Review Article

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Stroke Rehabilitation for Early Physical Activities among Patients Ongoing Rehabilitation: A Meta-Analysis

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ABSTRACT

Background: A report from the World Health Organisation says that stroke is the second largest cause of death and the primary reason for impairment in the world. Stroke is a worldwide well-being problem with an incidence of 0.2 to 2.5 per 1000 population. Stroke patients lead to paralysis on one or both sides of the body, causing difficulty in Activities of Daily Living (ADLS) and ambulation. **Methods:** A search for published materials was conducted from 1990 until 2023 through online sources such as Google Scholar, PubMed, Medline, Cochrane Library, and Embase. The following keywords were combined collectively to identify appropriate study papers. A total of seven studies were included in this study. **Results:** Higher heterogeneity was evident in the present meta-analysis (p=0.06, I squared=0.59). Prognosis-based outcome analysis showed a substantial difference in the online management system for early physical activity of stroke patients' continuous rehabilitation. **Conclusion:** Prognosis-based outcome analysis revealed that there was a significant difference in the online management system for early physical activity of stroke patients in rehabilitation.

Keywords: Functional Ambulation Category (FAC); Health-Related Quality of Life (HRQoL); High-Intensity Resistance Training (HBR); Spasticity; Stroke Rehabilitation

INTRODUCTION

Stroke is one of the most common causes of mortality and disability worldwide (Braakhuis *et al*., 2022; Li *et al.*, 2023). Stroke is a significant public health issue, accounting for 10% of global fatalities and 5% of years of life lost due to disability. Even in individuals who have received treatment, stroke causes substantial rates of morbidity and death (Wu *et al*., 2018). Similarly, stroke-related disability is the main cause of disability (Wu *et al.*, 2023). Stroke accounts for one-third of all fatalities globally and it is the second most common cause of death in China (Wang *et al*., 2017). Low- and middle-income nations account for 87% of stroke-related disability (Kayola *et al*., 2023). Stroke is a widespread, dangerous, and incapacitating health issue that affects the entire world. Stroke is typically the second or third primary cause for death worldwide and one of the primary contributors to impairments. The prevalence of stroke-related disability will probably increase during the next 20 years (Langhorne, Sandercock, & Prasad, 2009). Stroke is the most common cause of complicated disability. Almost half of all stroke survivors experience some level of disability. It affects a person's capacity to function more severely than any other chronic disease (Adamson, Beswick, & Ebrahim, 2004). Less than 50% of stroke victims will regain arm function, but the majority will be able to walk on their own again. When compared to lower extremity function, the recovery period for the upper extremities is frequently slower (Aoyagi & Tsubahara, 2004). The first 12 weeks following a stroke are crucial for recovery, when neuroplasticity is at its peak (Janssen *et al*., 2022). Adults with stroke experience a variety of issues, such as restrictions on their ability to participate in activities (Mayo *et al*., 2002). Physical

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activity is indicated for secondary prevention and rehabilitation (Nindorera *et al*., 2023). Physical activity, regardless of intensity, is crucial for stroke recovery and reducing the risk of future vascular events such as high blood pressure (Simpson *et al.*, 2022). According to one study, even three years after a stroke, 62% of stroke victims need assistance with daily tasks like washing, using the restroom, and getting dressed (Pettersen, Dahl & Wyller, 2002). Between 55% and 75% of stroke survivors consistently struggle to conduct their ADLS (Thrasher *et al*., 2008). In addition, despite receiving standard therapy, the majority of patients do not attain fully functional and community ambulation (Bogey & George Hornby, 2007). Physical inactivity is the second leading risk factor for stroke, and it is both independent and modifiable (Sammut *et al*., 2022).

After a stroke, being active physically and exercising may be helpful in several physical and psychosocial areas. Exercise is a type of physical fitness that is repetitive, scheduled, and whose primary or secondary goal is the maintenance or improvement of physical fitness. Physical activity is defined as "Energy is expended during every skeletal muscle-driven physiological motion". Exercise after a stroke can enhance cardiovascular health, according to substantial data. Different online intervention strategies have been created for stroke rehabilitation, which focus on getting the patient back to an active way of life (Neil, 2023; Pang *et al*., 2006). The primary goal of stroke rehabilitation is to improve participation in ADLs (Kuppuswamy *et al*., 2024; Slenders *et al*., 2024). Understanding the complicated relationships between physical activity, a multidimensional idea, and physical capacity may provide strategies to improve rehabilitation interventions (Braakhuis *et al*., 2022).

