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Rehabilitation of Lower limb balance For Post-Stroke Patients using Augmented Reality

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ABSTRACT
Applications that use augmented or virtual reality can create an immersive and engaging virtual environment for motor rehabilitation using the cooperative stimulation of several sensory channels, including sight, hearing, and movement. These applications can also improve the effectiveness of rehabilitation through repetition, feedback, and encouragement. In this study, we suggest an integrated application for teaching and assessing individuals with lower limb balance disorders. The Oculus Quest VR headset-based AR-based rehabilitation programme for post-stroke patients shows potential in improving patient outcomes. It provides more fun and successful approach to rehabilitation than traditional methods. Utilizing the headset to assess temperature and blood pressure could save time and resources, but accuracy must be verified. Virtual encounters with doctors using the VR app are convenient and allow for distant progress tracking. Workout videos tailored to a patient blood pressure range can assist assure safety, but they must be suited for the patient specific needs. Overall, the programme improves access to rehabilitation services, but it requires dependable and specialized technology to achieve the best results.

INTRODUCTION
Stroke is a significant cause of disability worldwide, with many patients experiencing lower limb paralysis and balance impairment. Rehabilitation is crucial in the recovery process, with several methods developed to improve mobility and balance. In recent years, augmented reality (AR)technology has emerged as a promising tool for enhancing rehabilitation outcomes. This project proposes an advanced AR-based rehabilitation program for lower limb balancing post-stroke patients, utilizing the Oculus Quest headset. The objective of this project is to develop an advanced AR-based rehabilitation system that can be used to improve the balance of stroke patients using the Oculus Quest headset. The proposed system will consist of a custom-built application that will provide advanced visual and haptic feedback to the patients. The system will use the Oculus Quest advanced motion tracking sensors and haptic feedback mechanisms to detect the patient movements and provide real-time feedback on their posture, balance, and weight distribution.
The proposed AR-based rehabilitation program will be evaluated using a randomized controlled trial. The study will involve stroke patients who have experienced lower limb paralysis and balance impairment. The patients will be divided into two groups: one group will receive traditional physiotherapy, while the other group will receive the advanced AR-based rehabilitation program using the Oculus Quest headset. The outcomes will be measured using advanced balance assessment tools, such as the computerized dynamic posture graphy and electromyography. The proposed advanced AR-based rehabilitation program has the potential to significantly improve the balance of stroke patients by providing advanced real-time feedback on their movements through the Oculus Quest headset. The use of the Oculus Quest headset advanced features has the advantage of being highly immersive, interactive, and engaging, which could help motivate patients to continue with their rehabilitation program. If successful, this project could lead to the development of

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more effective and advanced rehabilitation programs for stroke patients utilizing AR technology and the Oculus Quest headset.

History of VR/AR application in healthcare domain:

The first application of VR in the healthcare industry dates back to 1990. The system's primary goal was to assist clinicians in visualising complex medical data prior to performing surgery.Clark Atlanta University researchers got the notion in 1992 to employ this new technology to treat various mental problems, including phobias therapy.The worldwide association for virtual rehabilitation was founded in 2009 to bridge the gap between engineers, scientists, and physicians.Its primary mission was to implement new technologies such as virtual reality (VR) and augmented reality (AR) systems in motor, psychological, cognitive, and social rehabilitation.In 2014, a meta-analysis of 19 publications and 1474 patients indicated that "depression therapies using computer games significantly reduced the severity of depressive symptoms in the studied group."

Causes of stroke:

Strokes are caused by one of two things: a blocked artery (ischemic stroke) or a blood vessel leaking or bursting (hemorrhagic stroke). Some patients may experience only a brief disturbance in blood flow to the brain, known as a transient ischemic attack (TIA), which causes no long-term effects.

