Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 26s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Correlation between Pain, Logical Reasoning and Figural Memory in Patients with Chronic Cervical Radiculopathy

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Cite this paper as: Menna Allah M. Badwy, Salah A. Sawan, Ebtsam M. Fahmy, Ashraf A. Darwesh, (2025) Correlation between Pain, Logical Reasoning and Figural Memory in Patients with Chronic Cervical Radiculopathy. *Journal of Neonatal Surgery*, 14 (26s), 846-852.

ABSTRACT

Background: Pain is a subjective, multi-faceted experience influenced by sensory, emotional, and cognitive factors. Cervical spine radiculopathy discomfort adversely affects an individual's psychosocial aspects and mental health symptoms. The quality of life is correlated with spinal pain accompanied by radiculopathy. Only a limited number of research have examined the psychosocial aspects related to cervical radiculopathy (CR).

Purpose: To investigate the impact of cervical radiculopathy pain on logical reasoning and figural memory in patients with chronic cervical radiculopathy.

Methods: Sixty four subjects of both sexes enrolled in the study. They were allocated into two groups: patients' group that included 44 patients with chronic cervical radiculopathy suffering from cervical pain and control group that included 20 healthy matched subjects. The age ranged from 30-45 years. All subjects underwent clinical neurological evaluation, assessment of pain level using the visual analogue scale (VAS) and assessment of two cognitive functions domains (Logical reasoning and figural memory) using RehaCom device.

Results: A substantial disparity existed between the control group and the sick group on logical reasoning, evidenced by the number of incorrect items ($p = 0.018$), the number of color errors ($p = 0.034$), and quartile reaction time 1 ($p = 0.009$). Nonetheless, no substantial difference was observed between the two groups for logical thinking (including the number of items, types of errors, magnitude of errors, duration of errors, median response time, and third quartile reaction time) or any aspects pertaining to figural memory. A notable moderate positive association was seen between pain intensity and the number of errors ($r=0.336$, $p=0.026$), the total number of errors ($r=0.386$, $p=0.010$), and the number of reaction inter-stimulations ($r=0.376$, $p=0.012$) in the patient group. Conversely, a substantial negative association exists between pain severity and accurate responses ($r=0.497$, $p=0.001$), as well as median reaction time ($r=0.406$, $p=0.006$).

Conclusion: There is cognitive dysfunction that might be affected by pain in CR patients.

Keywords: *cervical radiculopathy, chronic pain, logical reasoning, figural memory*

1. INTRODUCTION

Cervical radiculopathy (CR) is typically induced by disc herniation, spondylosis, or a combination of both due to degeneration. Cervical radiculopathy induces pain that radiates to the arm in a specific nerve root distribution (1). Patients with CR also exhibit neurological signs, including sensory disturbances, weakness, and/or diminished tendon reflexes. Like patients with chronic neck pain devoid of radiculopathy, these individuals may exhibit nonspecific symptoms like headache, dizziness, and emotional discomfort. Functional restrictions and disabilities frequently occur, peaking throughout middle age (2).

Pain in the cervical spine, with or without radiculopathy, frequently has considerable adverse effects on an individual's physical and mental health, imposing a substantial burden on individuals, families, and society. Enhanced understanding of prognostic variables, including poor health, psychological influences, and previous pain episodes, is essential to inform clinical management (4, 5).

In recent years, numerous non-computer cognitive training methods have been created to assist individuals with cognitive impairment (CI). These encompass herbal therapy, passive muscle massage and joint mobilization, active training of the affected limb, rotational exercises from the healthy side to the affected side, balance training in sitting and standing positions, activities of daily living (ADLs) training, as well as problem-solving and written tasks (6). These programs vary from other rehabilitation programs regarding methodology, theoretical framework, support mechanisms, session duration and intensity, individual or group formats, and whether they are integrated or standalone. Furthermore, the outcomes of clinical trials have revealed numerous methodological constraints. This encompasses unsuitable randomization techniques and single-site studies, demonstrating the absence of adequate control groups and objective baseline neuropsychological assessments, as well as the inconsistency of outcome measurements and therapies. Among several techniques, computer-based cognitive training is characterized by its modularity, interactivity, dynamism, and flexibility (7).