The WHO defines rehabilitation as "a set of measures that assist individuals who experience or are likely to experience disability to achieve and maintain optimal functioning in interaction with their environments" (Kwakkel *et al*., 2023; Wang *et al*., 2022). In the medical history of individuals impacted by a moderate nerve case, rehabilitation is difficult. Particularly in terms of the quality of regaining and affordability, it has been established that physical therapy should be initiated as soon as possible following a stroke (Paolucci *et al*., 2000). But there are many different kinds of challenges (Lin *et al*., 2022). The challenge of obtaining a spot in a rehabilitation facility is just one of them (Kylén *et al*., 2022). Motivating the patient, who is frequently suffering from post-traumatic stress disorder, is important, (Polopalli *et al*., 2022) as they are often detained in the acute ward until a seat in a post-acute rehabilitation centre becomes available; lengthy waiting lists also drain resources (Chang *et al*., 2022). This happens when patients are unable to return home (for instance, if they were living alone) (Quaglini *et al*., 2004). This is expensive since the patient spends more time than necessary in the costly acute ward. Thus, there is a need for solutions that increase patients' autonomy in their recovery process.

The Stroke Prevention and Educational Awareness Diffusion (SPREAD) guideline is one example of current stroke prevention and treatment guidelines that suggest the prospective value of programs that might encourage a quicker and more thorough recovery, both in the hospital and at home (Tormene *et al*., 2009). The basic idea of this is to provide sufferers with their own rehabilitation technology, which can offer immediate feedback and motivate performance improvement. By enabling patients to attend more rehabilitation sessions than those that are regularly scheduled in the hospital, these systems could improve the traditional rehabilitation practice at home and enable therapy to be continued, possibly with remote supervision, implementing crucial continuity of care. Nurses are the largest professional group dealing with stroke survivors (Clarke & Holt, 2015). Nursing practice in stroke rehabilitation care varies and may be influenced by changes in stroke therapy, cultural norms, and ideology. Nurses help patients acquire problem-solving and stress management skills while also improving their quality of life by monitoring physiological and psychological changes. A rehabilitation nurse specialises in caring for those who are dependent or semi-dependent. They offer direct care, educate patients and families, and coordinate treatment. A rehabilitation nurse creates a dynamic process that promotes an individual's "functional capacity," including their engagement with the environment. This helps patients reach their full potential (Meng *et al*., 2020). The APEASE criteria for building scaled interventions are Affordability, Practicality, Effectiveness, cost-effectiveness, Acceptability, Safety, and Equity, which may be met by an online intervention as a strategy to

overcome these barriers (Michie, Van Stralen & West, 2011). More than 86% of Australians reported having access to the Internet at home (Clancy *et al*., 2022). Up to 80% of patients, according to surveys, are interested in receiving information online in addition to support from a clinician, and studies have repeatedly shown that online interventions for co-morbid populations for anxiety, depression, easing pain, and disability reduction are effective (Monnier, Laken & Carter, 2002). Information technologies are ideal for realising rehabilitative assistance and can be utilised locally or with therapists' support. In addition to financial and organisational reasons, computerised interventions are attractive as they make it possible to collect quantitative data on how the therapy is going (a lack of quantification is additional issue in the rehabilitation field). The therapy could be easily tracked, and a systematic record of its success could be provided via a computer-based rehabilitation tool. After a stroke, being active physically and exercising may be helpful in several physical and psychosocial areas. Exercise is a type of physical movement that is frequent or scheduled, and its primary or secondary aim is the maintenance or improvement of physical fitness. Physical activity is defined as "Energy is expended during every skeletal muscle-driven physiological motion".

METHODOLOGY

Data Mining and Search Strategy

A search for published material was conducted from 1990 until 2023 through online sources such as Google Scholar, PubMed, Medline, Cochrane Library, and Embase. The following keywords were combined collectively to identify an appropriate study paper.

