Additional exercises next to standard physiotherapeutic care improve physical functionality of stroke survivors

A literature review

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Abstract

Background: Stroke is a health problem causing long-term disabilities, including help with daily activities and participation. Increasing physical activity leads to improvement of physical functionality (PF) in stroke survivors, which results in independence, reduction of disability, and healthcare burden decrease. Finding exercises which optimize the stroke patient's PF, might lead to better stroke rehabilitation and more suitable physiotherapeutic approach for achieving successful treatment results. To determine most supportive exercise therapy for optimizing stroke patients' PF, the focus was set on the interventions aimed on improvement of static balance (SB), walking ability (WA), and capacity to perform the activities of daily living (ADL).

Methods: 12 RCT's, found on various databases, were descriptively analyzed. Data about SB, WA and capacity to perform ADL was collected with outcome measures: Berg Balance Scale, 6 Minute Walk Test, and Barthel Index respectively. Extraction of data considering: 1) participant characteristics, 2) stroke phase, 3) type of intervention in intervention group (IG) and control groups (CG), 4) outcome measures (incl. measurement tools for PF).

Results: 977 people with avg. age of 64.5 were in different mixed phases of stroke rehabilitation. 3 studies showed significant improvement in SB ($P<0.05$) of IG over CG for short term (ST). 2 studies showed a significant improvement in WA ($P<0.05$) of IG over CG for ST. 3 studies showed a significant improvement of ability to perform ADL in IG over CG ($P<0.05$) for ST. One study showed significant improvement of ability to perform ADL ($P<0.05$) in IG over CG for mid-term. No study showed a significant improvement of SB and WA between IG and CG for long-term.

Conclusion: Subacute-stroke patients' optimization of PF on ST can be achieved by conventional physiotherapy (CP) with core stability exercises, CP with sling exercise therapy, and FIT stroke programme rehabilitation. No additional benefit from additional exercise modalities next to CP on long-term was found.

Keywords: stroke, physical therapy modalities, rehabilitation, physical functionality

Introduction

Stroke is a global health problem causing long-term disabilities, including the need for help with daily activities and participation (Tadi et al. 2021). The morbidity rate has been decreased throughout the last decades, nevertheless, the global stroke burden is expected to drastically increase because of continuously growing numbers of the aging population (Feigin et al. 1990). People with stroke face a higher risk of developing other cardiovascular diseases, therefore, an intervention for proper recovery of health and physical functionality is of high importance (Boehme et al. 2017).

Physical activity (PA) can be described as bodily movement performed by skeletal muscles, such as working, climbing stairs, or traveling via public transport, which requires the expenditure of energy (WHO 2020). A decrease in physical activity due to stroke leads to a sedentary lifestyle. According to a study conducted by

Ashe et al. (2009), community-dwelling survivors of stroke are failing to meet even the minimal required amount of physical activity compared to the same-age population suffering from respiratory, cardiovascular, metabolic, or musculoskeletal diseases. Muscle weakness, reduced cardiorespiratory fitness, fatigue, and physical mobility limitations can lead to a low physical activity lifestyle. Decrease in physical activity, on the other hand, is closely related to health problems, leading to frequent hospitalization rates, and therefore, a vicious pathological cycle is being created. An increase in physical activity can lead to improvement of physical functionality and could reduce the recurrence risk of cardiovascular diseases in people who have suffered from a stroke, which might lead to a better quality of life without severe limitations (Kernan et al. 2014).

According to the International Classification of Functioning, Disability, and Health, activity is defined as an individual's performance of a task or action. Participation stands for engagement in a life circumstance with active commitment and social connection (Zhang et al. 2020). This literature review focuses on three important determinants of physical functionality (PF) on the level of activities and participation, which are static balance (SB), walking ability (WA), and capacity to perform the activities of daily living (ADL) (Verbeek et al. 2014). Static balance is a strong predictor of walking ability and an important risk factor for fall prevention after stroke. Even if the most functional recovery occurs in the first 2-3 months after stroke, evidence for the effectiveness of therapeutic exercise programs has been generated in individuals with stroke during the whole subacute phase (one to six months from onset of the disease) (Hatem et al. 2016). Benefits such as an improvement of mobility and balance have been noticed by stroke survivors in the subacute phase (Duncan et al. 2013). Whilst the vast majority of stroke survivors (75%) regain independent standing-balance ability, asymmetry in weight-bearing and increased postural sway perseveres, as well as a declined capacity to voluntarily shift body weight or to withstand external disturbances. That makes static balance improvement one of several key goals of rehabilitation (van Duijnhoven et al. 2016). Additionally, exercises focused on walking ability promote neuroplasticity and have beneficial effects on general functionality, cardiorespiratory fitness, and mobility (Nave et al. 2019). The benefit of exercise aiming on improvement of activities of daily living is focused on increasing the subacute stroke patient's independence in everyday life in the community and home environment as well (Han et al. 2020).