RehaCom is a computerized telerehabilitation program designed to enhance cognitive impairments. This software encompasses three primary therapy strategies: psychoeducation and cognitive function awareness, development of motivational functions, and training in compensatory and adaptive skills. It encompasses five distinct training regimens focused on attention, memory enhancement, visuospatial processing, and executive functions. Each program has one to four distinct tasks. RehaCom comprises 29 modules in English, along with modules available in 21 additional languages. For each module, the therapist can pick several parameters (initial level, session frequency and duration, stimulus selection, task time constraints, etc.) that facilitate personalized therapy for patients. The software possesses auto-adaptive capabilities, allowing the task's difficulty level to be automatically adjusted based on the patient's functionality. It also enables therapists to assess patients' performance online and offer feedback. Upon completion of the course, the therapist can analyze the results through charts, graphs, and comparative data. The predominant formats of the outcomes include the progression level (score), error count, and reaction time (8, 9, 10).

RehaCom evaluates attention, memory, visual-spatial processing, executive functioning, word memory, verbal memory (including entire texts rather than isolated words), and figural memory. The application comprises multiple modules with varying difficulty levels, which automatically escalate the task complexity as the participant successfully completes smaller tasks. The documentation of error counts and test completion durations for all patients, along with a results file, facilitates continuity across several sessions and the database storage of outcomes. The computer provides patients with suitable instructions and performance feedback in their native language (11). Despite the endorsement of RehaCom's efficacy in studies employing a pre- and post-design, with or without follow-up in Randomized Controlled Trials (RCTs) including patients with CI, the results remain insufficient and inconsistent (12).

In this study, we aimed to investigate the impact of cervical pain on selected cognitive domains (logical reasoning and figural memory) in chronic cervical radiculopathy patients.

2. SUBJECTS AND METHODS

Study design:

This research was a cross-sectional case-control study. The research was sanctioned by the ethical council of the Faculty of Physical Therapy at Cairo University, under registration number (NO P.T.REC/012/004749). This study was registered in the Clinical Trials (PACTR20241274745770). All subjects provided written consent before to participation.

Participants

Forty-four patients with chronic cervical radiculopathy and twenty matched healthy subjects were enrolled in the current study. Cervical radiculopathy patients were recruited from the outpatient clinic of Faculty of Physical Therapy, Cairo University between 2023 and 2024. Eligibility criteria were: patients diagnosed as cervical radiculopathy due to disc prolapse at the level of C5-C6 or C6- C7 evident by magnetic resonance imaging (MRI) of the cervical spine, age from 30-45 years, both sex, cervical pain for at least three months with sensory changes such as paresthesia (numbness, tingling, burning) in the upper extremity, Mini Mental State Examination (MMSE) score > 26 and normal vision and hearing. Patients were excluded if they had cervical myelopathy, neurodegenerative disorders, stroke, visual or auditory impairments, hypertension, diabetes mellitus, arrhythmia, myocardial infarction, or chronic obstructive pulmonary disease/asthma.

Procedures:

Neurological assessment: included full history taking, general medical examination and neurological evaluation according to a clinical evaluation sheet.

Assessment of cervical pain intensity: cervical pain was measured using the Visual Analog Scale (VAS). This scale allows individuals to categorize their pain as absent, mild, moderate, or severe. The VAS uses a 100 mm line with specific ranges corresponding to pain levels: 0-4 mm denotes no pain, 5-44 mm suggests mild pain, 45-74 mm represents moderate pain, and 75-100 mm denotes severe pain (13). Patients were guided to pinpoint the location on the line that they felt corresponded to their present pain intensity.

- Cognitive functions assessment (Logical reasoning and Figural memory):

All participants were evaluated using the RehaCom software suite, which assisted the therapist in the assessment and rehabilitation of cognitive problems impacting attention, concentration, figural memory, reaction behavior, and logical reasoning. It is an extensive and advanced set of protocols for computer-assisted cognitive evaluation and rehabilitation that has demonstrated outstanding results in clinical practice, with no significant adverse effects recorded (12). This software had five distinct treatment programs designed to rehabilitate attention, memory, executive functions, and visual field. Each program included 1 to 4 distinct tasks from which participants choose during each therapy session. RehaCom offered a series of standardized exercises with quick feedback, making it beneficial for patient follow-up assessments and clinical research (14).

Each participant was instructed to assume a comfortable seated position in a chair with back support and an appropriate seat height relative to the table, with a computer device positioned in front of them. Scores for each item were documented, and subsequently, the total score was computed. A computer-based cognitive gadget was utilized to evaluate cognitive skills, specifically figural memory and logical reasoning. The evaluation duration for each location was 30 minutes (15).