Eligibility Criteria

The study's inclusion criteria for patients required a diagnosis of stroke, including ischemic, hemorrhagic, or critical subcortical involvement, with a recovery period of more than 6 months. Patients also had to present clinical symptoms of hemiplegia or hemiparesis, be over 18 years of age, have the ability to understand basic instructions, and possess access to smartphones or a reliable internet connection. The exclusion criteria included the presence of other neuromuscular or neurological conditions, fractures, or significant structural abnormalities (Salgueiro, Urrútia & Cabanas-Valdés, 2022).

Intervention

The treatment strategy includes the following approaches: Early rehabilitation (mobilisation, chest physiotherapy, counselling of patient, weight-bearing activities, and stretching) The mode of exercise includes self-care activities, intermittent standing and sitting, low-level walking, seated activities, range-of-motion exercises, and motor challenges, all of which are suggested for stroke patients during a hospital stay and early convalescence (acute phase). Exercise therapy for patients and outpatients includes endurance and strengthening exercises for the muscles (resisted training of the lower and upper extremities, circuit training, trunk partial weight-bearing tasks, pulleys, elastic bands, spring coils, functional mobility), flexibility exercises for the trunk and upper and lower extremities, and neuromuscular activities (balance and coordination exercises, yoga, active video gaming).

Main Measurements Examined

The described data showed that for the results, different outcome measures were used; the most commonly used outcome was the Barthel Index, along with a stroke-specific quality of life scale.

The interpretation for the Barthel scores is:

a) Total independence indicated by a 0-20 score

b) Severe dependence indicated by a 21-60 score

c) Moderate independence indicated by a 61-90 score

d) Slight dependence indicated by a 91-99 score

Stroke Specific Quality of Life Scale (SS-QOL)

Scoring: each item shall be scored with the following key	
Total help – Couldn't do it at all – Strongly agree	1
A lot of help – A lot of trouble – Moderately agree	2
Some help – Some trouble – Neither agree nor disagree	3
A little help – A little trouble – Moderately disagree	4
No help needed – No trouble at all – Strongly disagree	5

Source: Williams et al. (1999)

Figure 1: Interpretation of Stroke-Specific Quality of Life Scale

Quality and Risk of Bias Assessment

The quality of the study was assessed by using the Cochrane criteria, which consist of four aspects:

1. Random sequence generation
2. Allocation of concealment
3. Blinding of outcome assessment
4. Incomplete outcome data

The first three aspects were scored as follows: "No = 0," "Unclear = 1," and "Yes = 2." The fourth aspect was scored as "No = 0" and "Yes = 1." Studies that received a score of two or more were considered to be of low quality and were included in the data synthesis. All studies were conducted based on the authors' assessments of the inclusion and exclusion criteria.

Statistical analysis was performed using Review Manager software. The incidence rates across studies were combined using a fixed-effects meta-analysis. I^2 statistics were used to assess the heterogeneity of the research, and a funnel plot was used to detect potential publication bias.

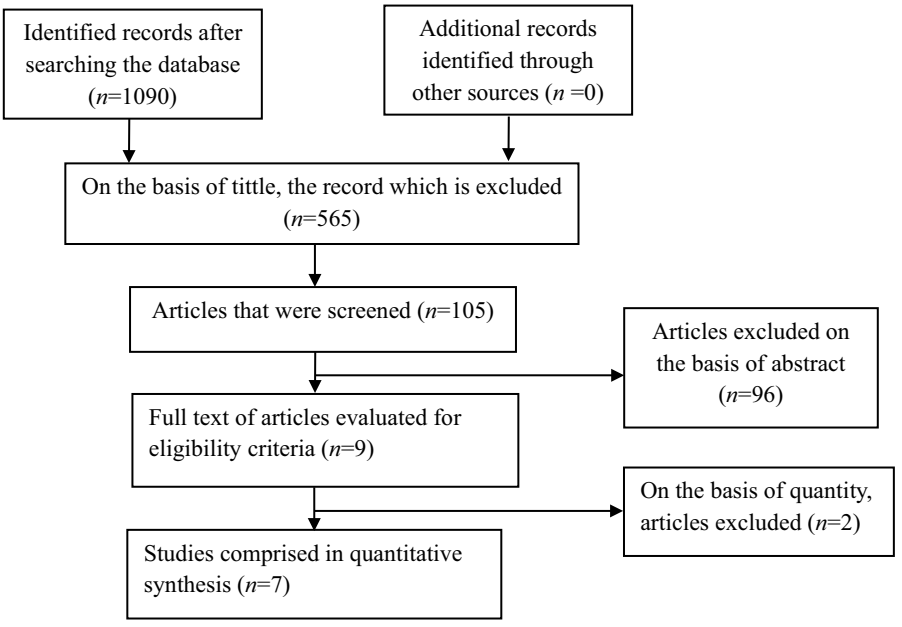

Figure 2: Flow Chart of Study Selection (PRISMA)

