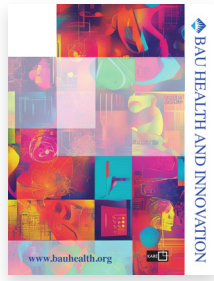
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Original Article

Cognitive Function and Left/Right Judgment Performance in Individuals with Chronic Neck Pain: A Cross-sectional Comparative Study

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Abstract

Objectives: Neck pain (NP) is associated with impaired cognitive function and altered neck awareness; however, its impact on implicit motor imagery performance, assessed by the left/right judgment task (LRJT), remains unclear. This study compared LRJT performance, cognitive function, and neck awareness between patients with NP and pain-free controls.

Methods: This cross-sectional comparative study included 35 patients with NP and 35 matched pain-free controls. Cognitive function was assessed using the Montreal Cognitive Assessment (MoCA), neck awareness using the Fremantle Neck Awareness Questionnaire (FreNAQ), pain levels by the Visual Analog Scale, and LRJT performance using the Recognize® application.

Results: Patients with NP had significantly lower MoCA scores and higher FreNAQ scores compared to controls ($p<0.05$). LRJT accuracy and right response time did not differ between groups; however, left response time was significantly shorter in patients with NP ($p<0.05$). A significant negative correlation was observed between MoCA scores and left response time in patients with NP ($r=-0.391$, $p=0.020$).

Conclusion: These results indicate that chronic NP is associated with reduced cognitive function and altered neck awareness, while overall LRJT performance may remain preserved. The observed association between cognitive function and response time suggests that cognitive capacity may influence lateralized motor judgment processes in individuals with chronic NP. Consideration of cognitive function may therefore be important when interpreting LRJT outcomes in this population.

Keywords: Cognitive performance, implicit motor imagery, left-right judgment task, neck pain.

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Neck pain (NP) is one of the most common musculoskeletal disorders, with an average prevalence of 23.1%, and negatively affects quality of life. The Global Burden of Disease study reports NP as the second most common musculoskeletal disease and the third cause of shortened life expectancy.[1,2] People with NP have activation disorders in the neck muscles compared to people without pain. Neuromotor control disorder[3] and disorders in head-and-neck position sense[4] compared to those in individuals without pain.

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Brain imaging studies in NP patients have shown that both structural and functional changes occur in brain regions involved in the cognitive and emotional modulation of pain.[5,6] Studies have shown that individuals with NP perform worse than healthy controls in tasks requiring attention, concentration, and working memory.[7,8] Furthermore, a recent study highlights additional impairments in executive functions, language, abstraction, visuospatial skills, calculation, and orientation.[9]

The left/right judgment task (LRJT) is a well-established method for evaluating implicit motor imagery, as it requires judgments of body part laterality (left vs. right) that draw upon cortical body schema in the sensorimotor cortex[10–12] from LRJT performance provides meaningful information about both cortical proprioceptive representations and efficiency of body-related information processing.[13–15]

Impairments in implicit motor imagery have previously been demonstrated in different studies examining pain in the body.[10,16–20] Impairments in LRJT performance have also been reported in patients with chronic NP.[13,21] Previous studies have shown that NP patients achieve lower scores on LRJT performance; however, these findings have not been examined in relation to cognitive performance. Furthermore, the interaction between cognitive function and LRJT performance has not been fully clarified.

NP is not only a physical problem, but also a condition that can profoundly affect cognitive functions.[7] However, there is limited information on the extent of these effects and their relationship to specific cognitive functions.[13,22] In particular, studies examining the interaction between implicit motor imagery and cognitive functions are quite rare.[21,23] This gap constitutes an obstacle to the development of more targeted treatment approaches for patients experiencing pain.

Although research has been conducted on the cognitive effects of NP, the relationship between these effects and implicit motor imagery LRJT has not been sufficiently investigated. There is limited evidence regarding how LRJT performance changes in individuals with NP and how it relates to cognitive function. Therefore, the primary aim of this study was to investigate LRJT performance in individuals with NP compared to pain-free controls. A secondary aim was to examine the relationships between LRJT performance, cognitive functions, and neck awareness.

