Final Study Report

(29 July 2026)

Study Title

The Effect of Virtual Reality Therapy Using the VR Medical System on Quality of Life and Motor Functions in Veteran Rehabilitation Care

Background

Virtual Reality (VR) has emerged as an innovative tool in veteran rehabilitation, offering immersive environments that provide a sense of "presence" capable of distracting the brain from pain signals and facilitate cognitive-motor improvement (Rawlins et al., 2021). Recent evidence suggests that incorporating VR into comprehensive, integrated rehabilitation programs can lead to a restoration of physical and psycho-emotional health, including a pain and anxiety reduction, and a substantial decrease in PTSD symptoms (Puchyna et al., 2025; Rawlins et al., 2021). Post-traumatic stress disorder (PTSD) is a complex mental health condition that may develop after exposure to traumatic events (e.g., combat experiences), causing mental or physical distress, changes in thoughts and feelings or leading to social isolation (Volovik et al., 2023).

This study aims to explore the effectiveness of VR-based interventions in enhancing the psycho-emotional and physical recovery of war veterans within a multi-modular rehabilitation framework. Furthermore, there is an urge to develop non-invasive, non-pharmacological alternatives to manage the complex somatic and psychological symptoms that hinder veterans' successful reintegration into civilian life. The interactive and immersive nature of virtual reality enables repetitive, task-oriented, and individually adaptable training, while providing opportunities to support motor function, balance, mobility, cognitive abilities, and patient engagement.

This study was implemented as part of the Czech Republic's *Aid for Trade* programme supporting the rehabilitation of war veterans in Ukraine.

Study Aim

The primary aim of this pilot study was to evaluate the effectiveness of virtual reality therapy using the VR Medical system as an adjunct to conventional rehabilitation in war veterans with neurological, orthopedic and psychiatric conditions.

The study specifically aimed to:

- evaluate changes in patients' quality of life following VR-based rehabilitation;
- assess improvements in upper limb motor function and movement performance using objective parameters recorded by the VR Medical system;
- evaluate patient adherence, motivation, and acceptance of VR therapy.

Study Site and Study Period

The pilot study was conducted in collaboration with the Lviv Regional Hospital of War Veterans and Repressed People named after Yu. Lypa

(Ukraine) and VR Medical s.r.o. (Czech Republic).

Participant recruitment, clinical assessment, and rehabilitation were performed at the Lviv Regional Hospital of War Veterans and Repressed People named after Yu. Lypa. Study methodology, data management, statistical analysis, and preparation of the final report were coordinated by VR Medical s.r.o.

The study was conducted over a period of approximately 10 months, while each participant completed a rehabilitation program lasting 4 weeks. The practical part of the pilot study, including participant recruitment, intervention, and post-intervention assessments, was completed on 10 April 2026. The subsequent period was dedicated to data processing, statistical analysis, and preparation of the final study report.

Participants

A total of 30 war veterans participated in the study. Participants were randomly (using block randomization) assigned into two groups: Experimental group (n = 15): standard rehabilitation combined with virtual reality therapy using the VR Medical system. Control group (n = 15): standard rehabilitation only. The study was initially planned to include 20 participants, with 10 participants allocated to the experimental group and 10 to the control group. Ultimately, considering risk of subject's exclusion during or after therapy, the study enrolled 30 participants in total, with 15 participants in each group – five more participants than originally planned in both the experimental and control groups.

It was agreed that the study would specifically include patients diagnosed with post-traumatic stress disorder (PTSD) who could also present with upper limb functional impairment, allowing the evaluation of virtual reality therapy in patients with combined psychological and motor rehabilitation needs. Participants had fulfilled the following inclusion criteria: war veteran status, age between 18 and 80 years, neurological, orthopaedic, and psychiatric diagnosis (post-traumatic stress disorder) requiring rehabilitation. Patients were excluded if they did not complete at least 75% (6 or more therapies) of the prescribed treatment plan or if they presented with inability to understand instructions, sensory aphasia, severe apraxia, hemiplegia, acute psychotic disorders, epilepsy, active seizures, suicidal tendencies, severe visual and balance disorders, acute infections, fatigue, fever, or overexertion.

Study Methodology

The study was designed as a prospective randomized trial evaluating the feasibility and effectiveness of virtual reality-based rehabilitation as an adjunct to conventional rehabilitation.

Participants were randomly allocated to either the experimental or control group after providing written informed consent. The experimental group received VR therapy utilizing an immersive head-mounted display with multiple interactive environments for 2 times per week. The VR intervention was non-invasive and was designed to complement standard rehabilitation without replacing conventional therapeutic procedures. The control group received standard rehabilitation according to the rehabilitation program of the hospital.

Prior to the initiation of the study, all participating physiotherapists and occupational therapists received in-person training in the use of the VR Medical system. This training standardized the application of VR therapy within the study, including system operation, patient safety, selection of therapeutic modules, and integration of VR into conventional rehabilitation.

