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SYNERGISTIC EFFECTS OF VIRTUAL REALITY-BASED REHABILITATION AND PHARMACOLOGICAL MANAGEMENT ON PAIN AND FUNCTION IN PATIENTS WITH KNEE OSTEOARTHRITIS: A NOVEL INTEGRATIVE APPROACH

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Abstract

Background:

A common degenerative joint disease, knee osteoarthritis (OA) is marked by persistent discomfort, decreased mobility, and a lower quality of life. Traditional pharmacological treatment, such as the use of analgesics and non-steroidal anti-inflammatory medications (NSAIDs), relieves symptoms but ignores functional restrictions. A promising supplementary therapy for increasing physical activity and encouraging neuromuscular engagement in a safe, stimulating setting is virtual reality (VR)-based rehabilitation.

Objective:

The purpose of this study is to evaluate the way pharmaceutical treatment and virtual reality-based rehabilitation work together to improve knee OA patients' functional abilities and reduce pain.

Methods:

Thirty people with grade 2 and grade 3 osteoarthritis of the knee were divided into two groups at random, with 15 participants each: Group A received pharmaceutical management, while Group B received pharmaceutical management combined with VR-based rehabilitation sessions. Low-Level Laser Therapy was also administered to both groups as a component of standard physical therapy. The Visual Analog Scale (VAS) for pain, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and range-of-motion evaluations will be used as outcome measures both before and after the intervention.

Outcome Measures:
WOMAC Questionnarie and VAS
Results
The Visual Analog Scale (VAS) scores indicated that both Group A (pharmacological management alone) and Group B (pharmacological management combined with virtual reality-based rehabilitation) were effective in reducing pain. However, Group B demonstrated greater improvement in pain reduction compared to Group A. In terms of functional improvement, assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and range of motion (ROM), Group B showed statistically significant improvement ($p < 0.05$) over Group A. Participants in Group B achieved faster gains in joint mobility and greater functional independence, indicating the added benefit of incorporating virtual reality-based rehabilitation alongside pharmacological treatment. These findings suggest that while both interventions were effective, the combination approach in Group B was more effective than Group A in improving both pain and functional outcomes, supporting the efficacy of a synergistic rehabilitation strategy for managing knee osteoarthritis.
Conclusion:
The combination of virtual reality-based rehabilitation with pharmacological management was more effective than pharmacological treatment alone in improving pain and functional outcomes in patients with knee osteoarthritis. This integrative approach enhances mobility and supports faster functional recovery**.**
Keywords: Knee Osteoarthritis, Virtual Reality Rehabilitation, Pharmacological Management, Pain Reduction, Functional ImprovementX

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INTRODUCTION:
Knee osteoarthritis (OA) ranks among the most prevalent degenerative joint diseases, especially impacting older adults. It is a long-term, advancing condition marked by the deterioration of cartilage, alterations in subchondral bone, the development of osteophytes, and differing levels of synovial inflammation (Hunter and Bierma-Zeinstra, 2019). Clinically, it presents with discomfort, stiffness in joints, swelling, grinding sensations, limited range of motion, and decreased functional ability (Sharma, 2021). The World Health Organization states that osteoarthritis is a primary source of disability globally and is linked to considerable individual, societal, and economic impacts (WHO, 2020). In India and various low- and middle-income nations, the occurrence is rising because of aging demographics, inactive lifestyles, and increasing obesity levels (Pal et al., 2016).
Conservative management is typically the first approach for individuals with mild to moderate OA. Included in this are pharmacological options such as nonsteroidal anti-inflammatory drugs

(NSAIDs), acetaminophen, and topical analgesics frequently used to reduce pain and inflammation (Hochberg et al., 2012). Though they may work well temporarily, pharmacological therapies do not address the mechanical and functional problems associated with OA and can lead to adverse effects, including gastrointestinal distress, kidney complications, and cardiovascular dangers, especially with extended use (Bjordal et al., 2004). As a result, healthcare practitioners are increasingly advocating for the incorporation of non-pharmaceutical methods as supplementary treatments.

Physical therapy continues to be a fundamental aspect of OA treatment, concentrating on alleviating pain, enhancing surrounding muscle strength, optimizing joint function, and fostering independence in daily activities (Fransen et al., 2015). Nevertheless, adherence of patients to conventional exercise regimens may be inadequate because of monotony, insufficient motivation, or anxiety about pain associated with movement. In this context, rehabilitation utilizing Virtual Reality (VR) has surfaced as an innovative therapeutic resource that provides an interactive and captivating platform for physical activity, especially appropriate for older adults or those with long-term musculoskeletal conditions (Li et al., 2016).

