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Impact of Pain on Reaction Behaviour and Attention-Concentration in Patients with Cervical Radiculopathy

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ABSTRACT

Background: Pain in the cervical spine, with or without radiculopathy, adversely affects an individual's physical and emotional health, imposing a considerable burden on individuals, families, and society at large.

Purpose: This study was conducted to investigate the impact of cervical radiculopathic pain on reaction behavior, attention and concentration.

Methods: Sixty-four participants, comprising forty-four patients with chronic cervical radiculopathy as the study group and twenty age-matched healthy individuals as the control group, were recruited for the study. The age varied from 30 to 45 years. All participants were evaluated for cognitive functions with the RehaCom equipment.

Results The findings indicated a significant disparity between the two groups regarding the number of errors with no reaction ($p = 0.001$), the number of errors with incorrect reactions ($p = 0.028$), the total number of errors ($p < 0.001$), and the correct reactions ($p < 0.001$). However, no significant differences were observed between the normal group and patients with cervical radiculopathy in other reaction-related metrics. Conversely, there were no notable changes between the two groups regarding any items related to attention and focus. Within the patient cohort, a significant moderate positive correlation was observed between pain intensity and the number of errors in reaction time ($r=0.336$, $p=0.026$), total errors ($r=0.386$, $p=0.010$), and reaction inter-stimulation ($r=0.376$, $p=0.012$). Additionally, a significant strong negative correlation was found between pain intensity and correct reactions ($r=0.497$, $p=0.001$). No substantial link exists between pain severity and behavioral response.

Conclusion: Reaction Behaviour and Attention-Concentration are affected in patients with CR, These cognitive domains might be affected by pain in such patients.

Keywords: *Cervical radiculopathy, Attention and concentration, reaction behavior*

1. INTRODUCTION

Cervical radiculopathy (CR) is a condition defined by a pathological process affecting the cervical nerve roots. This process typically involves a herniated nucleus pulposus that anatomically compresses a nerve root in the spinal canal. Spinal stenosis, caused by a combination of degenerative spondylosis, ligamentous hypertrophy, and spondylolisthesis, is a prevalent cause of radiculopathy. Inflammatory radiculitis represents an alternate pathophysiological mechanism that might induce radiculopathy[1].

Evidence indicates a positive association between pain duration and the degree of cognitive alterations; specifically, as pain persists, there is a greater impact on perception, comprehension, interpretation, and decision-making abilities[2,3]. Consequently, persistent pain persisting for over three months or recurring has garnered significant interest. It negatively affects individuals' cognitive and emotional responses, socioeconomic position, psychological well-being, and decision-making processes[4].

RehaCom is a computerized telerehabilitation program designed to enhance cognitive impairments. This program includes three main therapeutic strategies: psychoeducation and cognitive awareness, enhancement of motivational functions, and

training in compensatory and adaptive skills. It comprises five unique training protocols aimed at attention, memory improvement, visuospatial processing, and executive functions. Each program has one to four unique tasks[5,6].

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 enables therapists to oversee patients' performance online and offer feedback. Upon completion of the course, the therapist can analyze the results through charts, graphs, and comparisons. The predominant formats of the outcomes include progression level (score), error count, and reaction time[7,8].

RehaCom software is a comprehensive cognitive rehabilitation examination with 32 tasks evaluating attention, memory, logical thinking, and executive function[9].

A herniated nucleus pulposus that anatomically compresses a nerve root in the spinal canal is usually involved in this process. One common cause of radiculopathy is spinal stenosis, which is brought on by a confluence of spondylolisthesis, ligamentous hypertrophy, and degenerative spondylosis. Another pathologic mechanism that might result in radiculopathy is inflammatory radiculitis[10,11]. This remains unestablished for cervical radiculopathy and necessitates additional investigation.

This study aims to examine the impact of cervical radiculopathic pain on reaction time, attention, and focus in patients with cervical radiculopathy.

2. SUBJECTS AND METHODS:

Study design:

This study was a case-control investigation. With registration number (NO P.T.REC/012/004749), the study was approved by Cairo University's Faculty of Physical Therapy's ethical council. This study was registered in the Clinical Trials (PACTR20241274745770). All subjects provided written consent before to participation.

