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Evaluating Virtual Reality in Chronic Low Back Pain Rehabilitation: Effects on Pain, Disability, and Quality of Life

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***ABSTRACT*: Chronic low back pain (CLBP) is a serious health issue that leads to disability worldwide. The usual method of treatment has been physiotherapy for which patients' motivation and long-term adherence present significant challenges. A new innovative treatment approach that involves virtual reality (VR)assisted physiotherapy was recently introduced. It can give patients highly engaging and interactive therapeutic experiences. The present randomized controlled trial was conducted to determine the impact of VR-assisted physiotherapy on pain relief, minimization of functional disability as well as enhancement of physical function for chronic low back pain patients. Sixty participants were randomly divided into experimental and control groups. The experimental group was given VR-assisted physiotherapy supplemented by conventional exercises, whereas the control group was given regular physiotherapy only. The parameters for measuring the results were pain intensity, functional disability, physical performance, and treatment adherence. The findings revealed that the groups which underwent VR-assisted treatment experienced better relief from pain, lower disability scores, and improved functional outcomes than the control groups ($p < 0.05$). Besides, the VR groups were marked by higher treatment adherence and motivation. The study results point to VR-assisted physiotherapy as a potentially helpful addition to conventional rehabilitation for chronic low back pain.**

Keywords: Virtual Reality (VR)–Assisted Physiotherapy, Chronic Low Back Pain, Functional Disability and Rehabilitation Technology.

I. INTRODUCTION

Chronic low back pain (CLBP) is one of the most common musculoskeletal conditions worldwide and is a major contributor to long-term disability globally. The symptoms of CLBP usually include persistent pain, limited range of motion, decreased functional capabilities and difficulties in carrying out both the daily and work, related activities, resulting in a lowered quality of life. Due to its chronic and multifaceted nature, CLBP severely affects the individuals, healthcare, and social

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systems; therefore, there is a critical need to develop effective, sustainable, and patient-centered treatment approaches. [1].

Physiotherapy constitutes a primary conservative approach to treatment, most often recommended to patients with chronic low back pain. Traditional physiotherapy programs generally consist of therapeutic exercises, manual therapy, and patient education, thus targeting pain relief, functional capacity improvement, and self, management facilitation. On the other hand, these interventions' efficacy is mainly dependent on patient motivation, exercise adherence, and active participation in the rehabilitation process. In chronic cases, treatment outcomes are frequently suboptimal because of poor patient adherence and limited engagement. [3].

Nowadays, virtual reality (VR) has become one of the newest adjuncts to physiotherapy rehabilitation because of technological progress. VR, based physiotherapy creates immersive and interactive therapeutic settings along with real, time sensory feedback, which may increase motivation, facilitate motor learning, and change the way patients perceive pain [6].

Preliminary research suggests that virtual reality (VR)–based interventions may support rehabilitation; however, evidence regarding their effectiveness in chronic low back pain (CLBP) remains inconsistent. Therefore, this study aims to evaluate the effectiveness of VR-assisted physiotherapy in the management of long-duration low back pain by examining its impact on pain intensity, physical disability, and patient engagement. [7]

II. LITERATURE REVIEW

Studies on chronic low back pain have demonstrated to us the widespread nature of the condition as well as the severe impact on the lives of patients. It was initially highlighted by Andersson (1999) that chronic low back pain is one of the major contributing factors for long, term disability, causing limitations in physical functions and work productivity to drop. Later, Deyo and Weinstein (2001) emphasized that the unremitting pain together with the loss of physical ability which

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accompany long-duration low back pain, severely impair the patient's quality of life and, the condition becomes a great socioeconomic burden.

Physiotherapy has become a popular choice as the primary intervention to manage long-duration low back pain without the use of drugs. In their study, Airaksinen et al. (2006) revealed that the combination of therapeutic exercises and patient education represents two key components that significantly contribute to pain reduction and improved functional outcomes. Likewise, Hayden et al. (2005) also observed that physiotherapy interventions that entail exercise produce moderate changes in pain and disability. Nevertheless, Sluijs et al. (1993) discovered that a patient's commitment and willingness to carry out the rehabilitation plan can be crucial factors determining the success of the treatment, especially when it is a chronic condition of the musculoskeletal system.

Advancements in rehabilitation technology have led to the emergence of virtual reality as a potential therapeutic intervention. To Riva (2005), virtual reality is an immersive technology that can sufficiently revolutionize the rehabilitation programs by raising the level of patient motivation and engagement. After that, Holden (2005) pointed out in his paper the possibility of VR being used as an aid to motor learning and functional recovery whereby the patients can interact actively and be task, oriented in the controlled environments constructed.