Materials and Methods

Study Design, Sample Size, and Blind Design

This study was designed as a cross-sectional comparative study including individuals with NP and pain-free controls. The study was executed at the Istanbul FSM Medical Center Physical Therapy Clinic between May and November 2023. Participants provided written permission before study entry. Ethical approval was obtained from the Bahçeşehir University Non-invasive Research Ethics Committee (Approval No. 2022/09, 26.10.2022). The study was registered at ClinicalTrials.gov (NCT05750472).

The sample size of the study was calculated using G*Power 3.1.9.2 software. LRJT accuracy performance was determined by comparing the sample size with the standard deviation obtained from Elsig et al.'s[21] study for differences in mean values and primary results between groups. An effect size of 0.71, a power of 85%, and an alpha level of 0.05 for the laterality accuracy performance of the patients with NP compared with the healthy controls were obtained for 60 participants (30/group). A total of 80 participants were assessed for eligibility, of whom 10 were excluded due to not meeting the inclusion criteria or declining to participate. A total of 70 participants completed the study and were included in the final analysis (Fig. 1).

Participants, including individuals with NP and a pain-free control group, were given general information about the study but were not informed about the specific purpose of the questionnaires. The physiotherapist who administered the assessments was blinded to the study aims and hypotheses, ensuring an assessor-blinded design.

Participants

According to the NP task force (NPTF) classification,[24] all participants were evaluated by a physical therapist and diagnosed with Grade 2 or 3 nonspecific chronic NP before inclusion in the study. Individuals with chronic NP for at least 3 months were subjected to all measurements and tests by a physiotherapist after a physician examination. Participants who were between the ages of 18 and 65 years, had Grade 2 or 3 pain according to the NPTF classification, had a Visual Analog Scale (VAS) score of at least 30 mm, and were able to use a telephone and computer were enrolled in the study.

Individuals with a history of cancer within the last 5 years, previous neck surgery, visual or hearing impairment, suspected malignant or systemic disease, rheumatologic, psychiatric, or neurologic disease, and treatment for NP within the past 6 months were excluded.[21]

The control group consisted of asymptomatic and pain-free healthy individuals matched for age (±2 years) and gender. These individuals had no history of neck or back pain that limited their daily activities or pain that led to incapacity for work, and had not received any previous medical intervention or treatment for NP.

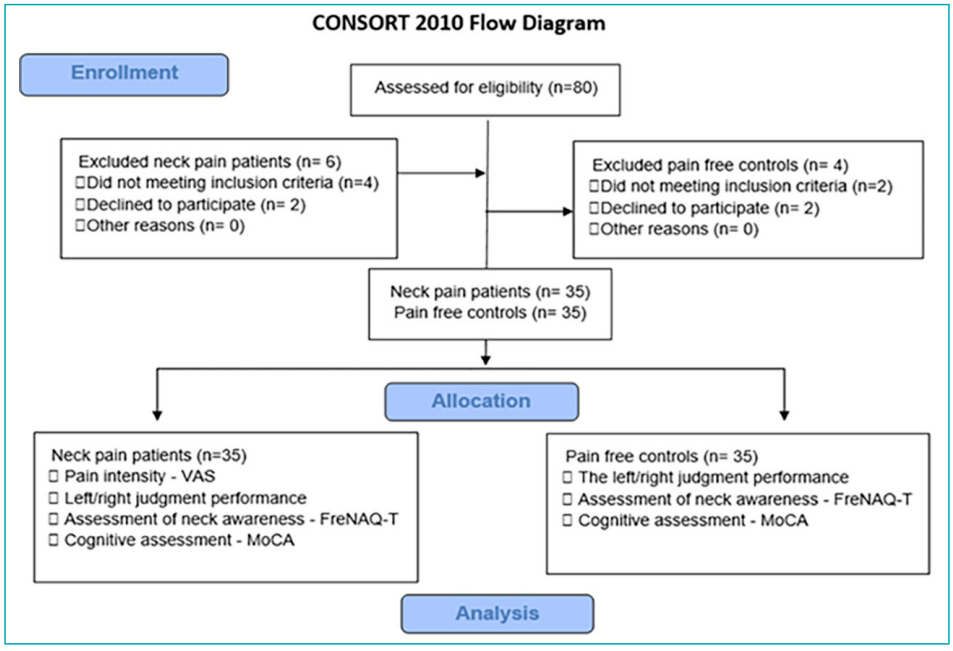


Figure 1. Flow chart of the study.

