

Research Paper

Sagittal Alignment, Central Sensitization, and Psychosocial Factors in Military Personnel with Chronic Low Back Pain



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ABSTRACT

Objectives: This study aimed to compare the sagittal alignment and range of motion (ROM) of the spine in military personnel with chronic non-specific low back pain (CNLBP) and asymptomatic individuals and to determine the relationships between spinal parameters and central sensitization, pain, disability, and psychosocial factors.

Methods: This cross-sectional study enrolled 104 male military personnel (49 with CNLBP). The participants completed the spinal examination using the spinal mouse. Central sensitization inventory (CSI), pain intensity (visual analog scale [VAS]), lumbar pressure pain threshold (PPT), psychosocial factors (Örebro musculoskeletal pain screening questionnaire [ÖMPSQ]), and disability (Oswestry disability index [ODI]) were assessed.

Results: Compared with controls, participants with CNLBP showed smaller segmental angles during forward flexion for lumbar (MD=10.9°, P<0.001), inclination (MD=20.3°, P<0.001), and sacral/hip angles (MD=11.4°, P<0.001). The spinal ROM was reduced across all movement transitions in CNLBP with moderate to strong effect sizes. In addition to these biomechanical changes, participants with CNLBP exhibited substantially lower PPT at the lumbar region (MD=-23.38, P<0.001) and higher CSI scores (MD=13.39, P<0.001). Correlation analyses revealed significant negative correlations between the VAS score and the lumbar angle in forward flexion and upright flexion (r=-0.44 and -0.40, P<0.001, respectively). The CSI correlated strongly with ÖMPSQ (r=0.61, P<0.001), and moderately with the ODI score (r=0.49, P<0.001), and showed correlations with the VAS and lumbar region PPT (r=0.31, P<0.05 and -0.38, P<0.001, respectively).

Discussion: CNLBP in military personnel is characterized by altered spinal biomechanics and neuro-psychosocial alterations. These findings suggest tailored interventions that address both mechanical impairments and neuro-psychosocial contributors.

Keywords:

Sagittal alignment, Low back pain (LBP), Psychosocial, Central sensitization

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Highlights

- Military personnel with CNLBP demonstrated significantly smaller spinal segmental angles and a notable reduction in spinal ROM compared to asymptomatic individuals.
- CNLBP was strongly associated with increased central sensitization and reduced PTT in the lumbar region.
- Our findings revealed moderate correlation between spinal biomechanics and pain intensity, disability, and psychosocial risk factors, suggesting that mechanical dysfunction interacts with neuro-psychosocial contributors.

Plain Language Summary

Low back pain is one of the most common health problems worldwide and is especially frequent in military personnel because of the physically demanding nature of their duties. This study found that military personnel with chronic low back pain have stiffer spines and reduced spinal range of motion (ROM) than those without pain. They are also more sensitive to pressure and report more disability. Importantly, we discovered that spinal movement changes were associated with pain, psychosocial factors, and disabilities. This means that chronic low back pain is not just a spine problem; it also involves the nervous system and mental health. The results suggest that both physical and mental health play a role in back pain and should be addressed simultaneously.

Introduction

Low back pain (LBP) is the most common musculoskeletal disorder and constitutes the largest portion of the global disability burden [1, 2]. In 2020, over 500 million individuals worldwide were affected by LBP, a number expected to rise to 800 million by 2050 [2]. The high prevalence of LBP has notable clinical, social, and economic consequences for individuals, health-care systems, and society. A significant proportion of LBP cases are categorized as chronic non-specific LBP (CNLBP), where pain persists without a clear cause associated with a specific injury or medical condition [3]. CNLBP is a complex condition influenced by biophysical, psychosocial, genetic, and comorbid factors that can interact with one another to develop this condition [4].

Studies have demonstrated the importance of sagittal spinopelvic alignment in maintaining postural balance in healthy individuals [5, 6]. Altered spinal curvature and sagittal imbalance are commonly observed in individuals with CNLBP who also experience reduced range of motion (ROM) compared to asymptomatic individuals [7, 8]. However, the findings on sagittal spino-pelvic alignment in patients with LBP are inconsistent. While some studies reported substantial differences in alignment measures such as lumbar lordosis, sacral slope, and pelvic tilt between patients with LBP and asymptomatic individuals, others have found no significant differences [9-12].

