Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
Broeren et al., 2004 PEDro score: N/A (single case pre-post study)	1 patient with subacute stroke	VR training using a head-mounted display (n=1) **Treatment details:** 12 x 90-minute sessions over four weeks	**At 4 weeks (immediately post-treatment) and at 5 months (follow up):** (+) Purdue Pegboard Test (+) Hand held dynamometer (+) Upper extremity movement
Burdea et al., 2010 PEDro score: N/A (pre-post study)	3 patients with chronic stroke	VR using the Rutgers rehabilitation system (n=3) **Treatment details** 3 times per week over 4 weeks. Amount of training progressed from 40 minutes (week 1) to 50 minutes (week 2) to 1 hour (week 3, 4)	**At 4 weeks (immediately post-treatment):** For 2 of 3 patients (-) Jebsen-Taylor Test of hand function (+) Range of motion (-) Jamar dynamometer (+) Pinch strength (+) Upper Extremity Functional Index (activities of daily living) **At 3 months (follow-up):** For 2 of 3 patients (-) Jebsen-Taylor Test of hand function (+) Range of motion (-)Jamar dynamometer (-) Pinch strength (+) Upper Extremity Functional Index (activities of daily living)
Burdea et al., 2011 PEDro score: N/A (pre-post study)	4 patients with chronic stroke	VR training using the Rutgers Arm II prototype (n=4) **Treatment details:** 3 x 1-hour session for 6 weeks	**At 6 weeks (immediately post-treatment):** (+) Fugl-Meyer Assessment -upper extremity subscale (+)*Upper Extremity Functional Index (activities of daily living) (+) Active range of motion

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(+)* Grip/pinch strength **At 3 months (follow-up) :** (+) Fugl-Meyer Assessment -upper extremity subscale (+)*Upper Extremity Functional Index (activities of daily living) (+) Active range of motion (+)* Grip/pinch strength *Improvements found in 2 of 4 patients who presented with severely impaired motor function at pre-treatment.
Crosbie et al., 2012 PEDro score: 8	18 patients with chronic stroke	VR training using a custom-bulit head-mounted display (n=9) vs. Conventional arm therapy (n=9) **Treatment details:** 9 x 30-45-minute sessions, 3 times a week for 3 weeks	**At 3 weeks (immediately post-treatment) and at 6 week (follow-up):** (-) Motricity Index (-) Action Research Arm Test
da Silva Cameirao et al., 2011 PEDro score: 5	25 patients with acute stroke	VR training using the Rehabilitation Gaming System (RGS) (n=13); vs. Intense Occupational Therapy (IOT; control#1) (n=6) vs. Non-specific interactive Games (NSG; control#2) (n=6) **Treatment details:** All three groups received 3 x 20-minute sessions/week of	**At 12 weeks (immediately post-treatment**): RGS vs. ITO & NSG combined: (+) Fugl-Meyer Assessment Test -upper extremities (+) Chedoke Arm and Hand Activity Inventory (-) Medical Research Council Grade (-) *Motricity Index –upper extremity (-) Barthel Index

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		their allocated treatment in addition to standard occupational therapy.	**At 3-month (follow-up):** RGS vs. ITO & NSG combined: (-) Fugl-Meyer Assessment Test -upper extremities (-) Chedoke Arm and Hand Activity Inventory (-) Medical Research Council Grade (-) Motricity Index –upper extremity (-) Barthel Index *Difference between groups approached significance Note: In addition to outcomes above, the evolution of arm speed over time was measured weekly over treatment, and showed a systematically significant difference at 9 weeks in favour of RGS vs. IOT and NSG combined. The authors also noted a 'high level of acceptance and satisfaction' at 12 weeks (post-treatment) for patients who used the RGS, based on a 5-point Likert scale.
Friedman et al., 2014 PEDro score: 4 (within-subjects design study)	12 patients with chronic stroke	VR training using a MusicGlove vs. Isometric movement training using the IsoTrainer vs. Conventional tabletop exercises **Treatment details:** 1 hour/session, 3 times/week for 2 week. Participants completed a total of 18 sessions.	**At 2 weeks (immediately post-treatment)** (+) Box and Block Test* (-) FMA-UE (-) Wolf Motor Function Test (-) ARAT (+) 9-Hole Peg Test* (-) Hand-held dynamometer (-) Pinch strength *In favour of MusicGlove VR training compared to conventional tabletop exercises

