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Influence of Central Sensitisation on Posture, Stability, and Walking Among Individuals with Non-Specific Chronic Low Back Pain

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ABSTRACT

Background: Non-specific chronic low back pain (NSCLBP) is a prevalent musculoskeletal condition often associated with central sensitisation, which amplifies pain perception and disrupts sensory processing, motor control, and postural regulation. This study investigated the association between central sensitisation and changes in postural stability, spinal posture, and gait in individuals with non-specific chronic low back pain (NSCLBP).

Methodology: A cross-sectional observational study was conducted at the Nitte Institute of Physiotherapy, Mangaluru, involving 87 young adults (18–25 years), comprising 35 males and 52 females, with NSCLBP. Participants were assessed using the Central Sensitisation Inventory (CSI), the Multi-Directional Reach Test (MDRT) for postural stability, the flexi-curve technique for spinal posture, the PALM meter for pelvic alignment, and 2D gait analysis for cadence, step length, and speed. Statistical analyses included one-way ANOVA, Tukey post hoc tests, and Pearson correlation.

Results: Higher Central sensitisation scores were associated with reduced postural stability, particularly in backwards and lateral directions ($p < 0.05$). Gait analysis revealed the differences in cadence ($p = 0.026$) and in step length ($p = 0.037$) among central sensitisation groups. Spinal mobility was inversely correlated with central sensitisation scores ($r = -0.187$, $p = 0.046$), and greater pelvic asymmetry was observed in participants with elevated central sensitisation. Correlation analysis confirmed that central sensitisation was significantly related to impaired postural control, altered gait, and disrupted body alignment.

Conclusion: Central sensitisation significantly impacts postural stability, spinal alignment, and gait in individuals with NSCLBP, highlighting the need for targeted rehabilitation strategies.

Trial Registration: CTRI/2024/06/068697

Keywords: Central sensitisation, Chronic low back pain, Posture, Stability, Gait analysis, Spinal alignment.

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INTRODUCTION

The presence of low back pain (LBP) represents one of the most prominent and common health challenges, affecting approximately 80% of individuals globally at some point in their lifetime [1, 2, 8]. Almost everyone eventually suffers from a single episode, yet a small percentage will go on to develop chronic low back pain (CLBP) lasting longer than ten weeks. LBP manifests as pain in the lumbar region, which can lead to disability due to a change in the activation threshold of the sensory neurons, resulting in postural muscle weakness and a limit to the range of movements [3]. LBP affects musculoskeletal strength, movement, function, and mobility. It is also influenced by psychological factors such as anxiety and depression, as well as cultural aspects including social, educational, and occupational beliefs [2, 3, 13]. Other risk factors include smoking, obesity, and other psychiatric disorders. Pain caused by LBP impairs the stability of the trunk, resulting in increased activities of daily life, movement, and balance while still maintaining intact sensory and motor functions [2].

Assigning a central sensitisation to a pathophysiological mechanism has been done for a chronic painful condition, and to some subset of CLBP patients as well [4, 5, 18]. Central sensitisation is defined as an injury to the nervous system at the level of the brain that involves structural, chemical, and functional changes concerning the processing of pain and other sensory inputs [6]. Marked noxious and peripheral sensitivity, disproportionate activity within supraspinal pain pathways, in addition to pain-modulatory systems (e.g., anxiety, depression, fear-avoidance beliefs), and increased activity in certain regions of the hypothalamic forebrain can lead to these changes [6, 7]. Changes in the pain process are achieved through facilitation and disinhibition, while simultaneously increasing pain intensity, duration, and geographic distribution [7].