There is also growing evidence that neuro-psychosocial factors play a significant role in the development and persistence of LBP [13-16]. Additionally, there is evidence of a relationship between postural balance and psychiatric disorders in individuals with CNLBP. Previous studies have shown that depressive disorders are strongly associated with increased thoracic kyphosis angle and elevated T1 slope, suggesting a potential psychosocial influence on sagittal alignment [17]. Psychological factors can also influence pain sensitivity and central nociceptive sensitization processes in patients with chronic LBP, as demonstrated by Steinmetz et al. for the first time [18].

LBP is a prevalent health issue in military personnel worldwide [19]. Military occupations often require exposure to physically demanding tasks and unpredictable environmental conditions. These factors, along with training loads and high-performance requirements, increase the risk of musculoskeletal conditions and LBP [20, 21]. Despite the high rate of CNLBP among military personnel, there is a notable gap in research on spinal alignment and ROM of the spine in this population. Moreover, the interplay between biomechanical factors and psychosocial properties, such as central sensitization, depression, and pressure pain threshold (PTT) remains poorly understood in patients with CNLBP. Therefore, this study aimed to evaluate sagittal spinal alignment and ROM in military personnel with CNLBP and to explore the correlations between these biomechanical parameters and factors such as central sensitization, disability and psychosocial factors.

Materials and Methods

Study design and ethics

This cross-sectional study was conducted on male military personnel affiliated with the [Islamic Republic of Iran Army \(AJA\)](#). Enrollment occurred between October 2023 and June 2024 at the Biomechanics Laboratory of the School of Medicine, [AJA University of Medical Sciences](#), Tehran City, Iran. The two groups were recruited: One consisting of patients with CNLBP and the other of asymptomatic patients. Two groups were matched using a frequency matching method. Ethical approval was obtained from the Ethics Committee at [AJA University of Medical Sciences](#). The participants received verbal and written descriptions of the study, and written informed consent was obtained.

Participants

Male military personnel aged 18-60 years, referred to the biomechanics laboratory at [AJA University of Medical Sciences](#), were eligible for inclusion. All study participants were of the same ethnicity (Iranian/Middle Eastern). The study population consisted of two groups: one with CNLBP and one asymptomatic, which were matched using a frequency matching method based on age, BMI, and smoking habits. The CNLBP group was recruited first, followed by the control group. A total of 230 military personnel with CNLBP and 239 asymptomatic personnel were invited to participate. Of those invited, 49 individuals with CNLBP enrolled (response rate=21.3%). In the healthy control group, 63 individuals agreed to participate (initial response rate=26.4%); however, eight were excluded during frequency matching for age and military service duration, resulting in a final sample of 55 controls (final response rate=23.1%). Only male participants were included due to the predominantly male composition of the Iranian military. The inclusion criteria for the CNLBP group were as follows: Individuals who had experienced CNLBP for more than three months without any underlying pathology, aged between 18 and 60 years, and can perform forward flexion and extension movements unaided. Asymptomatic participants were screened to confirm no history of LBP or related symptoms. The exclusion criteria included any obvious deformity of the spine, pelvis, or lower extremities; rheumatologic or neurologic diseases; spinal fractures; a history of back surgery and history of medical and/or physiotherapeutic treatment within the last 12 weeks. The sample size was calculated based on [Bujang et al.](#) with an alpha of 0.05, power of 80%, $R0=0.0$, $R1=0.4$ resulting in a minimum of 46 participants per

group [22]. We employed a convenience sampling method by recruiting participants by sending motivation letters to AJA personnel using the SMS system.