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			At 1 month (follow-up): (-) Box and Block Test* (-) FMA-UE (-) Wolf Motor Function Test (-) ARAT (-) 9-Hole Peg Test* (-) Hand-held dynamometer (-) Pinch strength * Changes persisted at follow-up; however, no statistical between-group analysis for significance was reported.
Holden et al., 2002 PEDro score: N/A (pre-post study)	2 patients with chronic stroke	VR using a laboratory computer system **Treatment details:** 3 x 1 hour sessions per week for 20-30 sessions in total	**At 20-30 sessions (immediately post-treatment):** (+) Fugl-Meyer Assessment –upper extremity subscale (+) Wolf Motor Test (+) Shoulder strength (-) Jamar dynamometer
Housman et al., (2009) PEDro score: 5	28 patients with chronic stroke	VR training using T-WREX arm orthosis and a PC computer monitor (n=14) vs. Conventional therapy (n=14) **Treatment details:** Both VR training and standard care involved 24 x 60-minute sessions, 3 times per week for 8-9 weeks	**At 8-9 weeks (immediately post-treatment):** (-) Fugl-Meyer Assessment –upper extremity subscale (FMA-UE) (-) Rancho Functional Test for the Hemiplegic/Paretic Extremity (RFTHPE) (-) Motor Activity Log –quality of movement (MAL-QOM) & –amount of use (MAL-AOU) (-) Hand-held dynamometer (-) Reaching range of motion

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			At 6-month (follow-up): (+) FMA-UE (-) RFTHPE (-) MAL-QOM & MAL-AOU (-) Hand-held dynamometer (-) Reaching range of motion
Jang et al., 2005 PEDro score: 5	10 patients with chronic stroke	VR using a large screen and cyber gloves (intervention)(n=5) vs. No therapy (control)(n=5) **Treatment details** 5 x 1-hour sessions per week for 4 weeks	**At 4 weeks (immediately post-treatment):** (+) Fugl-Meyer Assessment –upper extremity subscale (+) Box and Block Test (+) Manual Function Test
Jo et al., 2012 PEDro score: 4	29 patients with stroke (stage of stroke recovery not specified)	VR training using IREX® system (n=15) vs. Conventional therapy (n=14) **Treatment details:** VR: 20 x 60-minute sessions, 5 times a week for 4 weeks Conventional: 12 x 30-minute sessions, 3 times a week for 4 weeks	**At 4 weeks (immediately post-treatment):** (-) Wolf Motor Function Test (WMFT) – total score* (-) WMFT – arm subtest* (-) WMFT – hand subtest* (-) WMFT – time (+) Motor Free Visual Perceptual Test (MVPT) – score (+) MVPT- time (+) MVPT – Visual discrimination (+) MVPT – Form constancy (-) MVPT – Visual memory (-) MVPT – Visual closure (-) MVPT – Spatial relations

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			* Both groups demonstrated significant improvement from pre- to post-treatment on WMFT arm and hand scores, but between-group data was not reported.
Kiper et al., 2011 PEDro score: 5	80 patients with subacute and chronic stroke	VR training using reinforced feedback in virtual environment arm motor training (n=40) vs. Traditional neuromotor rehabilitation (n=40) **Treatment details:** 2 x 60-minute sessions, 5 times a week for 4 weeks	**At 4 weeks (immediately post-treatment):** (+) Modified Ashworth Scale* (+) Functional Independence Measure (+) Fugl-Meyer Assessment -upper extremity subscale *For patients with ischemic stroke only
Kim et al., 2011 PEDro score: 4	28 patients with acute and subacute stroke	VR training using IREX® system and computer-assisted cognitive rehabilitation (n=15) vs. Computer-assisted cognitive rehabilitation (n=13) **Treatment details:** VR group: 30-minute VR sessions, 3 times a week for 4 weeks + 30-minute computer-assisted cognitive rehabilitation sessions 2 times/week for 4 weeks Computer-assisted cognitive rehabilitation group: 30-minute computer-assisted cognitive rehabilitation sessions 5 times a week for 4 weeks	**At 4 weeks (immediately post-treatment):** (-) Korean version of the Mini-Mental Status Examination (+) Visual continuous performance test* (-) Auditory continuous performance test (-) Word color test – word (-) Word color test – color (-) Forward digit span test (-) Backward digit span test (-) Forward visual span test (+) Backward visual span test* (-) Visual learning test (-) Verbal learning test (-) Trail making test – A (-) Tower of London (-) Korean-Modified Barthel Index (-) Motricity Index

