Egyptian Journal of Physical Therapy (EJPT)

Egy. J. Phys. Ther. 2022;10: 16-25

Original article

https://ejpt.journals.ekb.eg

Telerehabilitation Interventions in Patients after Stroke: A Systematic Review

HANAN R. MOHAMED [1*], NAHED A. SALEM [2], IBTESAM M. FAHMY [3], YOUSSEF M. El-BALAWY [2]

[1] *The Department of Neuro-Rehabilitation, Faculty of Physical Therapy, Pharos University, Egypt.*

[2] *The Departments of Physical Therapy for Neuromuscular disorder, Faculty of Physical Therapy, Cairo University, Egypt.*

[3] *The Department of Neurology, Faculty of Medicine, Cairo University, Egypt.*

***Correspondence to** HANAN R. MOHAMED, The Department of Neuro-Rehabilitation, Faculty of Physical Therapy, Pharos University, Egypt.
Tel: 01010786397
Email; hanan.rashad3@gmail.com

Published online: June 2022

Abstract:

Objective: To summarize the best evidence effectiveness of telerehabilitation applications (Telephone, Video Conference, and Virtual Reality Therapy) for improving activities of daily living, upper limb function, balance, and cost-effectiveness in stroke patients.

Methods: Intensive search was done in electronic databases: PubMed (October 2020), Cochrane Library (November 2020), and PEDro (November 2020), we also checked the reference lists. This search was done to include RCTs that compare telerehabilitation applications with face-to-face therapy for patients after stroke. Then, the methodological quality of each included trial was assessed, and the data was extracted. Finally, the results were analyzed by pooling the data of change scores between pre-and post-intervention through calculation of the overall standardized mean differences with a 95% confidence interval.

Results: We included 14 studies with a total of 1353 participants. Telerehabilitation applications may have not a significant effect on activities of daily living, upper limb function, and balance. Only three studies reported the results of the use of the health services provided in the study or the cost of the interventions and found that the number of visits for people who received interventions during the three-month follow-up evaluation was significantly reduced, but this did not last six months.

Conclusion The included randomized controlled trials have no evidence to show the effectiveness of telerehabilitation applications in improving people's activities of daily living after stroke.

Keywords Telerehabilitation, Telephone, Video Conference, Virtual Reality Therapy, Stroke.

1.Introduction

Stroke is a neurological deficit of the central nervous system (CNS) caused by acute focal injury caused by blood vessels, including cerebral infarction, cerebral hemorrhage, and subarachnoid hemorrhage. It is manifested as paralysis or weakness on one side of the body, abnormal

speech, Sensory disturbances, changes in muscle tone and reflexes (1).

Because COVID19 is spread through person-to-person contact, stroke patients who receive outpatient rehabilitation during the COVID19 pandemic are at increased risk of infection because contact with other people is often unavoidable on the way to and from the hospital. As the frequency of contact increases, the likelihood of contracting COVID19 will increase. The first 6 months after a stroke are a critical period for recovery. Subacute stroke disabled patients receive regular rehabilitation in the hospital, which means that these patients are at increased risk of contracting COVID19. Here, remote rehabilitation of stroke patients helps reduce their risk of infection (2).

Telerehabilitation uses electronic communication technology to provide rehabilitation services. Therefore, rehabilitation treatment can be implemented remotely without the doctor and the patient meeting in person. Different types of information and communication technologies are used to implement remote rehabilitation interventions. These include phone calls, video conferencing, and virtual reality (non-immersive) (3).

Telephone service technology uses standard real-time voice level analog telephones. Telephone interventions are designed to manage survivors' emotions and behaviors, provide physical care, provide instrumental care (e.g., financial, transportation, respite services), and address people's responses to care provided in the home (4).

Video conferencing applications facilitate the communication and interaction of two or more users through the combination of high-quality video and audio on the Internet Protocol network. They are useful because they simulate real, face-to-face communication. These applications support individual user accounts, login names, and passwords to help restrict access and authenticate participants (5).

Virtual Reality (Non-immersive) technology consisted of 2 dedicated personal computer-based workstations, one located at the patient's home and the second at the rehabilitation hospital. It allows the creation of scenes similar to the patient's real environment and generates real-time feedbacks in various ways according to the motion task, thus quantifies the treatment plan and improves motivation in real-time through evaluation and reward tasks (6).

2.Materials and Method.

