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Virtual Reality-Based Upper Extremity Rehabilitation in Subacute Stroke: A Pilot Study

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Abstract

Background. Virtual reality (VR) technology has emerged as a promising modality for stroke rehabilitation, yet the relationship between baseline motor function and user experience remains poorly understood. Understanding how motor impairment severity influences VR engagement, satisfaction, and tolerability is crucial for optimising clinical implementation.

Aim. This pilot study investigated the relationship between baseline upper extremity motor function and key user experience metrics during VR-based rehabilitation in subacute stroke patients.

Methods. Twelve participants with subacute stroke (140 ± 23 days post-onset) completed a single 60-minute VR-based upper extremity training session. Baseline motor function was assessed using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE). Primary outcomes included user satisfaction (User Satisfaction Evaluation Questionnaire), training engagement (movement repetitions per minute), session duration, and adverse events.

Results. Participants (8 males, 4 females; age 41.58 ± 14.51 years) demonstrated substantial heterogeneity in baseline motor function (FMA-UE: 18–56 points, mean 39.08 ± 11.36). User satisfaction was consistently high across motor severity levels (22.92 ± 4.29 points). Counterintuitively, a moderate negative correlation emerged between baseline motor function and training engagement ($r = -0.445$, $p = 0.148$), with more severely impaired participants achieving higher movement repetition rates. Eight participants (66.7%) completed the full protocol, while four required early termination. Mild to moderate discomfort affected 50% of participants, with higher rates among those with severe to moderate impairments.

Conclusions. VR-based upper extremity training demonstrates feasibility and acceptability across motor impairment severities in subacute stroke. The unexpected finding that participants with greater motor deficits exhibited higher engagement challenges conventional assumptions about technology-assisted rehabilitation. These results suggest VR interventions should not be restricted to individuals with preserved motor function, though individualised safety protocols may be necessary for more severely impaired patients.

Keywords: stroke rehabilitation; virtual reality; motor function; user experience

1. INTRODUCTION

Stroke remains a leading cause of long-term disability worldwide, with upper extremity motor impairments affecting approximately 80% of survivors and significantly limiting functional independence and quality of life (Hatem et al., 2016; Langhorne et al., 2011). Despite their compensations, traditional rehabilitation techniques have drawbacks such as low exercise duration, low patient inspiration, and incomplete access to expert care (Laver et al., 2017). Interest in technologically reinforced rehabilitation methods that can supplement outmoded treatment methods has augmented as a result of these complications. Virtual reality-based therapy provides immersive, interactive environments that increase patient engagement and enable high-intensity, repetitive training (Saposnik et al., 2010). With roots in motor-powered advancement, neuroplasticity, and psychological involvement, the academic underpinnings of VR-based rehabilitation are well-established. According to Bergmann et al. (2018) and L. Chen et al. (2022), VR systems are able to deliver standardised, reproducible procedures for exercise along with right away feedback, adaptive struggle adjustment, and independent achievement monitoring. These features are hard to unswervingly utilise with outmoded behavioural therapy methods.

There are still a lot of unanswered interrogations about the best ways to employ VR-based treatment in rehabilitation succeeding a stroke, notwithstanding increasing evidence to the contrary. The connection between the user's standpoint during VR training and baseline motor development is one central area that needs investigation (Aderinto et al., 2023). To ensure adequate choice for patients and harvest evidence-based behaviour recommendations, it is crucial to comprehend how the severity of motor diminishing affects important characteristics like contribution, fulfilment, and broadmindedness. As a result of the assumption that sophisticated outstanding competence makes it easier to communicate consuming technological user interfaces, modern treatment frequently suggests that technology-assisted rehabilitation is best suited for persons with practically retained motor function. This hypothesis, however, is not maintained by empirical evidence and might unintentionally leave out patients who may profit from VR-based intervention. Additionally, because stroke-related motor discrepancies are variable, individualised comebacks to VR therapies are expected to fluctuate significantly, requiring a more nuanced knowledge of how underpinning features disturb training consequences.