Outcome assessments were performed twice, before initiation of rehabilitation (baseline assessment) and immediately after completion of the rehabilitation program. Clinical and demographic information collected for each participant included age, sex, diagnosis, length of hospitalization, affected upper limb if presented. The collected data were analysed using descriptive and comparative statistical methods.

Ethical Considerations

The study was conducted in accordance with internationally accepted ethical principles for clinical research. All participants provided written informed consent before enrolment. Participation in the study was voluntary, and participants could withdraw at any time without affecting their standard medical care. The intervention was non-invasive and represented an adjunct to routine rehabilitation. Patient confidentiality and protection of personal

data were maintained throughout the study. During the whole VR therapy session, a trained employee (such as occupational therapist or physiotherapist) was always present to ensure safety of the patient.

Study Procedure

After eligibility screening, participants received verbal and written information regarding the study and signed informed consent. Baseline clinical assessment was subsequently performed, including standardized questionnaires and objective movement measurements obtained using the VR Medical system. Participants assigned to the experimental group completed conventional rehabilitation together with virtual reality therapy. Therapy intensity and difficulty were individually adjusted according to the patient's functional abilities and rehabilitation goals. Individual VR sessions ranged between 8 to 15 minutes according to patient tolerance and clinical state evaluated at the initial assessment, with approximately same length maintained during the whole therapy programme.

The virtual reality intervention aimed to:

- increase patient engagement and motivation,
- encourage repetitive task-oriented movement,
- improve upper limb motor control,
- support cognitive functions,
- provide individualized rehabilitation in a safe and controlled environment.

Virtual Reality Therapy Modules

Therapy was delivered using the VR Medical rehabilitation system, which provides immersive therapeutic exercises focused on enhancing quality of life and motor skills recovery through interactive virtual environments. The therapeutic program was individually selected according to each participant's diagnosis and functional status. The VR modules targeted e.g., upper limb reaching activities, shoulder flexion and abduction, elbow movement, hand activation, endurance, postural control, breathing and relaxation, bilateral upper limb activities, functional task-oriented movements, cognitive-motor dual-task exercises. The VR Medical system continuously recorded movement characteristics during therapy, including maximum reaching distance from the shoulder joint and limb activity time, summarized by median, mean, maximum, minimum, and standard deviation.

Standardized Outcome Measures

Quality of life was assessed using Visual Analogue Scale (VAS) for subjective health status, and WHOQOL-BREF questionnaire evaluating overall quality of life across physical, psychological, social, and environmental domains. Secondary outcomes included upper limb motor performance measured by the VR Medical system (maximum reaching distance from the shoulder joint, limb activity time, session duration and frequency) together with patient-reported satisfaction and therapist evaluation of the VR employment. Other standardized clinical assessments included the Berg Balance Scale (BBS), evaluating functional balance and fall risk through performance-based tasks of static and dynamic postural control, and the Montreal Cognitive Assessment (MoCA), assessing global cognitive functioning across multiple domains, including attention, executive functions, memory, language, visuospatial skills, and orientation. Most of the parameters were used to monitor rehabilitation progress throughout the intervention, only MoCA as a confirmation of patient eligibility to participate in the study.

Clinical and Technical Support

Throughout the entire study period, the participating rehabilitation staff received continuous support from the VR Medical team to ensure the consistent and safe implementation of the VR intervention. Technical support was available to assist with the operation and maintenance of the VR Medical system and to resolve any technical issues.

In addition, an experienced VR Medical physiotherapist and occupational therapist provided ongoing clinical consultation to the participating physiotherapists and occupational therapists. This support included discussion of complex clinical situations, guidance on patient eligibility for inclusion in the study, assistance with selecting appropriate therapeutic plans and virtual reality applications, and recommendations for adapting therapy to participant's functional abilities and rehabilitation goals. This continuous support helped maintain protocol adherence, ensured consistent application of the intervention across therapists, and facilitated safe integration of virtual reality therapy into routine rehabilitation practice.

Sample and analytic approach

Thirty participants completed the study. Following a post-hoc review of treatment exposure, two participants from the experimental group were excluded from the final analysis because they completed fewer than 6 of the 8 prescribed VR therapy sessions, corresponding to less than 75% of the planned session count. To preserve equal group sizes, the two participants from the control group with the corresponding study ID numbers were excluded as well. Therefore, 13 participants in the experimental group (EXP) and 13 in the control group (CON) were included for the final analysis. No participant had any missing data, so all analyses were performed on complete cases.

Choice of test followed the distribution of the change scores. Where the assumption of normality was met, paired-samples *t* tests (within groups) and Welch's *t* test (between groups) were used; otherwise, the Wilcoxon signed-rank test (within groups) and the Mann–Whitney U test (between groups) were applied. All *p* values reported below are two-tailed and derive from the normal approximation with continuity and tie corrections. Effect sizes are reported as *r* for rank-based tests and as Cohen's *d* for parametric tests.