This review was conducted through electronic and manual search, from August 2020 to May 2021, to provide valid evidence regarding the effectiveness of telerehabilitation applications in the rehabilitation of stroke, and it followed the following steps:

Inclusion criteria for considering studies for this review:

I. **Types of studies:** This review included published Randomized Controlled Trials (RCTs) with or without blinding of participants, physiotherapists, and assessors, which compared Telephone, Video Conference and Virtual Reality Therapy with Usual Care Therapy.

II. **Types of participants:**

- Adult participants (between 18 and 80 years old) with a clinical diagnosis of stroke, either ischemic or hemorrhagic in origin, acute, sub-acute, or chronic.
- Studies on mixed populations of healthy individuals or patients with stroke were included only if separate data for patients were available.

III. **Types of interventions:** Different forms of Telerehabilitation Therapy including Telephone, Video Conference, and Virtual Reality (Non-Immersive applications).

IV. **Control/comparator*:*** The studies will include comparisons of interventions with control, placebo, or standard care; and comparisons of different doses, intensities, or timing of delivery of the same intervention.

V. **Outcome:** The primary outcome was the independence in activities of daily living assessed post-intervention the outcomes were analyzed to test the efficacy of the included intervention variations; measures were prioritized as follows:

1- Independence in activities of daily living: measures that examine self-care, mobility, and domestic life activity and participation domains.

- Barthel Index, Functional Independence Measure, and Nottingham Extended Activities of Daily Living Scale.

Exclusion criteria:

The studies were excluded if they were:

- Study designs other than randomized controlled trials and quasi controlled trials.
- Review articles, surveys, case reports, and case series.
- Published abstracts with no full-text articles available.
- Trials that investigate one of the included interventions together with the application of other interventions.
- Studies with low methodological quality (all studies with total PEDro scores less than 5).

Search methods for identification of studies:

Electronic database search was done in:

- PubMed (Medline) at http://www.ncbi.nlm.nih.gov/pubmed.
- CENTRAL at http://www.thecochranelibrary.com.
- Physiotherapy Evidence Database (PEDro) at http://www.pedro.org.au/.

The following keywords have been used to search the electronic databases (PubMed, CENTRAL (Cochrane), and PEDro): Telerehabilitation, Tele-rehabilitation, Tele-Home Care, Telephone, Video Conference* and Virtual Reality Therapy. An additional search was done using the following Keywords: stroke, Apoplexy, CVA (Cerebrovascular Accident), Cerebral Stroke, Cerebrovascular Accident, Cerebrovascular Accident, Acute, Cerebrovascular Apoplexy, Cerebrovascular Stroke, and Stroke. Databases were searched from August 2020 to May 2021 in addition to searching the database also the reference lists of relevant publications were also checked.

Study selection criteria:

Titles and abstracts of records identified by the electronic searches were assessed by two independent reviewers (Hanan Rashad and Youssef Elbalawy). A manual search was done by checking the reference lists of relevant publications and tracking the newer studies through "Scopus". Obvious Irrelevant trials were excluded. Then, the full text of the remaining studies was obtained and checked for eligibility against inclusion and exclusion criteria to exclude the studies that don't fulfill the inclusion criteria.

Data extraction:

A data collection form was used to extract and record the key features of each trial including details of the Participants, Interventions, Outcomes, and Results. One reviewer (Hanan Rashad) extracted data from the included studies and a second reviewer (Youssef El-balawy) cross-checked it.

Methodological quality assessment of the studies:

The methodological quality of the full papers was assessed by using the risk of bias assessment tool according to Chapter 8 of the Cochrane Handbook for Systematic Reviews of Interventions (7). And by applying the physical therapy evidence database scale (PEDro) which assess the eligibility criteria, method of randomization and blinding, concealment of allocation, the similarity of participants in treatment groups at baseline, whether an intention-to-treat analysis will be performed, and the number of participants lost to follow-up and missing values (Appendix I). The consensus was achieved through discussion, including a third author if necessary (Prof. Nahed Salem) and fourth author (prof. Ibtesam Fahmy).

Studies that got 9-10 points on the PEDro scale are considered to be excellent, studies that got 6-8 points on the PEDro scale are considered to be good, studies that got 4-5 points on the PEDro scale are considered to be average and studies that got 0-3 points on Pedro scale are considered to be poor.