Because of augmented adaptability and the opportunity of functional repossession, the subacute stage of stroke recovery, generally characterised as one to six months subsequently onset, characterises a crucial window for rehabilitation exertions (Bernhardt et al., 2017). Intense, task-specific exercise can optimise brain transformation and functional consequences at this time. However, little is known about the pragmatism and acceptance of VR-based therapies throughout this stage, specifically when seeing varying degrees of diminishing in undertaking harshness. Metrics associated to the patient experience, such as permissibility, involvement, and satisfaction, are more widely acknowledged as momentous determinants of rehabilitation consequences. While poor acceptability can confine training occurrence and length, high user appointment and fulfilment are accompanying to higher functional consequences and greater adherence to handling instructions (Laver et al., 2017). Despite their worth, stroke rehabilitation investigation has paid little consideration to these indicators, with the mainstream of studies absorbed more in motor consequences than patient involvement fundamentals.

In order to fill in these knowledge gaps, this pilot study systematically examines the connections between key user satisfaction metrics during wide-ranging VR-based rehabilitation in subacute stroke patients along with baseline motor upper extremity performance determined by Fugl-Meyer Assessment for Upper Extremity (FMA-UE). Our hypothesis was that baseline motor ability would be disapprovingly connected with adverse occurrences and early engagement relinquishment and positively associated with training participation and user satisfaction. The findings of this study have significant ramifications for clinical practice, including influencing protocols, safety monitoring techniques, and patient selection standards for VR-based stroke rehabilitation programmes.

2. METHODS

Study design and participants

This pilot study was conducted across multiple rehabilitation centres across Delhi, India over a single session. Ethical approval was given by the Institutional Ethical Committee of Galgotias University, Greater Noida, India (Ref: IEC/SAHS/PHD/24/12), and the study is registered with the Clinical Trial Registry of India (CTRI: REF/2025/03/102211). The study was conducted in accordance with the Declaration of Helsinki, all subjects gave written informed consent before participation.

Inclusion criteria: Participants were eligible for inclusion if they met the following criteria: (1) diagnosis of first-time stroke confirmed by neuroimaging (computed tomography or magnetic resonance imaging); (2) age 18–75 years; (3) stroke onset 1–6 months prior to enrolment (subacute phase); (4) presence of unilateral upper extremity motor impairment; (5) cognitive capacity to understand instructions and provide informed consent as determined by clinical assessment; (6) ability to maintain sitting balance independently or with minimal support for 60 minutes; and (7) corrected vision sufficient for VR display viewing.

Exclusion criteria included: (1) history of previous stroke or other neurological conditions affecting upper extremity function; (2) severe visual impairments incompatible with VR technology; (3) epilepsy or history of seizure disorder; (4) severe cognitive impairment (Mini-Mental State Examination (Folstein, 1975) score <20); (5) contraindications to prolonged sitting or upper extremity movement; (6) current participation in other research studies involving rehabilitation interventions; and (7) inability to provide informed consent.

Recruitment and sampling

Participants were recruited using a combination of convenience sampling and consecutive enrolment from the Neurological Rehabilitation Unit. Potential participants were identified through medical record review and clinician referrals. Eligible patients were approached by research staff during routine clinical visits and provided with detailed information about the study.

The target sample size of 12 participants was determined in accordance with pilot study guidelines for feasibility research and available resources, ensuring representation across varying levels of motor impairment severity. No participants withdrew during recruitment or initial assessment. Additionally, no serious adverse events or exclusions due to ineligibility or withdrawal of consent were reported.

Primary outcomes measures

User Satisfaction Evaluation Questionnaire (USEQ): The USEQ was used to assess participant satisfaction following the intervention. This validated six-item instrument is specifically designed to measure satisfaction with digital rehabilitation technologies. Total scores range from 6 to 30, with higher scores indicating greater satisfaction (Gil-Gómez et al., 2017). The questionnaire was administered immediately after completion of the VR session.

Training engagement: Engagement was quantified as the number of movement repetitions per minute during active VR training. These data were automatically recorded by the VR system, providing an objective measure of exercise intensity and user interaction during the intervention.

Session duration: The total session time (in minutes), including both active and rest periods, was recorded automatically from the beginning to the end of each session or early termination.

Secondary outcomes measures

Adverse events: All adverse events (e.g. discomfort, fatigue, dizziness, imbalance) were systematically monitored and recorded by research staff during the session and for 30 minutes afterwards. Events were categorised by type, frequency, and severity (mild, moderate, or severe).

Safety metrics: Physiological safety was monitored through continuous measurement of heart rate and blood pressure before, during, and after the VR session to identify any clinically relevant changes or abnormal responses.