LBP or low back pain is the highest contributor to global disability, accounting for 10.7% of years of life accumulated with disability due to various conditions. Furthermore, LBP ranks amongst the four most prevalent ailments reported globally. Actual reasons are unknown for 85% of cases of chronic low back pain [4, 8]. Talking about chronic low back pain, the symptoms of central sensitization are primarily termed as referrals, and patients who suffer from this condition tend to be less active, more disabled, and of poorer physical condition [5, 9]. Considerable increase in sensitivity to various stimuli, intersession variability in levels of discomfort and their mobility to perform activities, and reported body sway as well as self-perception of movement, lead to a change in posture showing a divergent population. The relationship between fear of movement and postural control remains unaccounted for in the evidence, where the concept of 'fear of movement/stimulation' poses an essential factor in recovery from low back pain [9, 10]. It has been noted that more specific movement phobia assessments could explain differential postural sway [10, 11]. The study aims to use the Central Sensitisation Questionnaire to identify symptoms of central sensitisation associated with generalised persistent non-specific low back pain, and to determine whether central sensitisation is linked to persistent non-specific low back pain and changes in walking stability and spinal posture.

AIM OF THE STUDY

To use the Central Sensitisation Questionnaire to identify symptoms of central sensitisation associated with generalised persistent non-specific low back pain, and to determine whether the condition of central sensitisation is linked to persistent, non-specific low back pain and changes in walking stability and spinal posture.

MATERIALS AND METHODOLOGY

This study was a cross-sectional observational study that was conducted at the Nitte Institute of Physiotherapy, Mangaluru, Karnataka, India, from July 2024 to March 2025. The study population consisted of young adults aged 18-25 years, comprising 35 males and 52 females. A convenient sampling technique was employed to recruit a sample of 87 participants. Ethical clearance was obtained from the Nitte Institutional Ethics Committee, and the study was prospectively registered in the Clinical Trial Registry – INDIA (CTRI/2024/06/068697). All participants provided informed consent before their involvement. The target population, who had non-specific low back pain, was taken for the study. The study design was observational, and the study type was cross-sectional. The study was a convenience, non-probability sampling with a study duration of one year. Eighty-seven patients who fulfilled the eligibility requirements were chosen to participate in the study. Subjects who fulfilled the evaluation criteria were considered for inclusion.

Inclusion criteria were:

The study focused on male and female individuals between the ages of 18 and 25 who were experiencing nonspecific low back pain. Participants were selected based on a combination of their symptoms and radiological findings, with all individuals reporting a history of low back pain lasting at least two months. The condition in all cases was of a non-specific and chronic nature, meaning there was no apparent underlying cause identified through imaging and medical diagnosis.

Exclusion criteria were:

The study excluded individuals who had recently undergone surgery within the past month, as well as those who had a history of low back pain extending more than three months. Participants were also excluded if they had any known malignancies, inflammatory joint or bone diseases, or if they presented with neurological signs such as perceived weakness in the lower limbs. Additionally, individuals with diagnosed psychiatric disorders or any severe cognitive impairments were not considered for inclusion for the clarity and consistency of symptom reporting and participation in the study procedures.

Outcome measures:

The Central Sensitization Inventory (CSI) questionnaire, comprising 25 questions, was used to assess the severity of central sensitisation symptoms following the methodology

outlined. Each question had five possible responses ranging from "Never" (0 points) to "Constantly" (4 points), with total scores that indicate the level of Central sensitisation: subclinical (0-29), mild (30-39), moderate (40-49), and severe (50-59) [6, 12].

- Postural Stability: The degree of stability in the four directions—forward, backward, right, and left is evaluated by the Multi-Directional Reach Test (MDRT). It is a straightforward, affordable, legitimate, and trustworthy screening tool and method for identifying stability constraints and components. The test moves COG to the limits of the lumbar range and base of support by measuring the deliberate reach with the feet shoulder-width apart and motionless [22].

Figure 1. Obtaining MDRT value (Forward)

- Gait Analysis: 2-D gait analysis. Walking is frequently and commonly assessed in patients with chronic LBP as part of observational and interventional research methodology, as well as during clinical evaluations, using 2-D gait analysis to establish walking parameters. Step-length, stride length, and cadence are the primary study outcomes that will be focused on because people with LBP may have altered spatiotemporal (like speed or step length), kinematic (like joint/segmental motion or coordination between joints/segments), or kinetic (like joint forces and torques) aspects of their gait biomechanics [20].

