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ORIGINAL

THE ROLE OF VIRTUAL REALITY IN ENHANCING REHABILITATION OUTCOMES FOR ATHLETES WITH UPPER LIMB INJURIES

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ABSTRACT

Although upper-extremity illnesses and injuries seldom pose a threat to life, improper management can lead to serious dysfunction. The current status of employing virtual reality to aid in the rehabilitation of patients with upper extremity injuries and disorders is discussed in this article, along with how these conditions affect upper-extremity functions. The research study determines thr role of virtual reality in enhancing rehabilitation outcomes for athletes. The research based on primary data analysis for measuring the research used Smart PLS software. To give a thorough overview of the field of virtual reality for upper-extremity rehabilitation, a scoping study was carried out. Between April and May 2021, two separate researchers searched PubMed, Web of Science, and the Cochrane Library to find pertinent literature, which were then analyzed using inclusion and exclusion criteria. Eleven studies of different target groups were found as a consequence of the literature research. Virtual reality technology was divided into two categories: game-based systems and multimodal high-end systems. Virtual reality-based technologies did not perform worse than conventional therapy in terms of functional recovery. The users also expressed great satisfaction and motivation. The findings highlight the need for more robust, empirically supported virtual reality solutions for upper extremity injury and illness rehabilitation.

KEYWORDS: Virtual Reality (VR), Rehabilitation Outcomes (RO), Athletes (AA), Upper Limb Injuries (ULI)

1. INTRODUCTION

Stroke is an acute occurrence that mostly causes damage to the nervous

system, which can result in disability and death. It is one of the primary causes of acquired adult impairment and the second or third most common cause of mortality worldwide. About 30 to 40 strokes occur for every 100,000 individuals in Saudi Arabia (SA) each year, resulting in an estimated 20,000 new strokes, 8,000 disability, and 4,000 fatalities. Numerous deficits are noted, including as weakness, exhaustion, tone changes, sensory loss, cardiovascular deconditioning, uncoordinated reactions, poor balance, and trouble walking, all of which may affect a stroke victim's capacity to carry out functional tasks. Functional limits of the afflicted arm and sluggish, uncontrolled hand movements are among the changes that are frequently more noticeable in the affected upper limb than in the affected lower limb. Common alterations include the inability to manage grabbing, finger-tip force, and timing during object manipulation, or the difficulty executing reaching activities owing to atypical postural modifications and changes in timing and coordination. Due to a mix of physical, cognitive, and perceptual issues, stroke patients frequently struggle to participate in daily living activities (ADLs) including eating, dressing, and grooming, as well as to participate in employment, community life, and the home. When stroke patients have enough practice chances, their impaired upper limb's functional ability can improve. Numerous methods and strategies, including physiotherapy, occupational therapy, conductive education, splinting, casts, medication, and surgery, as well as specialised methods like neurodevelopmental treatment or restricted induced movement therapy, can be employed in the management process. Nevertheless, there isn't any solid proof that any of these methods or strategies work (Kacprzak & Stańczak, 2024). Virtual reality is the use of computer-generated interactive simulations to provide people beneficial experiences by allowing them to interact and engage with three-dimensional settings that closely resemble real-world objects and events. It has been demonstrated that virtual reality therapy for stroke patients is engaging and participatory, and with enough use, it may assist to enhance upper limb function and motor control. Since virtual worlds are a potential future method in the rehabilitation and improvement of ADL after stroke, using virtual reality in rehabilitation (also known as virtual reality-based treatment) is one of the most inventive advancements in rehabilitation technology. Virtual reality-based treatment may be applied in a variety of contexts, such as nursing homes or patients' homes, which enables extra practice outside of scheduled rehabilitation sessions. There aren't many research that have examined the use of virtual reality for stroke rehabilitation, and none that have looked at the impact of virtual reality-based therapy on stroke patients (Richlan et al., 2022). Therefore, more research is needed to demonstrate the effectiveness of virtual reality-based training in enhancing upper limb skills in stroke patients in Saudi Arabia. Thus, the purpose of this study was to compare the effects of a traditional functional training program and virtual reality-based therapy on the improvement of upper limb skills in Saudi chronic stroke patients. There isn’t many research that have examined the use of virtual reality for stroke

