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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| Is virtual reality (I) an effective intervention for improving functional mobility and gait mechanics (O) in a 55-year-old adult patient post stroke (P) when compared to conventional therapy interventions (C)? |

**AUTHOR**

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| **Prepared by** | Raiya Feinberg | **Date** | 11/20/20 |
| **Email address** | raiyaf@med.unc.edu | | |

**CLINICAL SCENARIO**

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| The patient is a 55-year-old male who is 1 year post ischemic stroke. He is still demonstrating deficits in functional mobility and gait mechanics and presents to outpatient physical therapy to address these deficits. He has a goal of returning to work as an accountant as well as being more independent with activities at home. He was walking to work prior to the stroke but now struggles with community level ambulation. In pursuit of helping him reach his goals, I want to know if virtual reality therapy can be used as a successful intervention method to better improve functional mobility and gait when compared to conventional physical therapy interventions.  Currently, it is known that high repetitions of task specific activities can help improve function after a stroke; however, accomplishing this through the use of virtual reality systems is a newly arising intervention. The effect of virtual reality-based rehabilitation when compared to conventional therapy programs needs to be studied further to determine if one is better than the other or if the use of both combined provides the best benefit. |

**SUMMARY OF SEARCH**

[Best evidence appraised and key findings]

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| Eight studies met the inclusion and exclusion criteria including 6 systematic reviews, 1 randomized controlled trial, and 1 study protocol of a randomized controlled trial.   * Substituting some or all of standard therapy with virtual reality-based training elicits greater benefits in walking speed, balance, and overall mobility in post stroke patients1. * In adult patients post stroke, virtual reality can be used as an intervention method to moderately improve functional outcomes when compared to standard therapy2. * The use of virtual reality training can significantly improve walking speed and community walking time in post stroke patients. This may be due to practice dependent neuroplasticity3. * Virtual reality training is more effective at improving gait and balance abilities in stroke patients than training without virtual reality4. * While conventional therapy does provide benefits to stroke patients, overall, the effects of virtual reality training are higher2,5. |

**CLINICAL BOTTOM LINE**

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| Participation in virtual reality-based therapy provides more significant improvements in gait, walking speed, and functional mobility in stroke patients when compared to participation in conventional physical therapy. Virtual reality should be incorporated in to a physical therapy plan of care as an intervention whenever possible. Compared to standard therapy interventions, patients are able to participate better in virtual reality-based gait and mobility training and demonstrate greater improvements in standardized outcome measures which can translate into a patient’s daily life. |

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| ***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor*** |

*The above information should fit onto the first page of your CAT*

**SEARCH STRATEGY**

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| **Terms used to guide the search strategy** | | | |
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| Stroke  Post stroke | Virtual reality  Virtual reality therapy  VR  VRT | Conventional physical therapy  Physical therapy intervention | Functional mobility  Patient-reported function  Patient-reported outcomes  Stroke recovery |

**Final search strategy (history):**

PubMED

1. Stroke OR post stroke
2. Virtual reality OR VR
3. Virtual reality therapy OR VRT
4. Conventional physical therapy
5. Physical therapy intervention
6. Functional mobility
7. Stroke recovery
8. Patient reported function
9. **#1 AND (#2 OR #3) AND (#4 OR #5) AND (#6 OR #7 OR #8)- (162 results)**

Cochrane Library

1. Stroke OR post stroke
2. Virtual reality OR VR
3. Virtual reality therapy OR VRT
4. Conventional physical therapy
5. Physical therapy intervention
6. Functional mobility
7. Stroke recovery
8. Patient reported function
9. #1 AND (#2 OR #3) AND (#4 OR #5) AND (#6 OR #7 OR #8)- (39 trials, 0 Cochrane reviews)
10. #1 AND (#2 OR #3) AND (#4 OR #5)- (298 trials, 0 Cochrane reviews)
11. **#1 AND (#2 OR #3)- (493 trials, 3 Cochrane reviews)**