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			*significant between-group difference in change scores from pre- to post-treatment.
Kwon et al., 2012 PEDro score: 5	26 patients with acute and subacute stroke	VR training using IREX® system (n=13) vs. Conventional therapy (n=13) **Treatment details:** VR training: 30-minute sessions, 5 times/week for 4 weeks Conventional therapy: 70 minutes/session, 5 days/week for 4 weeks	**At 4 weeks (immediately post-treatment):** (-) Manual Function Test (-) Korean-Modified Barthel Index (-) Fugl-Meyer Assessment -upper extremity subscale
Lee et al., 2014 PEDro score: 6	64 patients with acute stroke	Group A: transcranial direct current stimulation (tDCS) (n=21) vs. Group B: VR training using computer, sensor glove and virtual objects (n=22) vs. Group C: tDCS and VR training applied simultaneously (n=21) **Treatment details:** 30 minutes, 5 days/week for 3 weeks	**At 3 weeks (immediately post-treatment):** (-) Modified Asworth Scale (-) Manual Muscle Test (+) Manual Function Test * (-) Box and Block Test (-) Korean-Modified Barthel Index (+) Fugl-Meyer Assessment -upper extremity subscale * *in favour of VR training with tDCS (group C) vs. VR training (group B) * in favour of VR training with tDCS (Group C) vs. tDCS alone (group A) * in favour of tDCS alone (group A) vs. VR training (group B)
Piron et al., 2009 PEDro score: 7	36 patients with chronic stroke	VR training using telerehabilitation system (VRRS net®) (n=18)	**At 4 weeks (immediately post-treatment):** (+) Fugl-Meyer Assessment - Upper extremity scale

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		vs. Conventional physical therapy (n=18) **Treatment details:** 1-hour/day, 5 days/week for 4 weeks	(-) ABILHAND (-) Modified Ashworth Scale At 2 months (follow-up): (-) Fugl-Meyer Assessment - Upper extremity scale (-) ABILHAND (-) Modified Ashworth Scale
Piron et al., 2003 PEDro score: 4	24 patients with acute stroke	VR using a laboratory computer system (intervention)(n=12) vs. Conventional therapy (control)(n=12) **Treatment details:** 5 x 1-hour sessions per week for 5-7 weeks	**At 5-7 weeks (immediately post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity scale (-) Functional Independence Measure
Piron et al., 2007 PEDro score: N/A (quasi-experimental study)	38 patients with subacute stroke	VR training using PC computer, large screen and 3D motion capture system (n=25) Vs. Conventional therapy (n=13) **Treatment details:** 5 x 1-hour sessions per week for 5 to 7 weeks.	**At 5-7 weeks (post-treatment):** (-)* Fugl-Meyer Assessment –upper extremity subscale (FMA-UE) (-)* Functional Independence Measure (FIM) Note: While no significant between-group differences were found, the VR group showed significant within-group improvements on both the FIM and the FMA-UE, whereas the standard care group showed only smaller non-significant improvements.
Piron et al., 2010 PEDro score: 7	47 patients with chronic stroke	VR training using a laboratory computer system (n=27)	**At 4 weeks (post-treatment):** (+) Fugl-Meyer Assessment –upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		vs. Standard rehabilitation (n=20) **Treatment details:** 5 x 1-hour training sessions per week for 4 weeks	scales (-) Functional Independence Measure (-) Kinematics (duration, linear velocity, submovements)
Rand et al., 2009 PEDro score: N/A (pre-post study)	6 patients with chronic stroke	VR using a simulated mall environment on a video screen (n=6) **Treatment details:** 10 x 60-minute sessions over 3 weeks.	**At 3 weeks (immediately post-treatment):** (+) Multiple Errands Test – Hospital Version (+) Virtual Multiple Errands Test (+) Instrumental Activities of Daily Living questionnaire
Shin et al., 2015 PEDro score: 6	35 patients with chronic stroke	VR training using RehabMasterTM + conventional occupational therapy (n=18) vs. Conventional occupational therapy alone (n=17) **Treatment details:** 30 minutes/day, 5 days/week for 4 weeks Both groups received an additional 30 mins of OT/day	**At 4 weeks (immediately post-treatment):** (+) Korean Short form Health Survey (SF-36) – Role limitations due to physical problems (-) Korean Short form Health Survey (SF-36) – Role limitations due to emotional problems (-) Korean Short form Health Survey (SF-36) – Physical functioning (-) Korean Short form Health Survey (SF-36) – Pain (-) Korean Short form Health Survey (SF-36) – General health (-) Korean Short form Health Survey (SF-36) – Social functioning (-) Korean Short form Health Survey (SF-36) – Mental health (-) Korean Short form Health Survey (SF-36) – Vitality

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Korean Hamilton Depressions Rating Scale (-) Fugl-Meyer Assessment - Upper Extremity scale Note: differences reflect change in scores from baseline to post-treatment.
Shin et al., 2014 PEDro score: 6	16 patients with acute/subacute stroke	VR training using Rehab Master system (n=9) vs. Conventional occupational therapy (n=7) **Treatment details:** 20-minute sessions, 5 times a week for 2 weeks Both groups also received Occupational therapy for 20 minutes/day	**At 2 weeks (immediately post-treatment):** (-) Passive range of motion (+) Modified Barthel Index (-) Fugl-Meyer Assessment - Upper Extremity scale Note: differences reflect change in scores from baseline to post-treatment
Shin et al., 2016 PEDro score: 7	46 patients with acute/subacute/chronic stroke	VR training using SmartGlove (n=24) vs. Conventional occupational therapy (n=22) **Treatment details:** 20 x 30-minute sessions, 5 times a week for 4 weeks Both groups also received conventional occupational therapy for 30 mins/day	**At 4 weeks (immediately post-treatment) and at 1 month (follow-up):** (+) Fugl-Meyer Assessment - Upper Extremity scale (FMA-UE)– total score (+) FMA-UE – proximal score (+) FMA-UE –distal score (+) Jebsen-Taylor Hand Function Test (JTHFT) – total score (+) JTHFT – gross (-) JTHFT – fine (-) Purdue Pegboard Test (PPT)– affected hand (-) PPT – both hands (-) PPT – assembly **At 4 weeks (immediately post-treatment):**