RESULTS

Table 1: Summary of the Studies on Stroke Rehabilitation Interventions

Author Year	Sample Size	Target Population	Study Design	Outcome Measure	Intervention		Results
					Interventional Group	Control Group	
Guillaumier *et al*., 2022	200	Between six and three years after a stroke, in adults	A prospective, blinded endpoint RCT	Using the EuroQol Visual Analogue Scale HRQoL was main result. HRQoL, as determined by the EQ-5D (descriptive health condition), was a secondary outcome.	For a 12-week period, the **intervention group** (n = 199; n = 28 lost afterwards) had remote access to the P2S programme that was available exclusively online	A list of the internet addresses for general health websites was emailed to the **control group** and posted (n = 200; n = 15 were lost afterwards).	After a period of six months, the intervention group showed a significantly higher median EQ-VAS HRQoL score compared to the control group (85 versus 80, with a difference of 5, 95% CI 0.79-9.21, p = 0.020). These results remained consistent when considering the assumption of random occurrence of missing data. However, the results did not hold under the assumption that there was a minimum 3-point disparity in HRQoL between individuals with missing data and those with complete data. The intervention group demonstrated a significantly higher proportion of individuals reporting no difficulties with personal care (OR 2.17, 95% CI 1.05-4.48, p = 0.0359) and routine activities (OR 1.66, 95% CI 1.06-2.60, p = 0.0256) compared to the control group. However, no significant differences were observed between the groups for all other secondary outcomes.
Guillaumier *et al*., 2019	160 individuals	Stroke survivor	RCT, A prospective, open, blinded end-point	Through the use of the EuroQol 5 Dimensions, 5 Levels (EQ-5D-5 L) questionnaire, HRQoL will be the main end measure.	An e-mail and letter including a link to P2S and their log-in information will be given to participants who were randomly assigned to receive the intervention. The P2S programme is a customised, modularised programme created aimed at stroke survivors to enhance their HRQoL and maybe lower their		The initial analysis will adhere to the intention-to-treat (ITT) principle, which involves comparing the change in HRQoL between groups from baseline to the six-month follow-up. The EQ-5D-5 L HRQoL score will be used as the outcome variable in the comparison, and the

					chance of experiencing a second stroke. In addition to receiving standard stroke follow-up treatment, participants randomly assigned to the control group will also get an email and letter with links to widely accessible, generic online health programmes created for the common public.		treatment group and baseline value of the outcome variable will be the key predictors of interest. **Secondary research** To evaluate the variations in changes of secondary outcomes between baseline and follow-up, generalised linear mixed models will be employed. The choice of distributional families and link functions for the models will depend on the nature of the specific outcome being examined.
DePaul *et al*., 2020	10 adults	Inpatient stroke rehabilitation unit	Pre-intervention/post-intervention design, RCT	Outcomes will be assessed at two additional time points: 90 days and 12 months from the randomization. These assessments will be conducted through scripted telephone conversations or video calls with a skilled research outcome assessor. To facilitate the evaluation process, participants will be provided with the health surveys electronically or via postal mail, one to two weeks prior to the scheduled assessment. All trial data are captured using REDCap9 software.	The Independent Mobility-related Physical ACTivity (IMPACT) Programme is a coach-supported intervention that encourages patients to take part in more independently walking-related activities both during and after inpatient rehabilitation by teaching them self-management techniques.	No control group	Each participant was able to establish a personal objective, agree on a practice schedule for an activity related to autonomous walking, and either fully or partially follow that schedule. Patients practiced on weekdays and weekends for an average of 36 minutes per day, without the supervision of a physiotherapist. All participants reported that the Independent Mobility-related Physical Activity program motivated them to increase their physical activity levels, particularly in relation to walking-related activities. Furthermore, they expressed their intention to engage in such activities even after the coaching period concluded.