CINAHL

1. Stroke OR post stroke
2. Virtual reality OR VR
3. Virtual reality therapy OR VRT
4. Conventional physical therapy
5. Physical therapy intervention
6. Functional mobility
7. Stroke recovery
8. Patient reported function
9. #1 AND (#2 OR #3) AND (#4 OR #5) AND (#6 OR #7 OR #8)- (2 results)
10. **#1 AND #2 AND #5- (108 results)**

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| **PubMED**  **Cochrane Library**  **CINAHL** | **162**  **3 reviews, 493 trials**  **108** | **N/A**  **Originally yielded 0 reviews and 39 trials- expanded search by erasing search terms to include more articles (seen above)**  **Originally yielded 2 results- expanded search by erasing search terms to include more articles (seen above)** |

## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| * Adult patients post stroke * Patient reported outcome measures used to assess functional mobility * Standardized outcome measures for functional mobility * RCTs * Case studies * Systematic reviews |
| **Exclusion Criteria** |
| * Not published in English * Studies older than 15 years * Grey literature |

**RESULTS OF SEARCH**

**Summary of articles retrieved that met inclusion and exclusion criteria**

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| **Author (Year)** | **Risk of bias (quality score)\*** | **Level of Evidence\*\*** | **Relevance** | **Study design** |
| **Corbetta (2015)1** | **AMSTAR- 9/11** | **Level 1** | **High** | **Systematic Review** |
| **Lohse (2014)2** | **AMSTAR- 7/11** | **Level 2 (included RCTs and quasi-RCTs)** | **Low** | **Systematic Review** |
| **Yang (2008)3** | **PEDro- 8/11** | **Level 1** | **High** | **RCT** |
| **De Rooij (2016)4** | **AMSTAR- 10/11** | **Level 1** | **High** | **Systematic Review** |
| **Iruthayarajah (2017)5** | **AMSTAR- 8/11** | **Level 1** | **Low** | **Systematic Review** |
| **De Rooij (2019)6** | **PEDro- 5/11** | **Level N/A** | **Low** | **Study protocol of RCT** |
| **Gibbons (2016)7** | **AMSTAR- 7/11** | **Level 1** | **Moderate** | **Systematic Review** |
| **Lee (2019)8** | **AMSTAR- 9/11** | **Level 1** | **High** | **Systematic Review** |

**BEST EVIDENCE**

The following 2 studies were identified as the ‘best’ evidence and selected for critical appraisal. Rationale for selecting these studies were:

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| * The 2008 randomized controlled trial by Yang et al. was chosen as best evidence for this specific clinical question. The researcher looks directly at virtual reality training and how it affects and improves ambulation in post stroke patients when compared to conventional therapy methods. The trial looks at 20 patients that fit the population of interest and the methods and results from this trial are highly relevant to the clinical question at hand. The level of evidence is very high (1) and the risk of bias is low to moderate which gives us confidence in the accuracy of results presented by this article. * The 2015 systematic review by Corbetta et al. was chosen as best evidence for this specific clinical question. The review looks directly at virtual reality training and how it improves gait and mobility in chronic stroke patients. The review examines 15 trials involving 341 participants that fit the patient population of interest. The level of evidence is high (1) and the risk of bias is low which gives us confidence in the accuracy of the results. |