Participants

Sixty-four subjects of both sexes, Forty-four patients with Cervical Radiculopathy Pain and twenty normal age matched subjects participated in the current study. Between 2023 and 2024, patients with cervical radiculopathy were gathered from Cairo University's Faculty of Physical Therapy outpatient clinic. Participants had to be between the ages of 30 and 45, have had cervical pain for at least three months, and have a Mini Mental State Examination score of at least 26 to be considered to have adequate cognitive function. Patients with high blood pressure, diabetes, arrhythmia, myocardial infarction, chronic obstructive pulmonary disease/asthma, stroke, neurodegenerative diseases, upper cervical radiculopathy, cervical myelopathy, and significant cognitive impairment were excluded.

Assessment:

Clinical assessment: include full history taking, general medical examination and neurological evaluation according to the clinical evaluation sheet.

Assessment of cervical radiculopathy pain intensity: To assess the intensity of cervical following CS, all participants in both groups were evaluated using the Visual Analog Scale (VAS) before and the assessment of cognitive function. This scale allows individuals to categorize their pain as absent, mild, moderate, or severe. The VAS employs a 100 mm scale with designated ranges for pain levels: 0-4 mm indicates no pain, 5-44 mm signifies mild pain, 45-74 mm identifies moderate pain, and 75-100 mm represents severe pain[12]. Participants were guided to pinpoint the location on the line that they felt corresponded to their present pain intensity.

- Cognitive functions (Reaction behavior and Attention concentration) assessment:

All participants were subjected to assessment using the RehaCom software suite, which assists therapists in evaluating and rehabilitating cognitive impairments that impact attention, focus, and reaction behavior. It is an extensive and advanced set of protocols for computer-assisted cognitive evaluation and rehabilitation that has demonstrated exceptional outcomes in clinical practice, with no significant adverse effects recorded[13]. The five distinct treatment regimens in this software are intended to improve visual field, executive functioning, memory, and attention. During each therapy session, participants choose from one to four distinct tasks in each program. RehaCom was useful for clinical research and patient follow-up assessments since it offered a set of standardized tasks with fast response times[14].

RehaCom procedure is performed through a regular PC with at least a 19-inch screen, RehaCom panel, and a software (1990–1997) EN/ ISO-13485 certified. Patients were subjected to two tests: (a) assessment of reaction behavior (RB) and (b) assessment of attention/concentration (A/C).

a) RB tests consisted of 16 levels of difficulties. Each level consisted of an average 50 stimuli. Average time of assessment was about 30 min. Time period between stimuli (interstimulus interval) was preset to the default of about 2000 ms. Maximum

reaction time was preset to the default of 1200 ms. An answer was considered incorrect when the time taken to answer exceeded 1200 ms and the next stimulus appeared. Percentage of correct reactions was calculated as the percentage value of relevant to irrelevant stimuli. The patient was shifted to the next level of assessment, if the percentage of correct reactions was 75% or more. If the patient was unable to complete a certain level for a long period of time, the test was stopped and results were calculated according to the maximum reached performance level. Upon achieving optimal performance levels in various activities during RB tests for each patient, the results, including the percentage of accurate responses and median reaction times, were presented in tabular format accompanied by graphics.

b) The A/C assessments comprised 100 degrees of complexity. Each level comprises an average of 22 subtests. The maximum duration of the session was around 60 minutes per patient, with a 5-minute intermission between levels. The evaluation of each patient commenced at level 'one' and advanced to the subsequent, more challenging level. A gray performance bar displayed on the left side of the screen adjusted according to the quality of patient performance. It expanded with each correct response and diminished with each erroneous response. As the performance bar increased, the patient finished the level and advanced to the more challenging level. If the performance bar decreased after three consecutive incorrect answers, the test was terminated, and the patient's highest level of achievement was documented at the corresponding difficulty level. No time constraints were imposed during the evaluation. Maximum and minimum reaction times were evaluated for each patient.