MoCA: Montreal cognitive assessment, VAS: Visual analog scale, FreNAQ: Fremantle Neck Awareness Questionnaire.

Outcome Measure

Pain Intensity

Participants' current NP intensity was subjectively assessed using the VAS. This scale consists of a 100 mm linear line. The starting point of the line is 0, representing no pain, and the ending point is 100, representing the most severe pain experienced. In the present study, participants were asked to mark the point on the line corresponding to their pain.[25]

LRJT Performance

In a previous study with individuals with NP, participants reported their performance on an LRJT task using neck images. In the current study, neck images from Recognize Online (NOI Group, Adelaide, Australia) were used to assess left/right neck judgment task performance.[26] Each experimental block in Recognize Online consisted of 20 neck images. Participants were asked to respond as quickly as possible, without guessing whether the head of the model in each image turned left or right relative to the shoulders. Each image was seen on the screen for a maximum of 5 s. Before the application started, two training images were presented to the participants, and then the test phase started. The difficulty level of the task was set as "Vanilla." The outcome variables were the accuracy rate, calculated as the percentage of correct responses, and the response time measured in seconds.[10,26]

Assessment of Neck Awareness

Neck awareness was assessed using the FreNAQ. The Turkish version of the scale FreNAQ-T was developed by Onan et al.,[27] and its validity and reliability for the Turkish population have been proven. The FreNAQ-T consists of 9 items related to NP, attention, and proprioceptive awareness. Each item is scored between 0-4, and the total score ranges from 0 to 36. High scores indicate low neck awareness.[27]

Cognitive Assessment

Cognitive functions were assessed using the MoCA scale. The MoCA is a widely performed cognitive screening tool developed by Nasreddine et al.[28] for the detection of mild cognitive impairments. In this study, the Turkish version adapted to the cultural and linguistic characteristics of the participants was used. The MoCA assesses eight cognitive domains: Visuospatial/managerial functions, naming, memory, attention, language, abstraction, delayed recall, and orientation. The total score range is 0–30; scores of 26 and above indicate normal cognitive performance.[28]

Statistical Analysis

All statistical analyses were conducted using IBM Statistical Package for the Social Sciences Statistics 22.0 (IBM Corp., Armonk, NY, USA). Statistical significance level was accepted as $p<0.05$. Continuous variables were reported as mean±standard deviation, and categorical variables were reported as number and percentage (%). Distributional characteristics of the data were evaluated by Shapiro–Wilk test. Group differences between demographic variables were evaluated by an

Table 1. Demographic and clinical data of the participants

Variables	Patients with NP (n=35)	Pain-free controls (n=35)	p
Age (years), Mean±SD	38.89±11.72	36.63±11.03	0.438[a]
Body mass index (kg\m^2), Mean±SD	23.94±3.53	22.96±3.28	0.184[a]
Gender, n (%)			0.806[b]
Female	22 (62.9)	21 (60)	
Male	13 (37.1)	14 (40)	
Education level, n (%)			
Primary school	7 (20)	5 (14.3)	
Secondary school	2 (5.7)	3 (8.6)	
High school	7 (20)	5 (14.3)	
Bachelor's degree	19 (54.3)	21 (60)	
NP duration, n (%)			
3–6 months	8 (22.9)		
6–12 months	9 (25.7)		
More than 12 months	18 (51.4)		
NPTF, n (%)			
Grade 2	23 (65.7)		
Grade 3	12 (34.3)		
Visual Analog Scale (0–100), mean±SD	79.06±12.45		
MoCA (0–30), mean±SD	24.89±2.83	26.74±2.16	**0.006**[c]
MoCA sub-test scores, mean±SD			
Visuospatial/Executive	3.74±1.09	4.54±0.61	**0.000**[c]
Attention	4.57±1.46	5.06±1.11	0.122[c]
Language	2.31±0.79	2.49±0.65	0.399[c]
Abstraction	1.57±0.55	1.80±0.47	**0.042**[c]
Delayed recall	3.74±1.01	3.89±1.38	0.624[c]
Orientation	6	6	
FreNAQ-T	5.66±3.58	1.34±1.13	**0.000**[c]
Smoking history, n (%)			
Yes	17 (48.6)	21 (40)	
No	18 (51.4)	14 (60)	
Alcohol history, n (%)			
Yes	6 (17.1)	8 (22.9)	
No	29 (82.9)	27 (77.1)	

