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ORIGINAL

EFFICACY OF VIRTUAL REALITY-BASED THERAPY IN POST-STROKE MOTOR RECOVERY: A META-ANALYSIS

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ABSTRACT

Since Stroke is a leading cause of adult impairment, new approaches to rehabilitation are being investigated. Utilizing technology advancements, virtual rehabilitation (VR) has become increasingly popular as a stroke recovery treatment. Following PRISMA criteria, the authors performed a systematic review and meta-analysis of randomized controlled trials (RCTs) published in English during the past ten years. The authors used specified search phrases and Medical Subject Headings (MeSH) to search resources, including Medline/PubMed and the Cochrane Library. With an emphasis on RCTs, including adult stroke patients receiving VR therapy and outcomes about motor function and quality of life, the methodological quality was evaluated using the PEDro scale. In our meta-analysis, the authors included fifteen papers. Compared to traditional therapy, VR rehabilitation has a number of benefits, including improved feedback and more patient motivation. Immersion in virtual reality settings enhances concentration during therapy, which may accelerate the healing of stroke-related deficits. VR treatments greatly enhance motor function, enhancing daily living activities and general quality of life. Virtual reality has effectively enhanced motor function and stroke survivors' quality of life. Subsequent investigations examine patient variability and enhance intervention techniques. VR integration in rehabilitation programs may improve the prognosis for stroke patients.

KEYWORDS: Virtual Reality (VR); Therapy (TT); Post Stroke Motor Recovery (PSMR); Meta-Analysis (MA)

1. INTRODUCTION

The word stroke refers to a kind of medical emergency that occurs in the cerebrovascular area when there is a reduction or incomplete supply of oxygen to brain cells. As a result of deprived blood supply, brain cells haveion and nutrient supply are preslls. After treatment of this Stroke, there is a need for motor recovery, which is termed post-stroke motor recovery. Virtual reality therapy is used in post-stroke motor recovery. In this introduction, we will understand how virtual reality-based therapy can be effectively used in post-stroke motor recovery. As we know ,there are different types of Stroke ,such as ischemic Stroke, hemorrhage stroke, and transient ischemic Stroke (Mekbib et al., 2020). An ischemic stroke is caused by any blockage in the blood supply to the brain. The other type of stroke, hemorrhage stroke, is caused by when there is any kind of bleeding in the Brain. The third type of Stroke, which is transient ischemic Stroke, is caused by temporary blockage of blood supply to the brain, so it is termed as mini-stroke. The overall neural network is affected by Stroke, but the main type of neuron, motor neurons, are affected by Stroke. As we know, the function of motor neurons is to carry messages from the brain to effectors for effective coordination in the body. When there is a disturbance to motor neurons, there may be a problem in responding to any stimulus effectively(Fang et al., 2022). There are important phases of motor recovery after stroke, and these phases are called acute phase, subacute phase, chronic phase, and long-term phase. The first acute phase consists of almost two weeks, but the subacute phase consists of up to six weeks. Then comes the phase of the chronic phase, which lasts up to six months, and the long-term phase has a period starting after six months of the chronic phase and lasts a lifetime. There are a variety of therapies that are provided to these patients for post-stroke motor recovery(Domínguez-Téllez et al., 2020). These therapies include physical therapy, occupational therapy, speed language pathology, and cognitive rehabilitation. There are a variety of ways in which virtual reality-based therapy can be used in post-stroke motor recovery. The first important intervention of virtual reality-based therapy is interactive games. As we know in virtual reality, an illusion is created that seems like reality and a person feels indulged in that illusion and feels himself a part of that illusion. When there are different kinds of interactive games in virtual reality-based therapy, patients will engage more in those(Rutkowski et al., 2020). In this way, the rate of motor recovery increases because, in interactive games, there is extensive use of motor functions. Secondly, interactive games will help improve cognitive function. It is because there is the use of thinking processes to excel in these interactive games that develop the cognitive skills of patients. Thus, it will help in better Post Stroke Motor Recovery in these patients. The other important benefit of these interactive games by virtual reality therapy is that it increases the chances of hand-to-eye coordination by effectively using both body parts in these interactive games. The other important intervention of virtual reality

