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ORIGINAL RESEARCH

Network Analysis of Contemporaneous Symptoms and Identification of Core Symptoms in Patients with Lumbar Disc Herniation

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Objective: To construct a contemporaneous symptom co-occurrence network of patients with lumbar disc herniation (LDH) to extract symptom clusters and identify core and bridge symptoms using network analysis.

Methods: A questionnaire was administered to 312 LDH patients hospitalized in a tertiary-level hospital in Hubei Province from September 21, 2024, to March 31, 2025, using convenience sampling. Instruments included a general information questionnaire, the Japanese Orthopaedic Association's Low Back Pain Assessment Scale (JOA), the Visual Analogue Scale (VAS), and the Self-Rating Anxiety Scale (SAS). Symptomatic data were collected and downscaled using exploratory factor analysis to reduce dimensionality and extract symptom clusters with intrinsic associations. The symptom network was constructed using R, relationships between symptoms were analyzed, and centrality indices were calculated to identify key symptom nodes.

Results: Exploratory factor analysis extracted four symptom clusters. They were the symptom cluster of limited lumbar mobility function, the symptom cluster of limited lower extremity mobility function, the symptom cluster of abnormal distal limb sensation, and the symptom cluster of lower extremity motor coordination disorder. The top three symptoms for node strength were Difficulty standing (rs = 5.72), Difficulty walking (rs = 5.43), and Difficulty turning over (rs = 5.35); the top three for bridge strength were Difficulty standing (rs = 4.58), walking ability (rs = 4.49), and Difficulty walking (rs = 4.37).

Conclusion: Difficulty standing, Difficulty walking, and Difficulty turning are the most central symptoms in LDH patients, while Difficulty standing, walking ability, and Difficulty walking are bridge symptoms.

Keywords: lumbar disc herniation, intervertebral disc degeneration, low back pain, network analysis, contemporaneous network, core symptoms, nursing

Lumbar Disc Herniation (LDH) is a highly prevalent degenerative disease of the spine and is one of the leading causes of lower back pain and sciatica,[1] Epidemiologic data show that about 540 million people worldwide suffer from low back pain.[2] of which LDH is one of the major causes,[3,4] significantly affecting patients' functional status, quality of life and causing socioeconomic burden.[5–9] The clinical manifestations of LDH are complex and varied.[10] In addition to the typical low back pain, it is often accompanied by clinical symptoms such as lower limb numbness, sensory abnormality,[11] muscle weakness, gait abnormality, and even dysfunction of urinary and defecatory functions.[12–14] These symptoms do not exist in isolation, but are interrelated and interact with each other to form a complex clinical syndrome. However, traditional studies have primarily focused on assessing single symptoms or linear association analysis studies.[15] Although such studies provide basic data, they fail to adequately reveal the underlying, nonlinear structure of interactions among these complex symptoms, especially the identification of core symptoms (those that have the most significant impact on the entire symptom cluster) and bridge symptoms (key symptoms that connect different symptom clusters and may exacerbate the overall burden).[16] This lack of understanding of the dynamic

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network relationships between symptoms constitutes an essential gap in the current literature, limiting our understanding of the overall burden of LDH symptom clusters and their underlying mechanisms of action. In recent years, network analysis methods have demonstrated unique strengths in understanding symptom interactions in complex disorders (eg, fibromyalgia, depression, cancer-related symptom clusters), revealing core and bridging symptoms and their critical roles in sustaining symptom clusters, which are difficult to capture with traditional methods. However, a dearth of studies in the field of LDH has applied network analysis systems to explore the complex relationships among contemporaneous symptoms. Given the aforementioned research gaps and the potential of network analysis in complex symptom research, this study aimed to apply network analysis, an emerging computational method, to assess the symptom occurrence status and symptom clusters of patients with LDH, to construct a network of contemporaneous symptoms that can intuitively reflect the complex interactions among the symptoms, and to analyze the network centrality metrics (eg, strength centrality, proximity centrality, mediator centrality). This approach provides a new perspective to understand the complexity of LDH symptoms, revealing which symptoms are central to the overall network and which symptoms are key hubs connecting different symptom clusters, thus providing a more comprehensive assessment of the patterns of symptom interactions and their contribution to the overall disease burden. The results of this study not only help to deepen the understanding of the synergistic mechanism of symptoms in the pathophysiological process of LDH, but also aim to provide a direct reference for clinical healthcare professionals to construct precise symptom management programs based on the key targets of the symptom network.[17–20]

Objects and Methods

Subjects

This cross-sectional study enrolled patients with lumbar disc herniation (LDH) at a tertiary hospital in Wuhan (September 21, 2024–March 31, 2025) via convenience sampling.

Inclusion Criteria

A herniated disc that meets the diagnostic criteria of the 2021 Clinical Practice Guidelines for Rehabilitation in Traditional Chinese Medicine - Low Back Pain (Lumbar Disc Herniation) for typical clinical symptoms (low back pain and/or radiating pain in the lower extremities) or corresponding radicular signs, as well as imaging confirmation of the herniated disc.[2] Age 18–80 years;[3] Informed consent from patients/families and voluntary participation.

Exclusion Criteria

(1) Severe cardiovascular/cerebrovascular or life-threatening comorbidities; (2) Significant memory loss, psychiatric disorders, or impaired consciousness. The sample size of this study was determined by the cross-sectional sample size formula: n [Zα/2(1-p) p]/δ2, with α taken as 0.05 and the tolerance error δ taken as 0.05. The pre-test yielded a symptom incidence rate of P = 0.8. Considering the 20% loss-to-follow-up rate, at least 152 cases should have been included in the sample. The final sample size of this study was 312 cases. This study has been approved by the Medical Ethics Committee of the University of South China (Approval Number: 2024HLSC070), with the approval date being September 18, 2024.