Measures of treatment effect:

The primary and secondary outcome variables of interest were continuous outcomes. Data of change scores between pre-and post-intervention measures

were evaluated and entered as means and Standard Deviations (SDs) and the Standardized Mean Difference (SMD) with 95% Confidence Intervals (CIs) for each trial was calculated. Data were pooled through calculation of the overall SMD and 95% CI.

Data analysis:

A comparison between the Telerehabilitation and conventional therapy or placebo therapy was made, and a pooled analysis of primary and secondary outcomes was conducted as described above, using a random-effects model instead of a fixed-effect model if heterogeneity of the studies was high. A subgroup analysis was performed to establish the effectiveness related to the used outcome measures, (Telerehabilitation and independence in activities of daily living).

3.Results

Results of the search:

1020 studies were identified from the search of PubMed, Cochrane, and PEDro databases and additional 530 studies from the other sources (screening the reference lists of all relevant articles). After excluding all duplicate studies, a total of 1514 studies have been screened then, 1447 studies have been excluded and the full-text articles of 67 studies that appear to meet the eligibility criteria have been assessed. Results of the search are displayed in **Fig (1).**

Included studies:

14 studies met the inclusion criteria of this review, all of them were about stroke. Fourteen studies are based on telerehabilitation intervention (8:21).

Sample size and participants

The 14 studies included a total of 1353 participants. Individual sample sizes of identified trials ranged from 23 [12] to 573 [10]. Detailed descriptions of patient characteristics are given in (Table 1). The mean age of participants in the included studies is 64.2 years, and it ranged from 55.5 years [8] to 75.1 years [16]. There were more male (58.3%) than female (38 %) participants.

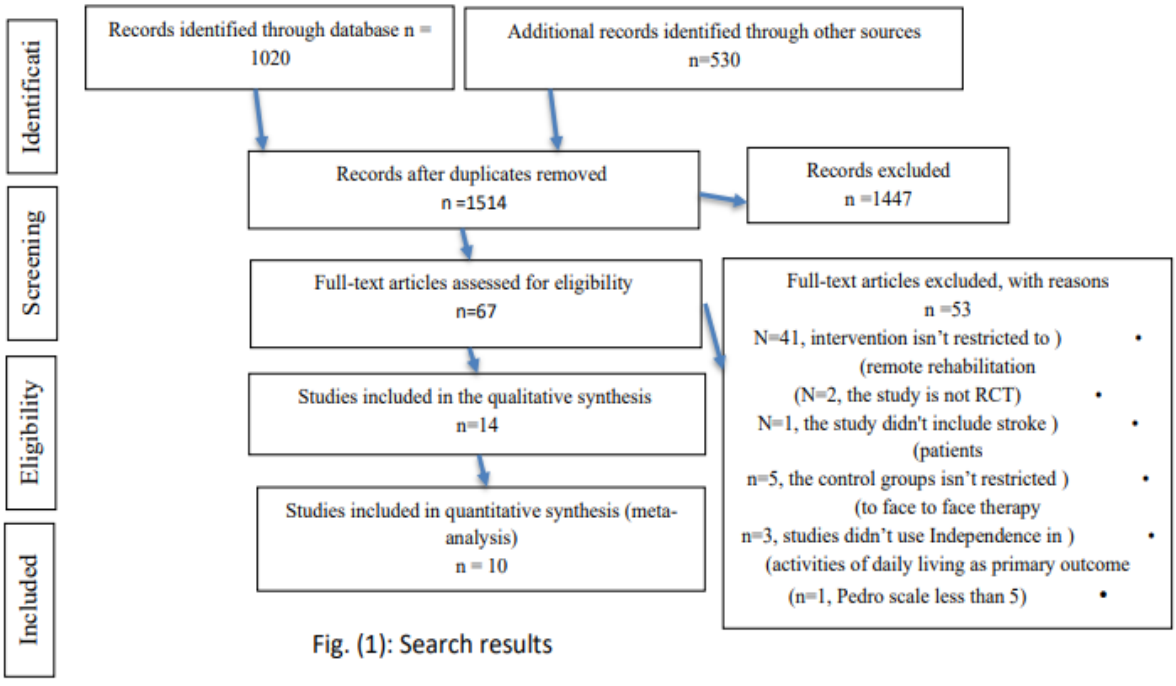

Fig. (1): Search results

ke:

we do not include the use of telerehabilitation (8:21).

