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Research Protocol

Physiotherapy Section

Effect of Virtual Reality Training in Adjunct to Conventional Physiotherapy on Dynamic Balance, Hop Test and Function in Badminton Players with Ankle Instability: A Research Protocol of a Randomised Controlled Trial

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ABSTRACT

Introduction: Ankle instability, which is common in athletes, results from ligament strains or tears, leading to pain, swelling, and discomfort. Acute lateral ankle sprains are typically treated with functional management, while chronic instability is usually addressed with conservative measures and may shift to surgical intervention if rehabilitation fails. Low-grade injuries are managed with conventional physiotherapy that focuses on cryotherapy, muscle strengthening, and range of motion exercises. Additionally, virtual reality training is emerging as a modern rehabilitation tool.

Need of the study: There is considerable evidence regarding the effects of conventional or exercise therapy on patients with ankle instability. Even among athletes, literature supports the effectiveness of conventional treatment for this condition. However, there is a dearth of literature on the use of virtual reality training as an adjunct to conventional therapy in patient recovery.

Aim: To compare the effects of virtual reality training as an adjunct to conventional therapy on dynamic balance, hop test performance, and functional outcomes in badminton players with ankle instability.

Material and Methods: A randomised controlled trial will be conducted at the Wardha District Stadium and the Department of Sports Physiotherapy at Ravi Nair Physiotherapy College, Wardha, Maharashtra, India, from March 2024 to March 2025. A total of 40 patients with ankle instability will be included and divided into two groups. Group A will receive conventional therapy, while Group B will receive virtual reality training in addition to conventional therapy for six weeks. The parameters will be assessed using the Y Balance Test (YBT), the Cumberland Ankle Instability Test (CAIT), and the Hop Test at baseline and at the end of the sixth week of the intervention. The Mann-Whitney U test or Student's unpaired t-test will be employed to compare the groups at baseline and after six weeks. The signed rank test or Student's paired t-test will be used to investigate within-group effects. A p-value of <0.05 will be considered statistically significant.

Keywords: Ankle sprain, Conservative therapy, Cumberland ankle instability test, Y balance test

INTRODUCTION

The ankle joint is formed through the articulation of the talus, fibula, and tibia bones, and it is classified as a hinged synovial joint [1]. Up to 40% of ankle sprains can lead to persistent symptoms such as pain, swelling, instability, and recurring injuries that last for at least 12 months after the initial injury. This activity focuses on the assessment, treatment, and management of recurrent ankle sprains [2]. Ankle sprains are a common injury among both athletes and the general public [3]. They typically involve injury to the Calcaneofibular Ligament (CFL) and the Anterior Talofibular Ligament (ATFL) and can result from various mechanisms, including low energy versus high energy injuries, rotational forces exerted on the supporting ligamentous structures and the joint, and foot postures. Injury to the syndesmotic structures leads to high-degree (grade III) ankle sprains, while low grade (grades I and II) injuries occur due to stretching or partial rupture of the stabilizing ligaments [4].

The most common injury sustained from a lateral ankle sprain is to the ATFL, which is the weakest ligament and has the lowest ultimate stress in relation to its anatomical placements and insertions [5]. Ankle instability is classified into two types: mechanical and functional instability. An indication of mechanical instability is aberrant laxity of the ligamentous structures. Functional instability is characterised by recurrent bouts of ankle weakness due to abnormal function [6]. An ankle joint fracture that fails to heal within the first six weeks results in a loss of both functional and mechanical integrity of the joint, which is identified as chronic ankle instability. Functional ankle instability arises from poor postural control, muscle weakness, proprioceptive deficits, and impaired neuromuscular function, while mechanical ankle instability originates from ligament laxity [7]. A standard series of ankle X-rays would include anteroposterior, lateral, and mortise views [8].

Magnetic Resonance Imaging (MRI) is a dependable method for diagnosing injuries related to syndesmotic and tendinous trauma, concealed fractures, and osteochondral lesions. The MRI for Anterior Talofibular Ligament (ATFL) injuries has a specificity of 100% and sensitivity ranging from 92% to 100%. For chronic ankle instability (CAI), multimodal rehabilitation regimens are typically advised as non operative therapy [9].

Several rehabilitation techniques have been studied to ameliorate deficiencies related to CAI. These techniques range from straightforward, progressive strength and balance regimens to multicomponent rehabilitation strategies that address strength, balance, range of motion, and self reported function, all of which can be successfully improved by these functional rehabilitation methods. However, few studies have evaluated the gains in power and agility. Any dynamic, closed kinetic chain activity that is not merely standing still is considered a functional activity [10].

Human-computer interaction in virtual reality technology can be categorised into two main components: stimulus signal input and action output that provides feedback. The computer communicates tactile, auditory, and visual signals to the user through various input and output devices, such as data gloves, stereo headsets, and display helmets [11]. Beyond the frequently mentioned high fun factor and increased motivation, which lead to higher compliance, the use of virtual reality (VR) technology in preventive and rehabilitative balance training offers several other advantages. VR makes it possible to practice in situations that typically cannot be recreated in rehabilitation centers, therapy rooms, or gyms [12].

