Effects of Virtual Reality Rehabilitation on Pain and Disability in Cervical Radiculopathy among Computer Users - A Quasi-Experimental Study

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Abstract:

Background: Cervical Radiculopathy (CR) is a condition resulting from the compression or irritation of a nerve in the cervical spine, usually due to degenerative changes or disc herniation. The condition is characterized by pain extending into the arms, along with weakness, numbness, and disability. Conservative treatments include physical therapy, non-steroidal anti-inflammatory medicines (NSAIDs), epidural steroid injections, and, in extreme situations, surgery. Virtual reality is an emerging technology that has demonstrated promise as a treatment method for several musculoskeletal conditions, including chronic neck pain. This study aims to assess the effects of virtual reality rehabilitation on pain and disability in cervical radiculopathy among computer users.

Objective: To determine the effects of virtual reality rehabilitation on pain and disability in cervical radiculopathy among computer users.

Methodology: This study was a quasi-experimental study design, and a non-probability convenience sampling technique was used. A total of 40 participants were included in this study. Participants with age of 18-60 years, both genders with cervical radiculopathy diagnosed and confirmed by clinical assessment and imaging studies (MRI or CT) showing compression of cervical nerve roots (C5, C6, or C7) with symptoms of neck pain, radiating arm pain, numbness, or weakness were included in the study. The NDI assessed the degree of disability resulting from cervical radiculopathy on daily activities. The NPRS was used to assess the pain intensity level before and after treatment. Data was collected at only two clinical settings in Lahore, Pakistan. Participants who met the inclusion and exclusion criteria were included in this study who gave written consent. The study was done in 6 months, and data was assessed before and after treatment of 6 weeks. The data was analyzed by using SPSS, version 25.

Results: There were 40 participants with a mean age of 35$\pm$7.85. There were 21 males and 19 females included in this study; 30 were married, and 10 were unmarried. The majority of participants worked a maximum of 8 hours a day, and the maximum participants had work experience of 3 years. There were 17 participants with moderate and 23 with severe levels of pain intensity at the baseline. The Shapiro-Wilk test results for neck pain and disability were 0.000 and 0.188, respectively. The Wilcoxon signed rank test p-value for comparing pre-post NPRS values was less than 0.05, indicating changes that were highly statistically significant. The paired sample t-test p-value for comparing pre-post values of NDI was likewise less than 0.05, demonstrating highly statistically significant changes over time and suggesting potential effects of VR on pain and disability in individuals with cervical radiculopathy.

Conclusion: It is concluded that virtual reality rehabilitation has significant effects on reducing pain and improving the disability in cervical radiculopathy among computer users. The interactive nature of VR encourages active participation, which may lead to better adherence to rehabilitation protocols compared to traditional methods.

Key words: Cervical radiculopathy, disability, pain, virtual reality

Introduction:

Cervical Radiculopathy (CR) is a condition resulting from the compression or irritation of a nerve in the cervical spine, usually due to degenerative changes or disc herniation. The condition is characterized by pain extending into the arms, along with weakness, numbness, and disability (1).

Cervical radiculopathy is frequently associated with neck strain, repetitive motion, and bad posture, all of which are common among computer users who frequently maintain still positions for extended periods. Because they spend so much time with their necks flexed or rotated, people who work in occupations that require prolonged neck positioning, such as office workers, IT professionals, and gamers, are especially vulnerable to developing CR (2).

Patients with cervical radiculopathy experience pain, stiffness, and limited range of motion in their necks, making it difficult for them to perform work-related tasks like typing, reading, or using a computer mouse, or even just sit comfortably at a computer. These limitations can lead to disability in both professional and everyday activities, such as doing housework or participating in recreational activities. These symptoms not only impair physical health but also contribute to emotional distress, such as depression and anxiety, which makes rehabilitation even more difficult. Disability in this context includes both functional limitations in performing work-related tasks and social or personal activities, all of which negatively impact quality of life (3).

Conservative treatments include physical therapy, non-steroidal anti-inflammatory medicines (NSAIDs), epidural steroid injections, and, in extreme situations, surgery are usually used to treat cervical radiculopathy. The goals of physical therapy are frequently to strengthen the muscles that support the neck, increase cervical spine movement, and improve posture. These conventional therapies, however, might not always offer enough alleviation, especially for those with persistent or chronic difficulties. As a result, more cutting-edge treatments are being investigated, such as virtual reality (VR) (4).

Virtual reality is an emerging technology that has demonstrated promise as a treatment method for several musculoskeletal conditions, including chronic neck pain, in recent years. Virtual reality (VR) is an immersive technology that may engage people in virtual settings by simulating sensory experiences like visual, auditory, and tactile sensations. VR has gained interest as an alternative treatment for chronic pain management and physical rehabilitation. Research has indicated that VR can be a useful tool for pain management by involving patients in motor rehabilitation activities and distraction strategies (5).