Statistical analysis

SPSS for Windows, version 26, was used to conduct the statistical analysis (SPSS, Inc., Chicago, IL). The data were checked for outliers, homogeneity of variance, and normality before the final analysis, with a p-value set at less than 0.05. Prior to the parametric testing of the differences analysis, this analysis was carried out. In order to determine whether there were any notable differences between the normal group and the Cervical Radiculopathy Pain group, the mean values of a number of parameters were compared between the two groups using the Mann-Whitney Test. The association between pain and cognitive abilities was evaluated using the Pearson correlation coefficient.

3. RESULTS

Characteristics of participants

Forty-four patients with Cervical Radiculopathy Pain and twenty normal subjects participated in the current study. The distribution of males and females in the normal group was 30 % (6) and 70 % (14) and in the cervical radiculopathy group it was 34.1 % (15) and 65.9 % (29) respectively. The Chi-square test comparing the gender distribution of all patients in both groups indicated no significant difference (p = 0.747). The unpaired t-test comparison of mean values for age, weight, height, BMI, and symptom duration in months across both patient groups revealed no significant differences: Age (p = 0.363), weight (p = 0.816), height (p = 0.367), and BMI (p = 0.50), as illustrated in Table 1. The average pain intensity for the CR Group was 5.07±2.128.

Table 1: Descriptive statistics and the t-test for the mean values of the demographic data.

Variable	Mean ± SD		t-value	*P*-value	Sig.
	Normal Group N = 15	Cervical Radiculopathy Group N = 15			
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/m^2)	26.150 ± 4.877	26.912 ± 3.812	0.6780	0.5003	NS

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

Reaction behavior

Reaction behavior domains include 10 outcomes: number of errors reaction time, number of errors no reaction, number of errors incorrection reaction, number of total errors, correct reactions, number of reactions interstim, Quartile 1 reaction time1, median reaction time, Quartile 3 reaction time 3, number of items. The results revealed that there was a significant difference between groups for number of errors no reaction (p = 0.001), number of errors incorrect reaction (p = 0.028), number of total errors (p < 0.001) and correct reactions (p < 0.001). On the other hand, there are no significant differences between normal and patients with cervical radiculopathy in the other items related to reaction behavior (Table 2).

Table 2: Comparison between both groups regarding items of Reaction behaviour.

Reaction behaviour	Mean ± SD		Mann-Whitney U	*P*-value	Sig.
	Normal Group N = 20	Cervical Radiculopathy Group N = 44			
No. rel./irrel. Stimuli	0.495±0.436	0.55±0.373	450	0.883	NS
No. errors react. Time	0.3±0.657	3.3±7.69	217	**0.001**	**S**
No. errors no react.	0±0	0.16±0.68	410	0.235	NS
No. errors incor. React.	0.6±0.94	2.11±3.07	297	**0.028**	**S**
No. total errors	0.9±1.165	5.59±7.753	161	**0.000**	**S**
correct reactions	97.6±2.72	84.45±16.8	156	**0.000**	**S**
No. react. Interstim.	0.2±0.41	0.8±1.9	414	0.602	NS
Quartil1 React. Time1	477.30±184.171	570.07±242.73	396	0.523	NS
Median react. Time	524.90±195.988	698.95±334.783	357	0.229	NS
Quartil3 React. Time3	603.60±222.157	883.52±508.469	348	0.182	NS

NS: non significant S: significant

Attention and concentration

Attention and concentration domain including 6 outcomes; number of trials, Diff. errors, Time error, Maximum, median and minimum reaction time. The descriptive statistics were illustrated in Table 3. The results of Mann-Whitney The test indicated no significant changes in attention and concentration between normal individuals and patients with cervical radiculopathy across all assessed items (Table 3).

Table 3: Comparison between both groups regarding items of attention and concentration.