Variables

Spinal alignment and ROM: A spinal mouse® (Idiag, Volkswill, Switzerland), which is a wireless electronic measurement device used to assess spinal mobility and posture in the sagittal plane. Before examination, the participants were registered in Spinal Mouse® software with their gender, age, and study codes. The participants were asked to undress their upper bodies. Then, the spinous processes were palpated, and specific vertebral landmarks (C7 and S3) were marked. All measurements were obtained in the following sequence: Upright position, maximum flexion in standing, and maximum extension in standing, to enhance reproducibility. The device's mobile unit was slid along the spinous processes from C7 to S3 to capture skin contours and calculate sagittal spinal alignment by measuring the lumbar lordosis, sacral/hip, and inclination angles. The ROM was measured by repeating this process with participants in maximum flexion and extension.

Central sensitization inventory (CSI): Patients in the CNLBP and asymptomatic groups were assessed using the Persian translation of the CSI (CSI-Per). The CSI-Per showed strong validity and reliability (test re-test interclass correlation coefficient [ICC]=0.934, $P<0.001$; internal consistency Cronbach's $\alpha=0.87$) for assessing chronic pain symptoms in Persian-speaking patients [23].

PTT: Patients in the CNLBP and asymptomatic group were assessed using a Korean-made Algometer Device (SF model). This device, equipped with a one-centimeter disk, digitally displays the amount of pressure in Newtons and kilograms. A higher number on the screen indicates a greater pain tolerance in the patient, signifying less sensitivity. The algometer was applied at various points: 2 cm and 5 cm lateral to the first and third lumbar vertebrae, and 2 cm lateral to the fifth lumbar vertebra, on both sides [24]. The sensitivity threshold was measured three times, with a 30-second interval between each measurement. The mean of these measurements was calculated and recorded as the primary sensitivity data. This methodological approach ensured the accuracy and reliability of the data collected. Finally, the values measured on the right side and the values measured on the left side were added, and their average was expressed as the final number.

Pain: To assess pain intensity (only in the CNLBP group), the visual analog scale (VAS) was used to mark a 10 cm line segment and provide the necessary explanations to the patient. The number 10 in this diagram indicates maximum pain, and the number zero indicates the pain-free point [25]. The patient was asked to indicate his average most severe pain in the past week on the chart.

Disability: Disability was measured using the Persian version of the Oswestry disability index (ODI) questionnaire in the CNLBP group [26].

Psychosocial occupational disability status: The Örebro musculoskeletal pain screening questionnaire (ÖMPSQ) is a widely used tool [27]. This questionnaire is a self-reported tool for the early identification of patients at risk of chronic musculoskeletal pain, particularly work-related LBP. It predicts work disability and assesses psychosocial risk factors affecting recovery and return to work. The validity and reliability of the Persian version of this questionnaire have been proven in the study of Sharafi et al. [27] in 2017 (ICC=0.82, Cronbach's α =0.82).

Outcome measures

Measurements were conducted by the first author (Seyed Mostafa Teymouri), an MSc student in physical therapy with over four years of clinical experience treating patients with LBP. To mitigate the impact of diurnal variations in joint mechanics, all participants were assessed simultaneously (10 AM-1 PM). All assessments were conducted concurrently.

Statistical analysis

Descriptive statistics, including Mean $\pm$ SD, frequencies, percentages, and interquartile ranges, were calculated to summarize the participant characteristics. The Kolmogorov-Smirnov test was employed to assess the normality of the data. Parametric tests were applied if the variables were normally distributed; otherwise, non-parametric tests were used. The independent t-tests were utilized for comparisons between groups. The chi-square test was used to compare qualitative variables. Spearman's correlation coefficient was employed to examine the relationships between variables. All analyses were conducted using SPSS software, version 27 (IBM, Armonk, New York, USA), and the significance level for all tests was set at 0.05.

Results

We recruited 104 participants, including 49 in the CNLBP group and 55 asymptomatic individuals. The mean age of the participants was 36.67 ± 11.84 years, and the mean body mass index (BMI) was 25.72 ± 4.13 kg/m². Table 1 presents the demographic information of the participants divided into two groups.