Table 1: Participants of the Included Studies

	Experimental group					Control group				
Study	N	Male	Female	Age	Duration (in months)	N	Male	Female	Age	Duration (in months)
Lloréns., et al (2014)	15	10	5	55.4	10.7	15	7	8	55.6	11.1
Askın., et al 2018	18	13	5	53.2	24.72	20	14	6	56.5	24.45
Rodgers., et al (2019)	285	174	111	71	2.4	288	168	120	70.6	2.3
Piron., et al (2009)	18	11	7	66	14.7	18	10	8	64.4	11.9
Karasu., et al (2018)	12	5	7	62.3	4.8	11	5	6	64.1	4.8
Benvenuti., et al (2014)	143	78	65	69.1	32.4	45	24	21	72.2	48
Chen., et al (2017)	27	18	9	66.1	0.83	27	15	12	66.1	0.86
Kairy., et al (2015)	26			71.1		26			71.1	
Lin., et al (2014)	12	10	2	74.6	1.06	12	7	5	75.6	1.39
Standen., et al (2014)	17	8	9	59	12.3	12	8	4	59	15.3
Redzuan., et al (2012)	44	21	23	63.7	0.43	46	31	15	59.4	0.36
Saposnik., et al (2016)	71	46	25	62	1.0	70	48	22	62	1.0
Standen., et al (2016)	17	8	9	59	7.3	10	8	2	63	3.3
Chumbler., et al (2012)	25	24	1	67	1.5	23	23		67	1.69

Interventions:

Telerehabilitation is the use of information and communication technology to provide rehabilitation services to patients in remote locations. Interaction and communication technologies include telephone, Internet, virtual reality, and monitoring through sensors or wearable devices. We include rehabilitation programs that use "store and forward" communication methods or real-time interactions. Interventions are provided by one or more health disciplines (for example, we plan to include studies involving only one health profession and studies involving multidisciplinary interventions). When the purpose is to provide education or support to healthcare professionals rather than patient care,

Outcome: Activities of Daily Living:

For a measure of the primary outcome, activities of daily living, 5 studies used the Barthel index score of the daily living activities (13, 14, 16, 18, 19), 2 studies used the Functional Independence Measure [19, 21] and one study used the Nottingham Extended Activities of Daily Living (10).

Risk of bias in included studies:

All details of the methodological quality of the included studies using the risk of bias assessment tool (7) and the PEDro Scale are provided in Fig. (2) and (**Table 2**).