The present study aims to assess the effectiveness of virtual reality training as an adjunct to conventional therapy in badminton players with ankle instability, focusing on dynamic balance, hop test performance, and overall function.

Objectives of the study are:

Primary Objective

- To evaluate the effect of virtual reality training combined with conventional therapy on dynamic balance, hop test performance, and function in badminton players with ankle instability.
- To evaluate the effect of conventional therapy alone on dynamic balance, hop test performance, and function in badminton players with ankle instability.

Secondary Objective

- To compare the effect of virtual reality training combined with conventional therapy versus conventional therapy alone on dynamic balance, hop test performance, and function in badminton players with ankle instability.

Null hypothesis: Virtual reality training as an adjunct to conventional physiotherapy will be equally or less effective than conventional therapy alone in badminton players with ankle instability.

Alternate hypothesis: Virtual reality training as an adjunct to conventional physiotherapy will be more effective than conventional therapy alone in badminton players with ankle instability.

REVIEW OF LITERATURE

A randomised controlled trial from 2015 concluded that participants with functional ankle instability showed improvements in their dynamic and static balance after participating in virtual reality programs. When utilised under proper supervision by a physiotherapist, virtual reality programs can be employed more safely and effectively [13]. Another study from 2016 found that Core Strength Training (CST) led to complementary improvements in core endurance and Star Excursion Balance Test (SEBT) directions, although it did not demonstrate significant improvements in agility [14]. In 2023, further investigations were conducted to examine the impact of conventional versus virtual reality training methods on athletes' subjective perceptions of instability and balance. While the virtual reality cohort exhibited superior performance compared to the control cohort, the magnitude of this effect was minimal. Their results suggest that both training methods helped reduce instability and improve balance among individuals with functional ankle instability. Additionally, participants expressed a strong preference for virtual reality training [15].

MATERIALS AND METHODS

A randomised controlled trial with a single-blinded design will be conducted at the Wardha District Stadium and the Department of Sports Physiotherapy at Ravi Nair Physiotherapy College, Wardha, Maharashtra, India, from March 2024 to March 2025. The institutional ethical approval has been obtained with reference number DMIHER(DU)/IEC/2024/184. The trial has been registered on the Clinical Trial Registry of India (CTRI) website, with the registration number CTRI/2024/05/067433. Written informed consent will be obtained from the participants, and this will be signed and confirmed for confidentiality before conducting the study.

Inclusion criteria: Badminton players of either gender, aged 18 to 30 years, who have been diagnosed with ankle instability following grades I and II injuries will be included in the study [16].

Exclusion criteria: Patients with neurological conditions affecting balance, patients with fractures or recent surgeries, patients who are unwilling to participate in rehabilitation, and any medical or musculoskeletal conditions that may interfere with study outcomes will be excluded from the study.

Sample size calculation: A total sample size of 40, with each group containing 20 individuals, will be used. The sample size formula employed is as follows:

$n = (\sigma1^2 + \sigma2^2 / k)\ (Z1\text{-}_{\alpha/2} + Z_{1\text{-}\beta})^2)\ /\Delta^2$

n_1: Sample size of Group 1

n_2: Sample size of Group 2

σ_1: Standard deviation of Group 1

σ_2: Standard deviation of Group 2

Δ: Difference in group means

k: Ratio = n1/n2

$Z(1\text{-}\alpha/2)$: Two-sided Z value (e.g., 1.96 for 95% confidence interval)

$Z_{1\text{-}\beta}$: = power

Mean Cumberland ankle instability in resistance band group=20.50

Mean Cumberland ankle instability in control group=16.64

σ1= SD of Cumberland ankle instability in resistance band group =2.61

σ2= SD of Cumberland ankle instability in control group =5.50

For detecting mean difference of 3.86 i.e. Δ =20.50-16.64=3.86

K=1

$$N = \frac{(2.61*2.61 + 5.50*5.50)\ (1.96+0.84)^2}{0.24*0.24}$$

=19.50 = 20 participants needed in each group (20+20=40)

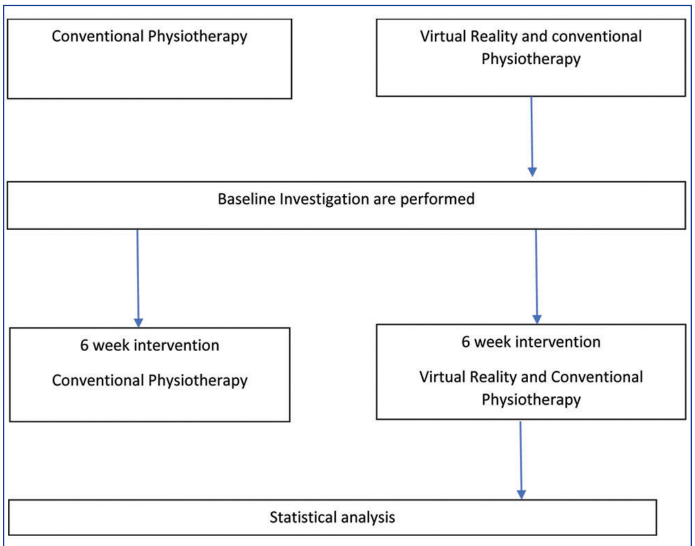
Reference: Spencer Cain M et al., [17].