Erbil *et al*., 2018	48 patients	Chronic stroke	Pivotal study	By the Tardieu and Modiefied Ashworth scale Spasticity was assessed Berg Balance Scale, Timed Up and Go test, and Rivermead Visual Gait Assessment. Were used to assess the balance and gait	BoNT-A therapy for spastic muscles in the lower extremities was randomly distributed in a 2:1 ratio across the RAT (n = 32) and control (n = 16) groups. The RAT group got 60 minutes of physical therapy in addition to 30 minutes of RAT (RoboGait®).	Controls received ninety minut es of physical therapy for three weeks during weekdays	For all factors, the demographic and baseline characteristics were comparable between the two groups (p >0.05). Following treatment, there were discernible improvements in spasticity, balance, and gait in the RAT and control groups. In terms of post-treatment evaluation at Weeks 6 and 12, the scores of the participants in the RAT group exhibited notable improvements compared to the control group across multiple assessments. Specifically, the Timed Up and Go test (p = 0.003 and p = 0.002, respectively), the Berg Balance Scale (p = 0.001 and p< 0.001), and the Rivermead Visual Gait Assessment (p < 0.001 and p < 0.001, respectively) - all demonstrated significantly higher scores for the RAT group.
Brauer *et al*., 2018	41 patients	Subacute stroke	Qualitative approach	The shoulder abduction finger extension (SAFE) score and Motor-evoked potentials (MEPs)	Researchers with degrees in qualitative research and years of applicable research practice utilised a qualitative technique to collect information from chosen key informants on all perceived factors impacting the onset of methampheta mine use. Interviews with participants		A combined total of 41 volunteers participated in the study, representing four distinct communities. Of these volunteers, 19 were from the Akha community, and 22 were from the Lahu community. The study identified four primary factors that were perceived to contribute significantly to the initiation of methamphetamine use among youths belonging to the Akha and Lahu communities in northern Thailand. These factors include low self-esteem, family member drug use, positive expectations associated with methamphetamine use, and the drug's availability. Additionally, five supportive factors were

					were conducted to learn more about their believed reasons for starting to use amphetamines, as well as information about their family, environment, and other factors that may have contributed to starting to use methampheta mine.		identified, namely social norm perception, school dropout, family-related issues, poor economic conditions, and lack of Thai citizenship. Collectively, these factors were found to influence the onset of methamphetamine use within these communities.
Shimizu *et al*., 2020	34 patients	Subacute stroke	A randomised longitudinal study	Gait independence was assessed by the functional ambulation category (FAC) at baseline	Involved group. The entire group were undergoing a standard rehabilitation programme that included physio therapy which can (including exercises for ROM, muscle strengthening, posture balance, transferring, and walking), occupational therapy can(including exercises for (ADL), such as using the restroom, cleaning, wearing, and bathing), and speech therapy can be (including exercises for dysphagia and aphasia), with a total of 18All 0 minutes per day.	The noninvolved group receives no treatment	The better group demonstrated significantly higher values in all physical activity measures, except for non-therapy time moderate-to-vigorous physical activity (MVPA), compared to the non-improved group (p <0 .05). Analysis revealed a substantial association between higher levels of light-intensity physical activity (LIPA) during the daytime and functional ambulation category (FAC) improvement (odds ratio [OR] = 1.068, 95% confidence interval [CI]: 1.009 to 1.140). Furthermore, a longer duration of LIPA outside of treatment was significantly associated with improved FAC (OR = 1.253, 95% CI: 1.002 to 1.568).