Results

Baseline comparability

The two groups did not differ significantly on any outcome at baseline (all $p \geq .088$; Table 1). The largest baseline separations were on the BBS, where the experimental group started 4.6 points higher (48.85 ± 6.39 vs 44.23 ± 4.02; $U = 118.0$, $p = .088$, $r = .335$), and on the WHOQOL Physical domain, where it started 2.2 points lower ($U = 51.5$, $p = .091$, $r = .331$). Although neither reached the threshold, both correspond to effect sizes of moderate magnitude, and with 13 participants per group the tests had limited power to detect imbalance.

Table 1. Baseline values by group and test of baseline comparability.

Outcome	EXP M ± SD	EXP Mdn (IQR)	CON M ± SD	CON Mdn (IQR)	U	p	r
BBS	48.85 ± 6.39	51.00 (42.00–54.00)	44.23 ± 4.02	42.00 (42.00–46.00)	118.0	.088	.335
VAS QoL	53.85 ± 14.46	50.00 (40.00–60.00)	50.54 ± 8.81	50.00 (44.00–60.00)	94.5	.618	.098
WHOQOL Physical	49.45 ± 12.86	46.43 (42.86–50.00)	51.69 ± 5.96	53.57 (50.00–57.14)	51.5	.091	.331
WHOQOL Psychological	57.18 ± 10.97	58.33 (50.00–66.67)	53.85 ± 5.50	54.17 (50.00–58.33)	100.5	.418	.159
WHOQOL Social	70.51 ± 16.53	75.00 (58.33–83.33)	63.46 ± 11.56	66.67 (58.33–75.00)	109.0	.210	.246
WHOQOL Environment	68.51 ± 13.16	71.88 (59.38–75.00)	64.42 ± 6.69	62.50 (62.50–68.75)	107.0	.255	.223

Note: EXP, experimental group (n = 13); CON, control group (n = 13). IQR reported as the 25th–75th percentile.

Motor and functional outcomes

Balance (BBS)

Both groups improved on the BBS over the study period, but the pattern of improvement differed (Table 2, Figure 1). In the experimental group, the median score rose from 51.0 to 52.0 points and the mean gain was 2.15 points (95% CI [0.17, 4.14]); the Wilcoxon signed-rank test did not reach significance ($z = 1.896$, $p = .058$, $r = .372$, HL = 2.50, 95% CI [0.00, 4.00]). In the control group the median rose from 42.0 to 50.0 points, a mean gain of 4.92 points (95% CI [3.19, 6.66]), and the change was significant with a large effect ($z = 3.038$, $p = .002$, $r = .596$, HL = 5.00, 95% CI [3.00, 7.00]).

Direct comparison of the change scores favoured the control group (Table 4): median change 0.0 points (IQR 0.0–5.0) in EXP versus 6.0 points (IQR 2.0–8.0) in CON, $U = 40.5$, $z = 2.298$, $p = .022$, $r = .451$. The Hodges–Lehmann estimate of the between-group difference was −3.00 points (95% CI [−6.00, 0.00]), the upper limit falling exactly on the null value.

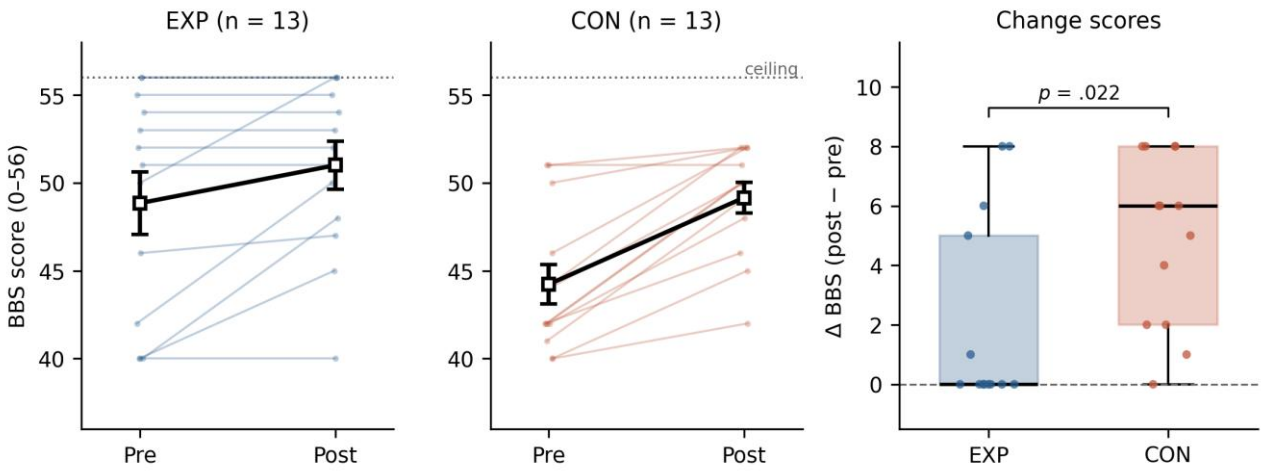
This result should not be read without reference to the scale ceiling. The BBS is bounded at 56 points, and the experimental group began substantially closer to that bound. Mean available headroom was 7.15 points in EXP against 11.77 points in CON, with 2 of 13 experimental participants already at the maximum and 4 of 13 within two points of it, compared with none in the control group. Within the experimental group, baseline score and subsequent change were strongly and inversely associated (Spearman $\rho = -.68$, $p = .011$), the corresponding association in the control group being weaker and non-significant ($\rho = -.39$, $p = .186$). Expressed as a proportion of the headroom actually available, the two groups realised comparable gains (30.1% in EXP, 41.8% in CON). The apparent superiority of the control group on this outcome is therefore confounded with a ceiling effect; therefore, the between-group comparison of raw BBS change cannot be interpreted as an unbiased estimate of differential treatment effect.