We measured lumbar, sacral/hip, and inclination segmental angles and segmental ROM using a Spinal Mouse; angles were recorded in three positions (upright, forward flexion, and extension), and ROM was analyzed across three motion directions (upright to flexion, upright to extension, and extension to flexion). Table 2 presents the Mean $\pm$ SD values for CNLBP and asymptomatic participants, along with between-group effect sizes (Cohen's d) and P. Significant differences were observed between the groups at all three positions. In the upright posture, participants with CNLBP had greater inclination angles compared to the asymptomatic group ($P=0.015$). During flexion, the inclination, sacral/hip, and lumbar angles were significantly lower in the CNLBP group ($P<0.001$, $P=0.002$, and $P<0.001$, respectively). Additionally, patients with CNLBP consistently exhibited higher sagittal inclination compared to the control group during extension ($P=0.001$). Analyzing the segments' ROM revealed statistically significant differences in the lumbar angle and sagittal inclination in all motion directions. The difference in sacral/hip was statistically significant for both upright to flexion and extension to flexion ($P=0.004$ and $P=0.001$, respectively).

Next, CSI and PPT were measured in both CNLBP and asymptomatic participants, while VAS, ODI, and ÖMPSQ were assessed exclusively in the CNLBP group. Participants with CNLBP showed significantly higher CSI scores (28.51 ± 11.92) compared to asymptomatic individuals (15.13 ± 10.69), with a large effect size (Cohen's $d=-1.18$, 95% confidence interval [CI] [-1.60, -0.77], $P<0.001$). PPT was lower in the CNLBP group (58.69 ± 24.47) than in the asymptomatic group (82.07 ± 29.52), indicating a significant difference (Cohen's $d=0.86$, 95% CI, 0.45%, 1.26%, $P<0.001$). Among CNLBP participants, the Mean $\pm$ SD values for VAS, ODI, and ÖMPSQ were 5.2 ± 1.63 , 23.67 ± 11.74 , and 94.47 ± 24.01 , respectively.

Table 3 presents the correlations between spinal segmental angles and neuro-psychosocial factors in the CNLBP group. In forward flexion, lumbar angle was negatively correlated with CSI ($r=-0.27$, 95% CI, -0.44%, -0.08%, $P<0.05$) and VAS ($r=-0.44$, 95% CI

Table 1. Demographic characteristics of the study participants

Variables	Mean±SD/No. (%)		P
	CNLBP (n=49)	Asymptomatic (n=55)	
Age (y)	38.2±11.61	35.31±11.99	0.18
Age categories			0.38
<30	14(28.6)	23(41.8)	
0–39	11(22.4)	14(25.5)	
40–49	15(30.6)	11(20)	
50+	9(18.4)	7(12.7)	
BMI (kg/m ²)	26.2±4.75	25.34±3.5	0.29
BMI categories			0.57
Below normal	2(4.1)	1(1.8)	
Normal	18(36.7)	21(38.2)	
Overweight	22(44.9)	29(52.7)	
Obese	7(14.3)	4(7.3)	
Smokers	13(26.5)	18(33.7)	0.49
Military rank			0.31
Conscripts	24(49)	34(61.8)	
Junior officers	16(32.7)	11(20)	
Senior officers	9(18.3)	10(18.2)	

Abbreviations: CNLBP: Chronic nonspecific low back pain; BMI: Body mass index.

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*P<0.05 is considered statistically significant.

-0.65%, -0.17%, $P<0.001$). The inclination angle was also negatively correlated with CSI ($r=-0.27$, 95% CI, -0.44%, -0.08%, $P<0.05$), VAS ($r=-0.34$, 95% CI, -0.57%, -0.05%, $P<0.05$), ODI ($r=-0.33$, 95% CI, -0.56%, -0.04%, $P<0.05$), and ÖMPSQ ($r=-0.41$, 95% CI, -0.63%, -0.14%, $P<0.001$). The sacral/hip angle was negatively correlated with ÖMPSQ ($r=-0.35$, 95% CI, -0.58%, -0.07%, $P<0.05$). In extension, neither the lumbar angle nor the sacral/hip angle showed any significant correlations with VAS, ODI, or the psychosocial factors. However, the inclination angle was negatively correlated with ÖMPSQ ($r=-0.39$, 95% CI, -0.61%, -0.12%, $P<0.001$) and CSI ($r=-0.21$, 95% CI, -0.16%, -0.39%, $P<0.05$).