Chae *et al.*, 2020	23 patients	A prospective comparative study	Beck Depression Inventory, the Wolf Motor Function Test (WMFT), the Fugl-Meyer evaluation of the Upper Extremity, the grip power test, and the shoulder joint's range of motion (ROM) evaluation at 0, 6, and 12 months	HBR group. An off-the-shelf wristwatch, a smartphone, and specially created applications make up the HBR system.	Received baseline treatment for 0, 6 and 12 months	In comparison to the utilization of an accelerometer (98.13% accuracy, 5496/5601) or gyroscope data (96.07% accuracy, 5381/5601), the developed machine learning (ML) model, which incorporated private data involving both accelerometer and gyroscope data, demonstrated the highest level of accuracy (99.80% accuracy, 5590/5601). During the 12-week period of the comparative trial, the drop-out rates for the control group and the high-intensity resistance training (HBR) group were 40% (4 out of 10) and 22% (5 out of 22), respectively. At the 18-week mark, the drop-out rates increased to 100% (10 out of 10) for the control group and 45% (10 out of 22) for the HBR group. Among the participants in the HBR group (n=17), significant improvements were observed in the mean score of the Wolf Motor Function Test (WMFT) (P=0.02), as well as in the range of motion (ROM) for flexion (P=0.004) and internal rotation (P=0.001). In contrast, the control group (n=6) exhibited a significant difference only in terms of shoulder internal rotation (P=0.03).

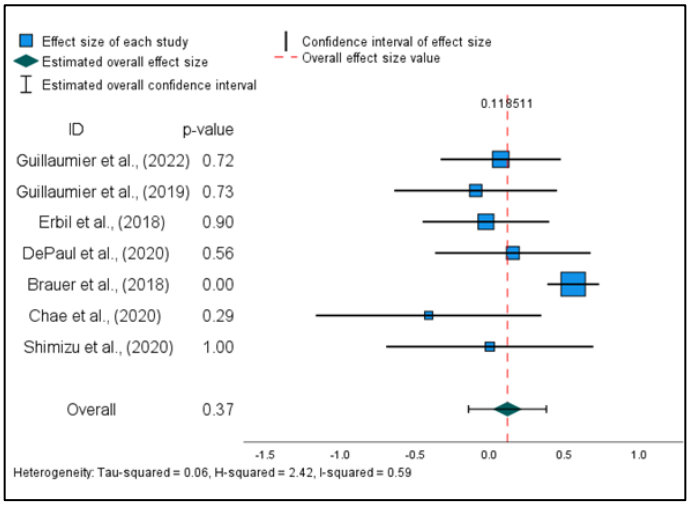

Figure 3: Forest Plot Showing an Acceptable Intervention Based on the Pooled Evidence from the 7 Studies

This foster plot graph showed that the overall *p*-value was 0.37 while heterogeneity: Tau-squared=0.06.

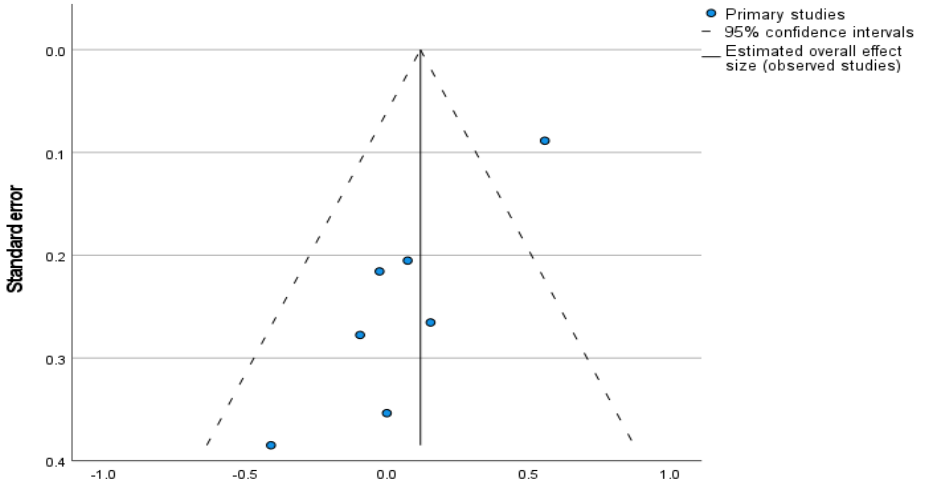

Figure 4: Funnel Plot Showing No Biases on the Studies Selected

DISCUSSION

Seven publications were involved in the present meta-analysis, none of which had controversial conflicts or conclusions. The purpose of the study was to develop a stroke rehabilitation algorithm as an online management system for the early physical activity of stroke patients during ongoing rehabilitation. To measure physical activity, the Barthel Index, a stroke-specific quality of life scale, was used. The outcomes of the recent meta-analysis were consistent with the included research and demonstrated significant differences in online management systems for the early physical activity of stroke patients' ongoing rehabilitation. However, only a few randomised controlled trials have focused on online management systems for early physical activity in stroke patients.