[a]: Independent samples t-test; [b]: Chi-square, [c]: Mann–Whitney U test. Bold values indicated significant differences. NP: Neck pain, SD: Standard deviation, MoCA: Montreal cognitive assessment, FreNAQ-T: Fremantle neck awareness questionnaire Turkish, NPFT: The Neck Pain Task Force.

independent sample t-test for continuous variables and Chi-square test for categorical variables. When the data were not normally distributed, nonparametric tests were used in the analyses. As the variables were not normally distributed (Shapiro-Wilk test, $p<0.05$), correlations were analyzed using Spearman's rank correlation coefficient. In addition, Cohen's d effect size was calculated; 0.20–0.49 was interpreted as a small effect, 0.50–0.79 as medium effect, and 0.80 and above as large effect.

Results

Sociodemographic Characteristics of the Participants

Thirty-five patients with NP and 35 age- and sex-matched controls were included. No significant differences were found between groups in demographic characteristics ($p>0.05$, Table 1). Pain intensity in patients with NP was 79.06 mm (95% confidence interval [CI]: 75.12–82.97).

Table 2. MoCA total and domain/sub-test scores according to NPFT in patients with NP

NP patients (n=35)	Grade 2 (n=23) (Mean±SD)	Grade 3 (n=12) (Mean±SD)	Between-group p[b]
MoCA	25.22±2.50	24.25±3.41	0.449
Visuospatial/Executive	4.00±0.95	3.25±1.21	0.034
Attention	4.35±1.55	5±1.20	0.222
Language	2.26±0.81	2.42±0.79	0.542
Abstraction	1.61±0.49	1.50±0.67	0.745
Delayed recall	3.91±0.90	3.42±1.16	0.230
Orientation	6	6	1.000

[b]: Mann–Whitney U test. Bold values indicated a significant difference. NPFT: The neck pain task force; Grade 2 and Grade 3; NP: Neck pain; MoCA: Montreal cognitive assessment; SD: Standard deviation.

Table 3. Correlation coefficient between MoCA and LRJT task in patients with NP and pain-free controls

MoCA	Patients with NP (n=35)		Pain-free controls (n=35)	
	Correlation coefficient (r)	p	Correlation coefficient (r)	p
Response time				
RRT	-0.187	0.283	-0.281	0.102
LRT	-0.391	**0.020**[c]	-0.176	0.311
Recognition accuracy (ACC, %)				
RACC	-0.028	0.873	0.087	0.619
LACC	0.172	0.323	-0.287	0.095

[c]: Correlation is significant at the 0.05 level (2-tailed). Bold values indicated significant difference. RRT: Right response time, LRT: Left response time, RACC: Right accuracy in %, LACC: Left accuracy in %, MoCA: Montreal cognitive assessment, LRJT: Left/right judgement task, NP: Neck pain.

Neck Awareness Levels of Participants

FreNAQ-T scores were significantly higher in individuals with NP compared to pain-free controls ($p<0.05$, Table 1). Mean scores were 5.66 (95% CI: 4.54–6.91) in patients with NP and 1.34 (95% CI: 0.97–1.77) in pain-free controls.

Cognitive Levels of the Participants

MoCA total scores were significantly lower in patients with NP compared to pain-free controls ($p=0.006$, Table 1). Among MoCA subdomains, visuospatial/executive function ($p<0.001$) and abstraction ($p=0.042$) differed significantly between groups, while no significant differences were observed in attention, language, delayed recall, or orientation.

No significant differences were observed in total MoCA scores between NPTF Grade 2 and Grade 3 ($p=0.449$, Table 2). However, visuospatial/executive scores were significantly lower in individuals with Grade 3 compared to Grade 2 ($p=0.034$, Table 2).