During upright to flexion motion, both lumbar inclination and inclination angle were negatively correlated with CSI ($r=-0.29$, 95% CI, -0.46%, -0.1%, $P<0.001$)

and VAS (lumbar: $r=-0.40$, 95% CI, -0.62%, -0.13%, $P<0.001$; inclination: $r=-0.37$, 95% CI, -0.6%, -0.09%, $P<0.05$). Additionally, both the inclination angle and sacral/hip angle were negatively correlated with ÖMPSQ ($r=-0.42$, 95% CI, -0.63%, -0.15%, $P<0.001$). In the upright to extension transition, inclination angle was negatively correlated with ÖMPSQ ($r=-0.39$, 95% CI, -0.61%, -0.12%, $P<0.05$). Lastly, during extension to flexion motion, both lumbar angle and inclination angle were negatively correlated with the VAS score (lumbar: $r=-0.39$, 95% CI, -0.6%, -0.11%, $P<0.05$; inclination: $r=-0.34$, 95% CI, -0.57%, -0.05%, $P<0.05$). ÖMPSQ was negatively correlated with both sacral/hip angle ($r=-0.39$, 95% CI, -0.61%, -0.12%, $P<0.001$) and both lumbar and inclination angles. Table 3 presents a detailed presentation of all correlation coefficients and significance levels.

Table 2. Comparison of sagittal spinal alignment and segmental ROM between CNLBP and asymptomatic groups

Position	Segment	Participants		P	Cohen's d (95% CI)
		CNLBP (n=49)	Asymptomatic (n=55)		
U	Lumbar	-25±10.8	-24.6±9.3	0.964	0.038 (-0.35, 0.42)
	Inclination	4.6±3.3	3.3±2.5	0.015*	-0.44 (-0.83, -0.05)
	Sac/Hip	12±6.6	11.3±6.8	0.956	-0.11 (-0.5, 0.27)
F	Lumbar	20.7±14.2	31.6±10.2	<0.001*	0.891 (0.49, 1.29)
	Inclination	79.5±27.5	99.8±15.9	<0.001*	0.92 (0.51, 1.32)
	Sac/Hip	48.1±20.7	59.5±16.3	0.002*	0.62 (0.22, 1)
E	Lumbar	-29.8±11.8	-34±12.5	0.082	-0.35 (-0.73, 0.04)
	Inclination	-16.8±8.7	-22.2±7.6	0.001*	-0.66 (-1.05, -0.26)
	Sac/Hip	-4±10.7	-6.1±10.3	0.318	-0.19 (-0.58, 0.19)
U-F	Lumbar	45.7±14.2	56.1±11.3	<0.001*	0.82 (0.42, 1.22)
	Inclination	74.7±27.4	96.6±16.3	<0.001*	0.98 (0.57, 1.39)
	Sac/Hip	36±21.4	48.2±16.3	0.004*	0.65 (0.25, 1.04)
U-E	Lumbar	-4.9±12.2	-9.5±10.1	0.038*	-0.41 (-0.8, -0.02)
	Inclination	-21.5±8.7	-25.4±7.2	0.014*	-0.49 (-0.83, -0.1)
	Sac/Hip	-16±10.2	-17.3±8.5	0.495	-0.14 (-0.52, 0.25)
E-F	Lumbar	50.6±19.4	65.5±15	<0.001*	0.87 (0.46, 1.27)
	Inclination	96.2±31.7	122±19.2	<0.001*	0.99 (0.59, 1.4)
	Sac/Hip	52.1±23.9	65.5±17.1	0.001*	0.65 (0.25, 1.04)

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Abbreviations: CNLBP: Chronic nonspecific low back pain; U: Upright position; F: forward flexion; E: Extension; U-F: Upright to flexion; U-E; Upright to extension; E-F: Extension to flexion.

*Statistically significant ($P < 0.05$).

Note: Negative values present lordotic angles, and positive values present kyphotic angle of the spine.