A vast number of studies regarding the relationship between PA and its beneficial effect on rehabilitation of stroke survivors has been conducted. Various randomized controlled clinical trials looked separately into the effect of exercise on static balance, walking ability, and capacity to perform ADL (Cabanas Valdes et al. 2015, Marsden et al. 2016, Nave et al. 2019). Despite that, there is a significant gap in the literature, as no review has investigated the exercise application and its potential effects on all three domains of PF simultaneously, therefore, providing no evidence for or against exercise and its effects on static balance, walking ability and capacity to perform ADL. On top of that, no systematic data extraction, critical appraisal of the methodological quality of such studies and available evidence synthesis have been conducted.

As the literature review is based on optimization of physical functionality, the research focused on gathering information about different intervention types aimed to improve one or several of three meaningful domains: static balance, walking ability, and capacity of performing the activities of daily living. Therefore, this literature review aims to find the best type of exercise for improving the functional performance of people suffering from a subacute stroke.

If the most supportive exercise program, which can be adapted to the patient's needs could be found, the training effectiveness might be increased. The effectiveness of training fosters better treatment outcome for patients with subacute stroke (Emmerson et al. 2017). Subsequently, this might also lead to an increase of PA, resulting in better recovery for the patients and a more suitable physiotherapeutic approach for achieving a successful treatment result. Moreover, the findings of this research could be used further to improve the resources management in healthcare system, as according to the study conducted by Billinger et al. (2014), physical activity has been shown to reduce disability, therefore leading to a reduction in healthcare burden.

The insight from this literature review could help the healthcare system to reduce their expenditures as patients could reach their treatment goals sooner. Therefore, its aim is to answer the following research question: *What type of exercises are most supportive for optimizing subacute stroke patient's physical functionality?*

Methods

Data sources and search string

Five databases were used during search: Pubmed, Cochrane, PEDro, CINAHL and Google Scholar. A variety of keywords were used referring to population and treatment. The search was conducted over a two-month period, starting April 12, 2021.

Following keywords were used for the search: “exercise,” “subacute stroke,” “home”, and “activities of daily living”. The following synonyms for the keywords were used:

Keyword 1: Exercise OR Physical therapy, or rehab* OR Physiother*
Keyword 2: Home OR Home setup
Keyword 3: Sub-acute stroke OR late rehab*, OR late rehabilitation phase OR late subacute OR chronic phase
Keyword 4: ADL OR activities of daily living

The keywords and synonyms were used in connection with Boolean operators “AND” and “OR”. The final keywords per database are as following:

Pubmed

“Stroke” OR stroke OR cva OR Cerebrovascular Accident* AND sub-acute OR subacute OR chronic OR late rehab* AND “Physical Therapy Modalities” OR “Rehabilitation” OR rehab* OR physiotherapy OR physical therapy OR neurophysiotherapy OR exercis* NOT telerehab*

Filters: 10 years, English, RCT and clinical trials. Results: 34

PEDro

Exercise rehab* stroke adl
Filters 10 years, English, clinical trials. Results: 7

Cochrane

exercise program AND subacute stroke AND activities of daily living in title abstract keyword Result: 18 trials.
Filter used: 10 years, English, trials

Google Scholar

subacute stroke activities of daily living
Filters used: in the title of the article; publications from 2011 or higher. Results: 21

CINAHL

Exercise, subacute stroke, ADL No filters used. Results: 5

Search Strategy:

The results of the initial search were then screened by title and then by abstract. The references of related systematic reviews and of the found studies were checked to ensure any other relevant ongoing or unpublished studies were included. Duplicates were deleted, and the remaining articles were screened on the inclusion and exclusion criteria which is explained in the subsequent paragraphs. The articles were then assessed on their quality.