Guillaumier *et al*. (2022) conducted a trial focusing on the effectiveness of an accessible health behavior change intervention aimed at preventing second strokes. Within the six-month follow-up, the study found improvements in health-related quality of life (HRQoL) among stroke survivors. According to the study's conclusions, stroke survivors' self-reported global HRQoL scores (as measured by EQ-VAS) improved at the six-month mark due to the P2S online healthy living program.

Results for patients with stroke fighters between 6 and 36 months after the stroke were evaluated for patients involving just stroke survivors. Moreover, specific data on online management for the physical activity of stroke survivors is lacking. However, different studies have developed different online management tools (smartwatches, and others).

The recent meta-analysis presented higher heterogeneity (p=0.06, I^2=0.59). Prognosis-based conclusion analysis showed there was a significant difference in the online management system for early physical activity of stroke patients' ongoing rehabilitation. Guillaumier *et al*. (2019) conducted a randomised controlled open-label trial in which a total of 530 stroke adults were selected according to block randomization and divided into a control group and an interventional group. The EuroQol-5D questionnaire was used to measure the primary outcome HRQoL. In the secondary outcome, cost-effectiveness was measured using Client Service Receipt Inventory along with MBS and PBS data. Vegetable and fruit intake was measured using the Australian Recommended Food Score, while physical activity was measured with the Godin Leisure Time Exercise Questionnaire (GLTEQ). Anxiety and depression were measured using the Patient Health Questionnaire four-item (PHQ-4). Instrumental Activities of Daily Living (IADL) scores and

the Barthel Index were used to assess physical functioning and independence. According to the study's findings, P2S, a low-cost per-user alternative to augment existing treatment, may help stroke survivors' HRQoL and reduce their chance of having another stroke (Guillaumier *et al*., 2019).

The result of the current study may also change if different online interventional tools are separately considered, but there is little literature review on algorithm development for the online management of stroke survivors. However, different online management tools, such as P2P and others, may prove beneficial for stroke survivors, but different trials on this may be required.

Other research on physical therapy (which included exercises for range of motion, strengthening of muscles, posture balance, transferring, and walking) and an Independent Mobility-related Physical Activity (IMPACT) Program were contrasted with a standard physical therapy treatment plan. Because the included studies employed various statistical methods, care was taken in the analyses.

Limitations

The limitations of the study include:

Variability in intervention design: Differences in online platforms, exercise protocols, and engagement strategies may affect results. **Small sample sizes:** Limited sample sizes may impact the generalizability of findings. **Inconsistent outcome measures:** Varied outcome measures complicate direct comparisons across studies. **Short follow-up periods:** Limited follow-up may not capture long-term effects. **Publication bias:** Potential bias as positive results are more likely to be published.

CONCLUSION

According to the meta-analysis, online management solutions for early physical activity during stroke rehabilitation have been shown to considerably improve patient outcomes. According to the analysed research, stroke patients who used these online platforms saw significant increases in their Barthel Index scores, indicating more autonomy with everyday tasks. Furthermore, according to the Stroke-Specific Quality of Life Scale, these patients reported a higher quality of life. Even though the results were generally positive, there was a lot of variation in each study's effectiveness, which suggests that program design and patient participation are two important aspects that may affect how well these online interventions work. This variation highlights the need for additional studies to evaluate the long-term advantages of online rehabilitation techniques and standardize them.

Recommendation

Further recommendations of the study include:

Implementation of targeted treatments: To reduce the risk of falls in chronic stroke patients, health practitioners should consider into normal care.

Further research: Conduct longitudinal studies with bigger and more varied populations to evaluate the therapies' efficacy and investigate their long-term effects.

Enhanced training: Create and deliver training programs for healthcare personnel that focus on fall risk assessment and treatment in patients with chronic stroke.

Policy development: Evidence-based fall prevention methods should be included into public health guidelines and stroke treatment standards

Conflict of Interest

The authors certify that they have no conflicting personal or financial interests.

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