rehabilitation, and none that have looked at the impact of virtual reality-based therapy on stroke patients in Saudi Arabia. The prevalence of stroke is predicted to rise in Saudi Arabia and is already a serious issue, contributing to both mortality and morbidity as well as affecting the ability of the Saudi populace to carry out daily tasks. As a result, Saudi stroke victims require therapies that may enhance upper limb skills more quickly and effectively. Thus, the purpose of this study was to compare the effects of a traditional functional training program and virtual reality-based therapy on the improvement of upper limb skills in Saudi chronic stroke patients (Demeco et al., 2024). The research paper determines that role of virtual reality in enhancing rehabilitation outcomes for athletes with upper limb injuries. The research paper divided into five sections first portion describe that introduction related to the virtual reality and rehabilitation outcomes. The second section describe literature review the third portion represents result and its descriptions also that last section summarized overall research study and present discussion about topic.

2. Literature Review

Studies accounts a chronicle survey of mediation (for example., preparing) concentrates on utilizing Computer generated simulation in athletics settings. Accordingly, mediations in computer generated simulation (or expanded simulation) can possibly evoke genuine impacts in athletics execution improvement over preparing of centrifugal & mental abilities & capacities in competitors, involving discernment activity abilities, vital, planned & navigation, answering startling occasions, & upgrading mental flexibility & psychological execution pursuant tension(Richlan et al., 2022). The reason for this survey was to efficiently audit & basically assess the restrained medical preliminaries that examined computer generated simulation viability in Orthopedical restoration. Computer generated simulation & practices have comparative impacts in arthritic joint pain, Knee joint inflammation, lower leg flimsiness, & after-knee tendon recreation. In favor of fibrositis & back-torment, also post Knee joint replacement, the proof of computer generated simulation adequacy contrasted & practice is missing or uncertain(Gumaa & Rehan Youssef, 2019). Studies explain that in the contemporary time of athletics preparing, the cooperative energy among movement catch & Augmented simulation provides a creative way to deal with improving preparation accuracy. This efficient survey dives toward the use of movement catch inside computer generated simulation toward athletics preparing, its groundbreaking capacity to feature. The survey terminates along an accentuation on the more extensive cultural ramifications, proposing a move into a comprehensive competitor prosperity procedure(Li et al., 2024). The essential goal of this study is to distinguish the bionic danger elements related along knee tendon wound. Furthermore, computer generated simulation maybe utilized to prepare competitors in area-explicit strategies & establish protected & restrained helpful conditions to after-wound recuperation. Besides, computer generated

simulation provides an adjustable way to deal with therapy in view of single performer information. It tends to be utilized toward the two counteraction & recovery, fitting the restoration & preparing conventions as indicated by the competitors' particular requirements (Demeco et al., 2024). The reason for this research was to decide the cutting edge in the space of computer-generated simulation in serious competitors of various degrees of skill in different forfeitures & indicate the region of its diligence. Studies also show that computer generated simulation appears to assume a negligible part in serious competitors' preparation. Essentially, augmented simulation is successfully & usually employed to examine execution in serious competitors. There's yet a necessity of making completely intuitive computer generated simulation, where competitors will actually want to help out a cyber-accomplice & impact the climate(Akbaş et al., 2019). Researchers reveal that computer generated simulation depends on an online-world that makes straits impacts & video recording that supplant the genuine climate. Computer generated simulation considers the Personalization of therapy along a versatile therapy stage, that might work on the engagement of the sufferer & increment worthiness & adhesion to extended haul recovery schemes. Scholars give proposals & ideas to prospective exploration & utilization of computer generated simulation in Musculo-skeletal recovery(Chaplin et al., 2023). The point of this primer riffled dominated research was to examine the impacts of sport-founded virtual reality kayak rowing preparing, when joined along regular actual recovery schemes, on spinal alignment equilibrium & Upper limb capability in thirty sufferers along continuing fondle. Sport-founded virtual reality kayak rowing preparing is a powerful recovery treatment that improves spinal alignment equilibrium & Upper limb capability in sufferers along continuing fondle when joined with traditional actual restoration schemes(Lee et al., 2018). Studies expected to assess the effect of a computer-generated simulation put together recovery framework with respect to upgrading dynamic restoration period over Shoulder works out. In any case, no massive contrast was seen in the activity study Arm trial evaluations. This research recommends that computer generated experience may assume a critical part in improving Shoulder works & expanding dynamic recovery period toward fondle sufferers(Hosaini et al., 2024). Studies suggest that computer generated simulation works on the two coordinated movements & certainty toward everyday subsistence & in various circumstances to upgrade practical outcomes, working on the medical & societal advantages of a medical procedure. Consequently, sport-founded computer generated simulation is being created to permit general practitioners to make sport-founded virtual reality errands & this will effectively move propels in restoration mediations(Jeyakumar et al., 2022). Scholars suggest that upper extremity wound frequently obliges dreary & extended haul actual recovery that may bring about miserable adhesion because of the dreary & inside propelled essence of the activities. Studies outcomes recommend that encounters such as Open-Butterfly give solid stages to extended haul active recuperation