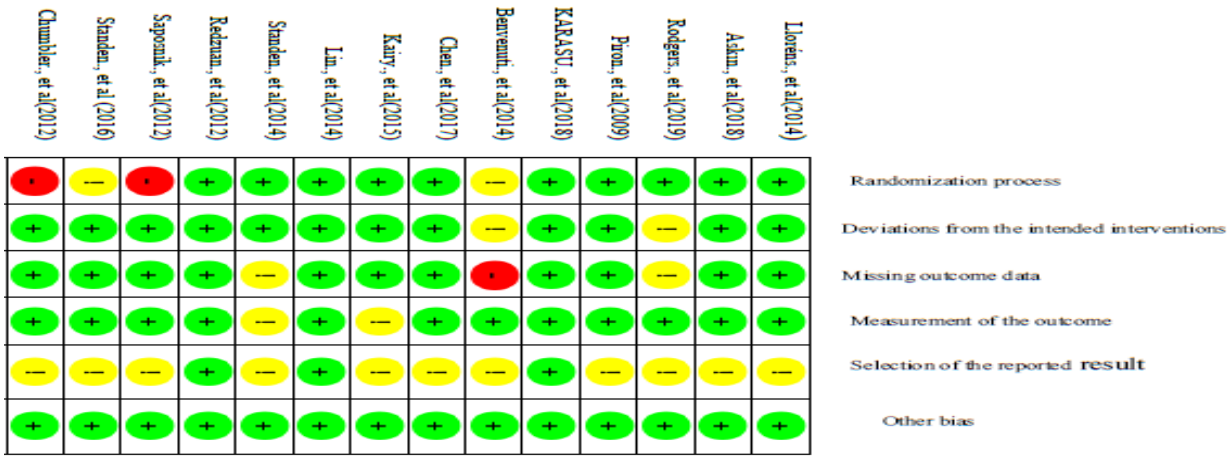

Fig 2: Risk of Bias Summary

Table (2): Pedro scale

	9-10 points excellent 4-5 point's average								6-8 points good 0-3 points poor				
Article	1	2	3	4	5	6	7	8	9	10	11	Total	Classification
Lloréns., et al (2014)	Yes	1	1	1	0	0	1	1	1	1	1	8	Good
Askın., et al (2018)	Yes	1	0	1	0	0	1	1	1	1	1	7	Good
Rodgers., et al (2019)	Yes	1	0	1	0	0	1	1	1	1	1	7	Good
Piron., et al (2009)	Yes	1	1	1	0	0	1	1	1	1	1	8	Good
KARASU., et al (2018)	Yes	1	1	1	0	0	1	1	1	1	1	8	Good
Benvenuti., et al (2014)	No	1	0	1	0	0	1	1	0	1	1	6	Good
Chen., et al (2017)	Yes	1	1	1	0	0	1	1	1	1	1	8	Good
Kairy., et al (2015)	No	1	1	1	0	0	1	0	1	0	0	5	Average
Lin., et al (2014)	Yes	1	1	1	0	0	1	1	1	1	1	8	Good
Standen., et al (2014)	No	1	1	1	0	0	0	1	0	1	1	6	Good
Redzuan., et al (2012)	Yes	1	1	1	0	0	1	1	1	1	1	8	Good
Saposnik., et al (2012)	Yes	1	0	1	0	0	1	1	1	1	1	7	Good
Standen., et al (2016)	Yes	1	0	1	0	0	1	1	1	1	1	7	Good
Chumbler., et al (2012)	No	1	0	1	0	0	0	1	1	1	1	6	Good

Effects of interventions

Comparison 1: Telerehabilitation versus conventional therapy

We included 8 studies in a pooled analysis on daily living activities functions (10, 13, 14, 16, 18, 19, 21) we performed an analysis of change scores between pre-and post-assessment. The 8 studies were divided into 3 subgroups according to the time after which the cases were assessed.

1-Daily Living Activities measured less than 3 months: Telerehabilitation has an insignificant effect of fewer than 3 months in patients after stroke compared with conventional therapy (SMD= -0.16, 95%CI= -0.71 to 0.4). Heterogeneity was not significant in the pooled result (Chi-square value= 1.79; I2= 44% and p= 0.18) **Fig. (3).**

2- Daily living activities measured 3 to 6 months: Telerehabilitation has an insignificant effect from 3 to 6 months in patients after stroke compared with conventional therapy (SMD= 0.16, 95%CI= -0.33 to 0.65). Analyses of the effect of possible heterogeneity, p, which is a parameter derived from the chi-square statistics (chi-square value= 13.67), shows a high value of heterogeneity, I^2= 78% in the pooled result with p-value = 0.003) **Fig. (4).**

3- Daily living activities measured from 6 months and more: Telerehabilitation has insignificant effect from 6 months and more in patients after stroke compared with conventional therapy (SMD= 0.15, 95%CI= 0.03 to 0.27). Heterogeneity was not significant in the pooled result (Chi square value= 0.40; I2= 0.0 and p= 0.94) **Fig. (5).**

4.Discussion

Overall completeness and applicability of evidence:

This review was able to answer the research questions; about the effect of telerehabilitation therapy on daily living activates in post-stroke patients. For some outcomes, the number of studies and participants was low, so it was hard to conclude. For example, there were only two included trials (16, 19) less than 3 months that investigated the effectiveness of telerehabilitation therapy on the daily living activates of patients after stroke. This downgraded the overall quality of evidence due to small sample sizes and the large heterogeneity between the measured outcomes. It is important that future research, of high methodological quality, is powered and designed to study the effects of telerehabilitation therapy on daily living activates.

***Applicability of evidence*:**

This review aimed to synthesize the best evidence on using telerehabilitation therapy on stroke rehabilitation, thus supporting clinicians and policymakers in clinical decision-making for rehabilitation. Before any evidence is applied, it is recommended that clinicians and policymakers carefully consider the details of the trials synthesized within that review, specifically reflecting on the relevance of the participant population, trial setting, interventions delivered, and outcomes assessed about the clinical decision to be made.