The effectiveness of VR in lowering pain in a variety of musculoskeletal conditions is the subject of another study. Virtual reality can assist patients with cervical radiculopathy by diverting their attention from their suffering by immersing them in virtual environments. Researchers investigated the impact of virtual reality on the management of chronic pain in musculoskeletal patients in a 2022 study. Patients reported feeling less pain during VR sessions, suggesting that distraction was one of the primary causes (6).

Cervical radiculopathy-related disability influences several aspects of everyday life, especially for computer users who spend a lot of time using their upper bodies. By encouraging active rehabilitation through modified physical training sessions, ergonomic adjustments, and cognitive retraining, virtual reality has the potential to improve functional results. VR enables individualized and dynamic therapy that may adjust to the patient's progress and issues, in contrast to standard rehabilitation techniques that may be inactive and repetitive (7).

A study investigated VR rehabilitation for people with musculoskeletal disorders and chronic pain. According to this research, VR-based activities improved neuroplasticity, which in turn stimulated the brain to restructure and create new neural connections that facilitate mobility and pain management. VR rehabilitation can be a promising

treatment option for diseases like cervical radiculopathy because it has been linked to increases in strength and range of motion, leading to a good quality of life (8).

Patients with cervical radiculopathy may also benefit from VR in terms of motor learning and sensory integration. With visual and aural feedback to reinforce proper motion patterns, exercises in a virtual reality setting can help patients to complete movements that might otherwise be unpleasant or challenging. This is particularly helpful in treating problems with restricted neck strength, mobility, and coordination, which are prevalent among computer users with CR (9).

Research on the impact of virtual reality (VR) therapy, specifically on cervical radiculopathy (CR), was noticeably lacking, particularly for computer users who are more susceptible because of prolonged bad posture and repeated strain. Although virtual reality has been researched for pain treatment and rehabilitation in a variety of musculoskeletal illnesses, its use in CR is still somewhat unexplored, especially when computer users are present in real-world situations. This quasi-experimental study aims to determine the feasibility and efficacy of VR therapy by examining its effects on pain intensity and disability in computer-using people suffering from cervical radiculopathy.

Methodology:

This study was a quasi-experimental study design, i.e., a single-group pre-post intervention design to evaluate the effectiveness of virtual reality (VR) on pain and disability in individuals with cervical radiculopathy (CR) among computer users. The subjects acted as their controls, and baseline measurements were obtained before the intervention and six weeks later for post-treatment evaluations. A total of 40 participants were included in this study (38 from a prior study with a 10% attrition rate, making 42, but 2 participants dropped out, therefore, 40 were considered for final data analysis) (6). The study lasted for six months. The NPRS (Numerical Pain Rating Scale) was used to assess the pain intensity levels before and after treatment. On a scale of 0 (no pain) to 10 (worst pain possible), participants scored how much pain they were experiencing. The NDI (Neck Disability Index) assessed the degree of disability resulting from cervical radiculopathy on daily activities. This 10-item survey assesses social activities, neck mobility, discomfort, work performance, and sleep quality. Higher scores denoted greater disability. Each item was evaluated from 0 (no difficulty) to 5 (severe difficulty). Non probability convenience sampling technique was used. Only two clinical settings, the Bashir Medical and Kidney Centre and the Ayesha Poly Clinic in Lahore, Pakistan, were used for this study. Participants with age of 18-60 years, both male and female genders with Cervical Radiculopathy diagnosed and confirmed by clinical assessment and imaging studies (MRI or CT) showing compression of cervical nerve roots (C5, C6, or C7) with symptoms of neck pain, radiating arm pain, numbness, or weakness were included in the study. For eligibility, participants had to have used computers for work, study, or leisure purposes for at least four hours every day for the previous six months, have a pain intensity score of at least four on the Numerical Pain Rating Scale (moderate pain), and have consented to take part in the study and adhere to treatment guidelines. Participants with acute cervical injuries or severe neurological deficits (e.g., motor paralysis, severe weakness, or loss of sensory function), with severe co-morbidities (e.g., uncontrolled diabetes, cardiovascular conditions, autoimmune diseases) that may interfere with participation in physical activities or VR sessions, with psychiatric conditions (e.g., major depression, schizophrenia) that may affect their ability to participate, having any history of previous cervical spine surgery or spinal fusion or Pregnant female, any currently use of medication that may significantly alter pain perception (e.g., opioids) and systemic disorders (e.g., active cancer, systemic infections) were excluded. Participants were included after giving written consent. Data was taken before the start of treatment and at the end of the last session after 6 weeks. The data was analyzed by using SPSS for Windows software, version 25. Statistical significance was set at $P = 0.05$. For descriptive statistics, frequency tables were used to show the summary of measurements

over time. Normality was checked by the Shapiro-Wilk test, and for the variables whose value was less than 0.05, the non-parametric test, the Wilcoxon Signed Ranks Test, was used to show the progress in pre and post-test. For the variables whose value was more than 0.05, the parametric test, the paired sample t-test, was used to show the progress in pre and post-test.