**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of (Virtual reality-based training improves community ambulation in individuals with stroke: a randomized controlled trial) by (Yang et al., 2008)3**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of the study by Yang et al. was to determine the effect of virtual reality-based treadmill training on the rehabilitation of community ambulation skills for individuals with stroke. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| This study is a single blind randomized controlled trial that consisted of 20 patients with a history of stroke. All subjects were randomized into groups: 9 subjects were assigned to the control group which received standard treadmill training while 11 subjects were assigned to the experimental group that received virtual reality-based treadmill training. Walking speed, community walking time, the walking ability questionnaire (WAQ) and the activities-specific balance confidence scale (ABC) were used as outcome measures to track progress as well as compare groups. The training period for both groups was 3 weeks, with 9 sessions occurring over that time. Subjects were evaluated prior to starting the training period, at the end of the 3-week period, and 1 month after completion of training. Information from all subjects was then entered into a computerized database and analysed using the SPSS statistical package. A significance level of 0.05 was set for all analyses. Baseline characteristic comparisons between groups were made by using independent samples t-tests for means and chi-squared tests for frequencies. A one-way repeated analysis of variance was performed on the differences of each dependent variable to explain the effect of training and follow up data. Changes for each subject were calculated by subtracting pretraining data from post training data or follow up data and standard deviations of change were calculated. An analysis of variance was also used to determine the differences of change of each dependent variable between groups. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| Taipei, Taiwan |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| All subjects were recruited from community groups in Taipei, Taiwan. 24 subjects met the inclusion criteria of: hemiparetic from a single stroke occurring at least 6 months earlier, limited or unlimited household walker or limited community walker, not presently receiving any rehabilitation services, no visual field deficits, stable medical condition, and ability to understand instruction and follow commands. Of the 24 subjects, 12 were randomly assigned to the control group and 12 to the experimental group. There were no statistically significant differences between groups at baseline for age, stroke onset, gender, hemiparetic side, functional walking category, or walking aid. There were also no statistical differences in outcome measures between the experimental and control groups before treatment. 3 subjects from the control group and 1 subject from the experimental group did not complete the protocol. This left 20 total subjects, 9 in the control group and 11 in the experimental group. Patients in the control group ranged from 46-73 years of age. 5 of them were males and 4 were females. The average time since stroke was 6.10±10.32 years. In the experimental group the age range was 30-76 years old with 5 being male and 6 being female. The average time since stroke was 5.93±4.17 years. Walking speed, community walking time, WAQ score, and ABC score were taken for all patients at baseline, after the 3-week training period, and at a 1 month follow up. Results for these values can be seen in the “main findings” section below. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| Subjects in the control group received 9 20-minute treadmill training sessions over a 3-week period. Subjects were asked to start walking at a comfortable walking speed. After each session, the treadmill speed was increased 5% as long as the patient was able to maintain the speed and feel safe while doing so. A therapist was present and standing by each patient for each session to prevent falls. While walking, subjects were asked to perform tasks such as lifting legs to stimulate stepping over an object or walking up or down a hill. |
| *Experimental* |
| Subjects in the control group also received 9 20-minute virtual reality-based treadmill training sessions over a 3-week period. The same 5% increase in speed was conducted for the experimental group as it was for the control group and a therapist was standing by to prevent falls. The virtual reality aspect of the intervention was created by using a screen in front of the treadmill with a wide field view as well as three-dimensional acceleration graphic card and auditory outputs. The virtual environments projected were created to simulate a typical Taipei community with scenarios such as crossing a street, walking over obstacles, and walking through a park. Changes in the incline and speed of the treadmill were adjusted in conjunction with the scenery. An electromagnetic system tracked leg movements to record any collisions with virtual objects. |
| **Outcome Measures**  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| All outcome measures were performed by a physical therapist that was not involved in the training protocol and was blinded to the subjects’ groups. The outcomes used in this study were walking speed, the community walk test, the walking ability questionnaire (WAQ), and the activities-specific balance confidence scale (ABC). Subjects were allowed to use any assistive devices when needed; however, use of a device did affect some scores.    Walking speed was calculated by performing a 10-meter walk test and recording the time in seconds.  Community walking was calculated by instructing a subject to walk 400 meters (including crossing a street, up and down a ramp, and stepping over an obstacle) and recording the time in minutes. This number was then multiplied by a factor corresponding to the assistive device used. Using no device was x1, an orthosis x2, cane x3, quadruped cane x4, orthosis and cane x5, and orthoses and quadruped cane x6.  The WAQ is a 19-item subjective measure of mobility. Each item is scored from 0-4 with 4 representing independence with the activity. The highest score possible is 76 which indicated excellent walking ability.  The ABC scale is a patient reported outcome in which a patient is asked to rate their confidence from 0-100 when performing a specific task. The measure includes 16 activities to rate. |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable. You may summarize results in a table but you must explain the results with some narrative.] |