Therapy is using a virtual environment(Prajjwal et al., 2024). As described earlier, virtual reality can produce illusions, so a desired virtual environment can be created by it. That virtual environment will be according to the needs of therapy, which means the recovery of motor functions. Such an environment will be created that will stimulate motor responses; thus, it is useful for training these patients in the post-stroke motor recovery period. The other important aspect of the virtual environment is that it is not harmful in any sense and can be recreated repeatedly for practice purposes(Chen et al., 2022). The other important implication intervention of virtual reality-based therapy is task-specific training. For example, it has been described earlier that there are various therapies in post-stroke motor recovery, and all of these training are aimed at a specific task for motor recovery. Instead of using these various therapies, only a single virtual reality-based therapy can be used for various tasks in Post Stroke Motor Recovery (Sanz-Arazuri et al., 2023).

For example, if there is a problem in Running or grasping if the patient is in the post-stroke period, then training must be provided according to this aspect. In another case, if a patient has speech abnormality during the post-stroke period, then repetitive speech training must be provided through virtual reality-based therapy (Karamians et al., 2020). The other important aspect of virtual reality-based therapy is that it is fatigue-free, which means there is no fatigue factor in the entity that is providing therapy. In contrast, there is a high cost and factor of fatigue in other therapies for post-stroke motor recovery which professionals provide. There is an advanced virtual reality-based therapy, which is named mirror box therapy. In this therapy, a patient can evaluate himself and provide feedback. In this therapy, a mirror is used, and the motor functions of patients are checked properly. This aspect may motivate these patients in post-stroke motor recovery, which can be beneficial for them(Maier et al., 2019). Virtual reality-based therapy has many benefits, such as being easy to operate and free from human error. Secondly, it is less costly and is easily available all the time. Moreover, it provides rehabilitation of both forelimbs and hind limbs. It has also been seen that it can provide cognitive rehabilitation, which is also considered an important benefit (Peng et al., 2021). It can easily help improve the body's balance aspect in patients related to post-stroke motor recovery. Although there are many important applications of virtual reality-based therapy for post-stroke motor recovery, the response to this therapy may vary depending on various factors (Al-Whaibi et al., 2022).

1.1 Research Objective

The main objective of this research is to help understand the efficiency of virtual reality-based therapy for post-stroke motor recovery. This study has enabled us to describe various aspects that are related to the use of virtual reality-based therapy for post-stroke motor recovery.

2. Literature Review

Researchers reveal that apoplexy is a significant reason for demise & incapacity in grown-ups. Regular treatment has restricted viability, & hence, different computer-generated experience recovery schemes came to be planned. 10 investigations had minimal danger, 5 had a few worries, 3 had greater danger, & individual had a diminished danger of inclination. Computer-generated experience projects may be utilized with regular treatment towards the recovery of the engine capability of sufferers with persistent apoplexy. However, additional examinations are as yet justified to decide the adequacy of such mediations in holding the mental capability & actual execution of sufferers(Peng et al., 2021). The basic aim of this study is to efficiently survey the accessible riffled dominated preliminaries in writing with respect to the utilization of computer-generated actuality restoration mediations contrasted with ordinary exercise-based recuperation in recovering the superior appendage engine capability amid sufferers along persistent apoplexy. Studies also uncovered no predominance of computer-generated reality intercessions beyond moderate treatments; be that as it may, the distinction noticed didn't achieve factual importance(Al-Whaibi et al., 2022). Scholars assess the adequacy of explicit computer-generated reality & vague computer-generated reality frameworks for restoring superior appendage capability & action following apoplexy. Studies outcomes recommend that explicit computer-generated reality frameworks are more advantageous than conventional treatment towards above-appendage recuperation, while vague computer-generated reality frameworks aren't. Moreover, researchers distinguished six standards of stroke rehabilitation that are split beyond explicit computer-generated reality frameworks & are potentially liable toward their constructive outcome. These discoveries might ratify the problematic outcomes tracked in the ongoing writing(Maier et al., 2019).