According to Spearman's correlation analysis, there was no significant correlation between MoCA score and LRJT performance in the pain-free controls (Table 3). In individuals with NP, a significant negative correlation was observed between MoCA score and left response time ($r=-0.391$, $p=0.020$, Table 3).

Multivariable linear regression analysis was performed with left response time as the dependent variable and MoCA score, age, education level, and pain intensity as predictors. MoCA score was at the threshold of statistical significance ($\beta=-0.353$, $p=0.050$), while the overall model was not statistically significant ($p=0.254$).

LRJT

No significant differences were observed between individuals with NP and pain-free controls in LRJT accuracy or right response time ($p>0.05$, Table 4). However, left response time was significantly shorter in individuals with NP compared to controls ($p=0.039$, Table 4).

Table 4. Comparison of LRJT task results in patients with NP and pain-free controls

LRJT	Patients with NP (n=35)	Pain-free controls (n=35)	Between-group p[a]	Effect size (Cohen's d)
Response time, Mean±SD				
RRT	1.79±0.43	2.04±0.61	0.088	0.47
LRT	1.91±0.42	2.14±0.54	**0.039**	0.47
Recognition accuracy (ACC, %), Mean±SD				
RACC	67.43±21.73	68.57±22.89	0.769	0.05
LACC	60.29±21.75	62.86±24.80	0.626	0.11

[a]: Mann–Whitney U test. Bold values indicated significant difference. RRT: Right response time, LRT: Left response time, RACC: Right accuracy in %, LACC: Left accuracy in %, SD: Standard deviation, LRJT: Left/right judgement task, NP: Neck pain.

Discussion

In the current study, we compared MoCA scores, neck awareness, and neck LRJT performance between patients with NP and pain-free controls. We also investigated the relationships between LRJT performance and MoCA score. The patients with NP had lower MoCA scores and neck awareness scores than the controls. LRJT accuracy and right response time did not differ between groups, whereas left response time was significantly shorter in patients with NP. in addition, a negative correlation was found between MoCA scores and left response time in the patients with NP, suggesting a potential link between cognitive function and motor imagery performance in these patients.

LRJT

In the current study, no significant difference was found between patients with NP and pain-free controls in terms of LRJT accuracy. Several systematic reviews have reported that individuals with chronic musculoskeletal pain tend to show reduced accuracy and prolonged response times in LRJT when identifying images of painful body parts.[29,30] These findings have been interpreted as impairments in body schema and impaired cortical proprioceptive representations. However, the study's findings do not fully align with those of studies conducted in patients with NP.[13,21] Knee pain,[31] and low back pain[20,32] reporting impaired LRJT performance. However, these results are consistent with earlier studies that also reported no impairments in LRJT performance among the NP population.[20,33] The inconsistency between these findings may be due to variability in sample characteristics, particularly pain severity, chronicity, or NPTF classification levels. Differences in cortical involvement or impairment of proprioceptive feedback may become apparent only at higher levels of dysfunction or in more severe clinical subgroups (e.g., Grade 3 vs. Grade 2). in addition, the sample size and subgroup distribution in the current study may not have been sufficient to detect subtle differences in performance, especially when stratified by gender or severity.

In the current study, in terms of response time, patients with NP demonstrated shorter left response times compared to pain-free controls, while no significant differences were observed for other response time parameters. This finding was unexpected. In studies comparing individuals with chronic musculoskeletal pain and healthy controls, contradictory results were found in the literature. It was reported that there was an increase in response time in individuals with han[34] and knee osteoarthritis,[31] no difference in response time in individuals with chronic pelvic pain[35] or leg or foot pain,[16] while there was a difference in response time in individuals with neck,[13] low back pain,[20] and shoulder pain.[36] As previous research has frequently shown delayed response times in individuals with chronic pain, often interpreted as a reflection of disrupted sensorimotor processing or increased cognitive load.[19,30,37] However, this faster response in the current study may indicate an impulsive or less attentive response pattern, potentially related to reduced attentional capacity in the patients with NP - an interpretation supported by the significantly lower attention subscores in MoCA among these individuals. Furthermore, the significant negative correlation between the MoCA score and left side response time adds further meaning to this interpretation. In particular, poorer cognitive performance was associated with faster left side responses, which likely reflects a compensatory or maladaptive strategy (e.g., "guessing" or "responding hastily") in the context of impaired cognitive function, particularly in attentional or visuospatial/executive domains. The lateralized nature of this correlation (only on the left side) could also hint at asymmetrical processing