| Table 1. Comparison of main measures within groups   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **Measures** | **Control** | | | **Experimental** | | | | **Pretraining** | **Post training** | **Follow-up** | **Pretraining** | **Post training** | **Follow-up** | | Walking speed (m/s) | 0.71±0.57 | 0.73±0.63 | 0.77±0.71 | 0.69±0.30 | 0.85±0.31\*\* | 0.86±0.33\*\* | | Community walking time (min) | 22.50±22.04 | 20.62±24.66\* | 19.95±23.61\* | 23.12±19.15 | 16.98±18.39\*\* | 15.76±19.25\*\* | | WAQ score | 57.67±12.29 | 58.67±12.81 | 59.00±12.80\* | 54.91±8.73 | 58.36±9.25\* | 59.00±8.83\*\* | | ABC score | 67.86±15.13 | 72.23±16.86 | 72.79±16.27 | 78.52±12.39 | 87.38±6.81\* | 84.58±8.55 |   Values are mean ± standard deviation. \* is P<0.05. \*\* is P<0.01.  Values with a \* or \*\* represent statistically significant results. Significant improvements were seen in all four measures (walking speed, community walking time, WAQ score, ABC score) of the experimental group at post training and in walking speed, community walking time, and WAQ score at follow-up. In the control group, significant improvements were only seen in community walking time at post training and community walking time and WAQ score at follow up.  Table 2. Comparison of change values of main measures between groups   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **Measures** | **Post training-pretraining** | | | **Follow-pretraining** | | | | **Control** | **Experimental** | **P\*** | **Control** | **Experimental** | **P\*** | | Walking speed (m/s) | 0.03±0.15 | 0.17±0.11 | 0.03 | 0.06±0.22 | 0.18±0.14 | 0.17 | | Community walking time (min) | -1.89±1.85 | -6.14±5.53 | 0.04 | -2.56±2.98 | -7.36±6.72 | 0.06 | | WAQ score | 1.00±1.94 | 3.45±5.11 | 0.19 | 1.33±1.50 | 4.01±3.33 | 0.03 | | ABC score | 4.37±8.69 | 8.86±10.10 | 0.31 | 4.93±6.98 | 6.05±9.91 | 0.78 |   Values are mean ± standard deviation.  The experimental group performed significantly better than the control group when looking at change in pre versus post training values for walking speed (p-value of 0.03) and community walking time (p value of 0.04). The experimental group also showed significantly better WAQ scores (p value of 0.03) when looking at change in pretraining versus follow up values. |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| After only 3 weeks and 9 sessions, greater improvements in walking speed and community walking time were seen by the experimental group when compared to the control group. Improvements were maintained at the 1 month follow up. This study supports the perceived benefits of using virtual reality as an intervention for gait training and community level mobility in stroke patients and suggests that even more training may result in even greater benefits. |
| **Critical Appraisal** |
| **Validity**  [Summarize the internal and external validity of the study. Highlight key strengths and weaknesses. Comment on the overall evidence quality provided by this study.] |
| This level 1 randomized controlled trial has a low to moderate risk of bias based on the 8/11 score on the PEDro scale. This indicated moderate to high confidence in the author’s findings. One major strength of this study was the examination of community ambulation in multiple domains. The study did not just look at gait speed but also included the 400-meter community walking test, the WAQ scale, and the ABC scale. The study also was able to measure data prior to the trial starting, immediately after the trial, and one month after the trial ended to determine the follow up effect of training. One weakness of the study is the small sample size of only 20 subjects. This study also was conducted over a 3-week period. A longer duration of treatment may be required to determine the long-term effects of virtual realist-based rehabilitation since the short intervention period may limit the results. The authors also note the generalization of results as the results were based on poor community ambulators after a stroke and may not be transferable to other patient populations. |
| **Interpretation of Results**  [This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| The results presented by the authors demonstrate that virtual reality-based rehabilitation is more effective at improving walking speed and community walking time as well as WAQ scores when compared to standard therapy. Data showed statistically significant results in favour for the use of virtual reality as an intervention. The study is of a high level of evidence and presents with low risk of bias. The outcome measures used were also appropriate and therefore confidence can be had in the results of the objective data found by this study. However, the study was performed with only 11 subjects in the experimental group and 9 subjects in the control group. The small patient population as well as the short duration of treatment period need to be taken into consideration when applying this evidence to the general population of stroke patients. |
| **Applicability of Study Results**  [Describe the relevance and applicability of the study to your clinical question and scenario. Consider the practicality and feasibility of the intervention in your discussion of the evidence applicability.] |
| This study is highly applicable to the clinical scenario presented. My patient is a 55-year-old patient 1-year post stroke with the goal of gaining functional mobility and independence. This study looked only at adult patients at least 6 months post stroke with deficits in functional mobility and community ambulation. My clinical question was related to the effect of virtual reality-based rehabilitation when compared to standard therapy interventions for treating patients post stroke. This article directly addresses my question and provides evidence in support of virtual reality-based therapies. Based on the findings from this article, I believe that a virtual reality-based rehabilitation program could help my patient improve his walking speed, confidence, and community ambulation skills so he is able to return to walking to work and helping around the house independently. |