Study Selection:

Articles from the initial search were first screened by title and abstract. Then, the relevant systematic reviews were scanned to identify additional relevant literature focusing on the topic of interest. After deleting the duplicates, the remaining articles were screened on inclusion and exclusion criteria. Finally, the quality assessment of included articles took place.

Inclusion & Exclusion Criteria

Inclusion/exclusion criteria were defined to select the articles that best responded to the research question and further define the scope of this literature review. Inclusion was limited to full-text randomized controlled trials (RCT) only. The population studied had to have suffered from stroke. Only articles in English language were included. The date of publication had to be after 2011, since such resources were more recent and reflected on the newest discoveries and best application of practices. This ensured that the research covered the most current information in the field of physiotherapy. Articles also had to provide the outcome measures of at least one or several determinants of physical functionality, which were defined as: static balance, walking ability, and capacity to perform activities of daily living. However, no restriction was made on the tool used to measure this. The articles providing intervention via tele-rehabilitation, exergames, robot-assisted arm therapy, baduanjin training, tai-chi, transcranial direct current stimulation, and constrained induced movement therapy were excluded as they were not relevant in the scope of this research.

Data extraction:

Extraction of the data from included RCT's was performed as followed: 1) participant characteristics, including gender and age, 2) phase of stroke, 3) type of intervention, including activity type, duration, and frequency, 4) control group intervention, including activity type, duration, and frequency, 5) Outcome measures including measurement tools for static balance, walking ability and capacity to perform ADL.

Quality assessment:

The grading of the articles was implemented via The PEDro scale. Decision on implementing the PEDro scale for the quality check was based on the provided acceptable reliability and practicality of this tool in the field of physiotherapy. It is also a practical tool for quality assessment of randomized controlled trials during the systematic review (Maher et al. 2003).

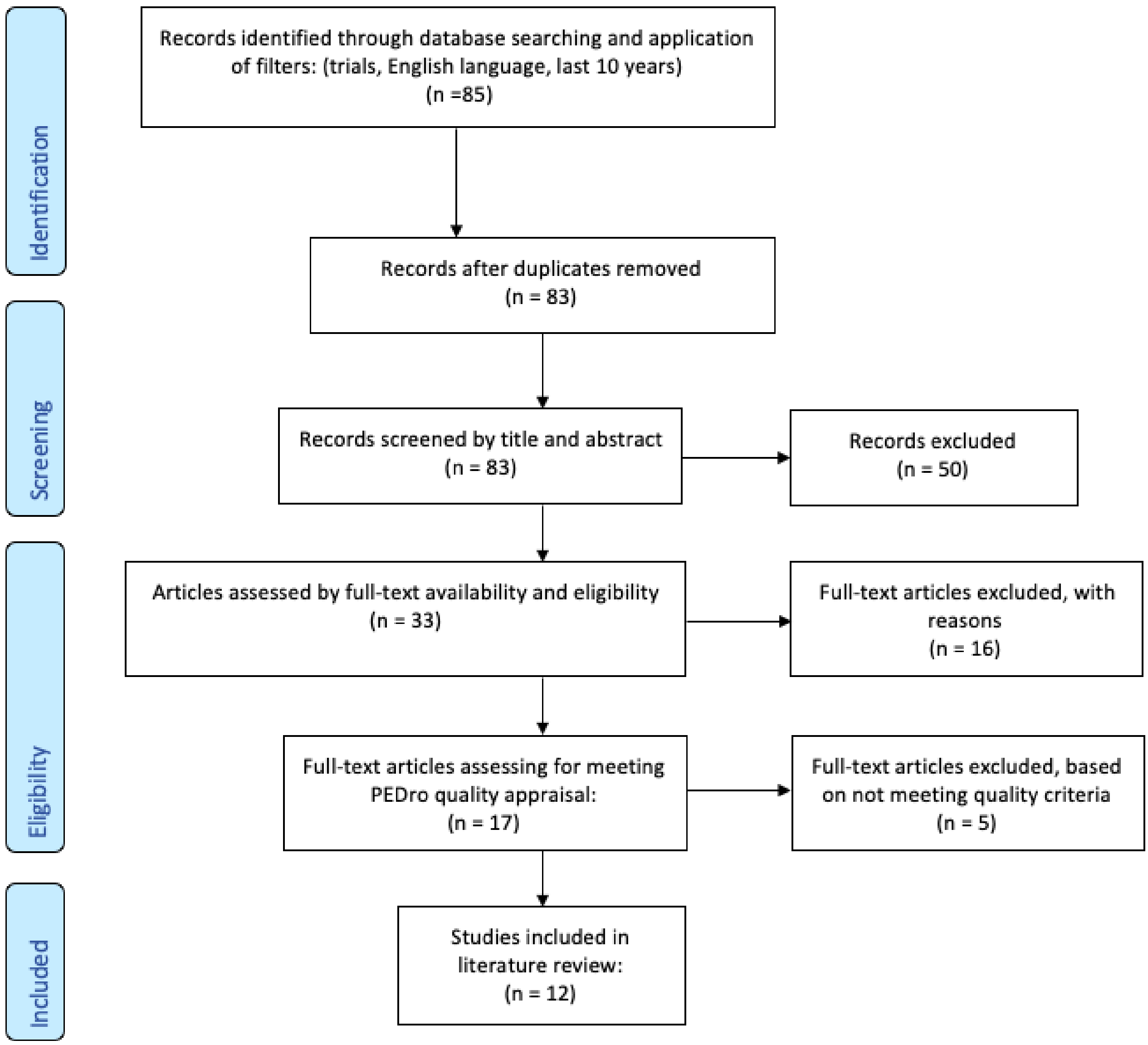
Recent studies recommend that the scale should not be combined to create an overall score but should rather consider the potential impact of each item of the PEDro scale (da Costa et al. 2013). It is an 11-item scale, where each satisfied item (except for item 1, which, unlike other scale items, pertains to external validity) contributes one point to the total PEDro score (range = 0-10 points) (Hariohm et al. 2015). Studies scoring 6 points or above will be considered as good quality, 4 to 5 points as fair and 3 or below as poor quality (Peng et al. 2019). Only the articles scoring 6 or above will be included for literature review. Additionally, the studies needed to meet the following three items to be eligible for inclusion in the literature review. These are: Item 4 (the groups were similar at baseline regarding the most important prognostic indicator); Item 8 (measures of at least one key outcome were obtained from more than 85% of the subjects allocated to the groups), and Item 10 (the results of between group statistical comparisons are reported for at least one key outcome). Two graders used PEDro scale and assessed the quality of the articles, to avoid the evaluation bias.