mechanisms or hemispheric dominance effects, although further neurophysiological research would be required to clarify this. Overall, these findings suggest that LRJT response time and accuracy may be influenced not only by pain-related changes in body schema but also by cognitive function, particularly attention and executive control. This is the first study to analyze MoCA-assessed cognitive domains and LRJT performance together in NP. The study's results highlight the importance of incorporating cognitive assessment into sensorimotor assessments and suggest that cognitive status should be taken into account when interpreting LRJT performance in chronic pain populations.

Cognitive Function, Pain, and LRJT

Previous studies have consistently reported that individuals with chronic pain exhibit poorer cognitive performance, particularly in domains such as visuospatial/executive function, attention, memory, and abstraction.[7,9] In the current study, patients with chronic NP exhibited significantly lower MoCA scores compared with pain-free controls, particularly in the visuospatial/executive and abstraction subdomains. These findings are consistent with increasing evidence that chronic musculoskeletal pain may negatively impact cognitive function due to neuroplastic changes and pain modulation in brain regions involved in sensory and motor processing.[8]

One of the main findings of the present study was a significant negative correlation between MoCA score and left response time in patients with NP. This indicates that higher global cognitive performance was associated with shorter (i.e., faster) left response times. This finding suggests that intact cognitive processes, particularly those related to visuospatial and executive functioning, may facilitate performance in implicit motor imagery tasks such as the LRJT. This may reflect potential lateralized processing differences or increased cognitive demand when evaluating less dominant directional stimuli, particularly in predominantly right-handed individuals. However, this association should be interpreted with caution, as it was not supported by the regression analysis. Nevertheless, the results highlight the potential relevance of cognitive functioning in sensorimotor task performance. Future studies are needed to clarify the underlying mechanisms and to determine whether specific cognitive deficits contribute to altered implicit motor processing in this population.

Neck Awareness

The present study showed that patients with NP demonstrated significantly lower levels of neck awareness compared to pain-free controls. This finding supports previous research indicating that chronic pain can disrupt cortically maintained body schema and lead to altered perception of the size, shape, or position of the affected body part.[19] The decreased neck awareness shown in the current study may be related to dysfunction in the deep cervical muscles and impaired proprioceptive feedback mechanisms.[38] These impairments may affect joint position sense and sensorimotor control, as shown in previous studies.[27,39] Given that the body schema is constantly associated with proprioceptive and sensorimotor input, persistent nociceptive signaling in chronic NP may interfere with accurate internal representations of the neck region. In summary, the study's findings add to the growing evidence suggesting that chronic NP is associated with impaired body perception and reduced sensorimotor awareness, and that this is mediated by central nervous system changes. These changes should be considered in the assessment and rehabilitation planning of patients with NP.

Study Limitations

There are some limitations in this study. First, the limited sample size and imbalances between subgroups (e.g., NPTF grades or gender distribution) may have reduced statistical power. Furthermore, it is possible that cognitive functioning may have been affected by uncontrolled variables such as sleep patterns, stress levels, or medication use. Furthermore, individual differences such as hand dominance were not taken into account in the analyses.

Conclusion

One of the main findings of the current study is that individuals with NP exhibited impairments in cognitive function and neck awareness. Overall, LRJT accuracy and right response time did not differ significantly between groups; however, left response time was significantly shorter in individuals with NP compared to pain-free controls. Another finding was a significant negative correlation between MoCA scores and left reaction time in individuals with NP, suggesting that reduced cognitive function, particularly in the visuospatial and executive domains, may affect motor imagery processes. These findings emphasize the importance of considering cognitive status when interpreting LRJT performance in patients with NP and suggest that motor-cognitive interactions may play a role. Further studies are needed to examine these relationships more comprehensively.

Disclosures

Ethics Committee Approval: The study was approved by the Bahçeşehir University Non-invasive Research Ethics Committee (no: 2022/09, date: 26/10/2022).

Informed Consent: Written informed consents were obtained from patients who participated in this study.

Conflict of Interest Statement: The author declare that there is no conflict of interest.

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