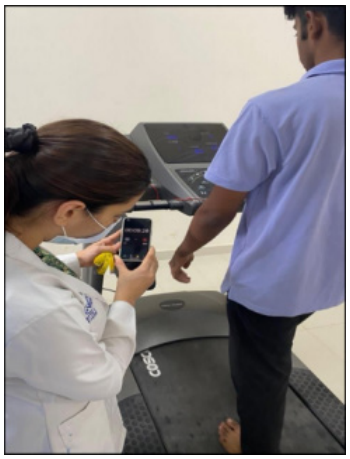


Figure 2: Obtaining cadence

Figure 3: Obtaining step length

- Spinal Posture: The flexi-curve method was used to evaluate lumbar sagittal mobility. A flexible ruler was contoured to the lumbar spine to capture and analyse its curvature.

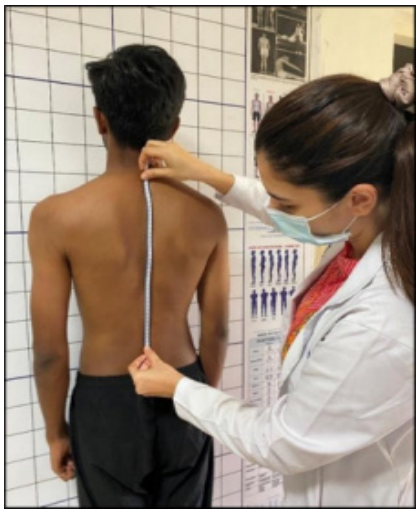
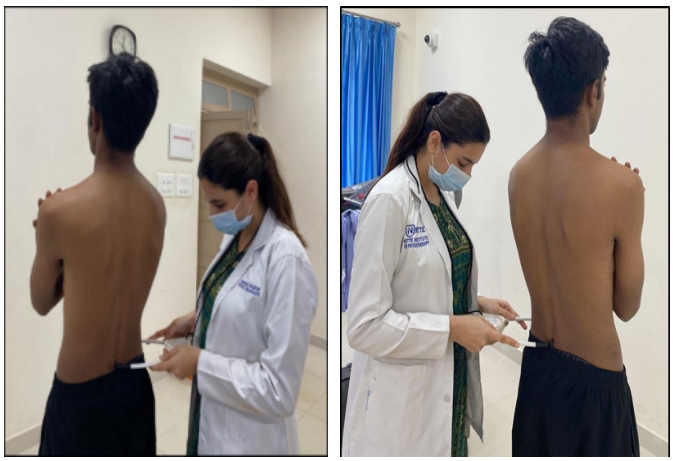


Figure 4: Measurement of the spine via flexi-curve

- Pelvic Alignment: The term "pelvic asymmetry" describes the uneven alignment of the pelvic bones in the sagittal plane (iliac anterior/posterior rotation asymmetry) and frontal plane (lateral pelvic tilt). About the vertical axis, or transverse plane (pelvic axial rotation). According to the traditional overload theory, biological tissues undergo anatomic adaptation when they are subjected to stress levels higher than usual while performing daily duties [24].



Figures 5 and 6. Angle measurement using PALM (Right and left side)

STATISTICAL ANALYSIS

Descriptive statistics (mean, standard deviation, frequency, percentage) were used to summarise the data. One-way ANOVA was used to compare age, MDRT, 2D gait analysis parameters, flexi-curve measurements, and PALM angles across different grades of central sensitisation. Post hoc Tukey tests were used for multiple comparisons. Pearson correlation coefficient (r) was used to determine the relationships between the measured variables, central sensitisation scores, and age. A p-value < 0.05 was considered statistically significant. Data were analysed using SPSS software version 29.0.10.

RESULTS

Table 1: Descriptive Statistics for age and central sensitisation score of the study population.

(n = 87)	Range	Mean	S.D.
Age (Years)	20 to 24	21.58	1.40
Central sensitisation score	9 to 58	31.81	11.04

It shows the central sensitization score and age descriptive statistics. The age of participants ranged from 20 to 24 years, with a mean age of 21.58 ± 1.40 years, indicating a homogeneous age group. With a mean score of 31.81 ± 11.04, the central sensitization score fell into the moderate sensitization category, ranging from 9 to 58. Any detected variations in posture, gait, or balance are more likely to be the result of central sensitization than age-related alterations because the age group is very homogeneous.