Ischemic stroke:

This is the most common kind of stroke. It occurs when blood arteries in the brain become restricted or obstructed, resulting in substantially reduced blood flow (ischemia).Blocked or restricted blood arteries are caused by fatty deposits that accumulate in blood vessels or by blood clots or other debris that migrate through the bloodstream, most often from the heart, and lodge in brain blood vessels

Haemorrhagic stroke:

A haemorrhagic stroke happens when a blood vessel in the brain leaks or ruptures. Many disorders that damage the blood vessels can cause brain haemorrhages. Factors associated with haemorrhagic stroke include:

- High blood pressure that is not within control
- Blood thinner (anticoagulant) overtreatment
- Aneurysms are bulges that form at weak points in your blood vessel walls.
- A traumatic event (for example, a vehicle accident)
- Protein deposits in blood vessel walls cause vessel wall weakening (cerebral amyloid angiopathy)
- Ischemic stroke that results in haemorrhage

The rupture of an irregular tangle of thin-walled blood arteries (arteriovenous malformation) is a less common cause of bleeding in the brain.

Transient ischemic attack (TIA):

A transient ischemic attack (TIA), often known as a mini stroke, is a brief period of symptoms resembling a stroke. A TIA does not result in irreversible harm. A transient ischemic attack (TIA) is caused by a short decrease in blood supply to a portion of the brain that can last as little as five minutes. A TIA, like an ischemic stroke, occurs when a clot or debris restricts or prevents blood flow to portion of the nervous system.

Risk factors:

Many variables can raise the risk of having a stroke. Potentially treatable stroke risk factors include:

Life Style risk factors:

- Inactivity on the physical front
- Binge or heavy drinking
- Illegal drug use, including cocaine and methamphetamine
- Being overweight or obese

Medical risk factors:

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- Inactivity on the physical front
- Binge or heavy drinking
- Illegal drug use, including cocaine and methamphetamine
- Hypertension (high blood pressure)
- Second-hand smoke exposure or cigarette smoking
- Cholesterol levels are elevated.
- Diabetes
- Cardiovascular illness includes heart failure, heart defects, heart infection, and irregular heart rhythms such as atrial fibrillation.
- A personal or family history of stroke, heart attack, or transient ischemic attackinfection with COVID-19

Other factors associated with a higher risk of stroke include:

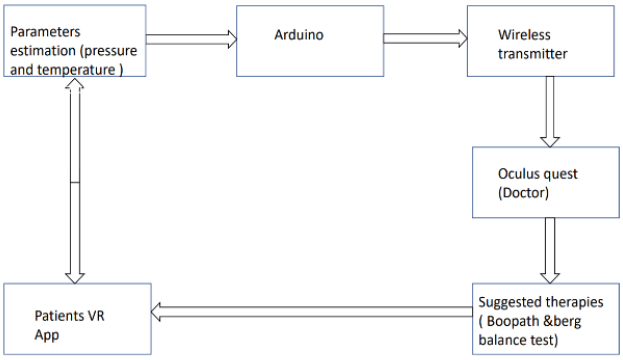
- **Age —** People age 55 or older have a higher risk of stroke than do younger people.
- **Race or ethnicity —** African Americans and Hispanics have a higher risk of stroke than do people of other races or ethnicities.
- **Sex —** Men have a higher risk of stroke than do women. Women are usually older when they have strokes, and they're more likely to die of strokes than are men.
- **Hormones —** Use of birth control pills or hormone therapies that include estrogen increases risk.

Problem Statement :

For Lower limb rehabilitation in post stroke patients we are providing therapies for their well being using Augmented and virtual reality. AR-based scientific quantitative evaluation - We provide an AR-based manner to quantitatively evaluate the parameters of patient's balance ability of lower limbs. The patient's movement data and balance ability are provided through visual graphics and quantitative data to give the doctor's more scientific references.

VR-based personalized treatment plan-According to the evaluation results, doctors can customize VR-based rehabilitation training programs of different difficulties for the lower limb balance abilities of different patients , Patients can engage in home therapies with the assistance of the doctor's advice.

BLOCK DIAGRAM



BLOCK DIAGRAM EXPLAINATION

In this project, we used an Arduino in pressure sensor to measure human blood pressure. If a patient has a fever, both the temperature and blood pressure are recorded. The temperature sensor is used to detect the temperature of the patients. The data will be sent to the doctor via a Zigbee wireless device. The goal of the Oculus Quest is to operate an Android-based operating system with modifications to improve performance in VR applications. The Doctor will then recommend matching therapies through their videos based on the blood pressure range. The patient will then watch the Doctor via the VR app while practising the exercise via videos.