**(2) Description and appraisal of (Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke: a systematic review) by (Corbetta et al., 2015)1**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of this systematic review by Corbetta et al. was to determine if virtual reality-based rehabilitation could improve balance, mobility, and walking speed in patients after a stroke when compared to standard rehabilitation of the same duration. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| This study is a systematic review and meta-analysis of randomized controlled trials.  **Search strategy/methods:** The authors used key terms such as “stroke”, “virtual reality”, “walking”, and “postural balance” to search The Cochrane Register of Controlled Trials, PubMed, Embase, CINAHL, and PEDro. Inclusion criteria were created based on study design, population, intervention, outcomes, and comparisons. They were as follows: randomized or quasi-randomized controlled trials, adults (older than 18 years) with a clinical diagnosis of stroke and no other pathological conditions affecting the lower limbs, an intervention of virtual reality-based rehabilitation using a head mounted device or conventional workstation set at any intensity with a duration exceeding a single treatment session, outcomes of walking speed, balance, and mobility, and a comparison of standard rehabilitation. The quality of studies used the Cochrane Collaboration’s tool for assessing bias.  **Articles selected:** After the initial search, 335 titles and abstracts were found. 31 of those were excluded after screening the abstracts, leaving 304 articles. After a full text evaluation only 31 articles remained and 16 of those were excluded due to ineligible study design, outcome measures, or control interventions. This left 15 randomized controlled trials to be included in the systematic review.  **Data analysis:** Results from the included studies were pooled using RevMan software. These pooled results are expressed as weighted mean differences with 95% CI. A forest plot as well as the I2 statistic and chi-squared test were used to assess heterogeneity. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| The included studies took place in seven countries: Korea, USA, Taiwan, Singapore, Brazil, Spain, and Italy. The authors are all from Milan, Italy and this is most likely where the review was conducted. |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| Over all of the included studies, 341 participants total were examined. 169 were randomized to the experimental groups while 172 were randomized to the control groups. 44% of participants were female and the mean age of all participants was 53 to 65 years old. The majority of all patients experienced a stroke greater than 6 months before the start of the studies and all had maintained the ability to walk with or without an assistive device. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| Intervention varied between studies; however, in 11 of the 15 studies virtual reality therapy was used in place of standard rehabilitation and therefore the control group received the same total treatment time as the experimental group. In 4 of the studies, virtual reality was added to standard rehabilitation and therefore the control group received less treatment time than the experimental group. Frequency ranged from 2-6 days per week for 2-6 week and sessions lasted between 20 minutest to 1 hour. Examples of conventional rehabilitation include working with physical and occupational therapy on standard exercises, treadmill training, walking in hallways, and stepping over obstacles. |
| *Experimental* |
| Interventions varied between studies. The frequency of treatment is the same as listed above for the control groups. Virtual reality-based training ranged from virtual reality treadmill training systems or treadmill training with a wide screen projecting real world environments in front for gait, Xbox 360 Kinect and Nintendo Wii Fit for balance, and head mounted devices. |
| **Outcome Measures**  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| Several outcomes measures were used. To look at locomotor function, 5 studies used the 10-meter walk test, 2 used the 6-minute walk test, and 2 used gait velocity. For balance and mobility, 9 studies used the Berg Balance Scale and 7 used the Timed Up and Go. 4 of the 15 studies included follow up evaluations after training. All other studies evaluated outcomes immediately after training ended. |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable. Use a table to summarize results if possible.] |
| Table 1. Virtual realist-based rehabilitation outcomes when same duration as standard rehabilitation (replacing standard rehabilitation)   |  |  |  | | --- | --- | --- | | **Measure** | **Mean difference (95% CI)** | **Heterogeneity observed (I2)** | | Walking Speed | 0.15 m/s (95% CI 0.10 to 0.19) | No (I2=26%) | | Balance | 2.1 points on BBS (95% CI 1.8 to 2.5) | No (I2=0%) | | Mobility | 2.3 sec on TUG (95% CI 1.2 to 3.4) | Yes (I2= 84%) |   Table 2. Virtual reality-based rehabilitation when added to standard rehabilitation   |  |  |  | | --- | --- | --- | | **Measure** | **Mean difference (95% CI)** | **Heterogeneity observed (I2)** | | Walking Speed | 0.21 m/s (95% CI -0.23 to 0.65) | N/A | | Balance | Too heterogeneous to be pooled | Yes (I2= 97%) | | Mobility | 0.7 sec (95% CI 0.4 to 1.1) | No (I2= 0%) |   **Walking speed:** Walking speed was measured in 7 studies that looked at replacement of standard therapy with virtual reality-based rehabilitation. This data includes 138 participants, 65 of which received virtual reality-based rehabilitation. Replacing some of all of standard rehabilitation with virtual reality-based rehabilitation significantly improves walking speed (table 1). 