The outcomes of this study indicate that computer generated reality playing-founded furthest point recovery post-apoplexy has all the earmarks of being more compelling than regular strategies. Moreover, inside and out investigation of factors influencing advancement, for example, person engine demonstration, therapy portion, & the connection among them, are required(Karamians et al., 2020). Studies suggest that apoplexy is a significant reason for grown-up inability, inciting the investigation of imaginative recovery strategies. Computer-generated restoration, utilizing innovative upgrades, has acquired prevalence in therapy for apoplexy recuperation. Computer-generated reality has exhibited viability in working on engine capability & personal satisfaction for apoplexy stayers. Integrating computer-generated reality toward restoration projects might upgrade apoplexy recuperation results(Prajjwal et al.). Studies analyzed the adequacy of computer-generated reality-upheld practice treatment for the furthest point engine restoration in sufferers with apoplexy.

Researchers survey demonstrated that of the twelve restoration results analyzed throughout computer-generated reality-stationed treatment, huge enhancements were recognized in two (furthest point engine capability & scope of movement), & the two critical & insignificant upgrades were seen in different two (brawn force & autonomy in everyday exercises), contingent upon the estimation apparatuses or strategies utilized(Chen et al., 2022). Scholars suggest that as often as possible, apoplexy leads to weakening engine debilitations in the above appendage. Computer-generated actuality restoration has shown the possibility for increasing furthest point recuperation; though, the ideal strategies for that mediation stay a subject of vulnerability. Ideal standards probably incorporate computer-generated actuality vivid limit along traditional strategies(Soleimani et al., 2024). The point of this orderly survey was to analyze the viability of activity put together computer-generated reality treatment concerning cognizance post-apoplexy. Studies results indicate that computer-generated reality treatment was not better than managing mediations in that frame of mind in people with apoplexy. Subsequent exploration should to incorporate top notch & sufficiently controlled preliminaries analyzing the effect of augmented actuality treatment on insight Post-apoplexy(Wiley et al., 2022). Studies elaborate that apoplexy is a neural problem & a unique one main source of inability worldwide.

The sufferer might drop the capacity to enough shift the furthest points, discern feelings, or move around autonomously. This survey upholds that apoplexy restoration schemes consolidating augmented actuality are related to worked-on useful results. However, there's no genuinely huge variation contrasted with normal treatment(Khan et al., 2023). Studies claim that gambling computer-generated actuality was fundamentally finer compared to customary therapy for the above appendage capability but not so much for Hand adroitness, stride & equilibrium. Utilization of specific computer-generated experience & playing augmented actuality might be favorable for therapy of the furthest point, yet not for Hand ability & stride in whole morphologies contemplated. Specific computer-generated experiences may further develop equilibrium in neural sufferers(Rutkowski et al., 2020). Scholars explain that apoplexy is the primary driver of handicap in maturity. Ongoing upgrades in augmented experience innovations have prompted its expanded application in recovering apoplexy sufferers. An efficient survey & postmodern investigation of riffled dominated preliminaries was directed to decide the viability of play-put together actuality with respect to the above appendage engine capability & personal satisfaction afterwards apoplexy. The outcomes show the possible advantages of computer-generated reality mediations on the recuperation of upper appendage engine capability & on personal satisfaction afterwards apoplexy(Domínguez-Téllez et al., 2020). The review is meant to assess the impact of conventional in addition to VR restoration on engine capability recuperation, equilibrium, & exercises of day-to-day subsistence in