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Blood pressure sensor:
Hypertension is a very prevalent cardiovascular disorder caused mostly by variations in Blood pressure. Although hypertension is not officially classified as a disease, it leads to a variety of health issues, including heart disease and, in some circumstances, death. If you believe you are at danger, or if your doctor agrees, he will almost certainly advise you to monitor your blood pressure using Blood pressure monitors on a daily basis. A Blood pressure sensor establishes a critical baseline for your blood pressure, which may be used to identify whether you are truly at risk of developing hypertension or other possibly chronic disorders.

Wireless transmitter:
Zigbee was used as a wireless transmitter in this project. Zigbee devices may carry data over vast distances by sending data across a mesh network of intermediary devices to more distant ones. Zigbee is often employed in low data rate applications that demand a long battery life and secure networking.

Oculus quest:
A VR headgear with integrated earpieces and touch controls, the Oculus Quest is entirely immersive. Instead of requiring a connection to a computer or external sensors, the technology powers the headgear via inside-out tracking. Room scale monitoring is possible with the Quest

Boobath therapy:
Patients and therapists engage in conversation throughout the process. The neuro-muscular system, spinal cord, and higher brain centers, as well as neuroplasticity, an interactive neurological system, and individual expression of movement, are the main areas of attention in therapy.

Berg balance test:
The Berg Balance Scale is a test that measures balance and has good validity and reliability. An individual's ability to maintain balance allows them to move physically and go on to complete everyday tasks.

Experimental Analysis :

RANGE	DESCRIPTION
0	No contraction
1	Flicker or trace of contraction
2	Active movement, with gravity eliminated
3	Active movement against gravity
4	Active movement against gravity and resistance
5	Normal power

Table 1: Levels of muscular power scale

Characteristic	Experimental (n=31)	Control(n=28)	*P*
Gender	7/24	8/20	0.637
Age	59.03/10.12	60.67/8.17	0.753
Post stroke time	2.74/1.10	2.71/0.99	0.493

Table 2: Levels of Stroke

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Methodology:

Prior to the start of this systematic review, a protocol was submitted to the PROSPERO International Prospective Register of Systematic Reviews. For the purposes of this review, the authors defined somatosensory function as the ability to perceive, discriminate, and distinguish bodily sensations. Somatosensory modalities previously reported to be affected by stroke were considered, including detection or localization of tactile stimuli, proprioception or kinaesthesia, stereognosis or object recognition, pressure or weight discrimination, vibration detection, texture discrimination, and two-point discrimination. Retraining of somatosensory function was defined as any intervention addressing the remediation of the aforementioned somatosensory modalities. Intervention approaches included instruction, repetitive practise and feedback in detecting, localising, discriminating, or distinguishing different sensory stimuli, pressure, or objects, proprioceptive training, and somatosensory stimulation.

From conception to January 16, 2019, electronic databases such as Cochrane Library, PubMed, MEDLINE, CINAHL, EMBASE, PEDro, PsycINFO, and Scopus were searched to discover relevant publications. Consultation with a librarian, the search method was devised by dividing down the review question into components: Population, interventions comparators, outcomes, and study design

Participants:

Initially, 76 patients were chosen for the trial, with twelve being excluded. Sixty-four patients were admitted to the research despite being excluded based on the exclusion

Types of interventions	Experimental Group	Control Group	Minutes of Therapy
Passive analytical exercises for each LE joint	NO	YES	10
Prone or supine active analytical exercises for LE joint	NO	YES	20
Active LE exercises from standing position, and proprioception	NO	YES	20
Active ergometer bicycle	YES	YES	10
Treadmill	YES	YES	10
VR exercises	YES	NO	32±5
MT exercises for ankle	YES	NO	18±5
Total time of physiotherapy exercises (minutes)	70	70	70

criteria.

1. Stroke survivors following the subacute period, at least six months post-stroke , and 1younger than four years were eligible. This time frame is the best choice for functional rehabilitation, and patients within this time frame have the best rehabilitation status, particularly VR (stroke survivors with poor rehabilitation have spasticity, stiffness, tissue retraction, joint misalignments over more than four years of stroke, which prevents the application of new techniques such as VR and MT).

2.Assessment criteria: at least 20 degrees of hip flexion and 10 degrees of hip abduction against gravity, as well as at least 30 degrees of knee flexion against gravity.