Logical reasoning: This screening measures the client's ability to complete a sequence, and problem solving. It examines wither the client can identify irregularities and is able to draw logical conclusions. This curriculum intends to enhance logical reasoning. The participant must finish a sequence utilizing logical principles (15).

Figural memory: It encompasses figurative content, picture-word associations, captions, and aphasia. This module evaluated nonverbal and verbal memory (working memory). The participant must memorize images with identifiable things. Subsequent to the "learning phase," words will manifest as if on a conveyor belt. The patient must hit the OK button each time a word corresponding to an object displayed during the learning phase is presented (15).

Statistical analysis

Statistical analysis was performed with SPSS for Windows, version 26 (SPSS, Inc., Chicago, IL). Prior to the final analysis, the data were evaluated for the normality assumption, homogeneity of variance, and the existence of outliers. This analysis was conducted as a prerequisite for parametric testing of the differences analysis. The Mann-Whitney Test was utilized to compare the mean values of several parameters between the two groups, identifying significant differences between them. The Spearman correlation coefficient test was employed to assess the relationship between pain intensity and all metrics of logical thinking and figural memory. The p-value was established at less than 0.05.

3. RESULTS

Characteristics of participants

The demographic characteristics of included subjects are demonstrated in table (1). The control group included six males (30 %) and 14 females (70 %), while the cervical radiculopathy group included 15 males (34.1%) and 29 females (65.9%), this was statistically matched (p = 0.747). The mean value of pain intensity in the patients group was 3.48 ± 2.949.

Table 1: Demographic characteristics of participants.

Variable	Mean ± SD		t-value	*P*-value	Sig.
	Control Group N = 20	Patients Group N = 44			
Age (years)	36.20 ± 4.808	37.45 ± 5.169	0.916	0.3633	NS
Weight (kg)	73.70 ± 14.068	74.45 ± 10.769	0.2341	0.8156	NS
Height (cm)	165.90 ± 8.341	167.48 ± 5.394	0.9095	0.3666	NS
BMI (kg/m2)	26.150 ± 4.877	26.912 ± 3.812	0.6780	0.5003	NS

SD= Standard deviation, t-value=t-statistic, P-value=probability, NS=non-significant.

Logical Reasoning

Comparison of items of Logical reasoning domain (number of items, number of incorrect items, number of errors forms, number of errors color, number of errors size, number of errors time, Quartile reaction time 1, median reaction time, and quartile 3 reaction time) is demonstrated in Table 2. There was a significant difference between both groups regarding number of incorrect items (p = 0.018), number of errors color (p = 0.034), quartile reactions time 1 (p = 0.009), being higher in patients compared to controls. On the other hand, there was no significant difference between normal and patients with cervical radiculopathy patients in the other items related to logical reasoning (Table 2).

Table 2: Comparison between both groups regarding items of logical reasoning.

logical reasoning items	Mean ± SD		Mann-Whitney U	*P*-value	Sig.
	Control Group N = 20	Patients Group N = 44			
No. of items	12.30 ± 6.375	14.432 ± 10.167	408	0.642	NS
No. of incorrect items	1.2± 1.361	3±4.199	280.000	**0.018**	**Sig**
No. of errors forms	0.3± 0.47	1.25±3.141	342.000	0.107	NS
No. of errors color	0.3 ± 0.657	1.09±1.723	312.000	**0.034**	**Sig**
No. of errors size	0.7±1.129	1.73±2.591	327.000	0.077	NS
No. of errors time	0±0	0.16±0.805	420.000	0.337	NS
Quartil reaction time 1	2912.5±84267	2256.41±1.784.60	261.000	**0.009**	**Sig**
Median reaction time	3740.4±1067.89	3851.18±2702.66	379.000	0.377	NS
Quartil reaction time 3	5020.5±2300.52	4345.3±4374.71	314.000	0.068	NS

SD= Standard deviation, P-value=probability, NS=non-significant, S=significant.

Figural Memory

Results of items of Figural memory domain in both groups are shown in Table 3. There were no significant differences between normal subjects and patients with cervical radiculopathy in all items related to Figural memory (Table 3).

Table 3: Comparison between both groups regarding items of figural memory.