Baseline assessments

Demographic and clinical characteristics: Comprehensive baseline data collection included demographic information (age, sex, education level), stroke characteristics (aetiology, location, time since onset, affected side), and relevant medical history. Stroke aetiology was classified as ischemic or haemorrhagic based on neuroimaging findings and clinical documentation.

Motor function assessment: The Fugl-Meyer Assessment for Upper Extremity (FMA-UE), 66-point scale measuring motor limitations in people with stroke, was used for evaluating the upper body's motor skills (Fugl-Meyer et al., 1975; Gladstone et al., 2002). Four domains of motor function are evaluated by the FMA-UE: sensation, passive joint movement, joint embarrassment, and upper extremity synchronisation and speed. Scores range from 0 (severe impairment) to 66 (normal motor function), with established severity classifications: severe (0–15 points), severe to moderate (16–34 points), moderate to mild (35–53 points), and mild (54–66 points) (Woytowicz et al., 2017). All assessments were conducted by trained research personnel with established inter-rater reliability.

Mini-mental state examination: Cognitive function was screened using the Mini-Mental State Examination (MMSE) to ensure participants possessed adequate cognitive capacity for VR training participation and outcome assessment completion (Folstein et al., 1975). Additional brief calculations of consideration, visual-spatial dispensation, and managerial function were shown as clinically designated.

VR intervention protocol

Equipment and setup: Custom rehabilitative software and head-mounted display (HMD) devices equipped with upper-body tracking sensors were used to create the virtual reality (VR) training environment. The Oculus Quest 2 (*Meta, USA*), a tablet-based HMD, was utilised in this study. The system provided immersive, three-dimensional environments with real-time motion detection and visual feedback. Training tasks were specifically designed for stroke rehabilitation and included reaching, gripping, and object manipulation exercises of varying difficulty levels.

Training session structure: Each participant completed a single standardised 60-minute VR training session. Before starting, a five-minute orientation was provided to familiarise participants with the VR environment and control interface. The training protocol incorporated progressively challenging levels that automatically adjusted based on performance indicators. Structured breaks were offered every 15 minutes, or as needed based on participant preference, to prevent fatigue.

Task description: Training activities, including goal-directed movements, coordination tasks, and object manipulation, were designed to simulate functional daily life activities within the virtual environment. The system provided real-time visual and auditory feedback on movement accuracy, speed, and task completion. Adaptive algorithms maintained optimal challenge by modifying task complexity in real time according to participant performance.

Safety monitoring: Continuous safety monitoring was conducted throughout each training session. Research personnel remained on site to observe participants, provide technical assistance, and ensure participant safety and confidentiality. Sessions were discontinued if requested by the participant, or in the event of significant discomfort, adverse symptoms, equipment malfunction, or investigator judgement.

Data collection

All baseline assessments were completed within 48 hours prior to the VR training session. The study procedures were thoroughly explained to all participants, who were also given the opportunity to ask questions. To minimise potential novelty effects during data collection, practice sessions with the virtual reality (VR) equipment were provided in advance. Each training session was carefully documented, including start and end times, task progression, rest intervals, technical issues, and any notable events or observations. Standardised data collection forms were used by the research team to ensure consistent recordkeeping for each participant. Participants filled in adverse event reports and satisfaction questionnaires immediately after completing or prematurely terminating the programme. Additional clinical assessments were conducted as needed, based on reported symptoms or observed concerns.

Statistical analysis

Baseline physiognomies and outcome procedures were summarised using apposite descriptive numbers. Continuous variables were described using means, standard deviations, medians, and ranges, while categorical variables were presented as frequencies and percentages. Pearson's correlation coefficients were calculated to examine relationships between baseline FMA-UE scores and primary outcome measures.

3. RESULTS

Participant characteristics

The study included 12 participants, comprising eight males (66.7%) and four females (33.3%), with a mean age of 41.58 ± 14.51 years (range: 23–64 years). The average duration since symptom onset was 140 ± 23 days (range: 96–171 days). The affected upper extremity was on the left side in nine participants and on the right side in three participants. The mean Fugl-Meyer Assessment for Upper Extremity (FMA-UE) score was 39.08 ± 11.36 out of the maximum possible score of 66, indicating a moderate level of motor impairment (Table 1). All participants demonstrated cognitive capacity to understand instructions and provide informed consent, with no severe visual, auditory, or cognitive impairments that would preclude VR participation.