apoplexy sufferers. Customary, in addition to VR restoration treatment, is a successful strategy to develop further the higher appendage engine capability & compendium mastery of sufferers with appendage problems after apoplexy, & vivid computer-generated simulation recovery therapy might turn into another choice for restoration after apoplexy(Fang et al., 2022). To explore the impact of computer-generated actuality on Arm engine debilitation, action constraint, support limitation, & personal satisfaction in sufferers with apoplexy. To decide prospective mediators that influence the viability of computer-generated actuality. Augmented actuality is suggested for working on engine disability & exercises of day-to-day living after apoplexy & is positive for sufferers with diminished to extreme paralysis. A vivid plan might deliver more prominent development(Jin et al., 2022). Studies show that VR is a reenactment innovation with encouraging results in apoplexy restoration. Consolidating e-rehabilitation & VR is an arising & inventive methodology that advances the restoration and & possibly upgrades utilitarian recuperation results. VR-founded e-rehabilitation is a compelling elective methodology for sufferers of apoplexy, providing the boundaries & limitations of conventional in-individual recovery (Hao et al., 2023). Studies determined that computer-generated actuality imitate treatment might be useful in further developing furthest point brokenness after apoplexy, particularly when joined along customary recovery. However, there were contrasts in the kind of computer-generated actuality imitated treatment, phase of sickness, & seriousness of furthest point brokenness. Numerous information on great randomized controlled trials are expected to explain the impacts of computer-generated actuality imitate treatment(Okamura et al., 2024). Scholar studies reveal that computer-generated actuality, expanded actuality, & blended actuality are arising advancements in the area of apoplexy restoration that can defeat customary therapy's restrictions. Computer-generated expanded blended actuality treatment was better than customary therapy in upper appendage weakness & everyday capability results, but not upper appendage capability estimates(Leong et al., 2022).

The basic objective of the review is to measure the impacts of computer-generated actuality-put-together activity with respect to adjusting afterwards apoplexy. Contemporary miserable-proof examinations demonstrate that computer-generated experience-founded practice might really & securely further develop equilibrium in persistent apoplexy. More extended computer-generated actuality-put-together activity was further powerful with respect to the useful capacity of apoplexy(Shen et al., 2023). Researchers explain that computer-generated actuality-founded restoration retains guarantee like effectual mediation in apoplexy restoration. Its vivid essence improves sufferer commitment & inspiration, possibly prompting finer therapy adhesion & results. The capacity of computer-generated actuality founded restoration to reproduce genuine situations, which provides an extraordinary stage (Aderinto et al.,

2023).

The purpose of this study was to survey the viability of computer-generated actuality-put-together mediation concerning despondency in apoplexy sufferers. Various devices were utilized to quantify sorrow. The postmodern examination showed that computer-generated actuality-founded mediation respectably affected melancholy in apoplexy sufferers contrasted with regulated bunch(Liu et al., 2023). Scholars reveal that apoplexy is a particular main source of inability around the world. The momentum study on post-apoplexy recovery generally centers around the engine incapacity angle. Mediations utilizing computer-generated actuality have displayed encouraging outcomes in further developing repetition remembrance & chief capability, particularly whenever computer-generated actuality intercession is joined with a mechanized helpful gadget. This blend treatment trains mental abilities yet additionally prepares the sufferer's coordinated movements at the same time(Gunawan et al., 2024). This research indicates that computer-generated actuality arises as a valuable device when utilized in traditional medicines to work on individuals' engine & mental capabilities following a blood-brain mishap. Furthermore, computer-generated actuality urges adhesion toward the intervening cycle of restoration over word-related treatment(Landim et al., 2024).