Results:

Study selection:

The original search resulted in 85 studies *(Figure 1).* The studies were screened by titles and abstracts, and duplicates were removed, which left 33 articles. After assessment of the articles on full-text availability and eligibility, 16 more articles were excluded, which left 17 articles for methodological quality appraisal via PEDro grading tool. 5 more articles were excluded based on not meeting quality criteria, which at the end left 12 randomized controlled trials for inclusion in the literature review.

Figure 1 – PRISMA Flowchart (Rethlefsen et al. 2021)



Methodological quality:

According to the quality appraisal from Peng et al. (2019), all included articles were at least of "good" quality. Additionally, all studies reported that: groups were similar at baseline regarding the most important prognostic indicator, measurement of at least one key outcome was obtained from more than 85% of the subjects allocated to the groups and the results of between group statistical comparisons were reported for at least one key outcome. More details about grading can be seen in *Table 1.*

Table 1 – Methodological quality of included studies

STUDY (year)	1	2	3	4	5	6	7	8	9	10	11	Points
Cabanas Valdes et al. (2015) a	√	√	√	√	√	√	√	√	√	√	X	9
Cabanas Valdes et al. (2015) b	√	√	√	√	√	√	√	√	√	√	X	9
Dubey et al. (2017)	X	√	√	√	√	X	X	√	√	√	X	7
Liu et at. (2020)	√	√	X	√	√	√	√	√	X	√	√	8
Koç et al. (2015)	√	√	X	√	√	√	X	√	√	√	√	8
Marsden et al. (2016)	√	X	X	√	√	X	X	√	√	√	√	6
Mayo et al. (2013)	√	√	X	√	X	X	√	√	√	√	√	7
Nave et al. (2019)	√	√	√	√	√	√	√	√	X	√	√	9
Park D et al. (2018)	√	√	X	√	√	X	√	√	√	√	√	7
Park H et al. (2019)	√	√	X	√	√	X	X	√	√	√	√	7
Vahlberg et al. (2017)	√	√	√	√	√	√	√	√	X	√	√	9
Van de Port et al. (2012)	√	√	√	√	√	X	X	√	√	√	√	8