Research Methodology

Survey Instrument

General Information Questionnaire

Researcher-designed, it collected socio-demographic data (gender, age, BMI, education, residence, and payment method) and disease-related data (family history, smoking history, and exercise frequency).

The Japanese Orthopaedic Association Low Back Pain Assessment Scale (JOA), developed in 2007 and translated into Chinese by Min Yao et al[21] in 2018, assesses low back pain severity.[22] It comprises three domains:[23] self-perceived symptoms, clinical signs, and daily life (score range: 0–29). Lower scores indicate greater dysfunction.

The Cronbach's alpha coefficient of this scale in this study was 0.86.

Visual Analogue Scale (VAS)

The scale consists mainly of a straight line, which is usually 100 millimeters (mm) in length, or a simplified version using a 10-

centimeter (cm) line.[24] For clinical use in China, a 10-cm vernier scale is more commonly used, with 10 scales on one side and "0" and "10" marks at each end. One end of the line represents "no pain at all," and the other end represents "the most severe pain imaginable" or "pain to the extreme."

Self-Rating Anxiety Scale (SAS)

The scale was compiled by Zung of Duke University School of Medicine in 1971[25,26] and includes 20 items, of which 15 are positively scored and five are negatively scored. A scale of 1 to 4 was used, and the scores of the 20 items on the scale were summed to obtain a crude score. The raw scores of the questions and the total score were then multiplied by 1.25k to get the standardized scores of the questions and the total score. A total standardized score <50 was regarded as having no anxiety disorder, and a total standardized score ≥50 or more was considered to have an anxiety disorder. The score between 50 and 62 (including 50 and 62) was regarded as having a mild anxiety disorder, and the score >62 was considered as having a severe anxiety disorder.To clarify, the assessment of anxiety in this study was conducted exclusively through the self-reported SAS questionnaire. A comprehensive psychiatric evaluation was not part of the study protocol.

Data Collection Method

Before this study was conducted, two graduate students and one undergraduate student who participated in this investigation were systematically trained to clarify the purpose of this study and the survey method. Before the survey, the investigator explained the purpose and significance of the study to the patients, obtained their consent, and had them sign the informed consent form. The investigator then thoroughly explained the meaning of each entry to the patients to ensure that they filled it out based on a clear understanding. During the survey process, the investigator answered patients' questions on the spot. The questionnaires were collected and checked on the spot, and any omissions and errors were confirmed immediately to minimize the number of invalid questionnaires. This survey was completed on the patient's admission to the hospital. Three hundred seventeen questionnaires were distributed in this study, of which 312 were valid, yielding an effective response rate of 98.4%.

Statistical Methods

SPSS 27.0 and R 4.4.2 software were used for data entry and analysis. Count data are presented as frequencies/percentages; measures obeying normal distribution were described using ($\bar{x} \pm s$), and measures not obeying normal distribution were expressed as medians, with the mean as the reference index; in this study, symptom clusters were extracted, and network analysis was performed for symptoms with symptom prevalence ≥ 20%.[27] Symptom clusters were extracted using principal component analysis in exploratory factor analysis combined with maximum variance orthogonal rotation, and at least two or more symptoms with factor loadings >0.4 were included within each factor.[18,28] Network analysis was performed using the qgraph package in R software to construct the symptom network,[19,29] Spearman correlation analysis was used to describe the relationship between symptoms, and the Fruchterman-Reingold force-guided layout was used to place the node with the strongest correlation in the center of the network;[30–32] standardization was performed for the JOA-related entries, VAS scores and SAS scores processed to construct the nodes with symptoms as the network, the lines between the nodes are the edges of the network, the thicker the edges, the darker the color represents the stronger correlation between the symptoms.[33] The centrality indices of the network model were calculated: Strength, Betweenness, and Closeness.[34,35] Strength is the sum of the absolute values of the correlation coefficient weights of the edges, and the greater the strength, the stronger the ability of the symptom to influence other symptoms.[36] Closeness is the reciprocal distance between the symptom and other symptoms, and a symptom with a high Closeness is located in the network's core. Betweenness is the number of times the symptom is an intermediary connecting other symptoms in the network.[37,38] When the numerical ordering of the three centrality metrics was inconsistent, the result prevailed based on the ordering of the intensity. The boot-net package was used to detect the correlation between the new dataset and the centrality indicators in the original dataset after reducing the sample size in the network,[39,40] and the correlation stability coefficient (CS) was calculated.[15,41] It is usually considered that the correlation stability coefficient should be at least 0.25;[15,42] a nonparametric bootstrap was used to calculate the 95% confidence intervals for the edge weights, and the narrower the resulting confidence intervals were, the more accurate the estimation of the edge weights.[43]

Results

General information of the study subjects: See Table 1.

Symptom Incidence and Symptom Cluster Extraction of Patients with Lumbar Disc Herniation

The top 3 patient symptoms were lumbar pain (84.9%), lower extremity pain and numbness (79.8%). Difficulty sitting for a prolonged period (1 hour) (78.8%), and the symptom with a symptom incidence of ≤20% of patient symptoms was limited bladder function (15.1%). Exploratory factor analysis was performed on the 14 symptoms with an incidence of ≥20% in this study, and the KMO value was 0.858, which indicated that it was suitable for factor analysis. The Bartlett's test of sphericity showed χ^2=1835.759, P<0.01. A total of 4 common factors with eigenvalues >1 were extracted in this study, and the cumulative variance contribution rate was 66.475%. Based on the common characteristics of symptoms, the four common factors were named the lumbar activity function limitation symptom group, the lower limb activity function limitation symptom group, the abnormal distal limb sensation symptom group, and the lower extremity motor coordination disorder symptom group. The results of symptom incidence and symptom exploratory factor analysis in patients with lumbar disc herniation are shown in Table 2.