Table 1. **Demographic and clinical characteristics of the cohort (n = 12)**

Items	Value
Gender (male / female; %)	8 males (66.7%), 4 females (33.3%)
Age (yrs. ± SD)	41.58 ± 14.51 [range 23–64]
Duration since onset (days)	140 ± 23 [range: 96–171]
Affected upper extremity (left / right)	9 / 3
FMA-UE (score ± SD; max 66)	39.08 ± 11.36

Note: SD – standard deviation; FMA-UE – The Fugl-Meyer Assessment for Upper Extremity.

Baseline motor function assessment

The Fugl-Meyer Assessment for Upper Extremity revealed substantial heterogeneity in baseline motor function, with scores ranging from 18 to 56 points (mean: 39.08 ± 11.36, median: 40.5). When categorised according to established severity classifications, six participants (50.0%) fell within the moderate to mild impairment range (35–53 points), five participants (41.7%) within the severe to moderate range (16–34 points), and one participant (8.3%) within the mild impairment category (54–66 points). Notably, no participants presented with severe impairment (0–15 points), indicating that the recruited sample represented individuals with residual upper extremity motor capacity, potentially suitable for technology-assisted rehabilitation interventions.

Table 2. **Fugl-Meyer assessment data of upper extremity**

Patient	Age (years)	Gender	Stroke	Side affected	Time from stroke onset (in days)	FMA-UE
1	27	M	Ischemic	Left	128	42
2	28	M	Haemorrhage	Left	160	34
3	23	M	Ischemic	Left	152	51
4	56	M	Haemorrhage	Left	96	47
5	24	M	Ischemic	Right	139	23
6	60	F	Haemorrhage	Left	170	39
7	45	M	Ischemic	Left	135	34
8	36	F	Ischemic	Right	116	32
9	38	F	Ischemic	Left	131	18
10	64	M	Haemorrhage	Left	171	56
11	44	F	Ischemic	Right	121	48
12	54	M	Ischemic	Left	161	45

Primary outcome measures

User satisfaction. Post-intervention user satisfaction, as measured by the User Satisfaction Evaluation Questionnaire (USEQ), demonstrated a mean score of 22.92 ± 4.29 (range: 17–29, median: 23.0). This moderate satisfaction level indicates generally favourable user acceptance of the VR intervention, with all participants scoring substantially above the theoretical minimum threshold of six points. The relatively narrow distribution and modest standard deviation suggest consistent user experiences across participants despite considerable variability in baseline motor abilities.

Engagement assessment. Task-related movement engagement, quantified as repetitions per minute during VR training, exhibited the greatest inter-individual variability among primary outcomes. Participants achieved between 7 and 18 movement repetitions per minute (mean: 13.33 ± 3.23, median: 14.0). This substantial range in engagement levels likely reflects complex interactions between residual motor capacity, cognitive processing, task comprehension, motivation, and individual adaptation to the virtual environment during the single training exposure.

Training tolerability. The overall mean training duration was 52.67 ± 11.79 minutes (range: 25–60 minutes, median: 60.0 minutes). Eight participants (66.7%) successfully completed the full 60-minute protocol, while four participants (33.3%) required early termination. Among those discontinuing prematurely, session durations ranged from 25 to 45 minutes, representing 41.7% to 75.0% of the intended training dose. The median completion time reaching the full 60-minute target suggests that the majority of participants tolerated the intervention well.

Safety and tolerability profile. Discomfort during VR training was reported by six participants (50.0%), whereas the remaining six participants (50.0%) reported no adverse sensations. Among those experiencing discomfort, stiffness was most common (n = 3; 25.0% of total, 50.0% of those reporting discomfort), followed by fatigue (n = 2; 16.7% of total) and a transient episode of imbalance (n = 1). Discomfort intensity was generally mild to moderate, with numerical ratings ranging from 5 to 7. No serious adverse events occurred, and all reported discomfort resolved spontaneously after session completion or early termination, with no lasting effects observed during post-session monitoring.

Pearson's correlation analysis. Although statistical power was limited, exploratory correlations between baseline Fugl-Meyer Assessment of Upper Extremity (FMA-UE) scores and training outcomes revealed a weak positive trend between FMA-UE scores and user satisfaction (r = 0.282, p = 0.375). This suggests that participants with higher baseline motor function may experience slightly greater satisfaction, although this relationship was not statistically significant (Table 3).