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Severe cognitive impairments, global or transcortical sensory aphasia, anaemia, atrial fibrillation, anticoagulant treatment imbalance, epilepsy, NYHA class IV heart failure, and other lower extremity dysfunctions such as surgery, fractures, severe osteoarthritis, peri arthritis, or moderate-severe pain were all exclusion criteria. Using basic randomization, 64 participants were divided into experimental and control groups. To avoid bias within our sample (n = 64), we generated numbers that divided patients into two groups using GraphPad Quick calcs. The allocation was carried out using sealed opaque envelopes with the group name that were placed in a plastic container in numerical order. The randomization technique was carried out by individuals who were unrelated to the work. During the study, five participants were recognised as having various health issues that prevented them from continuing to participate. Two patients suffered anaemia and atrial fibrillation, two developed anticoagulant medication imbalances, and one developed an epileptic crisis. As a result, the remaining 59 patients participated in the complete research programme. The participants were split into two groups: experimental (n = 31) and control (n = 28).

Recent trends of VR/AR application in healthcare domain:

VR technology may now transport bits of the actual world to persons suffering from anxiety and phobias such as claustrophobia and social anxiety. This is referred to as exposure therapy. In addition, a business called Limbix allows patients to be exposed to their fear via VR glasses and other equipment in order to overcome phobias such as Acrophobia (fear of high structures) and Arachnophobia (fear of spiders).Stanford University's medical school launched a project called "The Autism Glass Project."

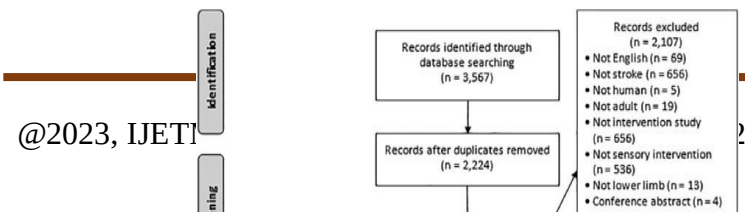
Its main goal is to use AR glasses to assist youngsters with autism in interpreting the emotions of others. This will lead to the children developing a certain level of social interaction through memory and practise of earlier interactions.The sense that an amputated or missing limb is still present is known as phantom limb. Patients who nonetheless feel a missing limb may endure agony from that phantom member. When patients try to move an amputated limb, AR technology allows them to see a virtual member on the screen. This may result in a therapeutic +effect on the patient's brain.

VR/AR efficiency compared to the classic post stroke rehabilitation therapies:

+Virtual reality (VR) technology has the potential to revolutionize the way we approach individualized treatment and assessment protocols. By providing a simulated environment, VR allows clinicians to tailor treatment to the specific needs of each patient, while also standardizing assessments and training protocols across individuals.In some VR systems, users interact with the virtual environment using a pointer operated by a mouse or joystick button. In other systems, a representation of the user's hand or other body part is generated within the environment, allowing for a more natural interaction with objects. This approach, known as "slaving," mimics the user's movements in real time, providing a more immersive and realistic experience.

Visual interfaces play a crucial role in creating immersion in the virtual environment. Conventional desktop monitors provide a basic level of immersion, while head-mounted displays (HMDs) offer a more immersive experience by blocking out external stimuli and providing a full 360-degree field of view. The cave automatic virtual environment (CAVE) is a more complex system that projects images onto the walls of a room-sized enclosure, creating a fully immersive environment.Overall, VR technology offers a unique opportunity to individualize treatment while maintaining standardized assessment and training protocols, and the development of more advanced visual interfaces is likely tofurther enhance the immersion and effectiveness of VR-based interventions.

PRISMA FLOW DIAGRAM:



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CONCLUSION:

The research suggests that utilizing virtual reality (VR) rehabilitation technology in combination with motor training (MT) exercises can improve the effectiveness of lower extremity rehabilitation in chronic stroke patients. This approach creates a more favourable environment for recovery by providing a variety of inputs to the brain, leading to greater neuroplasticity. The study's results show promise compared to standard physiotherapy, highlighting the need for further research on combining different interventions to find the best solutions for reducing disability and the overall burden on the individual, family, society, and health systems. This research provides a valuable contribution to the field of stroke rehabilitation and underscores the importance of innovative approaches to improve patient outcomes.

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