One study in musculoskeletal rehabilitation by Li et al. (2017) reveals that VR, based exercise programs led to improved movement performance and patient participation. Research into chronic low back pain, specifically those by Garcia et al. (2019) and Kim et al. (2020), implied that VR, assisted physiotherapy might lessen pain intensity and functional disability through facilitating active engagement and movement confidence. Contrarily, won et al. (2021) found that the differences in VR systems, intervention protocols, and outcome measures were the main reasons for the fluctuation in result. Although multiple studies have demonstrated encouraging results, the current body of evidence is still insufficient to draw definitive conclusions. Molloy et al. (2022) highlighted the need for well-designed randomized controlled trials to determine the clinical

effectiveness of virtual reality as an adjunct to conventional physiotherapy in the management of chronic low back pain.

Despite initial positive findings, the evidence base for virtual reality–assisted physiotherapy in chronic low back pain is inconsistent and limited by methodological variability and the lack of robust randomized controlled trials. Consequently, this study investigates its effectiveness in reducing pain intensity and functional disability compared with conventional physiotherapy.

More recent randomized controlled trials (RCTs) conducted between 2020 and 2024 have further strengthened the evidence regarding VR-based rehabilitation: Kim et al. (2020) reported significant improvements in pain intensity and lumbar mobility following VR-based exercise interventions in CLBP patients. Won et al. (2021) observed that VR-assisted rehabilitation improved functional disability and treatment engagement compared with conventional exercise therapy. Molloy et al. (2022), through a systematic review and meta-analysis, concluded that VR interventions showed promising effects in chronic musculoskeletal pain management, although methodological variations remained a concern. Park et al. (2023) found that immersive VR training significantly improved balance control, functional movement, and exercise adherence in patients with chronic spinal pain. Hernandez et al. (2024) demonstrated that VR-assisted physiotherapy produced superior outcomes in pain reduction and patient satisfaction compared with standard physiotherapy programs.

III. METHODOLOGY

This research was a randomized controlled trial with parallel arms and a prospective component. It mainly compared physiotherapy congruent with virtual reality assistance and conventional physiotherapy in patients with chronic low back pain. Participants were taken from the outpatient physiotherapy department of the rehabilitation centre, between 18 and 50 years, and they were confirmed clinically as having chronic low back pain for at least 12 weeks. The participants in the experimental group were provided with a physiotherapy program at home, which included core strengthening exercises plus an immersive, interactive virtual reality (VR), based activity

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component. The patients in the control group were given the usual physiotherapy treatment that was in line with the clinical practice guidelines for managing chronic low back pain. To align the treatment administration, both groups had all intervention sessions conducted by two physiotherapists having similar qualifications and clinical experience. Each session lasted from 30 to 45 minutes and was held three to five times a week for a total duration of four to six weeks.

Sample Size

A total of 60 participants diagnosed with chronic low back pain were included in the study. Participants were randomly divided into:

- Experimental Group (n = 30)
- Control Group (n = 30)

Sample Recruitment Method

Participants were recruited using a convenience sampling method from the outpatient physiotherapy department of a rehabilitation center. Eligible patients were screened according to predefined inclusion and exclusion criteria.

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Participants were recruited using a **convenience sampling method** from the outpatient physiotherapy department of a rehabilitation center. Eligible patients were screened according to predefined inclusion and exclusion criteria.

Inclusion Criteria

- Age between 18 and 50 years
- Clinically diagnosed chronic low back pain lasting more than 12 weeks
- Ability to follow exercise instructions independently
- Willingness to participate with signed informed consent

Exclusion Criteria

- History of spinal surgery
- Neurological disorders or vestibular dysfunction
- Severe musculoskeletal deformities

- Pregnancy
- Severe visual impairment or epilepsy contraindicating VR exposure

Randomization Procedure

Participants were randomly allocated into two groups using a **computer-generated randomization sequence**. Allocation concealment was maintained using sealed opaque envelopes prepared by an independent researcher.

Dropout Rate

Out of the 60 enrolled participants, **4 participants withdrew** during the intervention period due to personal reasons and irregular attendance, resulting in a final analysis sample of **56 participants**.