Table 2: Comparison of multi-directional reach test according to grades of central sensitisation of the study population.

		Mean	S.D.	"F"	p- value
MDRT: Forward (Cm)	Low (0- 29)	39.93	4.77	3.40	0.022 *
	Moderate (30-39)	37.58	3.81		
	High (40- 49)	36.25	4.51		
	Very high (≥ 50)	39.38	1.65		
MDRT: Backward (Cm)	Low (0- 29)	36.37	5.87	8.83	< 0.001*
	Moderate (30-39)	32.37	5.33		
	High (40- 49)	27.67	8.28		
	Very high (≥ 50)	27.50	7.69		
MDRT: Right (Cm)	Low (0- 29)	34.78	5.86	6.81	< 0.001 *
	Moderate (30-39)	30.85	5.50		
	High (40- 49)	28.61	6.18		
	Very high (≥ 50)	26.13	2.50		
MDRT: Left (Cm)	Low (0- 29)	34.14	5.40	7.30	< 0.001 *
	Moderate (30-39)	30.87	4.73		
	High (40- 49)	28.86	5.56		
	Very high (≥ 50)	24.50	4.88		

It contrasts MDRT performance by grades of central sensitisation with One-way ANOVA. There were significant differences ($p < 0.05$) in all four directions of MDRT (right, left, forward, and backward) between levels of sensitization, implying that greater levels of sensitization are associated with decreased balance and postural stability. These results suggest that individuals with higher central sensitisation exhibit greater postural instability, which may contribute to falls and reduced functional mobility.

Table 3: Comparison of 2-D gait analysis according to grades of central sensitisation in the study population.

		Mean	S.D.	"F"	p-value
Speed (M/s)	Low (0-29)	3.32	0.47	0.39	0.759
	Moderate (30-39)	3.38	0.50		
	High (40-49)	3.44	0.51		
	Very high (≥ 50)	3.50	0.58		
Cadence (Counts/ Min)	Low (0-29)	76.64	5.42	3.25	0.026*
	Moderate (30-39)	74.02	8.49		
	High (40-49)	72.06	3.96		
	Very high (≥ 50)	69.75	2.63		
Step length (Cm)	Low (0-29)	35.21	5.22	2.97	0.037*
	Moderate (30-39)	38.73	4.59		
	High (40-49)	36.47	3.62		
	Very high (≥ 50)	37.13	2.56		

It compares 2D gait analysis across levels of sensitisation grades with One-way ANOVA. It shows that cadence and step length are statistically significant ($p < 0.05$) between sensitisation groups, but speed does not change. This implies that patients with greater sensitisation can develop changes in step length and cadence, perhaps as compensatory gait adjustments due to instability or discomfort.

Table 4: Comparison of flexi curve (Cm) and PALM angle according to grades of central sensitisation of the study population.

		Mean	S.D.	"F"	p-value
Flexi curve (Cm)	Low (0-29)	40.37	3.91	3.13	0.030*
	Moderate (30-39)	37.27	3.79		
	High (40-49)	38.56	4.81		
	Very high (≥ 50)	39.50	2.89		

PALM angle (Right)	Low (0-29)	16.29	2.87	3.24	0.026*
	Moderate (30-39)	16.31	2.70		
	High (40-49)	18.61	2.68		
	Very high (≥ 50)	17.25	3.30		
PALM angle (Left)	Low (0-29)	16.54	2.62	2.91	0.039*
	Moderate (30-39)	16.54	2.69		
	High (40-49)	18.67	2.85		
	Very high (≥ 50)	16.75	3.10		

It analyses differences in flexi curve and PALM angle based on grades of central sensitisation. The analyses find statistically significant differences ($p < 0.05$) in the Flexi curve and PALM angle. This means that the spinal flexibility and the postural alignment vary with increments in central sensitisation. These findings indicate that the postural compensations increase linearity with incrementing sensitisation levels, potentially because of chronic pain or neuromuscular adaptations.