The review discoveries show that chest practices utilizing computer-generated actuality affect decreasing chest disability in sufferers with inveterate & persistent apoplexy. Enormous riffled controlled trials are expected to concentrate on the impacts of computer-generated actuality chest practices on the intense, inveterate, & persistent phases of apoplexy (Alhwoaimel et al., 2024). The ongoing review examined the impact of computer-generated actuality-put-together mediation with respect to misery & personal satisfaction in apoplexy sufferers. The ongoing review reasoned that computer-generated actuality-put together mediation has beneficial outcomes with respect to wretchedness & personal satisfaction in apoplexy sufferers(Thuan & Kim, 2024). This methodical audit portrays the adequacy of computer-generated actuality--upheld practice treatment on the above appendage engine capability & exercises of day-to-day subsistence after apoplexy. The majority of examinations recommended that computer-generated actuality, utilized close by traditional treatment, may further develop engine capability after apoplexy. However, the proof was deficient in explaining that computer-generated actuality beats regular methodologies(Dixit et al., 2024). This research aimed to assess the medical capability of the designated computer-generated actuality-founded remedial mediation in a little partner of sufferers explicitly with persistent apoplexy. Computer-generated actuality-preparing worked on engine results & crustal-edginess in sufferers with apoplexy(Nath et al., 2024).

3. Implications

The increasing rate of Stroke in the Young and elderly population has become the main concern in the medical field. As we know, Stroke mostly affects motor function in the human body, so it has a very pathetic impact. We need to implement such a therapy system, which will enable us to enhance recovery related to Motor function during the post-stroke period. Various therapies are suggested for motor recovery during the post-stroke period, but the efficiency of these therapies could be more satisfactory. Virtual reality-based therapy is one of the most emerging therapies that can effectively be used for motor recovery post-stroke. The following are the main implications of using virtual reality-based therapy for Motor Recovery during the stroke period:

3.1 Increased patient engagement, Enhanced way of feedback, improved motor function, less cost

The word virtual reality refers to the creation of illusions using real technology. Virtual reality is increasingly important in many fields, including the medical field. Virtual reality-based therapy can be used for motor recovery in many ways post-stroke. Stroke affects all brain functions, so there is a need to engage patients in different ways to galvanize recovery in patients. Using virtual reality-based therapy, such illusions are created, enabling a patient to think over it. For improved Motor Recovery during the stroke period, there is a need to work on patients' thinking abilities.

The other aspect is that cognitive functions decrease to the greatest extent due to Stroke. There is a time delay in processing and responding to the stimulus as a response. However, when we use virtual reality therapy, we create a real environment for the Patient, and he tries to respond to it. When the same stimulus is repeatedly provided, it will help process it easily and respond better. In all of this process, there is the enhanced engagement of patients; when there is Enhanced engagement, there is a better recovery in Motor function in the post-stroke period. The other important implication of virtual reality-based therapy for motor recovery is the enhanced way of giving feedback. As we know, virtual reality is artificial intelligence-based, and human intelligence is less used. This means there is no fatigue factor, and it can be performed repeatedly if there is no positive response. In some cases, patients respond swiftly to virtual reality-based; in my case, it takes much time to bring fruitful results. All of the therapy process is based on feedback. This aspect of virtual reality-based therapy makes it better than other therapies used for Motor Recovery in the post-stroke period. The other important implication of virtual reality-based therapy is improved patient motor function. It has been seen that patients who are provided with virtual reality-based therapy have shown better improvement in motor function compared to patients who got other therapies as well.

The other important implication of virtual reality-based therapy is its lower cost. Other therapies suggested for motor recovery in the post-stroke period have much higher costs and less chance of output, but in virtual reality-based therapy, there is less cost, and more accurate and swift results are provided. All of these important implications of virtual reality-based therapy convince us of the importance of virtual reality in daily life.