1 study measured virtual reality being added to standard therapy. This included 42 participants. When walking speed was added to standard rehabilitation, results were not statistically significant (table 2).  **Balance:** Balance was assessed in 5 studies using the Berg Balance Scale to look at replacement of standard therapy with virtual reality-based rehabilitation. This included 130 participants, 67 of which received virtual reality-based rehabilitation. Replacing some or all of standard therapy with virtual reality-based rehabilitation significantly improved balance (table 1). 4 studies measured virtual reality being added to standard therapy. These studies were too heterogenous to be pooled and therefore data could not be extracted (table 2).  **Mobility:** Mobility was assessed in 5 studies using the Timed Up and Go to look at replacement of standard therapy with virtual reality-based rehabilitation. This included 114 participants, 53 of which received virtual reality-based rehabilitation. Replacing some or all of standard therapy with virtual reality-based rehabilitation significantly improved mobility (table 1). 2 studies measured the addition of virtual reality to standard therapy. This included 42 participants, 21 of which received virtual reality-based rehabilitation. The addition of virtual reality significantly improved mobility (table 2). |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| Replacing some or all of standard therapy with virtual reality-based rehabilitation will significantly improve walking speed, balance, and mobility in patients post stroke. Adding additional virtual reality to standard therapy also shows some benefits with improved mobility; however, more research needs to be conducted. |
| **Critical Appraisal** |
| **Validity**  [Summarize the internal and external validity of the study. Highlight key strengths and weaknesses. Comment on the overall evidence quality provided by this study.] |
| A score of 9/11 on the AMSTAR assessment of risk bias for systematic reviews indicated moderate to high confidence in the author’s findings. One strength of this systematic review and meta-analysis is the high level of evidence (level 1) as it only included randomized controlled trials. The methodological quality of each study included was assessed. This review successfully examined how replacing some or all of standard therapy with virtual reality-based rehabilitation can benefit patients post stroke. However, the examination of adding virtual reality-based rehabilitation to standard therapy needs to be farther examined. For walking speed, only one study looked at the addition of therapy and for balance, the results were too heterogenous to be pooled. The statistically significant results in this review do show the benefit of virtual reality-based rehabilitation; however, the effects are small and therefore need to be further studied to determine the clinical relevance and worthwhileness of the intervention. The optimal frequency, duration, and intensity of intervention was also not studied in this review. |
| **Interpretation of Results**  [This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| The results presented by the authors in this systematic review and meta-analysis indicate that replacing some or all of conventional therapy with virtual reality-based rehabilitation provides greater benefits to the patient. Pooled results from 15 different randomized controlled trials show greater improvements in walking speed, balance, and mobility in experimental groups compared to control groups. All data from table 1 is statistically significant in support of the use of virtual reality as an intervention method. Results were inconclusive when virtual reality was added on to a standard therapy program rather than replacing standard therapy. The review is of a high level of evidence and demonstrates low risk for bias and therefore I have confidence in the authors’ conclusions. |
| **Applicability of Study Results**  [Describe the relevance and applicability of the study to your clinical question and scenario. Consider the practicality and feasibility of the intervention in your discussion of the evidence applicability.] |
| This study is highly applicable to the clinical scenario presented. My patient is a 55-year-old patient 1-year post stroke presenting with deficits in functional mobility and gait mechanics. This review examined studies looking at adult patients greater than 6 months post stroke with similar deficits. The findings from this review suggest that replacing some of the standard therapy provided in the outpatient setting with virtual reality-based rehabilitation can help improve walking speed, balance, and mobility to a greater degree than standard therapy alone. This review points out that the added cost of applying virtual reality to standard rehabilitation is small and once the one-time expense is made, many patients in the clinic can benefit from it. I believe that if my clinic did not already have a virtual reality system, I would advocate for one. This review demonstrates that large virtual reality systems as well as smaller headsets and even gaming systems such as the Wii or Xbox can provide benefits to patients. |