The dose of interventions is a critical issue when assessing the potential applicability of evidence. It is likely to impact effect size, and a specific minimum dose will likely be required to result in a change in outcomes. The necessary dose has not been established, and it is very difficult to be certain that the dose of intervention delivered within RCTs was sufficiently high. Consequently, evidence of 'no benefit or harm' may be a product of insufficient dose rather than of an ineffective intervention.

Quality of the evidence:

This review used several methodological domains (adequate sequence generation, adequate concealment of allocation, adequate intention to treat analysis (ITT), and blinding of assessors) to assess the risk of bias in the included studies. 4 studies were assessed as having unclear sequence

generation and 4 studies were assessed as using no or unclear concealed allocation of participants to study groups, 2 studies with no or unclear use of an

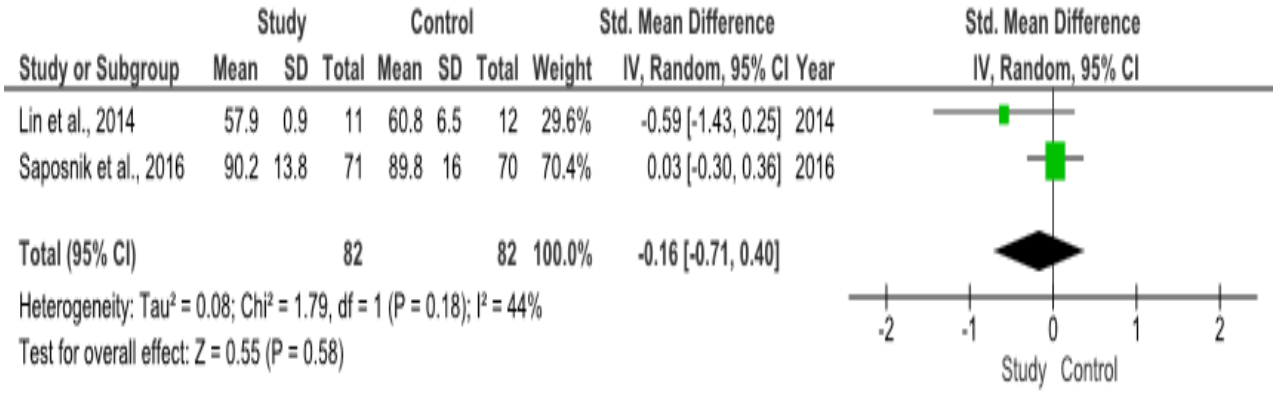

Fig. (3): Effect of telerehabilitation on daily living activities less than 3 months

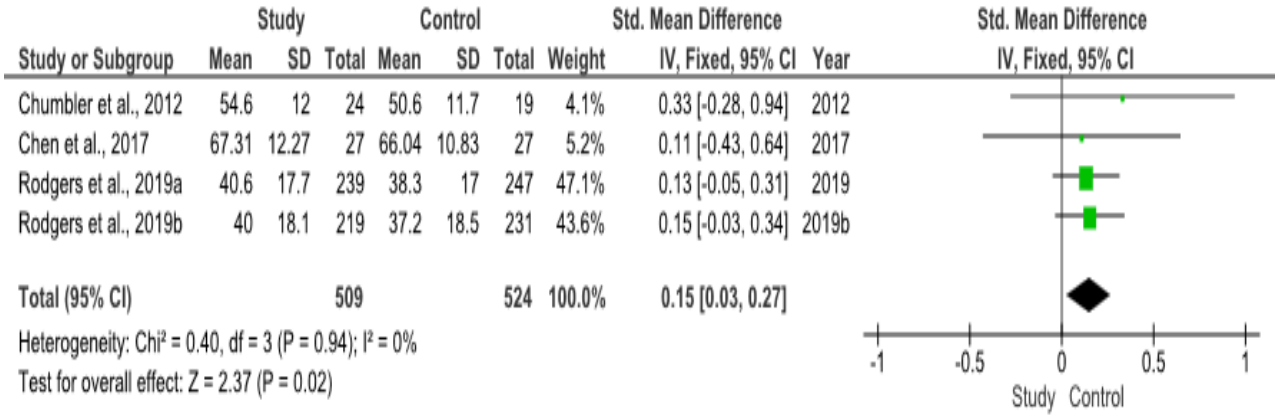

Fig. (4): Effect of telerehabilitation on daily living activities from 3 to 6 months