VR systems generate engaging environments where patients can execute purposeful movements, frequently within gamified or task-oriented situations, which activate neurocognitive and sensorimotor systems. This approach improves motor learning, facilitates movement by diverting attention from pain, and boosts compliance by enhancing enjoyment during therapy (Kim et al., 2017). Additionally, employing visual, auditory, and occasionally haptic feedback during VR interventions might enhance cortical reorganization and neuroplasticity, aiding in lasting functional improvements (Levac et al., 2015). Recent studies indicate that VR-based rehabilitation may result in significant enhancements in pain, balance, proprioception, gait, and psychological health for individuals with musculoskeletal disorders (de Vries et al., 2018).

Although the outcomes are promising, substantial research is lacking on the combined or synergistic effects of VR-based therapy alongside conventional pharmacological treatment in knee OA. Although medications target the biochemical and inflammatory aspects of OA, VR interventions might enhance neuromuscular control, functional mobility, and motivation. Combined, they could offer a biopsychosocial integrative method that is more efficient than either approach on its own.

This research introduces an innovative intervention model designed to assess the combined effects of virtual reality rehabilitation and medication management on pain and functionality in those with knee osteoarthritis. By evaluating results like pain severity and physical capability, the research aims to offer proof of the efficacy of a multimodal approach that targets both symptoms and structural-functional impairments. This method is consistent with contemporary rehabilitation values that prioritize comprehensive, patient-focused care, potentially leading to more interactive, efficient, and attainable rehabilitation approaches in clinical and community environments. The findings of this research may aid in the development of updated OA management guidelines and enhance the incorporation of cutting-edge digital health tools such as VR into standard physiotherapy practices. As technological accessibility grows and patients seek non-invasive alternatives, VR-based rehabilitation alongside medical therapy could signify the future of tailored musculoskeletal treatment.

METHODS

Study Design and Participants

A prospective, quasi-experimental study carried out at the Department of Physiotherapy, Apollo College of Physiotherapy, Government Hospital, Chittoor, spanning 10 weeks. Sixty elderly individuals (ages 60–75) diagnosed with bilateral knee osteoarthritis (Kellgren-Lawrence grade II–III) were enrolled. Participants were randomly allocated to the immersive VR intervention group (n=30) or the control group undergoing conventional physiotherapy (n=30).

Inclusion Criteria: Age between 60–75 years, diagnosed with bilateral knee OA (KL grade II–III), Able to walk independently, Willingness to participate in a structured rehabilitation program

Exclusion Criteria: History of knee surgery or replacement, Neurological or vestibular disorders, Severe visual impairment, Cognitive impairment (MMSE < 24)

Intervention Protocol: Group A received pharmacological treatment non-steroidal anti-inflammatory drugs (NSAIDs) and analgesics, under the supervision of a physician. No additional therapeutic modalities were administered to this group beyond the pharmacological approach. Group B received the same pharmacological treatment as Group A, in combination with virtual reality-based training. Low-level laser therapy (LLLT) is combined for both the groups . The VR training was conducted using the Oculus Rift S, a PC-powered immersive headset linked to a high-performance laptop. The application used was “Save the Jerry” (version vrpcv 10_0_3), Jeryy Costal saga developed for older adults with osteoarthritis.

Training modules included tilt-board balancing, walking trails, and lift the leg tasks aimed at enhancing proprioception and functional mobility. In virtual reality jerry costal saga and save the jerry game has game-based exercises of knee extension(sitting), Hip flexion, Hip abduction VR session lasted 30 minutes, conducted three times per week for four weeks for 2 months. The equipment was sanitized before each use, and the play area was calibrated according to manufacturer guidelines. Participants were provided with guided instructions and real-time feedback throughout the sessions to simulate functional tasks in a safe, engaging environment. In addition, low-level laser therapy was administered to both Group A and Group B with wavelength 808 cm and length 0.4 cm each point received energy 8 joules/point for 10 min, Duration with total dosage of 128 joules and width 0.4cm area 0.16 sq.cms with frequency 0.001 HZ , around the knee joint eight points are going to place the laser the medial and lateral epicondyle of the tibia and femur the medial and lateral epicondyle of the tibia and femur the medial and lateral knee joint gap, and the medial edge of the tendon of biceps femoris and semi tendinous muscle in the popliteal fossa as a complementary intervention. Laser parameters and application sites followed standard physiotherapy protocols for osteoarthritis. Both groups received care under standardized safety and ethical protocols throughout the intervention period.

OUTCOME MEASURES

The outcome measures used for this study as pre and post test pre at the start 1st week and post after the fourth week of the intervention. The following outcome measures were used:

Pain:

Measured using the Visual Analog Scale (VAS), a 10-centimeter horizontal line where

participants rated their pain intensity from 0 (no pain) to 10 (worst possible pain). It is a widely used, reliable tool for assessing subjective pain levels in musculoskeletal conditions.