Table 2. Within-group change in motor and functional outcomes.

Outcome ─ Group	Pre M ± SD	Post M ± SD	Δ M (95% CI)	HL (95% CI)	Statistic	p	Effect size
BBS ─ EXP	48.85 ± 6.39	51.00 ± 4.90	2.15 [0.17, 4.14]	2.50 [0.00, 4.00]	z = 1.896	.058	r = .372
BBS ─ CON	44.23 ± 4.02	49.15 ± 3.13	4.92 [3.19, 6.66]	5.00 [3.00, 7.00]	z = 3.038	.002	r = .596
ROM ─ EXP	54.23 ± 15.47	60.62 ± 16.86	6.38 [-6.80, 19.57]	3.00 [−3.00, 20.00]	z = 0.902	.367	r = .177
ACTIVITY ─ EXP	52.96 ± 16.76	88.58 ± 17.82	35.62 [19.81, 51.42]		t = 4.911	< .001	$d_z = 1.362$ [0.58, 2.11]

***Note**:* Δ = post − pre. HL, Hodges–Lehmann pseudomedian of the paired differences with distribution-free 95% CI (not available for parametric tests). BBS and ROM were analysed with the Wilcoxon signed-rank test; ACTIVITY with a paired-samples *t*-test.

Figure 1. Individual BBS trajectories and change scores by group.



Note: Thin lines show individual participants; the heavy black line marks the group mean ± SE. The dotted line marks the scale ceiling (56 points). The right-hand panel shows the distribution of change scores (post − pre); boxes span the interquartile range with the median indicated, and points are individual participants.

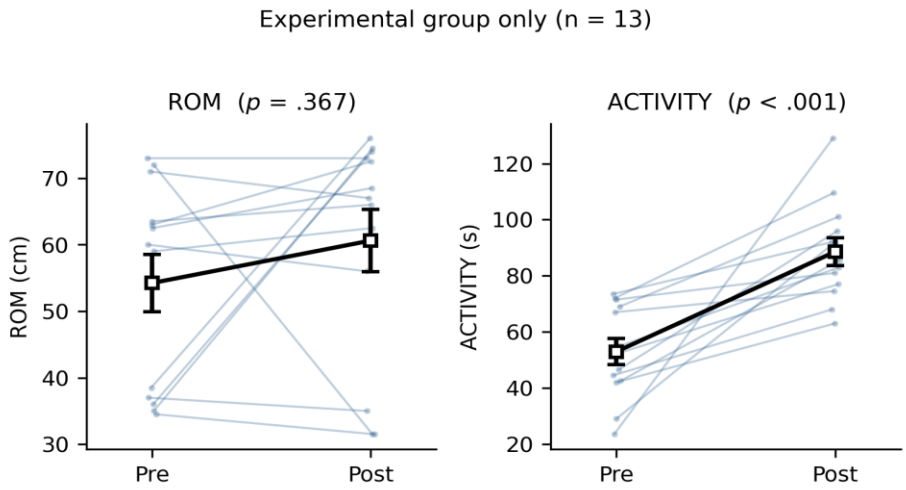
Range of motion (ROM)

In the experimental group, ROM increased from 54.23 ± 15.47 cm to 60.62 ± 16.86 cm, a mean gain of 6.38 cm (95% CI [−6.80, 19.57]). The change was not statistically significant ($T = 27.0$, $z = 0.902$, $p = .367$, $r = .177$; HL = 3.00, 95% CI [−3.00, 20.00]). Individual responses were highly heterogeneous, ranging from a loss of 40.5 cm to a gain of 39.5 cm, and 5 of 13 participants declined (Figure 2). The width of the confidence interval, spanning a clinically substantial loss as well as a clinically substantial gain, indicates that this outcome is essentially uninformative at the available sample size rather than that no effect exists. No control-group data were collected for ROM because of technology specific assessment bound to the experimental group.

Activity duration (ACTIVITY)

ACTIVITY duration in the experimental group increased from 52.96 ± 16.76 s to 88.58 ± 17.82 s. The mean increase of 35.62 s (95% CI [19.81, 51.42]) was significant with a very large effect ($t = 4.911$, $p < .001$, $d_z = 1.36$, 95% CI [0.58, 2.11]; $r = .817$). Every one of the 13 participants recorded a longer post-test duration, with individual increases ranging from 7.5 s to 105.5 s. Because of an increase in duration, the conclusion of significant improvement in the experimental group was made. However, as with ROM, the absence of a control condition means the change cannot be fully attributed to the intervention.