Treatment Protocol:

Frequency: 3 sessions per week for 6 weeks (18 sessions), lasting for 30 minutes.

Device: Xbox Kinect 360

Safety Considerations: The exercises were done under the supervision of an experienced physical therapist who monitored the session to ensure proper posture and technique.

Games:

For Pain Management (Relaxation and Distraction):

"Kinect Adventures" (Rallyball): Although primarily an action-based game, the activities in Kinect Adventures allow for low-impact aerobic activity that can also engage the arms, shoulders, and neck in a playful, stress-reducing environment.

Objective: Reduce pain perception through cognitive distraction, promoting engagement in an activity that reduces stress and provides relief from the focus on pain.

Duration: 10 minutes per session.

For Mobility and Range of Motion (Cervical Spine Movement) and Postural Training and Ergonomics (For Computer Use):

"Kinect Sports: Season Two" (Tennis): These sports-based games provide dynamic movements that involve upper body rotations, reaching, and bending. In tennis and golf, the movements can be modified to engage the cervical spine for gentle rotation, extension, and flexion.

Objectives: Increase cervical spine flexibility and ROM by encouraging neck movements in various directions (flexion, extension, rotation, lateral bending).

Improve posture and body alignment, particularly for those spending long hours working at a computer, to prevent exacerbation of cervical radiculopathy symptoms.

Duration: 10 minutes per session.

For Strengthening and Endurance (Neck and Upper Back Muscles):

"Kinect Sports" (Bowling): These sports-based games involve movements that engage the shoulders, arms, and upper back. In football, the player needs to make certain reaching and twisting movements that can engage the neck and upper back muscles. Bowling involves shoulder rotation and upper back strength, which can be useful for strengthening these areas.

Objective: Strengthen the cervical spine support muscles and improve endurance to reduce the strain on the neck.

Duration: 10 minutes per session.

Results:

Table 1A shows the demographic data that there were total 40 participants in this study having mean age in years was 35±7.85 with minimum age 23 and maximum age 48. Weight (in Kgs), working hours, and duration of job of participants were 72±14.17 (minimum: 44, maximum: 99), 6±1.46 (minimum: 4, maximum: 9), and 3±1.57 (minimum: 1, maximum: 8), respectively.

Table 1A: Demographic Data

Demographic Data				
	Age in Years	**Weight in Kg**	**Working Hours**	**Duration of Job**
Mean	35	72	6	3
Std. Deviation	7.85	14.17	1.46	1.57
Minimum	23	44	4	1
Maximum	48	99	9	8

Table 1B shows other variables demographic information that both genders (21 males and 19 females) included in this study, in which 30 were married and 10 were unmarried. Maximum participants worked for 8 hours and least participants worked for 4 hours in a day and maximum participants had work experience of 3 years. While no participant had mild pain but 17 had moderate and 23 had severe level of pain intensity at the baseline.

Table 1B: Demographic Data

Variables		**Frequency**	**Percent**
Gender	Male	21	52.5
	Female	19	47.5
Marital Status	Married	30	75.0
	Unmarried	10	25.0
Working Hours	4.00	3	7.5
	5.00	5	12.5
	6.00	10	25.0
	7.00	6	15.0
	8.00	12	30.0
	9.00	4	10.0
Duration of Job	1.00	2	5.0
	2.00	9	22.5
	3.00	10	25.0
	4.00	9	22.5
	5.00	6	15.0
	6.00	2	5.0
	7.00	1	2.5
	8.00	1	2.5
Pain Intensity	Mild	0	0
	Moderate	17	42.5
	Severe	23	57.5
	Total	40	100.0

A parametric test was used to check changes over time within a group (pre-post values), and a non-parametric test was used to check changes over time within a group (pre-post values). Table 2 demonstrates that the Shapiro-Wilk test was used to check the normality of the data, which included 40 participants and values of 0.188 for NDI (neck disability), which is more than 0.05, indicating that the data was normally distributed. So, a paired sample t-test was used. However, 0.000 for NPRS (neck pain), which is less than 0.05, indicating that the data was not normally distributed. So, the Wilcoxon signed rank test was used.

Table 2: Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Score of Neck Disability (NDI) Pre-test	.961	40	.188
Neck Pain (NPRS) Pre-Test	.865	40	.000

Table 3A shows the values of the Wilcoxon signed rank test to check the changes over time due to treatment for 6 weeks. A p-value less than 0.05 means it is highly statistically significant, and by comparing pre and post-values of NPRS, there was a huge change in the pain intensity of participants receiving virtual reality rehabilitation.