Network Analysis of Contemporaneous Symptoms in Lumbar Disc Herniation Patients

Edge weight correlation coefficients and node predictability analysis. Based on the edge weight correlation coefficients of the 15 symptoms included, a biased correlation network model was constructed, see Figure 1. The network-specific edge weight correlation coefficients are shown in Table 3. According to the results of the visual network analysis and the edge weight values, the strongest positive correlations among the top 3 were walking ability and walking Difficulty (D2-B3), sitting Difficulty and lifting Difficulty (A4-A5), and Difficulty standing - Difficulty walking (B1-B3). The top 3 strongest negative correlations were pain level-difficulty standing (E-B1), pain level-walking ability (E-D2), and pain level-difficulty turning over (E-A2). Node predictability is represented by the circle around the periphery of the node in

Table 1 Subject Characteristics (n=312)

Variable Number of Cases	Group	Cases (Percentage, %)
Gender	Male	139 (44.55)
	Female	173 (54.44)
Age (years, x ±s)	52.20±15.98	
BMI	Thin (<18)	9 (2.88)
	Normal (18–24)	152 (48.71)
	Overweight (>24)	151 (48.39)
Educational level	Elementary school and below	55 (17.62)
	Junior high school	52 (16.66)
	High school and above	205 (65.70)
	City	240 (76.92)
Area of residence	Urban	48 (15.38)
	Rural	24 (7.69)
Hospitalization payment method	Medical insurance	304 (97.43)
	Self-pay	8 (2.56)
Family history	Yes	65 (20.83)
	None	247 (79.16)
Smoking	Yes	57 (18.26)
	None	255 (81.73)
Exercise	Never	94 (30.12)
	Occasionally (<3 times per week)	137 (43.91)
	Frequently (≥3 times per week)	81 (25.96)

Table 2 Results of Exploratory Factor Analysis of Symptom Prevalence and Symptoms in Patients with Lumbar Disc Herniation

Symptom Group	Symptoms	Number of Cases [Cases (Percentage, %)]	Factor Loadings			
			Factor 1	Factor 2	Factor 3	Factor 4
Symptom cluster Functional limitation of lumbar mobility	Low back pain	265 (84.93)	0.714			
	Difficulty turning over	151 (48.39)	0.648			
	Difficulty in forward bending	201 (64.42)	0.593			
	Difficulty sitting	246 (78.84)	0.806			
	Difficulty in lifting	244 (78.20)	0.766			
Symptom cluster of functional limitation of lower limb movement	Difficulty in standing	141 (45.19)		0.669		
	Difficulty in washing	89 (28.52)		0.64		
	Difficulty walking	165 (52.88)		0.772		
Symptom cluster of distal limb sensory abnormalities	Straight leg raising test	145 (46.47)			0.684	
	Sensation	158 (50.64)			0.88	
	Muscle strength	85 (27.24)			0.667	
Lower Extremity Motor Coordination Disorder Symptom Cluster	Lower extremity pain and or numbness	249 (79.8)				0.91
	Walking ability	218 (69.9)				0.434

Figure 1, and the top 3 nodes, as measured by root mean square error (RMSE) values, were lower extremity pain and or numbness (0.86), anxiety depression (0.84), and low back pain (0.83).

Analysis of Core and Bridge Symptoms According to the results of the node centrality index, the symptoms in the top 3 of intensity were: Difficulty in standing *(rs* = 5.72), difficulty in walking *(rs* = 5.43), and Difficulty in turning over *(rs* = 5.35); the symptoms in the top 3 of intermediary centrality were: Difficulty in turning over (rb = 6), Difficulty in walking