3.2 Upper and lower limb rehabilitation, reduced pain and discomfort, increased range of motion, enhanced emotional regulation

In most stroke cases, motor function is affected in the upper and lower limbs. Because of this damage, there is much difficulty in motion, or the whole body becomes paralyzed, and the Patient cannot rehabilitate it. However, with consistent virtual reality-based therapy, much improvement has been seen in the motor function of the upper and lower limbs. In this way, virtual reality-based therapy is useful for rehabilitating upper and lower limbs in Stroke. The other important implication of virtual reality-based therapy for motor recovery post-stroke is reduced pain and discomfort. Although there are other therapies for motor recovery, virtual reality is considered better because it causes less pain or discomfort. All other therapies are Based on physical or intense mental work, which can cause fatigue, pain, or discomfort in patients, but this therapy has no limitations. In this way, virtual reality-based therapy is more reliable for patients in the post-stroke period.

The other important implication of virtual reality-based therapy in motor recovery during the post-stroke period is Enhanced range of motion. As we know, due to Stroke, various body parts are affected by motion in the body. It is because of the effect on neurons of that particular area, which does not receive or respond to stimulus effectively. As a result, there is no motion in that part of the body. However, virtual reality-based therapy has solved this problem as well. When virtual reality-based therapy is provided to these patients, they show better rehabilitation in affected body parts, so the range of their motion increases. The most useful benefit of virtual reality-based therapy is that it shows swift results in the form of motion in the body.

The other important implication of virtual reality-based therapy is the aspect of emotional regulation in the body. For rehabilitation, there is not only a need for physical therapy, but there is also a need for such therapies that can't provide better mental health. For rehabilitation, the Role of mental health can never be denied. Better Mental Health is related to emotional regulation in the body. When a person knows how to control his emotions, he will indirectly be able to control and balance his mental health. When mental health improves, the chances for better Motor Recovery in the post-stroke period increase.

3.3 Descriptive Statistic

Table 1: Results of Descriptive Statistic

NAME	NO.	MEAN	MEDIAN	SCALE MIN	SCALE MAX	STANDARD DEVIATION	EXCESS KURTOSIS	SKEWNESS	CRAMÉR-VON MISES P VALUE
VR1	1	1.510	1.000	1.000	4.000	0.703	1.994	1.415	0.000
VR2	2	1.653	2.000	1.000	3.000	0.624	-0.613	0.426	0.000
VR3	3	1.551	1.000	1.000	3.000	0.608	-0.484	0.641	0.000
TT1	4	1.592	2.000	1.000	3.000	0.636	-0.535	0.623	0.000
TT2	5	1.510	1.000	1.000	3.000	0.643	-0.200	0.912	0.000
PSMR1	6	1.633	2.000	1.000	3.000	0.629	-0.603	0.490	0.000
PSMR2	7	1.551	1.000	1.000	3.000	0.608	-0.484	0.641	0.000
PSMR3	8	1.449	1.000	1.000	3.000	0.537	-0.806	0.618	0.000
PSMR4	9	1.612	2.000	1.000	3.000	0.600	-0.615	0.426	0.000

The results of table 1 above show how descriptive statistical analysis may be used to characterize mean values, median rates, standard deviation rates, skewness rates, and probability values for both dependent and independent variables. The primary independent variable result for virtual reality is 1.510, 1.653, and 1.551, which indicate positive average values for the mean. 70%, 62%, and 60% of the standard deviation rate vary from the mean. The total probability value of 0.000 indicating that 100% significant levels between them. The results of TT1, TT2, which are both regarded as mediator variables, show that their respective means are 1.592 and 1.510. 64% of the data depart from the mean, with a 63% standard deviation rate. The PSMR1,2,3, and 4 variables, which are all regarded as dependent results, indicate a positive average rate with mean values of 1.633, 1.551, 1.449, and 1.612. 53% of the data depart from the mean, with a standard deviation rate of 60%. Stroke is a significant worldwide health issue, ranking second in terms of mortality and disability rates. Stroke accounted for approximately 11% of all fatalities in 2019 and was the second leading cause of combined death and disability. Age is a significant risk factor for stroke, with 67% of incidents involving those over 70. Males experience a higher incidence than females in the majority of age groups. Strokes frequently cause severe long-term impairment, such as hemiplegia, aphasia, vision issues, and cognitive dysfunction. One of the most common and debilitating effects of stroke is upper limb motor disability, which affects around 80%