Table 3. **Relationship between baseline FMA-UE scores and post-training user satisfaction (USEQ score)**

Outcome measures pair	**Pearson's r**	**p-value**
FMA-UE vs. user satisfaction	0.282	0.375
FMA-UE vs. movement repetitions/min	–0.445	0.148
FMA-UE vs. session duration	0.010	0.976

Note: FMA-UE – The Fugl-Meyer Assessment for Upper Extremity.

A more pronounced and clinically intriguing finding was the moderate negative correlation between FMA-UE scores and movement repetitions per minute (r = –0.445, p = 0.148). This counterintuitive relationship suggests that participants with lower baseline motor function demonstrated higher engagement rates during training. While not statistically significant due to sample size limitations, this trend may reflect several possible mechanisms: greater compensatory effort among more impaired individuals, increased concentration and focus during novel task performance, or potential adaptive algorithms within the VR system providing more practice opportunities for participants with lower baseline abilities. The relationship between FMA-UE scores and training duration was negligible (r = 0.010, p = 0.976), indicating that baseline motor impairment severity did not predict session completion capacity in this cohort.

Outcomes stratified by motor impairment severity

Severe to moderate motor impairment group (n = 5). Participants with severe to moderate motor impairments (FMA-UE: 16–34 points) exhibited distinct response patterns to the VR intervention. Their mean satisfaction score (22.4 ± 5.2) was comparable to other severity groups, indicating that motor impairment level did not substantially affect user acceptance or perceived intervention value. Notably, this group demonstrated the highest engagement rate (14.6 ± 1.1 repetitions per minute) and the lowest engagement variability, possibly reflecting consistent compensatory effort during training. The mean session duration of 53.0 ± 9.7 minutes indicated generally good tolerance; however, 60% of participants (3 of 5) experienced mild to moderate discomfort, representing the highest rate among all severity groups.

Moderate to mild motor impairment group (n = 6). Participants with moderate to mild impairments (FMA-UE: 35–53 points) showed similar satisfaction levels (22.3 ± 3.3) to the more impaired group, further supporting that perceived intervention value was not strongly dependent on baseline motor ability. Their engagement rate (12.5 ± 4.4 repetitions per minute) was lower and more variable, suggesting heterogeneity in effort, strategy, or task adaptation. The average session duration (51.2 ± 14.7 minutes) was comparable to that of the severe to moderate group, though completion times varied widely. Only 33.3% of these participants (2 of 6) reported discomfort, suggesting better overall tolerance than those with greater motor impairment.

Mild motor impairment group (n = 1). The single participant with mild motor impairment (FMA-UE: 56 points) achieved the highest satisfaction score (29.0), reflecting excellent user acceptance when motor function is relatively preserved. Their engagement rate (12.0 repetitions per minute) was moderate, and they successfully completed the entire 60-minute session. However, this participant reported fatigue (intensity rating: 6/10), indicating that even individuals with minimal motor deficits may experience exertion-related discomfort during intensive VR-based training.

Session completion patterns and clinical implications. Analysis of session completion patterns revealed nuanced relationships between baseline motor function and training tolerance. Participants who completed the full 60-minute protocol had a mean FMA-UE score of 40.63 ± 10.45, whereas those who discontinued early averaged 36.25 ± 13.23 points. Although session completers exhibited slightly higher baseline motor function, the modest difference and overlapping confidence intervals indicate that impairment severity alone does not reliably predict session completion or tolerance.

These findings carry important clinical implications: factors beyond baseline motor ability – such as individual fatigue susceptibility, pain tolerance, motivation, prior technology experience, and psychological adaptation to virtual environments – likely influence training endurance and engagement. The relatively small difference between completers and non-completers suggests that VR-based rehabilitation is feasible across a broad range of motor impairment severities in the subacute stroke population, provided that session duration and intensity are individualised to participant needs.

4. DISCUSSION

This pilot study presents the first systematic exploration of the relationship between baseline upper extremity motor function, assessed using the Fugl-Meyer Assessment for the Upper Extremity (FMA-UE), and user engagement metrics during intensive virtual reality (VR)-based rehabilitation in individuals with subacute stroke. The findings provide novel insights that challenge conventional assumptions regarding the association between residual motor function and engagement in technology-assisted rehabilitation.

Contrary to traditional expectations, participants with greater motor impairment demonstrated higher activity repetition rates during VR training, as indicated by a moderate negative correlation between baseline motor function and training engagement. Historically, many rehabilitation technologies have been designed for individuals with a certain degree of preserved voluntary movement, leading to the assumption that those with better motor function are more likely to engage effectively in technologically supported interventions (Colamarino et al., 2024). However, emerging evidence suggests that as VR systems become more adaptive and accessible, they can effectively engage individuals across a broader spectrum of motor impairment severity.