commitment, investigation, & recuperation. Ultimately, studies finishes up with contemplations to prospective investigation toward versatile immersive computer generated simulation physical therapist-restoration(Powell et al., 2020). Studies elaborate that computer generated simulation is an engaging methodology to expanding the commitment & consideration of sufferers over restoration. Lower arm brawns, excessive for sphere retention & delivery, were contained in the actuation cooperative energies in the augmented simulation climate. Ultimately, the collaborations were predictable beyond themes, particularly over the retardation stage. Outcomes are empowering to the utilization of computer generated simulation to supplement regular treatment, further develop commitment, & work with genuine estimations of bacteriology movement(Scalona et al., 2019). The outcomes of this study displayed an elevated discerned convenience of the framework, more noteworthy natural inspiration to play out the recovery works out, an elevated degree of drenching, & a decent involvement with the computer-generated simulation playing climate. Scholars review animates expanded intercession schemes circling back to this vivid computer generated simulation recovery framework to help football performers recuperating from Musculo-skeletal wounds(Gouveia et al., 2023). The current study accounts a story survey of mediation (for example., preparing) concentrates on utilizing Computer generated simulation in athletics settings. The neurological cognition systems (for example., ocular inquiry conduct, symbolism), strategic viewpoints (for example., versatile preparation trouble), & the problems of genuine exchange & quality of being generalizable by means of that such prospective games execution associated upgrades might happen are examined(Richlan et al., 2023). Studies claim that augmented simulation innovation has been broadly utilized in restoration preparing due to its vivid, intuitive, & creative highlights. A far reaching biblio-metric survey is expected to assist scholars along concentrate on prospective headings in light of the latest explanations of virtual reality advancements in restoration, that uncover latest circumstances & prerequisites(Fan et al., 2023). The principal point of the review was to assess the power of actual activity of pushchair fighters over a pugilism instructional meeting utilizing the (FitXR) application in vivid computer-generated simulation considering wellbeing associated physical activity proposals. The outcomes of this research show that pugilism practices in computer generated simulation may be an alluring & wellbeing associated type of physical activity toward pushchair fighters & an enhancement to their ordinary preparation(Polechoński et al., 2024). Studies expected to explore the effect of down Limb arrangement irregularities, explicitly Physiologic Knee talipes, on the practical recuperation results of competitors along meniscus wounds. Convenient recognition & revision of down Limb arrangement irregularities over the restoration interaction from meniscus wounds are significant to upgrade recuperation & further develop anticipation(Yang & Li, 2024). The results of this study indicates that vivid computer-generated simulation may be utilized being assistant in recovery of sufferers' post knee