Figure 2. ROM and ACTIVITY in the experimental group.



Note: Thin lines show individual participants; the heavy black line marks the group mean ± SE.

Quality of life

Global quality of life (VAS)

Both groups reported significantly higher global quality of life after the study period (Table 3, Figure 3). In the experimental group the VAS score rose from 53.85 ± 14.46 to 70.00 ± 14.43 points, a mean increase of 16.15 points (95% CI [7.25, 25.06]; $t = 3.951$, $p = .002$, $d_z = 1.10$, 95% CI [0.39, 1.78]). In the control group it rose from 50.54 ± 8.81 to 60.77 ± 11.35 points, a mean increase of 10.23 points (95% CI [5.89, 14.57]; $t = 5.139$, $p < .001$, $d_z = 1.43$, 95% CI [0.63, 2.19]). Ten of 13 experimental and 11 of 13 control participants improved.

The 5.92-point advantage of the experimental group in mean change was not significant (t = 1.302, $p = .210$; 95% CI [−3.65, 15.50]; $d = 0.51$, 95% CI [−0.27, 1.29]). The interval is compatible with anything from a small advantage for the control group to a substantial advantage for the experimental group. With only 13 participants per group and $\alpha = .05$, the achieved power for the observed effect was approximately .24, and a standardised difference of $d \approx 1.15$ would have been required for 80% power.

WHOQOL-BREF domains

The four WHOQOL-BREF domains gave a mixed and largely group-symmetric picture (Table 3, Figure 4). In the experimental group, only the Psychological domain changed significantly, rising by a median of 6.25 points (mean 6.28, 95% CI [1.05, 11.51]; $z = 2.280$, $p = .023$, $r = .447$). The Physical domain was essentially unchanged (0.82, 95% CI [−3.59, 5.24]; $p = .721$, $r = .070$), the Environment domain rose non-significantly (1.92, 95% CI [−2.63, 6.47]; $p = .379$, $r = .172$), and the Social domain declined non-significantly (−2.56, 95% CI [−9.50, 4.37]; $p = .599$, $r = .103$). However, the mean Social domain deterioration was driven largely by a single participant whose score fell by 33.3 points.

In the control group, three of the four domains improved significantly: Physical (4.30, 95% CI [0.75, 7.86]; $p = .044$, $r = .395$), Psychological (6.41, 95% CI [1.98, 10.85]; $p = .025$, $r = .439$) and Environment (6.25, 95% CI [1.31, 11.19]; $p = .036$, $r = .412$). The Social domain improved by a comparable amount but did not reach significance (5.13, 95% CI [0.75, 9.51]; $p = .106$, $r = .317$).

No between-group difference in domain change was significant after the result taken into account (Table 5, Figure 5). Psychological change was almost identical in the two groups (HL difference 0.00 points, 95% CI [−8.33, 4.17]; $p = .662$), and Physical and Environment change differed non-significantly in favour of the control group ($p = .288$ and $p = .179$ respectively). The Social domain reached nominal significance under the normal approximation ($U = 47.0$, $z = 2.002$, $p = .045$, $r = .393$; HL = −8.33 points, 95% CI [−16.67, 0.00]), but the exact test of the same data returned $p = .057$. It therefore straddles the conventional threshold, and it should be treated as inconclusive rather than positive.

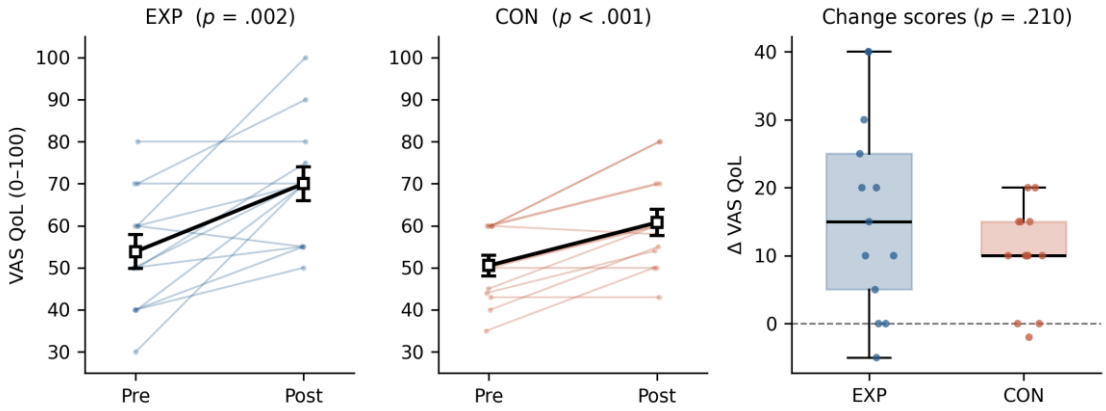
Table 3. Within-group change in quality-of-life outcomes.