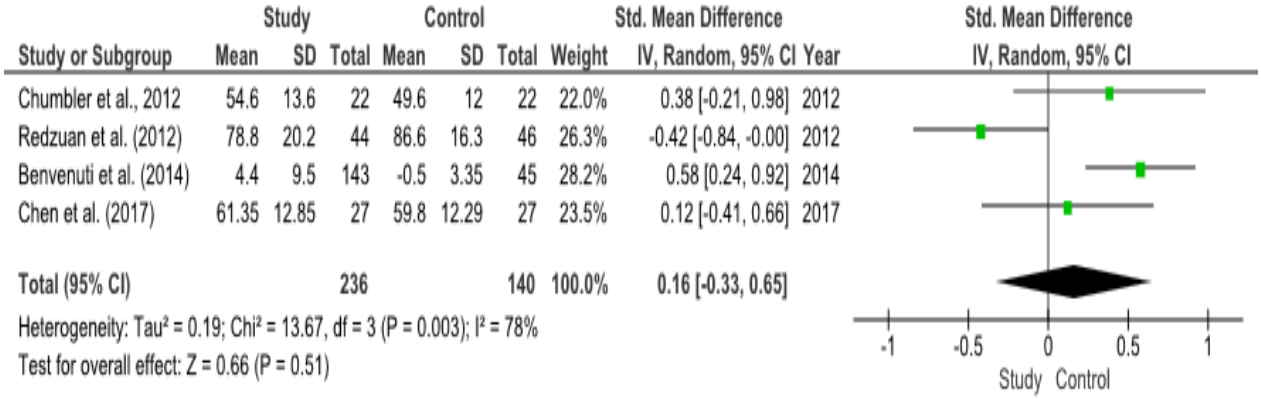

Fig. (5): Effect of telerehabilitation on daily living activities from 6 months and more

adequate ITT analysis, 4 studies with no or unclear use blinded assessors, and 3 studies only that have a low risk of reporting bias.

Additionally, the PEDro scale was used for evaluating the methodological quality of the studies. The median of the PEDro scale total scores was seven points, indicating the overall high quality of studies. However, 4 studies were classified to have a PEDro score lower than seven points. Overall limitations of the included studies were small sample sizes of most studies and there were multiple measures used to measure the same outcome in a study, we used the measure which was most commonly used amongst included studies.

Potential biases in the review process*:*

Through an extensive searching process, it is unlikely that any relevant trials have been missed. However, there is a possibility of additional (published or unpublished) studies that haven't been identified. The selection process, not restricting the search for a certain language, independent data extraction, and assessment of the risk of bias performed by the review authors did minimize errors and bias in data extraction.

There was heterogeneity between some studies in trial design (duration of follow-up and selection criteria for patients and characteristics of interventions (i.e., total amount of time of therapy). Furthermore, there were methodological limitations of studies.

Agreements and disagreements with other studies or reviews:

Compared with the items described in previous reviews (Appleby 2019; Chen 2015; Tchero 2018), this review identified more randomized trials. However, our conclusions are similar: despite the theoretical advantages of remote rehabilitation, the current evidence is insufficient to conclude its effects

5.Conclusion:

Few studies are robust enough and several studies included in this review are at risk of bias. At this point, it is difficult to conclude impact, because interventions and controls vary widely in different studies. Compared with conventional care, remote rehabilitation programs after discharge have not been shown to improve independence in activities of daily living.

The existing studies suggest there is no effect of telerehabilitation therapy after stroke, and they suffer from methodological problems such as small sample sizes and lack of proper reporting. There is thus an urgent need for well-designed and properly reported multicenter RCTs with large sample sizes to provide a high level of evidence. Further research should also address specific questions about the optimal dose, frequency, and duration of the interventions.

References

1. Sacco R.L., Kasner S.E., Broderick J.P., Caplan L.R., Connors J.J., Culebra S A., et al.: An updated definition of stroke for the 21 st century: A statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke, 44 (7): 2064-89.
2. Aggarwal G, Lippi G, Michael B: Cerebrovascular disease is associated with increased disease severity in patients with Coronavirus Disease (COVID-19): A pooled analysis of published literature [published online ahead of print, 2020 Apr 20]. Stroke. 2020;1747493020921664.
3. Cramer S, Dodakian L, See J, et al. Telerehabilitation in the home versus therapy in-clinic for patients with stroke: European Stroke Journal .3, 1 Suppl:590-1,2019.
4. Bakas T, McCarthy M, Israel J, Brehm B, Dunning K, Rota, et al: Adapting the telephone assessment and skill-building kit to the telehealth technology preferences of stroke family caregivers: Research in Nursing & Health nur.22075.
5. Billingsley L: Using Video Conferencing Applications to Share the Death Experience During the COVID-19 Pandemic: Journal of Radiology Nursing, S1546084320301437.
6. Kiper A, Luque-Moreno C, Pernice S, Maistrello L, et al: Virtual reality for the rehabilitation of post-stroke lower extremity.