We further analyzed the correlations between CSI, PPT, VAS, and ÖMPSQ (Table 4). ÖMPSQ was significantly correlated with CSI ($r=0.61$, 95% CI, 0.4%, 0.77%, $P < 0.001$), ODI ($r=0.55$, 95% CI, 0.31%, 0.72%, $P < 0.001$), and VAS ($r=0.39$, 95% CI, 0.12%, 0.61%, $P < 0.05$), indicating that higher levels of psychosocial distress were associated with increased central sensitization, disability, and pain intensity. Additionally, CSI was negatively correlated with PPT ($r=-0.38$, 95% CI, -0.54%, -0.2%, $P < 0.001$), suggesting that greater central sensitization was associated with lower pain threshold. CSI was also positively correlated with VAS ($r=0.31$, 95% CI, 0.03%, 0.55%, $P < 0.05$).

Discussion

This cross-sectional study investigated the relationships between sagittal spinal alignment, segmental ROM, and neuro-psychosocial factors in male military personnel with CNLBP. To our knowledge, this is the first study to comprehensively examine the relationships between spinal biomechanics and central sensitization, pain intensity, psychosocial factors, and disability in military populations.

Participants with CNLBP exhibited reduced lumbar flexion, altered sacral/hip and inclination angles across static and dynamic positions. Similar findings have been reported in patients with LBP, highlighting the relationship between restricted lumbar ROM, altered spinal posture, and LBP occurrence. For example, Feng et al. utilized a Spinal Mouse to evaluate spinal morphology in adolescents with and without CNLBP. They reported that a greater thoracic kyphosis angle and reduced lumbar ROM were correlated with the incidence of LBP [28]. Pourahmadi et al. found that participants with CNLBP presented decreased lumbar lordosis during sit-to-stand and stand-to-sit tasks compared to asymptomatic individuals [29]. The results from a systematic review that included 12 articles revealed that limited lumbar lordosis, unlike lumbar flexion and extension ROM, is associated with the development of LBP [30]. Although previous studies have also assessed spino-pelvic alignment in LBP and lumbar disk disease, the relationship between sagittal alignment and LBP remains unclear [9].

Table 3. Correlations between spinal segmental angles and neuro-psychosocial factors in CNLBP participants

Position	Segment	CSI	PPT	VAS	ODI	ÖMPSQ
U	Lumbar	-0.01	0.21*	-0.03	0.02	-0.25
	Inclination	0.08	-0.07	0.14	0.25	0.07
	Sac/Hip	-0.01	-0.13	0.05	0.02	0.17
F	Lumbar	-0.27*	0.23*	-0.44**	-0.25	-0.33
	Inclination	-0.27*	0.16	-0.34*	-0.33*	-0.41**
	Sac/Hip	-0.15	0.1	-0.19	-0.23	-0.35*
E	Lumbar	0.07	-0.02	0.11	0.22	-0.04
	Inclination	0.21*	-0.11	0.17	0.27	0.39*
	Sac/Hip	0.11	-0.06	0.09	0.13	0.26
U-F	Lumbar	-0.29**	0.1	-0.4**	-0.33*	-0.17
	Inclination	-0.29**	0.17	-0.37*	-0.37*	-0.42**
	Sac/Hip	-0.15	0.15	-0.24	-0.26	-0.42**
U-E	Lumbar	0.06	-0.20*	0.19	0.24	0.17
	Inclination	0.19	-0.1	0.14	0.23	0.39*
	Sac/Hip	0.12	0.02	0.13	0.05	0.11
E-F	Lumbar	-0.24	0.19	-0.39*	-0.35*	-0.24*
	Inclination	-0.29**	0.17	-0.34*	0.17	-0.46*
	Sac/Hip	-0.19	0.13	-0.22	-0.21	-0.39**

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Abbreviations: CNLBP: Chronic nonspecific low back pain; U: Upright position; F: Forward flexion; E: Extension; U-F: Upright to flexion; U-E: Upright to extension; E-F: Extension to flexion; VAS: Visual analogue scale; PPT: Pressure pain threshold; ODI: Oswestry disability index; ÖMPSQ: Örebro musculoskeletal pain screening questionnaire; CSI: Central sensitization inventory.

*Significant correlation at level 0.05, **Significant correlation at level 0.001.