Outcome – Group	Pre M ± SD	Post M ± SD	Δ M (95% CI)	HL (95% CI)	Statistic	p	Effect size
VAS QoL – EXP	53.85 ± 14.46	70.00 ± 14.43	16.15 [7.25, 25.06]		t = 3.951	.002	d_z = 1.096 [0.39, 1.78]
VAS QoL – CON	50.54 ± 8.81	60.77 ± 11.35	10.23 [5.89, 14.57]		t = 5.139	< .001	d_z = 1.425 [0.63, 2.19]
Physical – EXP	49.45 ± 12.86	50.27 ± 10.86	0.82 [-3.59, 5.24]	0.00 [-3.57, 5.36]	z = 0.358	.721	r = .070
Physical – CON	51.69 ± 5.96	56.00 ± 5.80	4.30 [0.75, 7.86]	5.36 [0.00, 8.93]	z = 2.012	.044	r = .395

Outcome – Group	Pre M ± SD	Post M ± SD	Δ M (95% CI)	HL (95% CI)	Statistic	p	Effect size
Psychological – EXP	57.18 ± 10.97	63.46 ± 9.65	6.28 [1.05, 11.51]	6.25 [1.25, 10.42]	z = 2.280	.023	r = .447
Psychological – CON	53.85 ± 5.50	60.26 ± 7.53	6.41 [1.98, 10.85]	6.25 [2.08, 10.42]	z = 2.240	.025	r = .439
Social – EXP	70.51 ± 16.53	67.95 ± 16.96	−2.56 [-9.50, 4.37]	0.00 [-8.33, 4.17]	z = 0.526	.599	r = .103
Social – CON	63.46 ± 11.56	68.59 ± 10.84	5.13 [0.75, 9.51]	4.17 [0.00, 8.33]	z = 1.618	.106	r = .317
Environment – EXP	68.51 ± 13.16	70.43 ± 12.57	1.92 [-2.63, 6.47]	2.90 [-3.12, 7.81]	z = 0.879	.379	r = .172
Environment – CON	64.42 ± 6.69	70.67 ± 7.61	6.25 [1.31, 11.19]	7.81 [1.56, 10.94]	z = 2.099	.036	r = .412

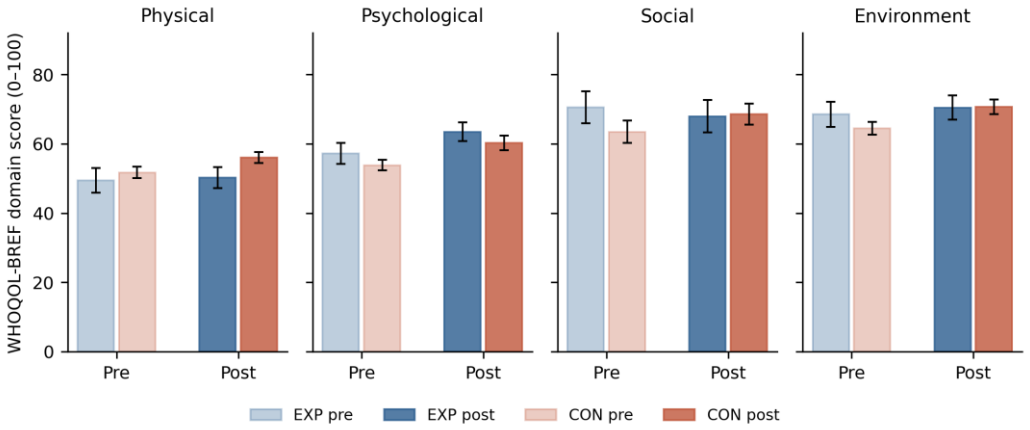
Note: Δ = post − pre. VAS QoL analysed with paired-samples *t* tests; WHOQOL-BREF domains with the Wilcoxon signed-rank test. HL, Hodges–Lehmann pseudomedian with distribution-free 95% CI.

Figure 3. Global quality of life (VAS) by group.



Note: Panels 1–2 show individual trajectories with the group mean ± SE overlaid; panel 3 shows change-score distributions.

Figure 4. WHOQOL-BREF domain scores before and after the study period.



Note: Bars show group means; error bars show ± 1 SE. Pale bars – pre-test; solid bars – post-test.

Between-group comparison of change

Table 5 and Figure 5 summarise all between-group comparisons of change. Of the six outcomes for which both groups provided data, one (BBS) reached significance and one (WHOQOL Social) was borderline; both favoured the control group. No outcome favoured the experimental group significantly. The direction of the point estimates was towards the control group on five of six outcomes, the exception being VAS QoL.