DISCUSSION

Impact of Central Sensitisation on Postural Stability

The study's findings using the Modified Dynamic Reach Test (MDRT) showed a significant, negative correlation between scores of central sensitisation and balance in all directions. Remarkably, backwards reach was the most handicapped, meaning that participants with a greater degree of central sensitisation have more difficulties in the control of the posterior postural. Lauenroth et al. [15], these observations align with previous research indicating increased postural sway in individuals with chronic non-specific low back pain due to altered changes seen in sensory-motor control mechanisms. The research conducted by Meinke et al. [4] demonstrates that pain-related kinesiophobia causes increased postural sway, which supports theories about balance regulation disturbances in individuals with enhanced pain sensitivity.

Cagnie B et al. [18] suggested that the underlying mechanisms contributing to postural instability in sensitized individuals may be due to their brains struggling to interpret data about their bodily location and movement patterns. According to research by Park J et al. [2], patients with CLBP experience reduced postural control and greater sway irregularity during extended standing periods, which may stem from impaired postural reflexes and the development of compensatory neuromuscular adjustments. Research findings support the conclusion that central sensitisation reduces sensory system cooperation, resulting in a weakened balance reaction and increasing the likelihood of falls. Alsubaie et al. [19] further proposed that chronic pain syndromes induce motor adaptation deficits affecting both movement coordination and postural stability. Based on recent research, treating central sensitization isn't just about one thing—it's about combining specific approaches. We need methods that focus on proprioception and re-educating the nerves to help improve balance and overall function. Scientific studies show that people with chronic lower back pain tend to develop a heightened sensitivity to pain, along with changes in how they control their movements. These changes often require focused postural exercises and balance training. When someone is experiencing this kind of heightened sensitivity, they tend to benefit most from a multidisciplinary rehab program. Such programs usually include psychological support along with biomechanical work to help improve stability. This comprehensive approach addresses both fear-avoidant behaviours, pain hypersensitivity, and postural issues to achieve the best results.

Gait Changes in People with Central Sensitisation

The 2D gait analysis conducted in this study revealed a correlation between central sensitization and changes in gait parameters. Notably, individuals with higher sensitization scores exhibited slower walking speeds and longer step lengths (when walking speed was kept constant). These findings imply that people with central sensitization may alter their walking patterns as a way to manage pain. Smith JA et al. [16] observed similar patterns in patients with chronic low back pain (CLBP), highlighting changes in spatiotemporal gait metrics like reduced cadence and increased stance time, which they attributed to pain-related adjustments in motor control.

CaluePapcke et al. [17] and Krekoukias G et al. [21] showed that people with low back pain engage in protective gait strategies like adjustments to walking speed and step length to maintain movement stability. This suggests that individuals who perceive pain modify the strategies they use to minimize levels of discomfort or strain based on their experience. Gait alterations may occur due to cortical reorganization in patients with chronic pain. According to neuroimaging literature, chronic pain can disrupt regular action planning and execution, leading to altered and less efficient walking patterns. Similarly, Rigaud et al. [14] reported that patients with chronic low back pain exhibit increased trunk variability and reduced gait stability, particularly in real-life walking conditions. According to Touche L et al. [20], individuals with lower self-efficacy expectancies may experience greater walking difficulties and issues with motor control, indicating the potential contribution of psychological aspects to movement control following chronic pain conditions. This increases the possibility of cortico-spinal functionality and motor planning issues in patients with chronic low back pain. Following previous studies, Zheng X et al. [7] focused on sensory issues and disorders of motor planning leading to abnormality with walking coordination, balance, and gait symmetry in patients with chronic low back pain. It is essential to incorporate and restore neuromuscular retraining, sensory desensitization techniques, and pain management strategies in conjunction with traditional rehabilitation methods to restore and sustain optimal

walking mechanics for individuals with pain-sensitive populations.