**SYNTHESIS AND CLINICAL IMPLICATIONS**

[Synthesize the results, quality/validity, and applicability of the two studies reviewed for the CAT. Future implications for research should be addressed briefly. Limit: 1 page.]

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| The concept of high repetition task-oriented exercise training for stroke rehabilitation is widely accepted to target locomotor recovery. Virtual reality-based rehabilitation offers an interactive form of practice containing high repetitions of real-life scenarios. It incorporates visual and auditory feedback systems to improve neural plasticity1,3,8. Both studies included in this CAT conclude that virtual reality-based rehabilitation provides greater benefits when compared to standard therapy and that patients demonstrate greater improvements in walking speed, balance, mobility, and confidence after participation in a virtual reality-based training program. The Yang et al. study looked more specifically at community ambulation whereas the Corbetta et al. study examined measures of walking speed, balance, and mobility. Both studies used virtual reality systems to recreate different environments and provide patients with tasks such as stepping over obstacles, crossing busy streets, walking up or down hills, etc1,3. The Yang et al. randomized controlled trial was able to demonstrate that after just 9 sessions, a virtual reality-based training program was able to improve walking speed and community walking time when compared to standard therapy and at a one month follow up WAQ scores improved significantly in the experimental group3. The Corbetta et al. systematic review and meta-analysis was able to show that replacing some or all of standard therapy with virtual reality-based rehabilitation significantly improves results of walking speed, balance scores on the Berg Balance Scale, and mobility scores on the Timed Up and Go1.  Both studies mention the need for further research to determine the most effective frequency, duration, and intensity of intervention. However, significant results were seen after only 9 20-minute sessions over a 3-week period in the Yang et al. study and significant improvements were seen in a range of 20 minute to 1-hour sessions over 2 to 6 weeks in the Corbetta et al. study. This indicated that in just a few short weeks, the positive effects of virtual reality-based rehabilitation can be seen in stroke patients1,3. Future systematic reviews should be performed to compare the effects of this intervention over different frequencies and durations of treatment time.  Based on the two studies described above, I conclude that virtual reality is an effecting intervention for treating patients post stroke. Virtual reality is able to provide greater improvements in functional mobility skills when compared to standard therapy. For the patient described in the clinical scenario, I would recommend the incorporation of virtual reality-based rehabilitation into his physical therapy plan of care. Replacement of some, if not all, of his functional mobility and gait training with virtual reality training can significantly benefit him in achieving his goal of returning to work via walking as well as independently preforming household activities. |

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