Table 4. Correlations among pain, disability, central sensitization, and psychosocial measures in CNLBP participants

Variables	VAS	PPT	CSI	ODI	ÖMPSQ
VAS	1				
PPT	0.16	1			
CSI	0.31*	-0.38**	1		
ODI	0.59**	0.07	0.49**	1	
ÖMPSQ	0.39*	-0.09	0.61**	0.55**	1

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Abbreviations: CNLBP: Chronic nonspecific low back pain; VAS: Visual analogue scale; PPT: Pressure pain threshold; ODI: Oswestry disability index; ÖMPSQ: Örebro musculoskeletal pain screening questionnaire; CSI: Central sensitization inventory.

*Significant correlation at level 0.05, **Significant correlation at level 0.001.

A key contribution of our study is the demonstration of robust associations between spinal biomechanical parameters and neuro-psychosocial variables. Our findings suggest a significant correlation between spinal morphology and ROM with psychosocial factors, disability, and pain intensity. Though statistically significant, these correlations were weak-to-moderate in magnitude, indicating that while mechanical dysfunction may play a role, other factors likely contribute to pain persistence, disability, and psychological burden [9]. Although psychological status is considered to be closely linked to LBP [31, 32], little is known about the relationship between a patient's psychosocial profile and sagittal alignment. Therefore, comparing our results with existing literature is challenging. Collinet et al. demonstrated that depressive disorders in patients with CNLBP are associated with increased thoracic kyphosis [17]. Additionally, another study revealed a strong correlation between balance parameters and depression in patients with CNLBP. These findings highlight the importance of assessing psychosocial aspects as part of the interventions in patients with CNLBP [33].

The association between central sensitization and CNLBP has been explored in prior studies [34, 35]. In our sample, CSI scores were substantially higher in the CNLBP group than in controls and were related to the extent of LBP [14]. This is the first study to examine the correlation between central sensitization and sagittal spinal morphology and segmental ROM. We observed weak, negative correlations between CSI scores and spinal biomechanical measures. In addition, CSI correlated with psychosocial burden (ÖMPSQ), disability (ODI), pain intensity (VAS), and lower lumbar PPT. Consistent with this pattern, another study reported that central sensitization in CNLBP is associated with psychosocial factors and higher ÖMPSQ scores [18]. These observations align with prior work: Dahmani et al. found higher CSI scores to be associated with greater disability, higher pain intensity, and elevated anxiety in CNLBP [36]. However, Mibu et al. reported no correlation between CSI and PPT [37, 38].

Conclusion

The findings of this study highlight that military personnel with CNLBP exhibit altered sagittal spinal alignment and reduced ROM across various positions, along with heightened central sensitization and greater psychosocial burden. These findings may inform the development of tailored interventions that combine targeted physical therapy with cognitive-behavioral strategies, addressing biomechanical and psychosocial contributors to CNLBP.

Limitations

This study has several limitations. First, our study has a cross-sectional design. Further longitudinal studies are needed to confirm the relationship between spinal parameters and neuro-psychosocial variables. Second, the sample was comprised exclusively of male Iranian military personnel, reflecting the predominantly male composition of the military personnel; therefore, generalizability to women and general population is limited. Moreover, cultural and organizational features of the Iranian military and distinct occupational demands may not mirror civilian contexts. Third, selection bias is possible due to convenience sampling and SMS-based recruitment, which may have preferentially enrolled individuals with a greater interest in spinal health or better digital access. Fourth, although the Spinal Mouse is validated, it lacks the precision of radiographic methods, and spinal alignment was assessed only in standing postures; seated and dynamic assessments may yield additional insights. Finally, we did not control for physical activity levels, fatigue, or occupational exposure, which could influence biomechanics and pain and introduce residual confounding. These limitations should be considered when interpreting the findings, and future studies are warranted to confirm and extend these results.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the [AJA University of Medical Sciences](#), Tehran, Iran (Code: IR.AJAUMS.REC.1402.176). The participants received verbal and written descriptions of the study, and written informed consent was obtained. All procedures adhered to the principles of the Declaration of Helsinki.

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Authors' contributions

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Conflict of interest

The authors declared no conflict of interest.

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