Postural Deviations and Spinal Flexibility

The evaluation of spinal flexibility and postural alignment in this study indicated that higher scores of central sensitisations were related to decreased spinal flexibility and increased postural misalignment. These findings indicate that central sensitisation could contribute to musculoskeletal adaptations that lead to chronic postural misalignments. Sanzarello et al. [9] reported similar findings, whereby central sensitisation was an identified factor for maladaptive adjustments in posture, in response to altered sensory-motor feedback Huysmans et al. [6] emphasised a greater degree of sensitisation correlated with greater postural instability and functional disability of the trunk or spine, thereby further suggesting that central sensitisation has an impact on spinal alignment and mobility.

One potential explanation for these postural deviations is the altered muscle activations in those who have CLBP. Du SH et al. [23] found compelling evidence of a relationship between spinal posture pathology (e.g., pelvic asymmetry) and central sensitisation in chronic lower back pain. This raises the possibility that treatment options such as postural realignment therapy and sensorimotor training may help restore spinal mobility and reduce the musculoskeletal impact of sensitisation.

CONCLUSION

The role of central sensitisation in posture, stability, and gait in individuals with non-specific chronic low back pain (NSCLBP) is highlighted in this study. The results confirm the association between increased postural impairment, deviant walking, impaired balance, and greater sensitisation levels. Reduced postural stability, altered gait, and reduced spinal flexibility are signs that central sensitisation exacerbates sensorimotor control. Treatment that enhances body awareness, postural control, and movement efficiency through neuromuscular retraining and pain management can reverse these problems. By using questionnaires to detect central sensitization, anomalies can be found early and treated individually. To enhance mobility and quality of life for individuals with NSCLBP, comprehensive rehabilitation interventions, including neuromuscular retraining, behavioural therapy, and pain neuroscience education, will be continued in future studies.

LIMITATIONS OF THE STUDY

- Sample size and population: a relatively small sample size and an age-constrained population (18–25 years) may limit the generalizability of findings to elderly age groups in the study.
- The absence of follow-up assessments prevents understanding and explaining the long-term effects of central sensitisation upon posture as well as gait.
- The study focused on young adults, limiting its applicability to older individuals with chronic low back pain.

FUTURE RECOMMENDATION

- Future study can be done on a larger population.
- Longitudinal research conducts studies over time to assess and observe the long-term effects of central sensitisation on posture differences and gait.
- Diverse age groups expand the scope of research to include middle-aged and elderly individuals for broader applicability.
- Intervention-based studies evaluate the effectiveness of targeted rehabilitation programs for managing central sensitisation.

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Disclaimer

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REFERENCES

[1] Bushnell MC, Čeko M, Low LA. Cognitive and emotional control of pain and its disruption in chronic pain. Nat Rev Neurosci [Internet]. 2013 May 30;14(7):502–11.

[2] Park J, Nguyen VQ, Ho RLM, Coombes SA. The effect of chronic low back pain on postural control during quiet standing: a meta-analysis. Sci Rep [Internet]. 2023 May 16;13(1):7928.

[3] GBD 2021 Low Back Pain Collaborators. Global, regional, and national burden of low back pain, 1990–2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. Lancet Rheumatol [Internet]. 2023 Oct;5(10):e623–36.

[4] Meinke A, Maschio C, Meier ML, Karlen W, Swanenburg J. The association of fear of movement and postural sway in people with low back pain. Front Psychol. 2022 Nov;13:1012345.

[5] Madsen AL, Gyntelberg F, Marott JL, Schnohr P, Astrup J. Cohort study of postural sway and low back pain: the Copenhagen City Heart Study. Eur Spine J. 2023 Sep;32(12):4390–6.

[6] Huysmans E, Ickmans K, Van Dyck D, Nijs J, Gidron Y, Roussel N, et al. Association between symptoms of central sensitization and cognitive behavioral factors in people with chronic nonspecific low back pain: a cross-sectional study. J Manipulative Physiol Ther. 2018 Feb;41(2):92–101.