Function:

Evaluated through the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). This validated survey assesses three areas: pain, stiffness, and physical function. Scores range from 0 to 96, with higher scores indicating greater disability.

Statistical Analysis

The data were analysed utilizing SPSS version 26.0. Descriptive statistics (mean ± SD) were employed for the demographic variables. Shapiro-Wilk test confirmed normality. A paired t-test was used for within-group comparisons (pre vs post), and an independent t-test for between-group comparisons. ANCOVA was applied to adjust for baseline differences. Statistical significance was set at $p < 0.05$.

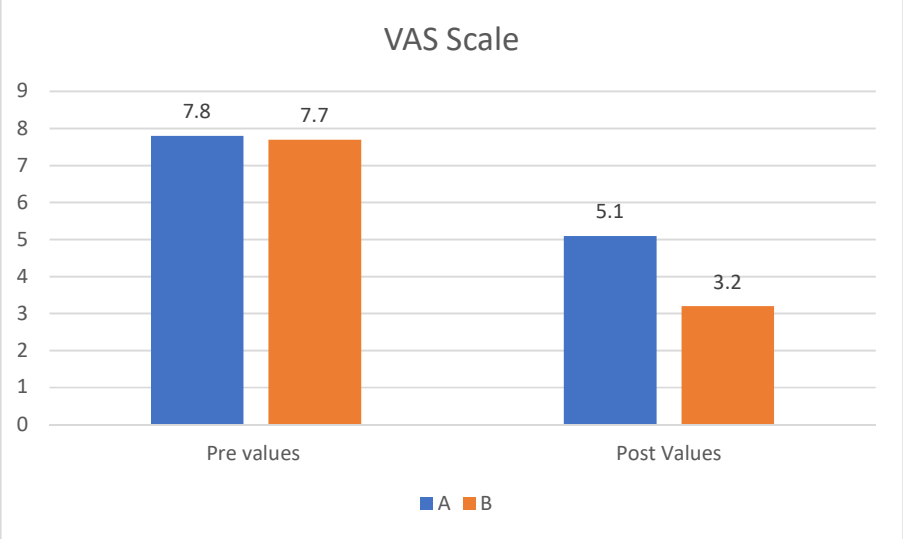
Table 1: Demographic Characteristics

Variable	Group A (n=30)	Group B (n=30)	p-value
Age (years)	61.3 ± 4.2	60.8 ± 4.5	0.58
Gender (M/F)	10 / 20	9 / 21	0.78
BMI (kg/m²)	27.2 ± 3.1	27.6 ± 2.9	0.62

Table 2: Pre and Post Intervention Scores

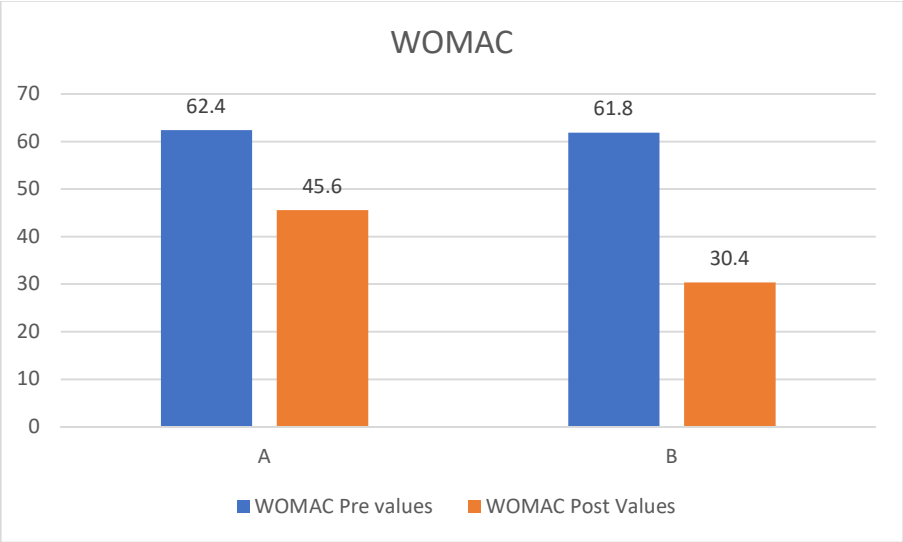
Outcome	Group A Pre	Group A Post	Group B Pre	Group B Post	p-value (Post)
VAS (Pain)	7.8 ± 1.1	5.1 ± 1.0	7.7 ± 1.2	3.2 ± 0.9	< 0.001
WOMAC Total	62.4 ± 7.6	45.6 ± 6.9	61.8 ± 6.9	30.4 ± 5.7	< 0.001