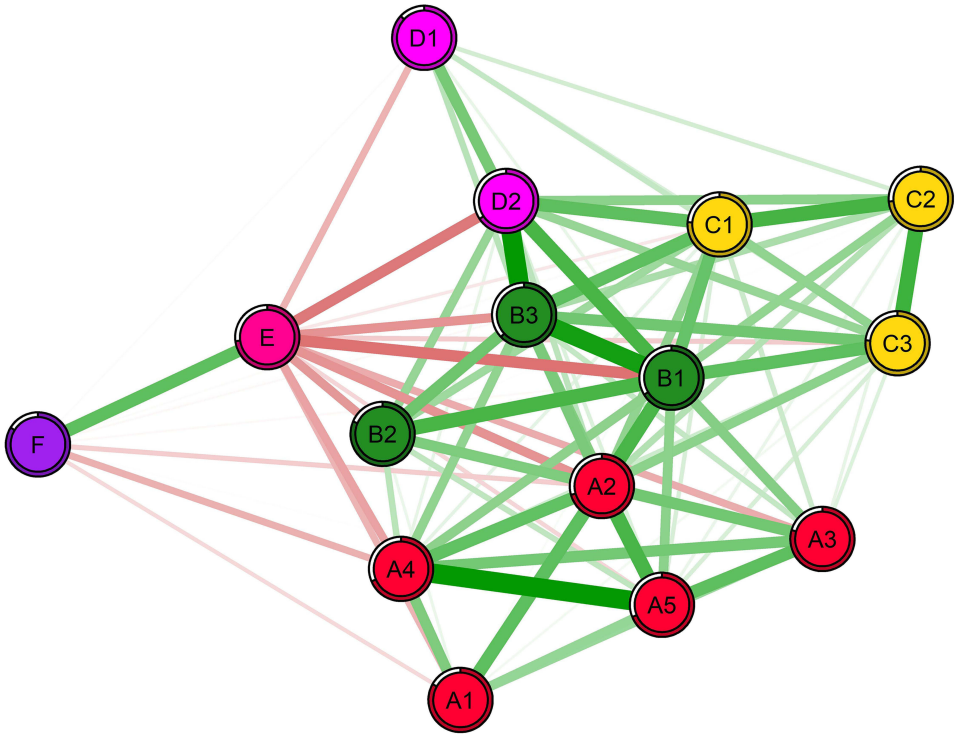

Figure 1 Symptom network of patients with lumbar disc herniation. Symptoms of functional limitation of lumbar motion. A1 Low back pain, A2 Difficulty in turning over, A3 Difficulty in forward bending, A4 Difficulty sitting, A5 Difficulty lifting objects. Symptom clusters of functional limitation of lower limb movement. B1, Difficulty standing; B2, Difficulty washing; B3 Difficulty walking. Symptom cluster of distal limb sensory abnormalities. C1 Straight leg raising test; C2 Sensation; C3 muscle strength. Lower Extremity Motor Coordination Disorder Symptom Cluster. D1 Lower extremity pain and or numbness D2 Walking ability. Other symptoms. E Pain level. F Anxiety and depression.

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Table 3 Edge Weight Values in the Symptom Network

Item	A1	D1	D2	C1	C2	C3	A2	B1	B2	A3	A4	A5	B3	E	F
A1	1														
D1	0.04	1													
D2	0.12	0.43	1												
C1	0.14	0.24	0.47	1											
C2	0.09	0.25	0.38	0.51	1										
C3	0.16	0.28	0.37	0.32	0.48	1									
A2	0.47	0.11	0.26	0.3	0.21	0.29	1								
B1	0.25	0.18	0.49	0.42	0.31	0.41	0.48	1							
B2	0.19	0.06	0.36	0.32	0.13	0.23	0.4	0.5	1						
A3	0.37	0.03	0.28	0.27	0.20	0.23	0.45	0.41	0.39	1					
A4	0.42	0.12	0.20	0.18	0.08	0.22	0.45	0.33	0.28	0.43	1				
A5	0.36	0.11	0.22	0.20	0.17	0.20	0.49	0.35	0.26	0.48	0.65	1			
B3	0.15	0.30	0.67	0.43	0.28	0.40	0.35	0.55	0.40	0.26	0.32	0.36	1		
E	−0.32	−0.31	−0.41	−0.17	−0.09	−0.25	−0.38	−0.43	−0.35	−0.31	−0.35	−0.24	−0.35	1	
F	−0.23	−0.15	−0.15	−0.15	−0.10	−0.07	−0.22	−0.13	−0.13	−0.17	−0.31	−0.14	−0.14	0.45	1

Notes: A1 Low back pain, A2 Difficulty in turning over, A3 Difficulty in forward bending, A4 Difficulty sitting, A5 Difficulty lifting objects, B1 Difficulty standing, B2 Difficulty washing, B3 Difficulty walking, C1 Straight leg raising test, C2 Sensation, C3 muscle strength, D1 Lower extremity pain and or numbness, D2 Walking ability, E Pain level, F Anxiety and depression.

(rb = 5), and ability to walk (rb = 5); and the symptoms in the top 3 of close centrality were: Difficulty in standing (rc = 0.027), difficulty in walking (rc = 0.025), and straight leg raising test (rc = 0.025). 3 symptoms were: difficulty standing (rc = 0.027), difficulty walking (rc = 0.025), and straight leg raise test (rc = 0.025) See Figure 2. The top 3 symptoms for bridge strength in the results of the bridge centrality index were Difficulty standing (rs = 4.58), ability to walk (rs = 4.49), and Difficulty walking (rs = 4.37). See Figure 3.

Network Accuracy and Stability Analysis

The 95% confidence intervals of the edge weights generated by the bootstrap method in this study (see Figure 4) indicate that the edge weights are sufficiently accurate. The stability test results of the centrality index show, see Figure 5, that the CS coefficient is> 0.5, indicating that the network stability is good.

Discussion

Patients with lumbar disc herniation symptoms can be categorized into four symptom clusters.

This study's exploratory factor analysis identified four symptom clusters in patients with LDH: limitation of lumbar mobility function, lower extremity mobility function, distal limb sensory abnormality symptom cluster, and lower extremity motor coordination disorder symptom cluster. This classification is consistent with the multidimensional nature of the pathogenesis of LDH. The symptom cluster of limited lumbar mobility reflects spinal dysfunction caused by mechanical compression. In contrast, the symptom cluster of limited lower extremity mobility highlights the distal effects of nerve root compression. The ability to walk is associated with pain and neurological function, suggesting that it is a unique marker of functional compensation. However, research on LDH-related symptom clusters remains insufficient, and the diversity of research methods may result in different types of symptom clusters among patients. Therefore, more relevant studies can be conducted to explore the various symptom clusters associated with LDH, providing targeted intervention programs for patients.