[7] Zheng X, Reneman MF, Preuper RHS, Otten E,

Lamoth CJ. Relationship between Physical Activity and Central Sensitization in Chronic Low Back Pain: Insights from Machine Learning. Comput Methods Programs Biomed. 2023 Apr;232:107432.
[8] Maher C, Underwood M, Buchbinder R. Non-specific low back pain. Lancet [Internet]. 2017 Feb;389(10070):736–47.
[9] Sanzarello I, Merlini L, Rosa MA, Perrone M, Frugiuele J, Borghi R, et al. Central sensitization in chronic low back pain: a narrative review. J Back Musculoskelet Rehabil. 2016 Nov;29(4):625–33.
[10] Nijs J, Leysen L, Vanlauwe J, Logghe T, Ickmans K, Polli A, et al. Treatment of central sensitization in patients with chronic pain: time for change? Expert Opin Pharmacother. 2019 Jul;20(16):1961–70.
[11] Akeda K, Takegami N, Yamada J, Fujiwara T, Nishimura A, Sudo A. Central sensitization in chronic low back pain: a population-based study of a Japanese mountain village. J Pain Res. 2021 May;14:1271–80.
[12] Echeita JA, Preuper HRS, Dekker R, Stuive I, Timmerman H, Wolff AP, et al. Central sensitisation and functioning in patients with chronic low back pain: protocol for a cross-sectional and cohort study. BMJ Open [Internet]. 2020 Mar;10(3):e031592.
[13] Šarabon N, Vreček N, Hofer C, Löfler S, Kozinc Ž, Kern H. Physical abilities in low back pain patients: a cross-sectional study with exploratory comparison of patient subgroups. Life. 2021 Mar;11(3):226.
[14] Rigaud M, Roerdink M, Lamoth CJC. Changes in trunk variability and stability of gait in patients with chronic low back pain: impact of laboratory versus daily-living environments. J Pain Res. 2021;14:1225–36.
[15] Lauenroth A, Reinhardt L, Schulze S, Laudner KG, Delank KS, Schwesig R. Does low back pain affect the reliability of postural regulation? Somatosensory Motor Res. 2019 Apr;36(2):116–21.
[16] Smith JA, Stabbert H, Bagwell JJ, Teng HL, Wade V, Lee SP. Do people with low back pain walk differently? A systematic review and meta-analysis. J Sport Health Sci [Internet]. 2022 Jul;11(4):450–65.
[17] Papcke C, Soares P, Vendramini IC, Machado RO, Scheeren EM. Low back pain leads to a protective action of pain on dynamic postural stability. Res Sports Med. 2021 May;30(6):628–N.
[18] Cagnie B, Coppieters I, Denecker S, Six J, Danneels L, Meeus M. Central sensitization in fibromyalgia? A systematic review on structural and functional brain MRI. Semin Arthritis Rheum. 2014;44(1):68–75.
[19] Alsubaie SF. The postural stability measures most related to aging, physical performance, and cognitive function in healthy adults. Biomed Res Int. 2020 Aug 24;2020:1–7.
[20] Touche L, Grande-Alonso R, Arnes-Prieto M, Paris-Alemany P. How does self-efficacy influence pain perception, postural stability, and range of motion in individuals with chronic low back pain? Pain Physician. 2019;22:E1–13.
[21] Krekoukias G, Sakellari V, Anastasia E, Gioftsos G, Dimitriadis Z, Soultanis K, et al. Gait kinetic and kinematic changes in chronic low back pain patients and the effect of manual therapy: a randomized controlled trial. J Clin Med. 2021 Aug 15;10(16):3593.
[22] Tantisuwat A, Chamonchant D, Boonyong S. Multi-directional reach test: an investigation of the limits of stability of people aged between 20–79 years. J Phys Ther Sci. 2014;26(6):877–80.
[23] Du SH, Zhang YH, Yang QH, Wang YC, Fang Y, Wang XQ. Spinal posture assessment and low back pain. EFORT Open Rev [Internet]. 2023 Sep 1;8(9):708–18.
[24] Yu Q, Huang H, Zhang Z, Hu X, Li W, Li L, et al. The association between pelvic asymmetry and non-specific chronic low back pain as assessed by the global postural system. BMC Musculoskelet Disord. 2020 Sep 5;21(1):639.