The current findings contradict the commonly held belief that patients with higher motor capacity are more frequent or effective users of rehabilitative technologies. Instead, the results indicate that individuals with greater impairments may exhibit increased motivation, determination, or cognitive engagement when introduced to novel, immersive rehabilitation tools. This aligns with recent evidence demonstrating that VR-based interventions can enhance motivation and encourage repetitive, task-specific practice – two critical elements of neuroplastic recovery following stroke (Amin et al., 2024; J. Chen et al., 2022; Peng et al., 2021). These findings highlight the potential of VR-based therapy to engage individuals with diverse neurological deficits and underscore the importance of considering user experience and motivation when designing technology-assisted rehabilitation programmes (Zhang et al., 2021).

Participants with moderate to severe impairment exhibited the highest and most consistent engagement rates (14.6 ± 1.1 repetitions/min). Several mechanisms may explain this observation. First, individuals with greater deficits may require more deliberate and effortful movements, naturally resulting in higher repetition frequency. Second, adaptive features within the VR software may have adjusted task difficulty or provided more opportunities for practice, thereby increasing repetition counts. Third, participants with limited success in traditional therapy may have found the novelty, immersive feedback, and interactive nature of VR particularly motivating (Zuki et al., 2024). Conversely, participants with mild impairments demonstrated greater variability in engagement (12.5 ± 4.4 repetitions/min), likely reflecting differences in intrinsic motivation, task interpretation, or perceived challenge level.

User satisfaction scores were comparable between groups of differing impairment severity (mean range: 22.3–22.4), suggesting broad acceptability of VR-based rehabilitation among individuals with varying degrees of neurological dysfunction. This is a clinically meaningful finding, implying that VR rehabilitation may not require strict motor function thresholds for user acceptance. Notably, the participant with mild impairment reported the highest satisfaction score (29.0), likely reflecting optimal alignment between task difficulty and motor capability.

The 50% incidence of mild to moderate discomfort during VR training warrants careful clinical consideration. Higher discomfort rates among participants with moderate to severe impairments (60%) compared to those with mild to moderate impairments (33%) suggest that individuals with greater motor limitations may require tailored supervision, shorter sessions, or more frequent rest periods. Most reported symptoms were stiffness-related, potentially arising from sustained compensatory postures or muscle overuse during intensive task performance. Importantly, all adverse effects were transient, and no serious events occurred, supporting the overall safety and tolerability of VR-based upper extremity training in subacute stroke rehabilitation. Nevertheless, the 33% early termination rate underscores the need for individualised adjustment of session duration and workload (Aderinto et al., 2023).

Previous studies have primarily examined the efficacy of VR-based stroke rehabilitation but rarely investigated user engagement or its relationship with baseline functional status. This study complements prior evidence by demonstrating that VR interventions can be engaging and well-tolerated across different impairment severities, while offering new insights into behavioural engagement patterns and user satisfaction (Villarroel et al., 2025). Consistent with task-matching theories of rehabilitation, optimal outcomes are achieved when training demands are aligned with individual functional capacities. The modest, nonsignificant correlation ($r = 0.282$) between baseline motor function and satisfaction supports this principle but highlights the need for larger samples to confirm the relationship.

Several limitations should be acknowledged. The small sample size ($n = 12$) limits statistical power and precludes multivariable analyses, restricting generalisability. The single-arm pilot design without a control group prevents causal inference, as improvements or engagement patterns cannot be distinguished from natural recovery or placebo effects. Additionally, the use of convenience sampling may have introduced selection bias, as participants willing to engage in VR training may differ from the broader stroke population in motivation or technological familiarity. Finally, the limited representation of severely impaired individuals restricts applicability across the full continuum of stroke recovery.

Overall, this study contributes preliminary but valuable evidence regarding the feasibility, tolerability, and user experience of VR-based upper extremity rehabilitation in subacute stroke.

5. CONCLUSIONS AND PERSPECTIVES

This pilot study demonstrates that VR-based upper extremity training is both feasible and well-tolerated across a spectrum of motor impairment severities in individuals with subacute stroke. The unexpected observation that participants with greater motor impairment exhibited higher engagement levels challenges traditional assumptions about technology-assisted rehabilitation and suggests that VR interventions should not be limited to those with relatively preserved motor function.