tendon remaking regarding working on their agony also their abstract Knee assessment. Huge riffled manage test is prescribed to additionally examine the viability(Gsangaya et al., 2023). The objective of this study is to examine the impacts of non-vivid computer-generated simulation on scope of movement, brawn force, spasms & useful versatility of Upper extremity in spasticity tetraplegic psychological paralysis kids. The two gatherings of this research demonstrated enhancement in spastic, useful standing, scope of movement & brawn force, however therapy bunch getting utilitarian portability practices utilizing Non-vivid augmented experience was viewed as greater powerful than the benchmark bunch(Ghaffar et al., 2023). Scholars explain that knee tendon wounds are normal in athletics like football, frequently obliging broad restoration after-medical procedure. Studies features the capability toward the two extended reality & computer generated simulation uses in recognizing knee tendon reconstruction-associated shortages, & rouses their reconciliation along regular medical return to athletic covering cannons(Van Wallendael et al., 2024). Studies provides a diligence on various degrees toward the restoration of themes who've experienced neurologic sicknesses & who've extinct specific faculties in their Upper extremities. The diligence involving computer generated simulation & a component toward Hand following focuses on the recovery of 3 unique developments of the Upper extremity, in particular flexure & expansion of the entire Arm, flexure & augmentation of the grope, & flexure of the carpus, along trials executed on solid matters(ŢOPA & RUSU, 2023). Studies show that propels in neurology & innovation, like man-made reasoning, may prompt greater customized & powerful restoration schemes. Perceiving & tending to the complex idea of knee tendon wounds may essentially further develop restoration results, guaranteeing competitors may securely & really come back toward their athletics(Kacprzak & Stańczak, 2024). Scholar studies reveal that improved drenching in computer generated simulation possibly expands the viability of development preparing by causing more practical & enamoring encounters toward clients. The vivid & intelligent conditions given by computer generated simulation innovation empower customized preparing encounters joined by exact, impartial criticism(Deng et al., 2023). Studies means to assess the job of online & expanded reality in the restoration of different Musculo-skeletal requirements. Practical preparation along reaction demonstrates huge capability in decreasing agony & further developing extremity workings. Fitting reaction form & dose toward the sufferer's situation is vital. Trend setting innovations such as expanded reality & computer generated simulation, may further develop interest, extended haul results & improve the adequacy of development reeducation techniques(Suraksha & Srikantaiah, 2024). Studies highlights the capability toward incorporating computer generated simulation & brain-computer miters innovations to comprehend & saddle brain adaptability toward mental & restorative uses. The scholars used the (Favored Revealing Things to Efficient Surveys & Postmodern-Examinations) technique to direct a thorough & deliberate audit of the current writing on brain adaptability, computer

generated simulation, & brain-computer miters(Drigas & Sideraki, 2024). Studies determined that Secondary School women football performers who've supported one or more blackout give off an impression of being exceptionally defenseless against center or Lower limb wrench, along the chance of wound intensified via a sluggish Arm arrive at response time. Macho soccer performers as a gathering showed fundamentally quicker Arm arrive at response time than that of women football performers, yet sluggish intuitive-centrifugal response time toward Arm arrive was as well distinguished as a possibly significant wound danger element toward macho performers(Wilkerson et al., 2024).

2.1 Descriptive Statistical Analysis

Table 1: The Result of Descriptive Statistical Analysis

NAME	NO.	MEAN	MEDIAN	SCALE MIN	SCALE MAX	STANDARD DEVIATION	EXCESS KURTOSIS	SKEWNESS	CRAMÉR-VON MISES P VALUE
VR1	1	1.633	2.000	1.000	3.000	0.629	-0.603	0.490	0.000
VR2	2	1.857	2.000	1.000	3.000	0.700	-0.931	0.211	0.000
VR3	3	1.673	2.000	1.000	3.000	0.651	-0.669	0.462	0.000
VR4	4	1.673	2.000	1.000	3.000	0.651	-0.669	0.462	0.000
RO1	5	1.653	2.000	1.000	3.000	0.591	-0.614	0.291	0.000
RO2	6	1.980	2.000	1.000	3.000	0.685	-0.830	0.027	0.000
RO3	7	1.612	2.000	1.000	3.000	0.664	-0.597	0.648	0.000
RO4	8	1.592	1.000	1.000	3.000	0.668	-0.544	0.713	0.000
AA1	9	1.592	2.000	1.000	3.000	0.636	-0.535	0.623	0.000
AA2	10	1.735	2.000	1.000	3.000	0.632	-0.609	0.290	0.000
ULI1	11	1.653	2.000	1.000	4.000	0.744	0.612	0.986	0.000
ULI2	12	1.531	1.000	1.000	3.000	0.642	-0.311	0.837	0.000
ULI3	13	1.653	2.000	1.000	3.000	0.656	-0.659	0.522	0.000