7. Higgins J. and Green S: Cochrane Handbook for Systematic Reviews of Interventions, Cochrane Book Series. Wiley-Blackwell, 2008.
8. Lloréns R, Noé E, Colomer C, Alcañiz M, et al: Effectiveness, usability, and cost-benefit of a virtual reality-based telerehabilitation program for balance recovery after stroke: S0003-9993(14)01220-9.
9. Aşkın A, Atar E, Hikmet Koçyiğit & Aliye Tosun: Effects of Kinect-based virtual reality game training on upper extremity motor recovery in chronic stroke.
10. Rodgers H, FRCP, Howel D, Nawaraj Bhattarai, MPH, Robin Can't, et al: Evaluation of an Extended Stroke Rehabilitation Service Stroke:50:00-00.
11. Piron L, Turolla A, Agostini M, et al: Exercises for paretic upper limb after stroke: a combined virtual-reality and telemedicine approach. J Rehabil Med; 41:1016-102, 2009.
12. Karasu A, Balevi Batur E, Gülçin K, et al: Effectiveness of Wii-based rehabilitation in stroke: ahead of print Apr 5. Rehabil Med, 50: 406–412.
13. Benvenuti F, Stuart M, Cappena V, Gabella S, et al: Neurorehabil Neural Repair 28: 611 originally published online 10 February.
14. Chen J, Jin W, Dong WS, et al: Effects of home-based tele supervising rehabilitation on physical function for stroke survivors with hemiplegia: American Journal of Physical Medicine and Rehabilitation. 96(3):152-60.
15. Kairy D, Veras M, Archambault P, Hernandez A, Higgins J, Mindy F, et al: Maximizing post-stroke upper limb rehabilitation using a novel telerehabilitation interactive virtual reality system in the patient's home: S1551-7144(15)30136, 2015.
16. Lin K, Chen C, Chen Y, et al: Bidirectional and multi-user telerehabilitation system: clinical effect on balance, functional activity, and satisfaction in patients with chronic stroke living in long-term care facilities. Sensors (Basel) 2014; 14:12451–66.
17. Standen PJ, Threapleton K, Connell L, et al: Patients' use of a home-based virtual reality system to provide rehabilitation of the upper limb following stroke: *Phys Ther*. 95:350–359, 2014.
18. Redzuan N, Julia P, Mazlan M, et al. (2012). Effectiveness of a Video-Based Therapy Program at Home After Acute Stroke: A Randomized Controlled Trial. .93:2177-83.
19. Saposnik G, Levin M: Outcome Research Canada Working Group. Virtual reality in stroke rehabilitation: a meta-analysis and implications for clinicians: Stroke. 42: 1380–86, 2012.
20. Standen PJ, Threapleton K, Richardson A, Connell L, Brown DJ, Battersby S, Platts F, et al: A low-cost virtual reality system for home-based rehabilitation of the arm following stroke.
21. Chumbler N, Patricia Q, Miriam M, Dorian R, et al: Effects of Telerehabilitation on Physical Function and Disability for Stroke Patients A Randomized Controlled Trial;.43:2168-2174, 2012.
22. Appleby E, Gill S, Hayes L, Walker T, Walsh M, Kumar S: Effectiveness of telerehabilitation in the management of adults with stroke: A systematic review. PloS One;14(11)**.**
23. Chen J, Jin W, Zhang X, Xu W, Liu X, Ren C: Telerehabilitation approaches for stroke patients: systematic review and meta-analysis of randomized controlled trials. Journal of Stroke and Cerebrovascular Diseases; 24(12):2660-8, 2015.
24. Tchero H, Table Teguo M, Lannuzel A, Rusch E: Telerehabilitation for stroke survivors: Systematic review and meta-analysis. Journal of Medical Internet Research; 20(10):