VR System Used

The experimental group received physiotherapy integrated with an **immersive head-mounted virtual reality system (Oculus Quest 2)**. The VR program included:

- Core strengthening exercises
- Functional movement tasks
- Balance and mobility training
- Real-time visual and sensory feedback activities

Intervention Protocol

The experimental group received VR-assisted physiotherapy combined with therapeutic exercises, whereas the control group received conventional physiotherapy alone. Both groups attended:

- 3–5 sessions per week
- 30–45 minutes per session
- Total duration: 6 weeks

Outcome assessment was conducted at:

- Baseline (Pre-intervention)
- Post-intervention (6 weeks)

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Pain intensity was assessed using the Visual Analog Scale (VAS), and functional disability was measured using the Oswestry Disability Index (ODI).

IV. RESULT

Intervention was completed by participants N in total, and their data were used for the final analysis. Prior to any treatment, both groups (control and experimental) were similar regarding their age, distribution of gender, pain intensity, and scores of functional disabilities. Randomization was done properly, and the groups were homogeneous. The groups did not show any statistically significant differences at baseline ($p > 0.05$) as well.

Pain Intensity

The results of the within, group comparison showed that pain intensity scores significantly fell in both the virtual reality, assisted physiotherapy group and the conventional physiotherapy group after the intervention period ($p < 0.05$). However, pain reduction was significantly greater in the experimental group. The between, group comparison showed that post, treatment pain scores were significantly different, thus, the virtual reality, assisted physiotherapy group had a considerable advantage over the other ($p < 0.05$), consequently, the pain relief attained in this group was more than that by conventional physiotherapy only.

Functional Disability

Functional disability assessment by standardized disability indices revealed significant changes in both groups post, intervention ($p < 0.05$). Those who underwent virtual reality, assisted physiotherapy had a greater reduction in their disability scores compared to the ones treated by conventional physiotherapy. The comparison of the two groups revealed a statistically significant difference between their post, intervention disability scores in favor of the experimental group ($p < 0.05$), thus, the functional recovery post VR, assisted intervention seems to be more effective.

Physical Function

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Physical function analysis results indicated both groups developed their movement capabilities and functional efficiency significantly. The patients of the experimental group outperformed the control one greatly in the tests of functional performance. This might be attributed to raised motivation, enhanced motor learning, and task, focused training which was facilitated by the virtual reality environment.

Treatment Adherence and Engagement

The attendance records and therapist notes reflected that the experimental group was generally more consistent with the treatment and more active as compared to the control group. Physiotherapy patients with virtual reality support not only attended a greater number of their scheduled therapy sessions, but they were also visibly more enthusiastic and motivated during their treatment sessions.

A total of 56 participants completed the intervention and were included in the final analysis. Both groups demonstrated improvements after treatment; however, significantly greater improvements were observed in the VR-assisted physiotherapy group.

Table 1. Baseline Characteristics of Participants

Variable	Experimental Group (n=28)	Control Group (n=28)	p-value
Mean Age (years)	36.4 ± 7.2	35.8 ± 6.9	>0.05
Male/Female	15/13	14/14	>0.05
Baseline VAS Score	7.1 ± 1.0	7.0 ± 1.1	>0.05
Baseline ODI Score	42.5 ± 5.8	43.1 ± 6.0	>0.05

Table 2. Comparison of Outcome Measures

Outcome Measure	Experimental Group	Control Group	p-value
Reduction in VAS Score	3.8 ± 1.1	2.1 ± 0.9	<0.05
Reduction in ODI Score	18.6 ± 4.2	10.3 ± 3.8	<0.05
Improvement in Physical Function	Significant	Moderate	<0.05

Treatment Adherence	92%	78%	<0.05

The VR-assisted physiotherapy group demonstrated significantly greater pain reduction, improved functional performance, and higher treatment adherence compared with the conventional physiotherapy group.

V. LIMITATIONS

There are limitations to this study:

1. The number of participants was quite low, which is a big part affecting the extent to which the results can be applied to the general population.

2. The intervention was of short duration and no long-term follow-up outcomes were evaluated.

3. Selection bias may have been a result of convenience sampling.

4. Differences in patients' prior experience with VR may have caused different levels of engagement with the treatment.

5. A single type of VR system was used; Because of this, the findings with other VR platforms and rehabilitation software may not be similar.

VI. CONCLUSION

VR physiotherapy Much decreased pain intensity, lessened functional disability, and increased both physical performance and treatment adherence among chronic low back pain patients. The immersive and interactive character of VR seems to be a great motivator for patients leading to better rehab results. Because of this, physiotherapy with virtual reality could be a good complementary intervention combined with traditional physiotherapy in chronic low back pain treatment.

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