of survivors. Upper limb motor dysfunction, which manifests as diminished arm and hand function, frequently impairs the ability to execute activities of daily living, fulfil professional obligations, and generally maintain a high standard of living for stroke survivors. Only 5–20% of patients fully regain function in their upper limbs, and around half of them experience chronic stiffness. Effective rehabilitation is therefore necessary for both the best possible recovery of upper limb motor control and the performance of functional tasks.

3.4 Correlation Coefficient

Table 2: Result of Correlation Coefficient

	VR1	VR2	VR3	TT1	TT2	PSMR1	PSMR2	PSMR3	PSMR4
VR1	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
VR2	-0.248	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
VR3	-0.037	-0.034	1.000	0.000	0.000	0.000	0.000	0.000	0.000
TT1	0.009	0.157	-0.052	1.000	0.000	0.000	0.000	0.000	0.000
TT2	0.011	-0.067	-0.145	-0.090	1.000	0.000	0.000	0.000	0.000
PSMR1	-0.130	0.039	0.156	0.033	0.211	1.000	0.000	0.000	0.000
PSMR2	-0.276	0.073	0.117	-0.421	0.273	0.102	1.000	0.000	0.000
PSMR3	-0.174	0.343	0.242	-0.001	-0.013	0.368	0.242	1.000	0.000
PSMR4	0.082	-0.305	0.138	0.120	-0.228	-0.053	-0.309	-0.093	1.000

The results of table 2 mentioned above show how the correlation coefficient analysis results characterize their overall positive and negative relationship. Rehabilitation makes possible the use of neuroplasticity and brain reorganization, two essential processes that aid patients in regaining lost abilities and developing compensating measures. Research has demonstrated a substantial correlation between the significance of early intervention in the rehabilitation process and improved functional outcomes for stroke patients. To tailor treatment regimens in the field of upper limb rehabilitation, a variety of elements need to be carefully evaluated. Many assessment tools have been created to look at different facets of upper limb rehabilitation. These include tests of motor function such as the Action Research Arm Test (ARAT), the Wolf Motor Function Test (WMFT), and the Fugl-Meyer Assessment Scale (FMA).

In addition, independence assessments are crucial, and tools such as the Functional Independence Measure and the Barthel Index (BI) are useful in this regard. For evaluating dexterity, the Box and Block Test (BBT) is a helpful instrument. After a stroke, spasticity is a common issue that may be evaluated with the Modified Ashworth Scale (MAS). Last but not least, the Stroke Impact Scale offers a thorough viewpoint for assessing the overall impact of a stroke (SIS). Healthcare providers may be able to more accurately adjust therapy by integrating these various evaluation methods into the rehabilitation process, improving the quality of life and recovery trajectory for stroke patients. Upper limb rehabilitation employs a variety of techniques that are customized to meet the requirements of stroke and injury victims. The exercises offered by physical and occupational therapy are specifically designed to improve motor skills, range of motion, and everyday tasks. By restoring function to the injured limb, constraint-induced movement therapy encourages neuroplasticity in the undamaged limb. Virtual reality (VR), which provides immersive simulated environments for stimulating therapy activities, interactive video games that boost motivation, telerehabilitation—which enables participation from a distance for better access—and robotic devices that provide tailored assistance for progressive exercise are a few examples of technology-assisted interventions that have gained popularity.