Attention and concentration	Mean ± SD		Mann-Whitney U	*P*-value	Sig.
	Normal Group N = 20	Cervical Radiculopathy Group N = 44			
No. of trials	13.10 ± 5.812	14.64 ± 7.806	385	0.424	NS
Diff. error	0.70 ± 1.031	2 ± 3.192	328	0.085	NS
Time error	0 ± 0	0 ± 0	440	1.000	NS
Max. React. Time	11822.40±14614.832	12886.55 10598.865	368	0.297	NS
Median React. Time	4267.70±2230.524	4,927.91±3865.502	410	0.664	NS
Min. React. Time	3377.80 ± 4,415.741	2836.77±4696.620	438	0.977	NS

NS: non significant

Correlation between cervical pain and reaction behavior and attention-concentration in patients group:

A moderate positive connection was seen between pain intensity and the number of errors in reaction time (r=0.336, p=0.026), total errors (r=0.386, p=0.010), and reaction inter-stimulation (r=0.376, p=0.012). Conversely, a substantial negative connection exists between pain severity and accurate responses (r=0.497, p=0.001). No substantial association was observed between pain intensity and reaction behavior (Table 4).

Table 4: Correlation between cervical pain and Reaction behavior and Attention in patients group.

Reaction behaviour		
	r	*p*-value
No. rel./irrel. stimuli	-0.120	0.439
No. errors react. Time	.336*	0.026
No. errors no react.	-0.137	0.374
No. errors incor. React.	0.087	0.574
No. total errors	.386**	0.010
correct reactions	-.497**	0.001
No. react. Interstim.	.376*	0.012
Quartil1 React. Time1	0.139	0.367
median react. Time	0.225	0.143
Quartil3 React. Time3	0.239	0.118
Attention		
	R	*p*-value
No. of trials	-0.116	0.453
Diff. error	-0.035	0.821
Max. React. Time	-0.148	0.337
Median react. Time	0.119	0.443
Min. react. Time	0.160	0.299

4. DISCUSSION

This study was conducted to investigate the impact of cervical radiculopathic pain on reaction behavior, attention and concentration. Reaction behavior, attention and concentration were evaluated by using Rehacom software in healthy and patients with cervical radiculopathy.

The environment, significance of the pain, and the individual's psychological condition all influence the complex sensory and emotional experience of pain, which can differ significantly between people and even within the same person. All patients presenting with CR experience some form of pain, which could be radicular somatic referred pain[16].

Chronic pain and related mental health issues are well documented in cases of low back pain[17,18,19]. As many as 20% of individuals with spinal pain, encompassing cervical discomfort with and without radiculopathy, may exhibit symptoms related to melancholy and anxiety[20,21]. Cervical radiculopathy, characterized by pain and incapacity, restricts an individual's engagement in social activities and professional life, so adversely affecting overall quality of life[22].

The findings of our study indicated a significant disparity between healthy controls and patients with cervical radiculopathy regarding the number of errors with no reaction ($p = 0.001$), the number of errors with incorrect reactions ($p = 0.028$), the total number of errors ($p < 0.001$), and the number of correct reactions ($p < 0.001$). On the other hand, there was no significant differences between in the other items related to reaction behavior. These results might be as the vast majority of reaction behaviors showed non-significant difference between both groups.

There was no previous study explained factors affecting reaction behaviors between different subjects in different situations and occasions, so further studies should be applied on this point, also the effect of different types of pain on reactions behavior.

Conversely, our study's findings indicated no significant differences in attention and concentration between normal people and patients with cervical radiculopathy across all assessed items. A possible explanation for our results is that chronic pain

in our population was not so severe to distract attention and concentration.

In contrast, a number of studies show that people with chronic pain have significant deficits in working memory and selective and sustained attention. Selective attention, or the ability to focus on one stimulus while ignoring competing inputs, is impaired in people with fibromyalgia and rheumatoid arthritis [25,26].

In comparison to healthy controls, patients with various chronic pain syndromes showed a modest effect size for reduced working memory, which is frequently seen as a more complicated type of attention, according to a review and meta-analysis of 24 observational studies[27]. The majority (20) of the 22 studies that looked at attention reported impairments in people who had chronic pain, and 15 of them included a control condition. These studies' findings, which cover a variety of pain conditions, including fibromyalgia, rheumatoid arthritis, diabetic neuropathic pain, chronic whiplash associated disorder (WAD), chronic musculoskeletal disorders, and low back pain, imply that chronic pain may impair performance on tasks requiring attention.

In conclusion, pain might differently affect reactions behaviors, attention and concentration in patients with cervical radiculopathy.

5. CONFLICTS OF INTEREST

The authors have no financial conflicts of interest.

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None

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