Standing Difficulty, Walking Difficulty, and Turning Difficulty are the Most Core Symptoms in LDH Patients

The results of this study showed that among the centrality indicators of the network nodes, both intensity centrality and mediated centrality analyses showed that Difficulty in standing, Difficulty in walking, and Difficulty in turning ranked

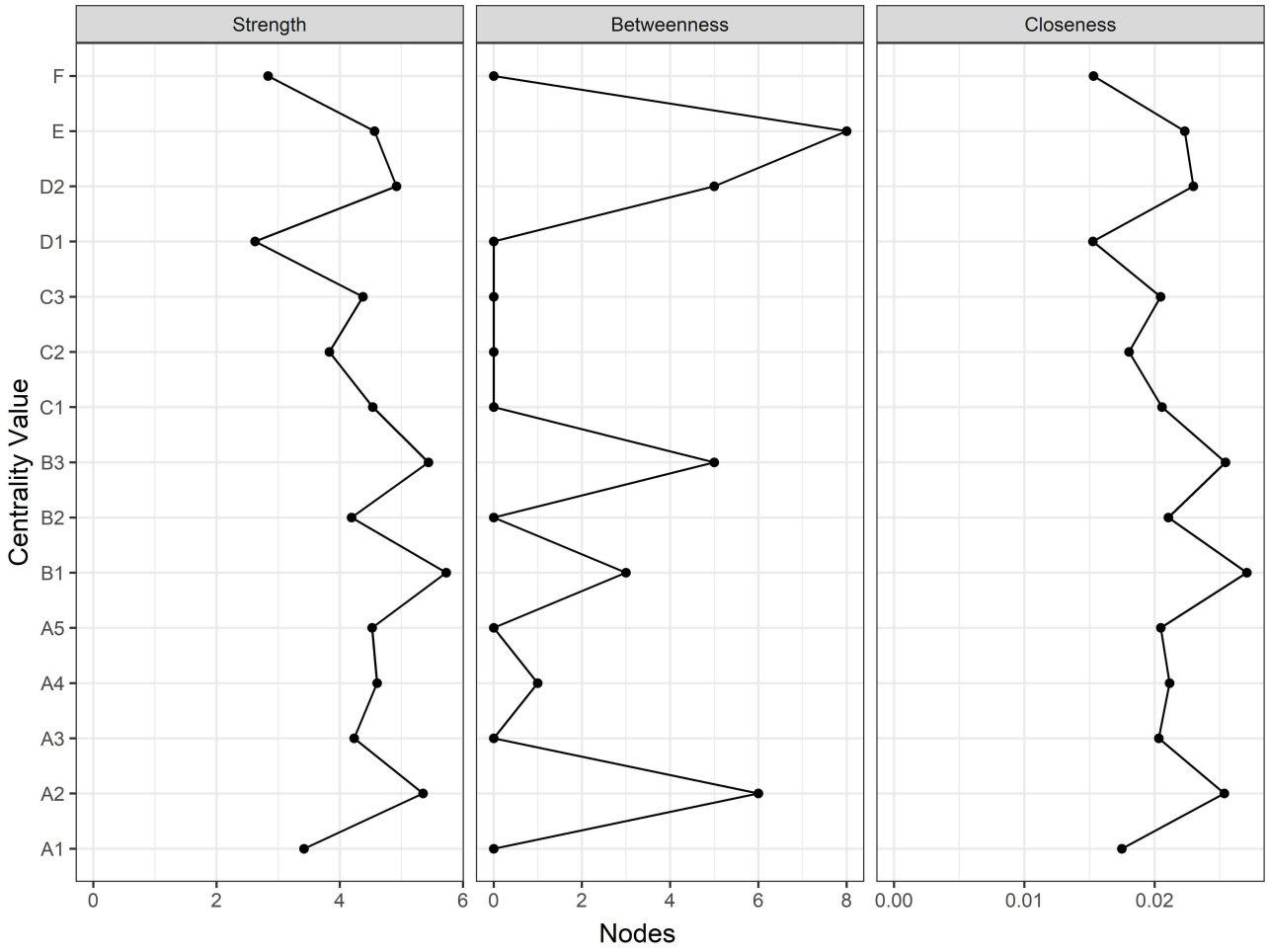

Figure 2 Node Centrality Indicator. A1 Low back pain, A2 Difficulty in turning over, A3 Difficulty in forward bending, A4 Difficulty sitting, A5 Difficulty lifting objects, B1 Difficulty standing, B2 Difficulty washing, B3 Difficulty walking, C1 Straight leg raising test, C2 Sensation, C3 muscle strength, D1 Lower extremity pain and or numbness, D2 Walking ability, E Pain level, F Anxiety and depression.

among the top three in terms of centrality, suggesting that they occupy a central position in the symptom network. These symptoms may exacerbate the pain-function decline vicious cycle by limiting patients' daily activities. Therefore, the improvement of core symptoms in the LDH contemporaneous network requires the implementation of a multidimensional intervention strategy, which firstly enhances standing endurance through progressive resistance training (eg, gradual transition from standing against a wall for short periods to standing independently), and secondly improves gait stability by using a metronome-assisted gait retraining technique, and at the same time, incorporates the ability to turn over into the ADL assessment system and designing a targeted bed transfer training. These three measures target the core symptoms of standing Difficulty, walking Difficulty and turning Difficulty, forming a full-cycle management program from static support to dynamic mobility, from bedside function to daily activities, and providing an actionable clinical pathway to interrupt the vicious cycle of pain and functional decline.

Difficulty in standing, ability to walk, and Difficulty in walking are bridge symptoms in the constructed network.