The largest separation was on the BBS, where the experimental group's median change of 0.00 points (IQR 0.00–5.00) fell short of the control group's 6.00 points (IQR 2.00–8.00); the Hodges–Lehmann estimate of the shift was −3.00 points (95% CI [−6.00, 0.00]; $U = 40.5$, $z = 2.298$, $p = .022$, $r = .451$,). The WHOQOL Social domain gave the next largest separation, a median change of 0.00 points (IQR −8.33 to 0.00) against 8.33 points (IQR 0.00–8.33), for a shift of −8.33 points (95% CI [−16.67, 0.00]; $U = 47.0$, $z = 2.002$, $p = .045$, $r = .393$). Global quality of life was the only outcome on which the experimental group gained more, 16.15 ± 14.74 against 10.23 ± 7.18 points, but the 5.92-point advantage was not significant (95% CI [−3.65, 15.50]; Welch's $t = 1.302$, $p = .210$, $d = 0.51$, 95% CI [−0.27, 1.29]). The WHOQOL Physical domain favoured the control group by 3.57 points (95% CI [−10.71, 3.57]; $U = 63.5$, $z = 1.061$, $p = .288$), the median change being 0.00 points in the experimental group against 7.14 in the control group. The Environment domain favoured the control group by the same 3.57 points (95% CI [−9.38, 3.12]; $U = 58.0$, $z = 1.345$, $p = .179$). Although the two medians were identical at 6.25 points, the estimated shift derives from the distribution of the pairwise differences rather than from any separation of the medians. The Psychological domain produced the smallest difference of all: both groups improved by a median of 4.17 points, and the Hodges–Lehmann shift was exactly zero (95% CI [−8.33, 4.17]; $U = 75.5$, $z = 0.438$, $p = .662$). Every one of the six intervals included zero.

Table 4. Between-group comparison of BBS change.

Outcome	Δ EXP Mdn (IQR)	Δ CON Mdn (IQR)	Difference (95% CI)	Statistic	p	Effect size
BBS (points)	0.00 (0.00–5.00)	6.00 (2.00–8.00)	−3.00 [-6.00, 0.00]	U = 40.5, z = 2.298	.022	r = .451

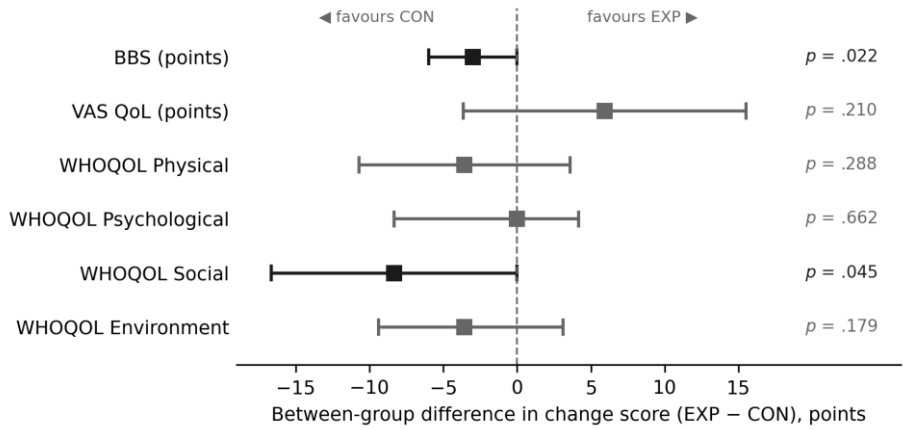
Note: Difference expressed as the Hodges–Lehmann estimate of the shift EXP − CON, with distribution-free 95% CI; negative values favour the control group. Mann–Whitney U test on change scores; $r = z/\sqrt{N}$.

Table 5. Between-group comparison of change in quality-of-life outcomes.

Outcome	Δ EXP	Δ CON	Difference (95% CI)	Statistic	p	Effect size
VAS QoL	16.15 ± 14.74	10.23 ± 7.18	5.92 [−3.65, 15.50]	t = 1.302	.210	d = 0.511
WHOQOL Physical	0.00 (−3.57–7.14)	7.14 (0.00–7.14)	−3.57 [−10.71, 3.57]	U = 63.5, z = 1.061	.288	r = .208
WHOQOL Psychological	4.17 (2.50–8.33)	4.17 (4.17–12.50)	0.00 [−8.33, 4.17]	U = 75.5, z = 0.438	.662	r = .086
WHOQOL Social	0.00 (−8.33–0.00)	8.33 (0.00–8.33)	−8.33 [−16.67, 0.00]	U = 47.0, z = 2.002	.045	r = .393
WHOQOL Environment	6.25 (−3.12–6.70)	6.25 (0.00–12.50)	−3.57 [-9.38, 3.12]	U = 58.0, z = 1.345	.179	r = .264

Note: VAS QoL analysed with Welch's t test (Δ reported as M ± SD, difference as the difference in means); WHOQOL domains with the Mann–Whitney U test (Δ reported as Mdn (IQR), difference as the Hodges–Lehmann shift). Negative values favour the control group.

Figure 5. Between-group differences in change, all outcomes.



Note: Squares show point estimates (Hodges–Lehmann shift for rank-based comparisons; difference in means for VAS QoL) with 95% confidence intervals. Estimates shown in black are nominally significant at α = .05; grey estimates are not.