Comparable satisfaction scores across impairment levels indicate broad acceptability of VR-based rehabilitation, while the higher discomfort rates among more severely impaired participants highlight the need for enhanced safety monitoring and individualised training protocols. The notable inter-individual variability observed across all outcomes underscores the importance of personalised approaches in VR-based therapy.

These findings provide essential preliminary data for the design of larger, controlled studies and offer valuable guidance for clinical implementation of VR rehabilitation programmes. Future research should aim to elucidate the mechanisms underlying engagement differences and develop predictive models to optimise individualised, technology-assisted stroke rehabilitation strategies.

Future research should include adequately powered randomised controlled trials with diverse samples and appropriate control conditions to validate and extend these findings. Such work will strengthen the evidence base for integrating immersive VR technologies into standard post-stroke rehabilitation practice and refine personalised protocols for safe and effective clinical application.

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Virtualios realybės technologija viršutinių galūnių reabilitacijai po insulto: bandomasis tyrimas

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Santrauka

Tyrimo pagrindimas. Virtualios realybės (VR) technologija tai perspektyvi priemonė reabilitacijai po insulto, bet ryšys tarp pradinės motorinės funkcijos ir vartotojo patirties nepakankamai ištirtas. Norint optimizuoti klinikinį VR technologijos taikymą, labai svarbu suprasti, kaip motorinių funkcijų sutrikimo sunkumas veikia vartotojų įsitraukimą, pasitenkinimą ir toleranciją.

Tikslas. Šiame bandomajame tyrime buvo tiriamas ryšys tarp pradinės viršutinių galūnių motorinės funkcijos ir pagrindinių vartotojo patirties rodiklių naudojant VR pagrįstą reabilitaciją pacientams, patyrusiems insultą.

Metodai. Dvylika dalyvių, patyrusių insultą (140 ± 23 dienos po insulto) atliko po vieną 60 minučių trukmės VR pagrįstą viršutinių galūnių treniruotę. Pradinė motorinė funkcija buvo vertinama naudojant Fugl-Meyer'io vertinimo skalę viršutinėms galūnėms (FMA-UE). Pagrindiniai rezultatai apėmė vartotojų pasitenkinimą (vartotojų pasitenkinimo vertinimo klausimynas), treniruotės intensyvumą (judesių kartojimų skaičius per minutę), treniruotės trukmę ir nepageidaujamus reiškinius.

Rezultatai. Dalyviai (8 vyrai, 4 moterys; amžius 41,58 ± 14,51 metai) pasižymėjo reikšmingais motorinės funkcijos skirtumais (FMA-UE: 18–56 balai, vidurkis 39,08 ± 11,36). Vartotojų pasitenkinimas buvo nuosekliai aukštas visuose motorinių funkcijų sunkumo lygiuose (22,92 ± 4,29 balai). Nustatytas prieštaringas rezultatas tarp pradinės motorinės funkcijos ir treniruočių intensyvumo (neigiama koreliacija $r = -0{,}445$, $p = 0{,}148$) – sunkesnių sutrikimų turintys dalyviai pasiekė didesnį judesių pakartojimų skaičių. Aštuoni dalyviai (66,7 %) baigė visą treniruotę pagal protokolą, o keturiems teko nutraukti dalyvavimą anksčiau laiko. Lengvas ar vidutinio sunkumo diskomfortas paveikė 50 % dalyvių, daugiausia tų, kurie turėjo sunkius ar vidutinio sunkumo motorinės funkcijos sutrikimus.

Išvados. Treniruotės naudojantis VR technologija rezultatai atskleidė, kad ši priemonė yra tinkama ir naudinga visais motorinių sutrikimų sunkumo atvejais po insulto. Netikėtas atradimas, kad dalyviai su didesniais motoriniais sutrikimais parodė didesnį įsitraukimą, kelia abejonių dėl tradicinių prielaidų apie technologijų naudojimą reabilitacijoje. Remiantis rezultatais, VR intervencijos neturėtų būti ribojamos tik asmenims, kurių motorinės funkcijos yra išsaugotos, nors sunkesnės būklės pacientams gali būti reikalingi individualizuoti protokolai.

Reikšminiai žodžiai: reabilitacija po insulto; virtuali realybė; motorinė funkcija; vartotojo patirtis

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