Bridge strength centrality analysis showed that Difficulty standing (bridge strength = 0.42), ability to walk (bridge strength = 0.38), and Difficulty walking (bridge strength = 0.35) were the top 3 symptoms, suggesting that these three symptoms are key nodes connecting the three different symptom clusters in the network analysis. The symptom network can be effectively restructured by targeting intervention on the bridge symptom, reducing the risk of other symptoms. For standing difficulties, a graded training model from chair standing to unassisted standing to dynamic balance training can be implemented; for walking deficits, multimodal rehabilitation can be used, combining with underwater treadmill

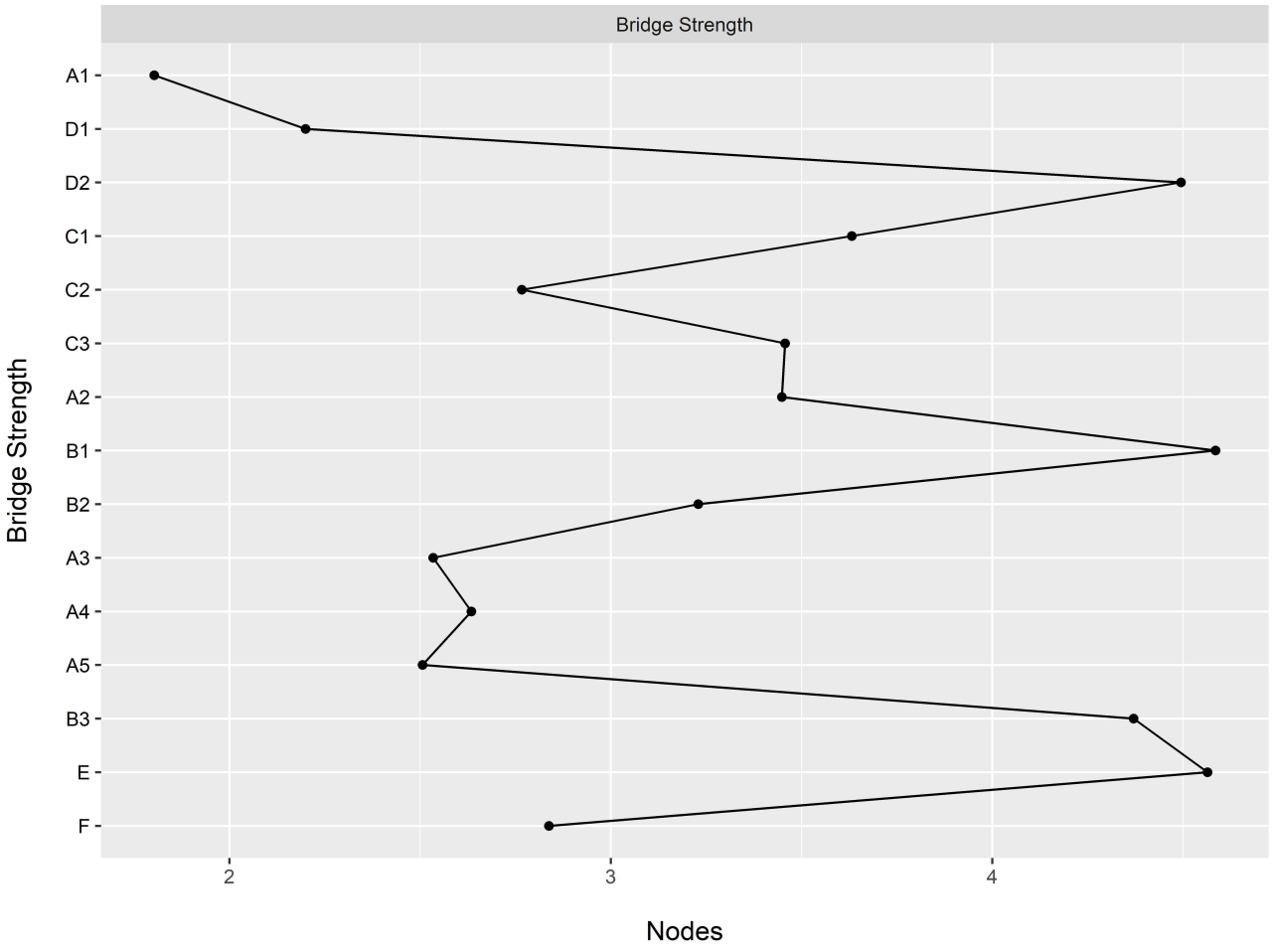

Figure 3 Bridge strength centrality index. A1 Low back pain, A2 Difficulty in turning over, A3 Difficulty in forward bending, A4 Difficulty sitting,A5 Difficulty lifting objects, B1 Difficulty standing, B2 Difficulty washing, B3 Difficulty walking, C1 Straight leg raising test, C2 Sensation, C3 muscle strength, D1 Lower extremity pain and or numbness, D2 Walking ability, E Pain level, F Anxiety and depression.

training to reduce joint loads, and synchronized with visual feedback training to improve the symmetry of the gait. Quadrupod walking poles can enhance the stability of patients with walking difficulties. As the bridge symptom connects different symptom clusters, it often serves as an essential target for intervention, and clinical staff of LDH patients should focus on the clinical symptoms of Difficulty in standing, walking ability and Difficulty in walking as potential targets for intervention and develop a precise intervention program. The study also showed that the top 3 strongest negative correlations were pain level-standing difficulty (E-B1), pain level-walking ability (E-D2), and pain level-turning difficulty (E-A2). Standing Difficulty showed the strongest negative correlation with pain level, suggesting it may mediate the vicious cycle of pain-functional decline. However, the negative correlation between walking ability and anxiety and depression was weaker; the high bridge strength may affect the psychological compensation mechanism. Mechanisms. In addition, pain level was significantly negatively associated with walking ability and turning difficulties. Anxiety and depression are positively associated with pain level, but with low centrality, and although it does not directly occupy the core of the network, it can also drive the chronicity process of the disease by modulating the intensity of physiological symptoms, and it also needs the attention of healthcare professionals. Daily progressive standing endurance training from sitting to standing position, together with isometric contraction training of core muscle groups with plate support, to strengthen the core symptom reinforcement training; nursing interventions of gait decomposition training method can be used for those with walking ability deficits; while improving the walking function, we introduce the positive thought stress reduction therapy (MBSR), and 2 times a week of group sessions together with home exercises to block the anxiety-pain vicious cycle. This study provides a precise intervention framework for clinical practice from the