Figural memory items	Mean ± SD		Mann-Whitney U	*P*-value	Sig.
	Control Group N = 20	Patients Group N = 44			
Acquisition Time	7.20± 4.808	13.10±17.206	493	0.270	NS
Solution Time	436.6±1212.98	198.16±1054.62	359	0.240	NS
No. of Items	28 ± 15.403	25.77±11.8	434	0.928	NS
Incorrect Items	0±0	0.18±0.54	380	0.085	NS
Missed items	0.4±0.681	0.16±0.428	365	0.110	NS

NS= non significant

Correlation between cervical pain and figural memory and Logical reasoning in patients group:

In the patients group, there was a significant moderate positive correlation between pain intensity and no. of errors (r=0.336, p= 0.026), no. of total errors (r=0.386, p= 0.010), no. of reaction inter stimulation (r=0.376, p= 0.012). On the other hand, there is a significant negative strong correlation between pain intensity and correct reactions (r=0.497, p= 0.001), and Median react time (r=0.406, p= 0.006), (Table 4).

Table 4: Correlation between pain intensity and items of figural memory and Logical reasoning domains in patients group.

Pain intensity	Figural memory	
0.030	R	Acquisition Time
0.852	P	
0.128	R	Solution Time

0.407	P	
-0.016	R	No. of Items
0.919	P	
0.215	R	Incorrect Items
0.162	P	
0.116	R	Missed items
0.455	P	
	Logical reasoning	
0.267	R	No. of items
0.079	P	
0.235	R	No. of incorrect items
0.124	P	
0.258	R	No. of errors forms
0.091	P	
0.293	R	No. of errors color
0.063	P	
0.253	R	No. of errors size
0.097	P	
0.105	R	No. of errors time
0.499	P	
0.139	R	Quartil1 React. Time1
0.367	P	
0.225	R	median react. Time
0.143	P	
0.239	R	Quartil3 React. Time3
0.118	P	

R: Correlation Coefficient P: probability value

4. DISCUSSION

Pain is a complex sensation that is impacted by psychological elements like fear, anxiety, sadness, and false beliefs (16). It has been suggested that a more comprehensive, biopsychosocial method be used to evaluate and treat pain (16). Only a small number of research examined the psychosocial variables linked to CR, and those that did were all conducted on individuals who had chronic CR.

The findings of the present investigation, conducted on participants exhibiting CR, suggest that felt pain is not solely a sensory phenomenon but also affects emotional and cognitive processes. Consequently, it appears that CR is a multi-dimensional pain condition that has been previously advocated for all pain experiences (17).

The results of this study revealed a significant difference between CR patients and healthy controls regarding certain items of logical reasoning (number of incorrect items, number of errors color, quartile reactions time 1). On the other hand, there was no significant difference between controls and patients with cervical radiculopathy in the other items related to logical

reasoning. This might be attributed to that logical reasoning performance is modulated by the emotional statues. The emotional status of patients with CR was affected by the unpleasant sensation of radicular pain, which might affect their performance throughout different tasks. Our findings concur with those of Oaksford et al. (18), who indicated that in multiple trials, individuals either experienced a mood induction or were selected based on their pre-existing emotional state, which frequently led to a decline in reasoning competence.

Furthermore, Jung et al. (19) discovered that both positive and negative emotions lead to a decline in logical reasoning skills. Studies should be conducted on the impact of physical or medicinal modalities that alleviate pain, followed by an assessment of cognitive skills related to logical reasoning.

On the other hand, the results of the current study showed no significant differences between healthy controls and patients with cervical radiculopathy in all items related to Figural memory. A probable explanation might be that healthy subjects may suffered from fatigue or tiredness, or other type of pain that would affect the results, so the results showed no significant difference between both groups. So further studies should be done on different groups of healthy subjects in different situation to detect if these differences causes significance difference or not.

Consistent with our research, Higgins et al. (20) indicated that chronic pain may lead to detrimental effects on quality of life and functioning (e.g., social and occupational impairment), as well as neurocognitive abnormalities (e.g., concentration and memory deficits), potentially indicating common neural mechanisms. Furthermore, research on persons with fibromyalgia, osteoarthritis, migraine headaches, and low back pain has revealed deficiencies in various facets of learning and memory in patients with these illnesses (21-25).

5. CONFLICTS OF INTEREST

The authors have no financial conflicts of interest.

6. FUNDING STATEMENT

None

7. ACKNOWLEDGMENTS

All participants who participated in this study.

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