The above result of table 1 demonstrate that descriptive statistical analysis result represent that mean values, the median rates, standard deviation rates, the skewness values also that explain the probability rate of each variables included dependent and independent. The VR1,2,3, and 4 result shows that mean value is 1.633, 1.857, 1.673 result shows that positive average value of mean. The standard deviation values of each variable are 62%, 70%, 65% deviate from mean values. The result also describes that overall probability value is 0.000 the overall minimum value is 1.000 the maximum value is 3.000 respectively. The RO1,2,3 and 4 represents that its mean value is 1.653, 1.980, 1.612 also that 1.592 result shows that positive average value of mean. The standard deviation rate is 68%, 66% and 63% deviate from mean. The standard deviation rate is 68%, 66% and 63% deviate from mean.

The result also describes that AA1,2, result shows that mean value is 1.592, 1.735 result represent that all mean value is positive average rates. Similarly, the standard deviation value is 63%, deviate from mean value. The ULI1,2,3 represents that 1.653, 1.531 and 1.653 result shows that positive average value of mean. The standard deviation rate is 74%, 64% and 65% deviate from mean value of each variable.

2.2 Correlation Coefficient Analysis

Table 2: The Results of Correlation Coefficient Analysis

	VR1	VR2	VR3	VR4	RO1	RO2	RO3	RO4	AA1	AA2	ULI1	ULI2	ULI3
VR1	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
VR2	-0.166	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
VR3	0.355	0.077	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
VR4	-0.143	0.211	0.134	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RO1	0.261	-0.317	0.183	-0.241	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RO2	-0.349	-0.176	-0.381	0.077	-0.018	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RO3	0.001	0.144	0.226	-0.010	0.073	-0.062	1.000	0.000	0.000	0.000	0.000	0.000	0.000
RO4	0.080	0.006	0.257	-0.072	0.210	-0.063	0.195	1.000	0.000	0.000	0.000	0.000	0.000
AA1	-0.069	-0.085	-0.174	0.122	0.003	0.121	-0.181	-0.008	1.000	0.000	0.000	0.000	0.000
AA2	0.063	0.191	-0.111	0.137	-0.083	0.035	-0.294	0.130	0.188	1.000	0.000	0.000	0.000
ULI1	-0.272	0.022	-0.234	0.061	0.237	0.146	0.141	-0.039	-0.040	-0.066	1.000	0.000	0.000
ULI2	-0.225	-0.149	-0.171	-0.074	-0.106	0.164	0.243	-0.161	-0.069	-0.156	0.044	1.000	0.000
ULI3	-0.062	-0.063	0.165	-0.265	0.269	-0.288	0.253	0.376	-0.095	-0.222	0.046	-0.047	1.000

The above result of table 2 represents that correlation coefficient analysis result shows that positive and some negative interrelation in between virtual reality and rehabilitation outcomes for athletes with upper limb injuries. The potential of VR-based systems to improve training efficiency in terms of human resources should be taken into account in future research areas. VR makes it possible to automate treatment sessions, allowing them to be finished without the continual oversight of a therapist. Additionally, the hassle of clinical visits may be eliminated by designing a VR system for a patient's home.

Although the idea of home-based rehabilitation is appealing from a technological and financial standpoint, as the technology advances, professional and user-centered concerns must also be taken into account. Therefore, evidence-based recommendations must constantly guide the proper development and usage of VR systems. Indeed, user viewpoints also play a significant role in this. Numerous research examined the difficulties of virtual reality from the viewpoint of the user in a particular or general field. Three types of obstacles to deploying and utilizing a VR-based system have been examined in this context: technical, practical, and user-based. One major drawback is the need for specialized technological knowledge. Clinical professionals and patients alike must be taught and trained in the appropriate and professional usage of virtual reality (VR) systems as beneficial rehabilitation aids. Users' age, degree of technological literacy, and prior VR system experience should all be taken into account while developing the required abilities. It goes without saying that training experts will have a significant influence on the more efficient usage of virtual reality.