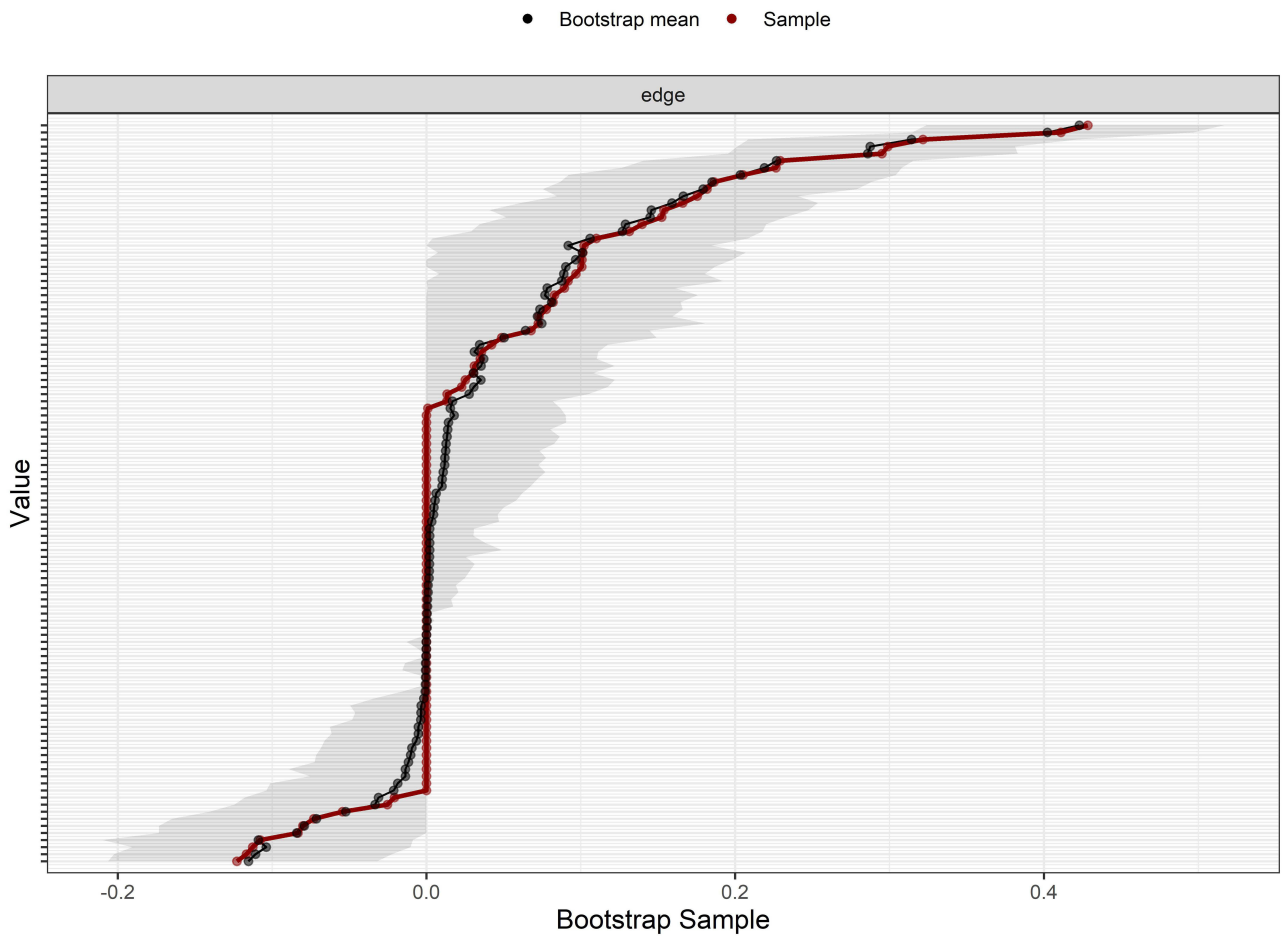

Figure 4 Results of the accuracy test for edge weights.

perspective of network medicine. In the future, it can be combined with wearable devices to monitor the dynamic changes of symptom networks in real time and realize the dynamic optimization of individualized rehabilitation pathways.

Limitations of the Study

The cross-sectional design of this study was unable to infer the causal relationship between symptoms and symptom clusters as well as the trend over time, and in the future, a longitudinal study can be conducted to explore the causal relationship between symptoms with dynamic network analysis [28]; this study was a single-center study and used a specific sampling method to collect data, and these factors may limit the generalizability and extrapolation value of the results to some extent. In the future, if a multi-center and large sample study is conducted, it will help to further validate and enhance the reliability and extrapolation of the results; in addition, the pathological basis of different age groups There may be differences in the pathologic basis of varying age groups, nucleus pulposus herniation is more common in younger patients, and degeneration, calcification, and spinal stenosis factors are more prominent in older patients; in the future, subgroup analyses can be carried out to explore the characteristics of symptomatic networks of different age groups in more detail; in this study, we constructed the network only from the symptomatic dimensions, and we did not incorporate the environmental factors, such as social support, so we need to integrate the multimodal network in future studies.