Graph 1: Demographic Characteristics Between Group A And Group B



Graph 2: Comparison Of VAS Pre- and Post-Intervention Between Group A And Group

B



Graph 3: Comparison WOMAC questionaries Of Pre- and Post-Intervention Between Group A And Group B

RESULTS:

Sixty participants with knee osteoarthritis were recruited and randomly divided into two equal groups: Group A (n = 30), which underwent pharmacological treatment alone, and Group B (n = 30), which received pharmacological treatment along with virtual reality (VR)-based rehabilitation. The baseline demographic traits of both groups were similar. The average age in Group A was 61.3 ± 4.2 years, whereas in Group B it was 60.8 ± 4.5 years ($p = 0.58$). The gender distribution was comparable across the groups, with 10 males and 20 females in Group A, while Group B had 9 males and 21 females ($p = 0.78$). The average Body Mass Index (BMI) did not show a significant difference between the groups, with Group A exhibiting a mean BMI of 27.2 ± 3.1 kg/m² and Group B 27.6 ± 2.9 kg/m² ($p = 0.62$). These findings suggest that the two groups were demographically similar at the onset of the study.

After the four-week intervention, both groups exhibited statistically significant enhancements in all assessed outcomes; nevertheless, Group B showed considerably greater improvements when compared to Group A. Regarding pain intensity, Group A's average VAS score fell from 7.8 ± 1.1 to 5.1 ± 1.0, while Group B's VAS score declined from 7.7 ± 1.2 to 3.2 ± 0.9. The comparison of post-intervention VAS scores between groups revealed a statistically significant difference supporting Group B ($p < 0.001$)

The functional status evaluated by the WOMAC index indicated a greater improvement in Group B. The total WOMAC score for Group A dropped from 62.4 ± 7.6 to 45.6 ± 6.9, whereas Group B's score improved from 61.8 ± 6.9 to 30.4 ± 5.7 ($p < 0.001$), signifying better physical function and symptom relief in participants who underwent VR-based therapy.

The results indicate that combining VR-based rehabilitation with conventional drug treatment

offers greater advantages in alleviating pain and improving physical function for those with knee osteoarthritis.

Discussion

The current research investigated the combined impact of virtual reality (VR)-based rehabilitation alongside conventional pharmacological treatment in patients diagnosed with knee osteoarthritis (OA). The findings clearly show that the combined strategy of integrating VR interventions with traditional pharmacological treatment led to better clinical results than pharmacological management by itself. These results highlight the increasing importance of multimodal rehabilitation approaches in effectively tackling the intricate symptoms of OA, such as pain, proprioceptive issues, and functional limitations.

The pain alleviation, both groups exhibited statistically significant enhancements, yet the level of pain relief was notably greater in the group undergoing VR-based rehabilitation (Group B). The decrease in Visual Analog Scale (VAS) scores was 58% in Group B versus 35% in Group A, highlighting a significant additional advantage of the VR element. This improved pain-relief effect could be related to the neurophysiological processes linked to immersive VR, including cognitive diversion, modified pain perception, and adjustment of central pain processing routes. VR environments can immerse patients fully, distracting them from pain signals and diminishing the perception of discomfort during rehabilitation activities and movements.

Functional enhancement, assessed via the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), also demonstrated better results in the VR group. Group B participants showed marked enhancement in physical abilities and everyday activities in contrast to those who were solely receiving medication. This enhancement is probably due to greater compliance with therapy, motivational involvement, and active engagement facilitated by the immersive and interactive qualities of VR platforms. The capability to mimic real-life activities and offer immediate feedback probably improved neuromuscular control, endurance, and confidence while moving, leading to better mobility and greater independence in everyday tasks.

The results of this research align with the growing body of literature that endorses the use of integrative, technology-aided rehabilitation approaches in the treatment of chronic musculoskeletal disorders. VR rehabilitation is gaining acknowledgment for its potential to encourage neuroplasticity, boost patient involvement, and provide tailored therapeutic settings. Considering that knee OA is a progressive and multifactorial issue, strategies that target both the mechanical and neurocognitive aspects of disability are crucial for improving outcomes.

In summary, combining VR-based rehabilitation with conventional pharmacological treatment seems to be a very effective approach for controlling pain, enhancing proprioception, and boosting functional abilities in individuals with knee OA. The findings of this research strongly support the integration of VR into standard clinical procedures, especially for older adults, where motivation, cognitive involvement, and fall prevention are essential aspects of care. Further investigations with larger sample populations and extended follow-up durations are needed to confirm the lasting advantages and cost-efficiency of this innovative rehabilitation method.

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