Power of the Test: 80%

Study design: Comparative study design

Level of significance: 5% (95% confidence interval)

A total of 40 participants will be assigned to two groups of 20 patients each, with one group receiving conventional therapy (Group A) and the other group receiving virtual reality training in addition to conventional therapy (Group B) [Table/Fig-1]. Basic random sampling



[Table/Fig-1]: Showing recruitment of subjects in the study.

will be used to assign the sequences utilizing a computer-aided chit technique. During this process, random numbers will be generated. Each number will be sealed within an opaque envelope so that the participant will not be able to see their group assignment or the intervention they will receive. Participants will be allowed to select an envelope containing the numbers, which will be provided in a sealed opaque envelope. The randomisation process will be overseen by the study coordinator and the principal investigator. To be recruited into either group, participants will be required to select from an envelope holding a sealed group allocation manually. The investigators will blindfold the participants to ensure separation between the groups. Subjects will be required to withhold any knowledge about their therapy from the tester in order to establish effective blinding.

Group A (Control Group)

Pain management: Mobilisations to the talocrural, subtalar, and midfoot joints will be performed for pain control and mobility. Mobilisations to the talocural, subtalar and midfoot joints will be performed for pain control and mobility. 3 cycles of mobilisation with rest in between, repeated for 3 times. Lace-up braces will be recommended for functional activities as needed.

Flexibility: Patients will perform gastrocnemius and soleus stretches, as well as knee-to-wall closed chain dorsiflexion mobilisations. These will be done for 10 repetitions, with each stretch held for 20 seconds in one set.

Strengthening exercises: These will include the use of therabands to perform dorsiflexion, plantarflexion, inversion, and eversion. As strength improves, progressively stronger therabands will be incorporated into the protocol, starting with heavy (light blue), then progressing to super heavy (dark blue), and ultimately ultra-heavy (purple) bands. These exercises will be performed for 10 repetitions in three sets. Additionally, double-leg heel raises, single-leg heel raises, and standing toe raises will be incorporated, also performed for 10 repetitions in three sets.

Proprioceptive and neuromuscular training: This will involve maintaining proper balance in both double and single-limb stances, gradually progressing to more challenging exercises by adding dynamic movements, such as throwing and catching activities, while maintaining balance.

Bosu ball exercises: These exercises will be included to improve balance and coordination and will involve double-leg balance, single-leg balance, and mini-squats performed on the Bosu ball.

Return to sports training: This will focus on high exertional, sports-related activities designed to prepare individuals for their specific sport. This will include single-leg hopping, double-leg hopping, lateral bounding, and plyometric exercises such as multidirectional jump drills.

Group B (Experimental group)

Conventional therapy will be administered as it is in Group A.

Virtual reality-assisted rehabilitation: While wearing the virtual reality headset, subjects will stand on a regular surface and play a game while holding the joystick as a badminton racket. The software will feature an opponent player competing against them. The virtual reality device includes a game called "Badminton," which will be performed for 10 minutes daily [18].

OUTCOME MEASURES

Assessment will be conducted on the first day and after six weeks of rehabilitation.

Y Balance Test (YBT): The YBT is an instrumented alternative to the Star Excursion Balance Test (SEBT), capable of measuring dynamic postural control. The YBT utilises three of the eight original SEBT reach directions (anterior, posteromedial, and posterolateral) and was developed to provide a more objective reach distance measurement, allowing for more accurate results to be collected in a less time consuming manner [19].

Cumberland Ankle Instability Test (CAIT): The CAIT is a 9-item scale measuring the severity of functional ankle instability. The total score ranges from 0 to 30, with items focused on the degree of difficulty in performing different physical activities related to the ankle [20].

Hop test: The hop test is used as an assessment tool for returning to sport after an injury, such as an ankle sprain or stress fracture. It involves single-leg hops, crossover hops, etc., to assess return to sport [21].

STATISTICAL ANALYSIS

Statistical Package for the Social Sciences (SPSS) version 27 will be used for statistical analysis. The demographic variables that yield the lowest and highest standard deviations of the mean and observed values will be determined based on the quantitative assessment. Frequency and percentage observations will be made for the quantitative evaluation. The Mann-Whitney U Test, along with the Student's Unpaired t-Test, will be employed to compare the groups at baseline and after four weeks. The Signed Rank Test and the Student's Paired t-Test will be used to investigate within-group effects. The level of significance will be set at $p<0.05$.

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