Multiple testing adjustment

All comparisons were additionally adjusted for multiplicity in the analysis. Because twenty tests were performed in total, results should be adjusted for multiplicity in the analysis. Under Holm–Bonferroni adjustment applied within families (Table 6), no between-group comparison retains significance; the smallest adjusted value being .129 for BBS. Four within-group results survive: the experimental group's ACTIVITY change (adjusted p = .001) and the control group's BBS gain (.007) among the motor outcomes, and the VAS QoL gains in both groups (.017 and .002). No other result comes close once adjusted, the nearest being the two Psychological-domain changes at .181.

Table 6. Adjusted p values by test family: Holm–Bonferroni.

(a) Within-group tests, motor outcomes (k = 4)

Test	p	p (Holm)	Significant (Holm)
BBS – EXP	.058	.116	no
BBS – CON	.002	.007	yes
ROM – EXP	.367	.367	no
ACTIVITY – EXP	< .001	.001	yes

(b) Within-group tests, quality-of-life outcomes (k = 10)

Test	p	p (Holm)	Significant (Holm)
VAS QoL – EXP	.002	.017	yes
VAS QoL – CON	< .001	.002	yes
Physical – EXP	.721	1.000	no
Physical – CON	.044	.221	no
Psychological – EXP	.023	.181	no
Psychological – CON	.025	.181	no
Social – EXP	.599	1.000	no
Social – CON	.106	.422	no
Environment – EXP	.379	1.000	no
Environment – CON	.036	.215	no

(c) Between-group comparisons of change (k = 6)

Test	p	p (Holm)	Significant (Holm)
BBS	.022	.129	no
VAS QoL	.210	.715	no
WHOQOL Physical	.288	.715	no
WHOQOL Psychological	.662	.715	no
WHOQOL Social	.045	.226	no
WHOQOL Environment	.179	.715	no

Note: Both adjustments are applied separately within each of the three families.

Patient adherence and acceptance

Overall, patient adherence and acceptance of VR therapy were high, based on the therapist and patient subjective evaluation. Participants were willing to engage in the VR sessions, showed interest in the intervention, and therapists reported positive observations regarding patient motivation during rehabilitation. However, a small number of patients declined participation because of poor health or reduced interest. Occasional technical issues were reported which affected the functionality of the system and the completeness of recorded data.

Adherence was also evaluated objectively based on both the number of completed VR sessions and the proportion of completed therapy time. Of the 15 participants originally assigned to the experimental group, 13 completed at least 6 of the 8 prescribed VR therapy sessions, corresponding to the predefined minimum attendance threshold of 75%, and were included in the final analysis. The remaining two participants did not meet this threshold and were excluded. However, the available study documentation did not provide sufficient information to determine the specific reasons for their low therapy count.

Among the included 13 participants, the mean therapy-time compliance was 95.58%, with a median of 97.50% and an individual range from 73.17% to 104.17%. Ten participants completed at least 95% of the prescribed therapy time, including four participants who exceeded 100% by completing more therapy time than originally prescribed. The minimum session-count threshold used for inclusion in the final analysis was assessed separately from therapy-time compliance. Overall, these results demonstrate high adherence among the participants included in the final analysis, while also indicating some individual variability.

Conclusion

In clinical perspective, both groups changed substantially over the study period. Four findings survive adjustment for multiple testing: activity duration in the experimental group increased by 35.62 s (d_z = 1.36), global quality of life (VAS QoL) improved in both arms, by 16.15 and 10.23 points respectively (d_z = 1.10 and 1.43), and balance (BBS) improved in the control group by 4.92 points (r = .596). The remaining within-group changes, such as range of motion, balance in the experimental group, and all eight WHOQOL-BREF domain results, did not reach significance once adjusted.

On four of the six group comparison outcomes, the point estimate lay on the control group's side (median BBS by −3.00 points, WHOQOL Physical by −3.57 points, Social by −8.33 points and Environment by −3.57 points), in one outcome (WHOQOL Psychological) it was close to zero. One outcome favouring the experimental group, global quality of life (VAS QoL), did so by a margin of 5.92 points. However, none of those comparisons reached the 0.05 significance threshold after adjusting p-values for multiple testing. Therefore, these results do not demonstrate a significant effect of the experimental condition, but neither do they exclude one. With 13 participants per group, the study had very small power to detect a difference of reasonable size. A conclusive

answer would require a larger sample, control data for VR measured parameters, and an analysis of balance that accommodates the scale ceiling.

From the feasibility perspective, the study demonstrated that the implementation of VR therapy into routine rehabilitation for war veterans was feasible and well accepted by both patients and therapists. Whole experimental group demonstrated strong adherence to the VR therapy, with a mean compliance of 95.58%, with ten patients completing more than or equal 95% of the prescribed therapy. Despite occasional technical issues, the intervention was successfully delivered with continuous clinical and technical support, and the outcome measures were collected and analysed as planned.

Although no statistically significant superiority of the experimental intervention over standard rehabilitation was demonstrated, the findings support the feasibility of VR-assisted rehabilitation and provide valuable data about the design of future studies with larger sample sizes and more comprehensive data collection.

Note

Although the contract specified that the report was to be submitted 30 days after the end of the study, its preparation was slightly delayed by waiting for clarification regarding the possible recruitment of substitutes for excluded participants.

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