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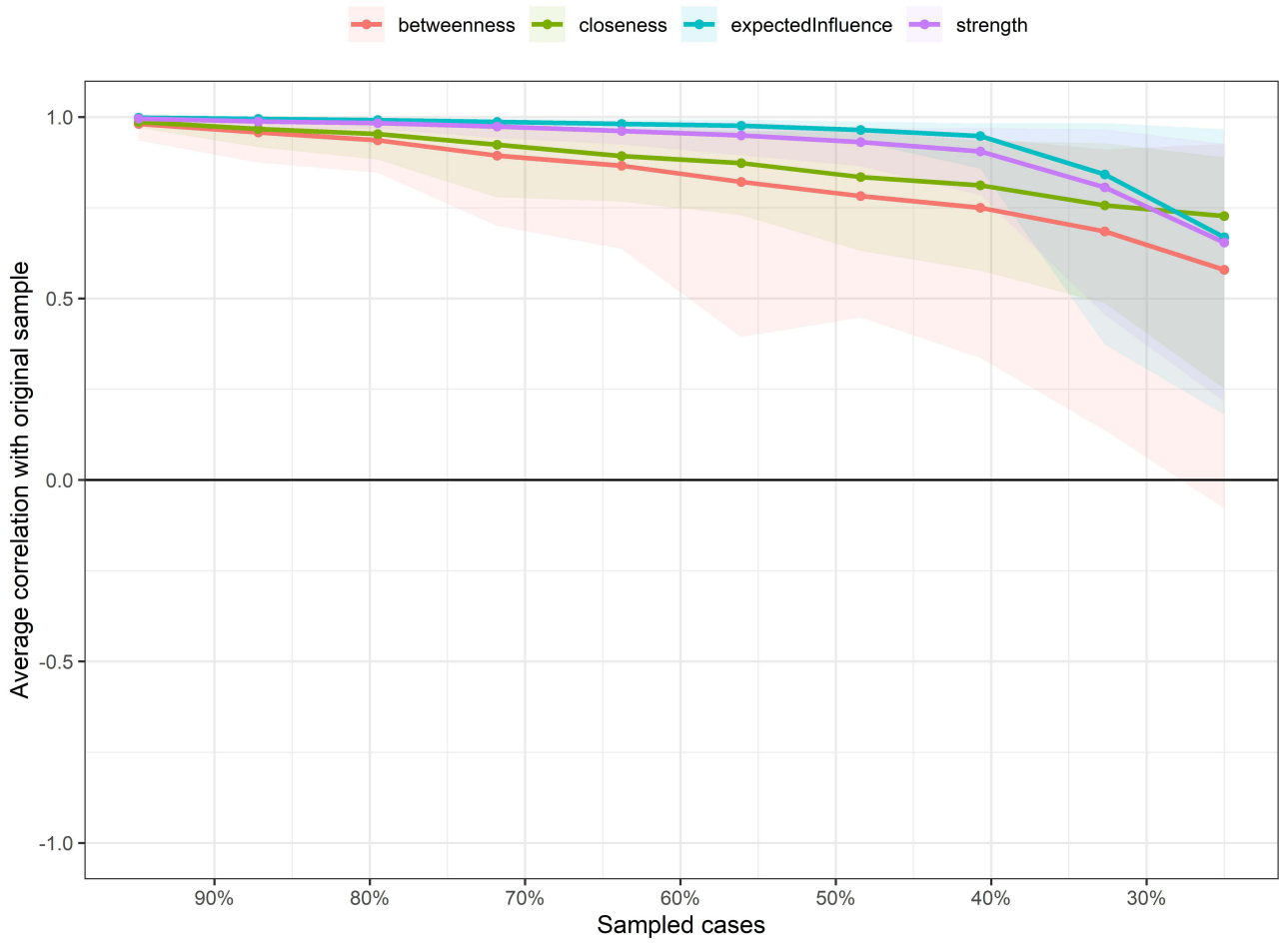

Figure 5 Results of the stability test for centrality.

Conclusion

This study reveals for the first time that the core symptoms of LDH patients are functional impairments (Difficulty standing, walking, and turning). Rather than pain per se through symptom network analysis, Difficulty in standing is potentially an optimal target for intervention because of its dual roles as the core symptom and the strongest bridging symptom; the research paradigm breaks through the limitations of the traditional linear analysis[44] and reveals the interaction mechanisms among symptoms, and the classification of symptom clusters provides a framework for individualized management, which is a key element in the study. Future research should focus on the mechanism-driven validation of core symptoms and the clinical translation of network-oriented intervention programs.

Abbreviations

LDH, Lumbar Disc Herniation; JOA, Japanese Orthopaedic Association's Low Back Pain Assessment Scale; VAS, Visual Analogue Scale; SAS, the Self-Rating Anxiety Scale; ADL, Activities of Daily Living.

Ethics Approval and Informed Consent

The study was performed in agreement with the 1964 Helsinki Declaration and later amendments or comparable ethical standards. Approval was obtained from the University of South China Medical Ethics Committee. Written informed consent was obtained from all participants.

Author Contributions

Hongping Lu and Haoke Shi are co-first authors, Xiaohong Zhang and Xinhong Yin are co-corresponding authors. All authors made a significant contribution to the work reported, whether to the conception, study design, execution, acquisition of data, analysis and interpretation, or all areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

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