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(+) Stroke Impact Scale (SIS) - composite score (+) SIS – overall score (+) SIS - Social Participation (+) SIS – Mobility (-) SIS - Memory and Thinking (-) SIS - Communication (-) SIS – Emotion (-) SIS – Strength (-) SIS – Hand Note: differences reflect significant change in scores from baseline to post-treatment and to follow-up
Subramanian et al., 2013 PEDro score: 7	32 patients with chronic stroke	VR training using supermarket scene simulated in CAREN system (n=16) vs. Upper extremity pointing movements in real physical environment (n=16) **Treatment details:** 12 x 45 mins/sessions, 3 times/week for 4 weeks	**At 4 weeks (immediately post-treatment) and at 3 months (follow-up):** (-) Reaching Performance Scale for Stroke (-) Fugl-Meyer Assessment - Upper Extremity scale (-) Wolf Motor Function Test (-) Motor Activity Log – Amount of Use (+) Arm and trunk kinematic data* (+) Intrinsic Motivation Task Evaluation Questionnaire** *Shoulder horizontal abduction for the lower middle target (post-treatment only) **Subjects from the physical environment group reported feeling more comfortable practicing movements than those from the VR group. Subjects in the VR group reported feeling less stress/anxiety during task

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			participation than those in the physical environment group.
Sucar et al., 2009 PEDro score: 2	22 patients with chronic stroke	VR training using Gesture T-WREX subsystem (n=11) vs. Conventional occupational therapy (n=11) **Treatment details:** 1-hour/session, 3 times/week for 5 weeks	**At 5 weeks (immediately post-treatment):** (-) Fugl-Meyer Assessment -Upper Extremity scale (-) Motricity Index (-) Intrinsic Motivation Scale
Sung In et al., (2012) PEDro score : 4	19 patients with chronic stroke	VR training reflection therapy program (n=11) vs. Conventional occupational therapy and sham program (n=8) **Treatment details:** 30-minutes/day, 5 days/week for 4 weeks.	**At 4 weeks (immediately post-treatment):** (-) Jebsen-Taylor Hand Function Test (+) Fugl-Meyer Assessment -upper extremity scale (+) Manual Function Test (-) Box and Block Test (-) Modified Ashworth Scale Note: differences reflect change in scores from baseline to post-treatment.
Thielbar et al., 2013 PEDro score: 6	16 patients with chronic stroke	VR training using virtual keypad (AVK) and a pneumatically actuated glove (n=8) vs. Conventional occupational therapy (n=8) **Treatment details:** 1-hour/session, 3 times/week for 6 weeks	**At 4 weeks (immediately post-treatment) and at 1 month (follow-up):** (-) Jebsen-Taylor Hand Function Test* (-) Fugl-Meyer Assessment - Upper Extremity scale (-) Jamar dynamometer (-) Pinch strength (-) Finger Individuation Index (+) Action Research Arm Test

Virtual Reality – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
Turolla et al., 2013 PEDro score: 4	376 patients with acute, subacute and chronic stroke	VR training + upper limb therapy (n=263) vs. Conventional upper limb therapy alone (n=113) **Treatment details:** 20 x 2-hour sessions, 5 times a week for 4 weeks VR training used the VRRS® system including computer workstation, 3D motion tracking system, and a high-resolution LCD projector	**At 4 weeks (immediately post-treatment):** (+) Functional Independence Measure (+) Fugl-Meyer Assessment - Upper Extremity scale
Yin et al., 2014 PEDro score: 6	23 patients with acute stroke	VR training using hand-held remote controller, base movement sensor, computer, gaming software, LCD screen; combined with conventional therapy (n=11) vs. Conventional therapy alone (n=12) **Treatment details:** 9 x 30-minute sessions, 5 times a week over 2 weeks	**At 2 weeks (immediately post-treatment) and at 1 month (follow-up):** (-) Motor Activity Log (Amount and Quality of Movement scales) (-) Action Research Arm Test (-) Functional Independence Measure (-) Fugl-Meyer Assessment -Upper Extremity scale