PEDro criteria list for quality assessment: (1) specification of eligibility criteria, (2) random allocation of subjects to groups, (3) concealed allocation, (4) groups similar at baseline regarding most important prognostic indicator, (5) subject blinding, (6) therapist blinding, (7) blinding of assessors, (8) measurement of at least one key outcome from more than 85% of the subjects allocated to groups, (9) intention to treat analysis, (10) between-group statistical comparison results reported for at least one key outcome, (11) point measures and variability measure for at least one key outcome (Maher et al. 2003); 6 + points - good quality; 4-5 points - fair quality; 3 or less points - poor quality (Peng et al. 2019).

Participants:

977 stroke patients in total with mean age of 64.5 years, from which 57.5% were male, were divided over 3 categories of stroke rehabilitation phases according to the classification provided by Hatem et al. (2016), namely: acute/early phase (24 hours to 1 month), subacute phase (1-6 months) and chronic phase (6+ months). The rehabilitation phases of stroke ranged from acute (1 week from onset) (Nave et al. 2019) to chronic (6 months post onset) (Vahlberg et al. 2017). Conjoint characteristics of the included studies are presented in *Table 2.*

Table 2 - Conjoint characteristics of the included studies (n=12)

Participants [total n]	977
Gender [% male]	57.5
Age [mean in years]	64.5
Age [mean in years] IG	63,3
Age [mean in years] CG	65,4
Age [range in years] IG	51,1 - 74,2
Age [range in years] CG	54,7 - 74,3
Outcome measures [n of articles]	
Berg Balance Scale (BBS)	7
Trunk Impairment Scale Version 2.0 (TIS 2.0)	1
6 Minute Walk Test (6MWT)	6
Barthel Index (BI)	6
Modified Barthel Index (MBI)	2
Nottingham Extended ADL (NEADL)	1

IG = Intervention Group CG = Control Group

Intervention group:

Different types of intervention aimed on one or several domains of PF, which are SB, WA, and capacity to perform ADL. Interventions focused on SB were: conventional physiotherapy (CP) with core stability exercises (Cabanas-Valdes et al. 2015), sling exercise therapy (Liu et al. 2020) with CP, CP with stationary cycling (Mayo et al. 2013), land based and aquatic trunk exercises with CP (Park H. et al 2019), Ankle self-mobilization with CP (Park D. et al. 2018), and progressive resistance, balance, and motivational group discussion (Vahlberg et al. 2017).

Interventions focused on WA were: individually tailored home and community-based exercise program together with CP (Marsden et al. 2016), aerobic, body weight supported treadmill based physical fitness training together with CP (Nave et al. 2019), progressive resistance, balance, and motivational group discussion (Vahlberg et al. 2017) and total FIT stroke programme (Van de Port et al. 2012).

Interventions focused on capacity to perform ADL were: CP with core stability exercises (Cabanas-Valdes et al. 2015), Pelvic stability training (Dubey et al. 2017), CP (Koç et al. 2015), sling exercise therapy with CP (Liu et al. 2020), aerobic, body weight supported treadmill based physical fitness training together with CP (Nave et al. 2019), land based and aquatic trunk exercises with CP (Park H. et al 2019), and ankle self-mobilization with CP (Park D. et al. 2018),

Control Group:

The activity of the control group (CG) did not show such heterogeneity. Majority of the groups received a CP, except of 2 groups: receiving CP with additional brisk walking (Mayo et al. 2013) and CP with self-ankle mobilization movement with a 10° inclined board (Park D et al. 2018) respectively. Two control groups did not receive any physiotherapeutic intervention at all (Koç et al. 2015, Vahlberg et al. 2017).

