efficacy Scale-International, TSK: Tampa Scale for Kinesiophobia, r: correlation coefficient.

* $P < 0.05$, ** $P < 0.01$.

IVC due to reduced oxygen supply to the muscles in PAD [23] and standing position due to venous insufficiency [2]. Han et al. [7] reported that patients with IVC-LSS had more pain than LSS, but there was no significant difference. On the contrary, Uesugi et al. [8] observed that the pain of patients with LSS more than those with IVC-LSS. The authors attributed this significant difference to the subjective nature of pain and the difficulty of detecting PAD [8]. IVC causes activity-induced cramps and pain in the distal of the lower extremities, especially in the calf region [5].

Pain intensity increases according to the severity of claudication [23]. In this study, the pain severity of patients with IVC-LSS was found to be higher. Compared to previous studies, the high number of women and the variability and level of disease severity may explain the pain in the present study. Pain is the most important factor in decreasing the quality of life of individuals. Therefore, it should be eliminated. Pain causes functional impairment and disability in activities of daily living. Truszczyńska et al. [10] and Fortin et al. [11] observed ODI scores of 49.3 (17.3) and 49.3 (16.7), respectively and reported that individuals with LSS have a severe disability, similar to the results in this study.

IVC leads to disability and reduced functional capacity by restricting mobility and physical activity [33]. Wood et al. [34] showed that patients with INC had more disability compared to patients with IVC, but could not find a significant difference. Also, the level of disability in patients with IVC was found to be higher than asymptomatic individuals [34]. In the present study, the severity of disability in patients with IVC-LSS was found to be higher than LSS. To the authors' knowledge, in addition to the low back pain in individuals with LSS, calf pain especially contributes to disability in the patients with IVC. In addition, the change from minimum to maximum in the severity of disease in the individuals with LSS and PVD in this study may affect functional performance.

Previous studies have shown that individuals with LSS have poor static balance functions in the anterior-posterior direction [15,16]. Somatosensory functions as well as decreases in the low back and lower extremity muscle strength can lead to loss of balance [15]. In studies evaluating dynamic balance and mobility, Kim et al. [28] and Fujita et al. [35] measured the TUG test performance as 14.1 ± 1.8 and 11.1 ± 3.7 seconds, respectively, and the researchers interpreted this result as balance disorders in individuals with LSS, similar to the results of the present study. In PVD, loss of balance occurs due to circulatory and neurological dysfunction in the lower extremities [17]. Lanzarin et al. [19] reported that there was a change in the anterior-posterior stability in the patients with IVC as a result of the functional impairment and loss of motor control

of the muscles [19]. It has been suggested that IVC caused insufficiency in static [17] and dynamic balance [18,19]. In the present study, the IVC-LSS group had poor static and dynamic balance performance. Because the problems caused by IVC are more distally located and lead to deficiencies in muscle function and neural interaction, the combination of LSS and vascular pathologies may cause poorer balance control.

Loss of balance results in fear of falling [14,21]. Previous studies have emphasized that there is a fear of falling in both LSS [36] and PVD [21]. It is assumed that individuals' physical abilities decrease due to the fear of falling and they avoid movement by developing various adaptations [37]. In this study, it was found that both groups had a fear of falling, but the level of fear was higher in individuals with IVC-LSS. Female sex, a history of falling, and higher age are known as risk factors for fear of falling [38]. As reported in previous studies [21,36], the high number of women, the presence of a fall history, and higher age may clarify the higher level of fear of falling in the IVC-LSS group in the present study. Fear, which depends on many factors, is based on personal experience and restricts functional activity [21]. Therefore, physiological and psychological risk factors that cause the fear of falling in patients should be determined.

Kinesiophobia, defined as a fear of movement, is known as an extreme fear of physical movements and activities resulting from a painful injury or re-injury [39]. Pain and disability caused by LSS [12,34] and PVD [34,40] increase kinesiophobia. Sharath et al. [40] examined the effects of pain beliefs on physical activity and health, and showed that individuals with IVC have high levels of kinesiophobia. Besides, it has been shown that pain is believed to be caused by walking, and fear avoidance behavior increases as severity of symptoms increases [40]. In this study, kinesiophobia was found to be higher in both groups. Moreover, individuals with IVC-LSS had more fear of movement. It was not easy to include individuals with similar severity of the disorder. It was observed that the symptoms of individuals with LSS and vascular pathology varied from mild pain to severe muscle cramps in the present study. Furthermore, patients with IVC-LSS had more pain. These factors may define the change in kinesiophobia.

This study is the first examining the relationship between functional and psychosocial factors in individuals with IVC-LSS. Pain was associated with static balance and disability in the IVC-LSS group. In contrast to the LSS group, the moderate correlation between pain and static balance shows that pain leads to functional impairment in LSS due to IVC. Contrary to expectations, no relationship was found between mobility and pain in the IVC-LSS group. IVC leads to deficiency in motor and sensory nerve

functions [17] and impairment in concentric strength due to adaptations in muscle structure [41]. When these findings are taken into account, in this study, changes in muscle and nerve functions in individuals with IVC-LSS may have affected dynamic balance rather than pain. Wood et al. [34] showed that in individuals with intermitant claudication, pain contributed indirectly to kinesiophobia due to mobility difficulties and depression, and there was no direct relationship between pain and kinesiophobia. Similarly, in this study, no relationship was found between pain and kinesiophobia in the IVC-LSS group. Kinesiophobia may be caused by disability, injury, and fear of increased severity of disease with movement, rather than pain. Individuals avoid movement due to pain [12,40], disability [12,34], and poor balance [17,26]. Therefore, it is thought that individuals with IVC-LSS develop a slower and more controlled walking pattern. This explains the relationship between kinesiophobia and dynamic balance. Moreover, the level of disability was observed to be associated with kinesiophobia and fear of falling in individuals with IVC-LSS. For this reason, individuals with functional disabilities avoid moving due to the fear of falling. Loss of static balance was also associated with an increase in fear of falling. It is thought that individuals with IVC-LSS can develop various adaptive strategies while standing or during activity.

One of limitations of the present study is that there was an inequality in sex distribution. There were more women participants than men in the IVC group. The possible explanations of the inequality in sex distribution are that stenosis is seen more widely in women [42], IVC increases with age in women [3], and, though the prevalence of IVC-LSS is unclear, the number of male patients admitted to the clinic due to pain is less. Besides, the difference in age distribution can be explained by the fact that vascular pathologies accompany LSS as age progresses [7,8]. Secondly, the presence of a control group of healthy individuals could strengthen the authors' interpretations. Third, the participants in this study were not grouped according to IVC severity. The differences in severity of vascular problems can affect outcomes. Further studies in which individuals are grouped according to imaging results are needed. Finally, although the balance tests used in this study can be applied clinically, future studies with balance devices are needed for more objective results.

The results of the present study show that in addition to LSS symptoms, IVC causes disability, fear of falling, and kinesiophobia as well as impairment in static and dynamic balance control. In individuals with LSS, the presence of IVC should be evaluated and biopsychosocial factors caused by it should be treated.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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