Table 3A: Wilcoxon Signed Ranks Test

	N	Median	Inter quartile Range	Minimum	Maximum	Z	Asymp. Sig. (2-tailed)
Neck Pain (NPRS) Pre-Test	40	6.00	1.00	5.00	8.00	-5.609	.000
Neck Pain (NPRS) Post-Test	40	2.00	0.00	1.00	4.00		

Table 3B shows the values of the paired sample t-test to check the changes over time due to treatment for 6 weeks. A p-value less than 0.05 means it is highly statistically significant, and by comparing pre and post-values of NDI, there was a huge change in the neck disability of participants receiving virtual reality rehabilitation.

Table 3B: Paired Samples t-test:

	Mean	N	Std. Deviation	df	Sig. (2-tailed)
Score of Neck Disability (NDI) Pre-test	24.1250	40	3.56038	39	0.000
Score of Neck Disability (NDI) Post-Test	12.7250	40	2.48057		

Discussion:

In the current study, 40 participants had a mean age in years, weight (in Kgs), working hours, and duration of job were 35±7.85, 72±14.17, 6±1.46, and 3±1.57 respectively. There were 21 males and 19 females included in this study; 30 were married, and 10 were unmarried. The majority of participants worked a maximum of 8 hours; the least participants worked for 4 hours in a day, and the maximum participants had work experience of 3 years. While no participant had mild pain, 17 had moderate, and 23 had severe levels of pain intensity at the baseline. Shapiro-Wilk test was used to check the normality of the data, and the values were 0.188 for NDI (neck disability) and 0.000 for NPRS (neck pain). For comparing pre and post-values of NPRS in the Wilcoxon signed rank test, a p-value less than 0.05 indicates highly statistically significant changes. For comparing pre and post-values of NDI, in a paired sample t-test, a p-value less than 0.05 shows highly statistically significant changes over time, suggesting potential effects of VR on pain and disability in cervical radiculopathy patients.

The potential of virtual reality for reducing pain in a variety of conditions, such as acute injury pain, phantom limb pain, and chronic musculoskeletal pain, has been thoroughly investigated. Virtual reality's impact on pain treatment in cervical radiculopathy has been the subject of recent research. According to Jensen et al. (2020), VR-based therapies considerably decreased the severity of pain in people with chronic neck pain, which is a frequent symptom of CR. Similarly, Moseley et al. (2019) found that VR therapies that encouraged distraction and relaxation resulted in less severe pain. The findings from the current study, showing a p-value of 0.000 for pain

reduction (NPRS), align with the findings of these previous studies. One of the most important outcomes of cervical radiculopathy is the reduction of pain, which frequently interferes with day-to-day activities, particularly for computer users who spend a lot of time in static postures (6), (10).

A study conducted by Tariq et al. (2019) found that VR-based rehabilitation significantly improved functional outcomes and disability levels in individuals with chronic neck pain. This supports the current study's findings that VR can improve functional capacities and lessen disability related to cervical radiculopathy, as evidenced by the significant improvement in NDI scores (p-value 0.000) (11).

Additionally, Kumar et al. (2021) carried out a pilot study to examine the benefits of VR for CR and concluded that VR could enhance mobility, lessen neck impairment, and boost patients' involvement in therapy, especially when combined with physical therapy exercises. This implies encouraging results, which could improve patient motivation and commitment to rehabilitation exercises. The results of the current investigation are supported by these findings that VR can improve pain and disability in CR.

Previous research suggests that VR therapies might not always lead to such consistent outcomes in contrast to the current trial, which reveals considerable improvements in both pain and disability. A study by Patel et al. (2018) found that the effectiveness of VR is influenced by several factors, such as the type of VR intervention being used, the length of the intervention, and the specific characteristics of the patient population (12).

Conclusion:

The current study's findings, with significant improvements in both pain (NPRS) and disability (NDI) in individuals with cervical radiculopathy, contribute valuable evidence supporting the use of VR as an effective intervention for this condition. So, it is concluded that virtual reality rehabilitation has significant effects on alleviating pain and improving the disability in cervical radiculopathy among computer users. The interactive nature of VR encourages active participation, which may lead to better adherence to rehabilitation protocols compared to traditional methods.

Limitations:

Due to the lack of articles having VR effects on cervical radiculopathy, the current study has some limitations. There was no comparative group, no randomization, no long-term follow-ups, and only one study group with a limited sample size.

Recommendations:

It is advised that to observe long-term follow-up effects, future researchers use randomization with a bigger sample size and incorporate comparator groups. Although participants' mood and anxiety levels improved in the current trial, these changes were not primary outcomes and were not assessed. It is advised that these results be included in future investigations.

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