2.3 Smart PLS Algorithm Model

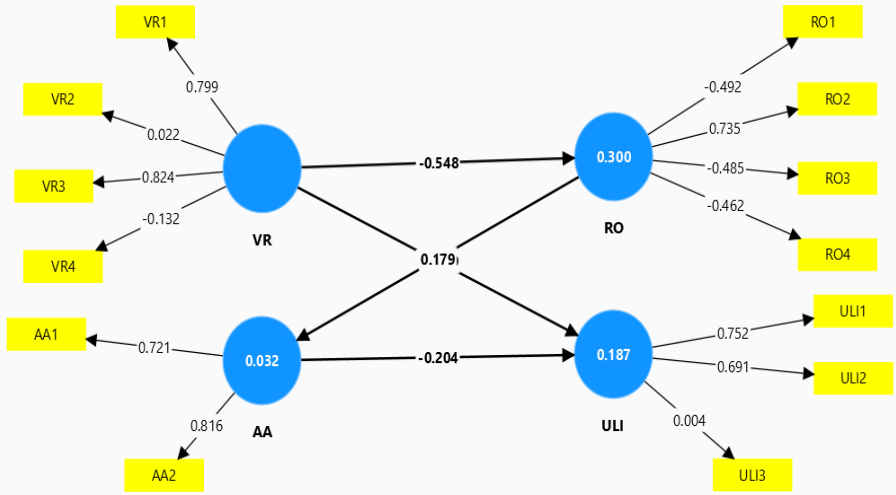

Figure 1: Smart PLS Algorithm Model

The above model of figure 1 represents that smart PLS Algorithm in between virtual reality in enhancing rehabilitation outcomes for athletes. The VR shows that 79%, 2%, 82% and 13% positive and significant rates. The result shows that 54% negative but its significant relation with RO. The virtual reality shows that 17% positive and significant link with ULI. According to the result its shows that 75%, 69% and 4% significantly values between them.

3. Discussion

The effective use of VR technology for rehabilitation, particularly in the context of neurological illnesses, has previously been demonstrated in a number of evaluations. On the other hand, there are very few publications

available for the rehabilitation of musculoskeletal disorders. Thus, the purpose of this scoping review was to give a general overview of VR technologies that are employed for upper-extremity injury and illness rehabilitation that goes beyond neurological problems. There is conflicting but encouraging data about the efficacy of VR technology in treating individuals with illnesses and injuries affecting the upper extremities. According to the results of this scoping study, VR-based therapies are not less effective than conventional rehabilitation and may even be more beneficial for pain management and functional recovery. High-caliber future research is required to arrive at a firmer conclusion. It is astounding how many research have made use of game-based virtual reality technologies. Healthcare professionals may accurately develop, deploy, and control complex and dynamic settings for user engagement by integrating inexpensive game-based virtual reality technology. Despite not being specifically created for rehabilitation, these kinds of technologies might be inspiring and economical substitutes. Therefore, inpatient, outpatient, and home-based care settings will find game-based VR rehabilitation activities that can be readily customized to meet the needs of each individual user to be a useful supplement to traditional therapy. A drawback, meanwhile, would be the lack of alternatives for tailoring and modifying game-based material to meet the requirements of certain illnesses or ailments. Additionally, there are a lot of distinct stimuli and aspects in content visualization, which might be overpowering. Furthermore, the motions that must be done are frequently excessively general and incongruent with the objectives of therapy. Motion detection systems, which display the virtual environment on huge displays, were a feature of the majority of VR technologies employed in the experiments. As a result, the user may view and interact with the simulated world. This has the benefit of maybe encouraging people to move in a natural way. As a result, VR-based rehabilitation is a useful tool for helping individuals with upper-extremity illnesses and injuries manage their motor impairment and regain the capacity to carry out self-care and activities of daily living (ADL), which are defined as the tasks necessary to lead an independent life, such as cooking or cleaning. Using a virtual kitchen to practice meal preparation or a virtual supermarket to practice shopping for those with traumatic brain injury are two examples of how VR may be used to help with ADL rehabilitation. Training manual skills with an exoskeleton robot that has an actuator to help with shoulder mobility is another example. The VR system was used to learn ADL chores including cooking, cleaning, and operating a ticket machine. The assist-as-needed approach was used to offer guidance when required. Additionally, patient motivation is a key component of successful recovery. Motivation and commitment may be attained by incorporating repetitious activities into virtual worlds in a fun and natural way. This offers the chance to train in real-world situations in a graded, risk-free manner. Most of the studies in this analysis comprised up to 10 training sessions with around 30 minutes of exercise per session, with the intensity and complexity of the exercises being adjusted based