3.5 Smart PLS Algorithm Model

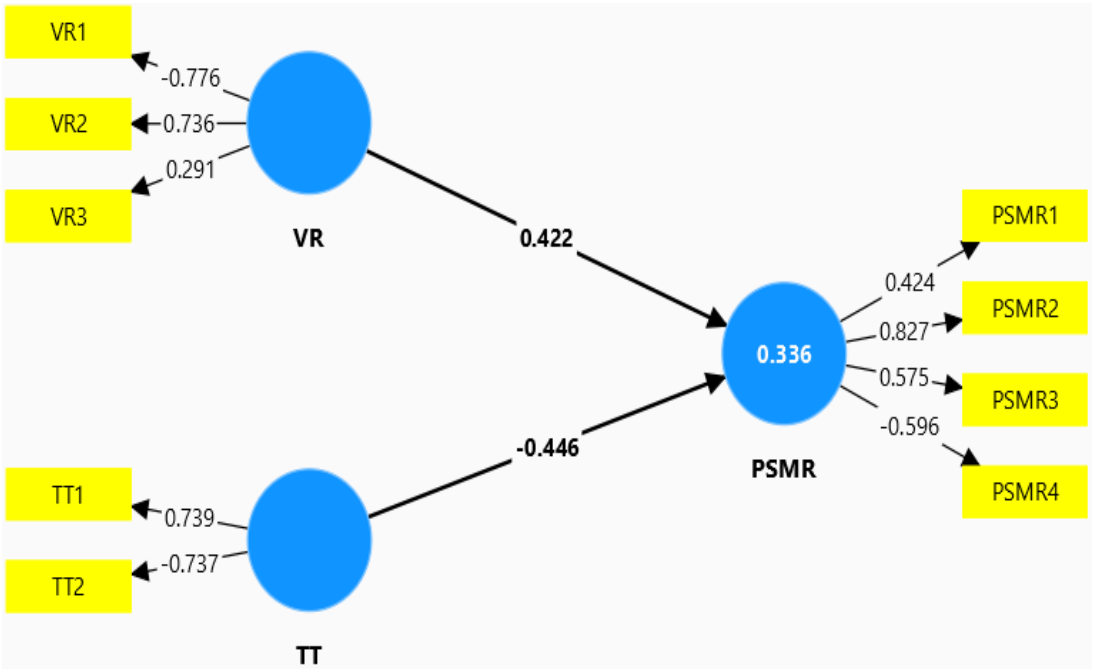

Figure 1: Smart PLS Algorithm Model

The above graph of figure 1 presents that smart PLS Algorithm model in between VR, TT and PSMR. The virtual reality shows that -0.776, 0.736 also that 0.291 its shows that 77%, 73% and 29% significant level between them. the TT shows that 73% positive and significant level with them. similarly, the

PSMR describe that 42%, 82%, 57% and 59% positive and significant levels between them.

4. Conclusion

The important best practices for cautiously incorporating virtual reality (VR) technology into upper limb rehabilitation programs for stroke sufferers are outlined in this thorough assessment. The meta-analysis's findings indicate that, although less immersive virtual reality platforms could be more advantageous for addressing fine motor dexterity deficits, fully immersive VR modalities are advised for the optimal rehabilitation of the paretic limb's gross motor skills. Additionally, it seems that starting VR-based treatments during the critical window of increased neuroplasticity that occurs in the first six months following a cerebrovascular accident and continuing therapy for a sufficient amount of time that exceeds six weeks is the most effective way to get the greatest amount of therapeutic benefit.

Additionally, it's critical to specifically tailor VR workouts to each patient's unique motor and functional abilities. Further research on VR's impact on the complex aftermath of stroke is necessary. The current systematic review provides strong evidence that the deliberate application of supplemental integration of VR-based techniques confers additional benefits for enhancing upper extremity motor function and performance of activities of daily living, as opposed to conventional occupational therapy alone. This highlights VR's potential as a rehabilitation aid to enhance stroke sufferers' outcomes. We may infer that virtual reality-based therapy is among the best therapies for motor recovery in stroke patients after reviewing these factors and the consequences of its effectiveness for motor recovery in the post-stroke period.

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