on each participant's performance. Since the Yerkes–Dodson law, which was initially described by Yerkes and Dodson in 1908, explains a link between arousal or motivation and performance, it is crucial to take this into account while creating VR activities. It suggests that linear responses are produced at low task difficulty levels. The connection turns inverse when the difficulty level rises, and performance may suffer as motivation or arousal levels rise. An intense training program may eventually reach a point where a higher level of intensity—such as longer session time or more sessions per week—is required to further push the functional improvements and patient motivation. Additionally, using VR makes it possible to measure and record the user's movements for performance tracking and analysis. Performance data recording helps specialists monitor patient development both inside and between sections and assess movement quality. The ability to see visualizations of their behavior from various angles may be helpful to users. Furthermore, prompt and precise feedback on exercise performance may help improve adherence and motivation. A few restrictions should be noted. Initially, only articles written in German and English were featured. Additionally, research that evaluated neurological conditions was not included. The fact that only 11 research could be found as a result emphasizes once again how little is known about the potential of VR technologies for the rehabilitation of upper-extremity illnesses and injuries. Comparability and interpretation of the results are limited by the small sample numbers in the research, the variability of endpoints and evaluation instruments, and both. Furthermore, it was unable to find specifics on VR technology' conceptual or tangible substance.

4. Conclusions

This scoping analysis concluded that game-based virtual reality (VR) systems, in particular, are quite common in the rehabilitation environment and appear to be becoming more significant as a way to boost motivation and assist therapy. According to the research currently available, these technologies have the potential to significantly influence motor and functional rehabilitation evaluation and intervention due to the special qualities of VR-based therapy. These characteristics make it ideal for accomplishing a wide range of rehabilitation objectives, such as promoting active learning, offering demanding yet secure settings, offering customized and graded treatments with flexibility, inspiring patients to reach their maximum potential, and capturing objective performance metrics. VR systems are being used to enable persons with upper-extremity problems have leisure possibilities by rehabilitating motor deficiencies. Significant gains in upper-extremity recovery have been made possible by VR-mediated therapy, particularly in terms of pain relief and range of motion. VR systems have the potential to be used for training in everyday life skills, such as navigating a virtual kitchen, crossing streets, and navigating a route around an area. VR technologies have the potential to be a useful aid in the rehabilitation of upper-extremity functions, according to the evidence from this

scoping study. VR systems are equivalent to current traditional rehabilitation treatments and can be utilized as an alternative or complement for the rehabilitation of upper-extremity injuries and disorders, even if the findings do not show that they are noticeably more effective than standard physiotherapy. Compared to traditional rehabilitation, the key benefits are the enhanced motivation to complete treatment activities and the risk-free, simulated training of functional exercises at a higher intensity. All things considered, virtual reality provides a special medium that allows rehabilitation to be provided in a motivating, useful, and meaningful setting that is easily gradable and recordable. Virtual reality technologies, particularly those based on games, are becoming more affordable and widely available, but they are still not entirely integrated into standard medical treatment. When VR technologies are easily incorporated into patients' and professionals' daily lives, they may be able to be used successfully and widely in rehabilitation. Designing and assessing VR technologies in a participative and user-focused manner will be essential for this goal. Learning about the impacts that next advancements may reveal, including user-specific viewpoints, is still fascinating.

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