Individual characteristics per study can be found in *table 3.*

Table 3 - Individual characteristics per study (n=12)

Study (year)	Participants (Intervention/control) % male	Intervention mean age (SD) / control mean age (SD)	Stroke Phase	Intervention Group	Control Group	Outcome measures (tool)
Cabanas Valdes et al. (2015) a	80 (40/40) 50%	74.92 (10.70) / 75.69 (9.40)	mixed: acute, subacute	conventional physiotherapy 5 times a week + core stability exercises for 15 minutes a day	conventional physiotherapy 5x/week	Static Balance (BBS); Capacity to perform ADL (BI)
Cabanas Valdes et al. (2015) b	68 (36/32) 50%	75.08 (11.05) / 75.81 (9.06)	mixed: acute, subacute	conventional physiotherapy 5 times a week + core stability exercises for 15 minutes a day	conventional physiotherapy 5x/week	Static Balance (BBS); Capacity to perform ADL (BI)
Dubey et al. (2017)	34 (17/17) 73 %	54.35 (11.64) / 58.24 (11.77)	mixed: subacute, chronic	Pelvic stability training and conventional physiotherapy 1 hour a day, 3x/week	conventional physiotherapy for 1 h/day, 3x/week	Static Balance (TIS 2.0); Capacity to perform ADL (MBI)
Koç et al. (2015)	72 (35/37)	67	subacute	conventional physiotherapy 1 h/day, 2x/week	No intervention	Capacity to perform ADL (BI)
Liu et al. (2020)	50 (25/25) 70%	56.52 ± 9.22 / 56.6 ± 9.12	mixed, acute-subacute	SET (sling exercise therapy) 30 min a day, 5x/week + conventional physiotherapy	conventional physiotherapy 30 min a day, 5x/week	Static Balance (BBS); Capacity to perform ADL (BI)
Marsden et al. (2016)	20 (10/10) 40%	54.4 (22.2) / 62.0 (16.8)	mixed: acute, subacute, chronic	Conventional physiotherapy + Individually tailored home and community-based exercise program	Conventional physiotherapy	Walking ability (6MWT)
Mayo et al. (2013)	87 (43/44) 69%	67.7 ± 14.4 / 67.8 ± 12.3	mixed: acute, subacute, chronic	conventional physiotherapy + stationary cycling 30 min a day	conventional physiotherapy + mobility exercise and brisk walking 15 min a day	Static Balance (BBS)
Nave et al. (2019)	200 (105/95) 59.5%	69 (12) / 70 (11)	mixed: acute, subacute	aerobic, bodyweight supported, treadmill based physical fitness training 25 min, 5x/week + conventional physiotherapy.	relaxation session 25 min, 5x/week + conventional physiotherapy	Walking ability (6MWT); Capacity to perform ADL (BI)
Park D et al. (2018)	28 (14/14) 50%	57.6±9.0 / 64.1±9.7	chronic	Conventional physiotherapy 30 min per session + self-ankle mobilization with movement 3x/week.	Conventional physiotherapy 30 min per session + self-ankle mobilization with movement with a 10° inclined board 3x/week	Static Balance (BBS); Capacity to perform ADL (K-BI)
Park H et al. (2019)	29 (14/15) 74.5%	56.23±13.74 / 57.13±11.73	chronic	Land-based and aquatic trunk exercises, 30 min a day, 5x/week + 30 min. conventional physiotherapy	conventional physiotherapy 30 min 2x/day, 5x/week	Static Balance (BBS-3L); Capacity to perform ADL (MBI)
Vahlberg et al. (2017)	67 (34 / 33) 76%	72.6 (5.5) / 73.7 (5.3)	chronic	Progressive resistance and balance + motivational group discussion 2x/week	usual activities (no intervention)	Static Balance (BBS); walking ability (6MWT)
Van de Port et al. (2012)	242 (125 / 117) 64.8%	56 (10) / 58 (10)	subacute	Total FIT-Stroke programme: 90 min graded task-oriented circuit training 2x/week, focusing on walking competency	Conventional physiotherapy (standing balance, physical condition, and walking competency)	Walking ability (6MWT); Capacity to perform ADL (NEADL)

Abbreviations: BBS, Berg Balance Scale; BBS-3L, 3-level Berg Balance Scale; 6MWT, 6 Meter Walk Test; BI, Barthel Index; MBI, Modified Barthel Index; K-BI, Korean version Barthel Index; NEADL, Nottingham Extended Activities of Daily Living

Outcome Measures:

Static balance: Berg Balance Scale (BBS)

The majority of articles included (n=6) used the Berg Balance Scale (BBS) for outcome measures on static balance. The BBS is a 14-item scale which was created for quantitative balance assessment in older adults, either statically or while performing various functional movements. BBS is identified as the most used assessment tool across stroke survivors starting from acute to chronic phase (Blum et al. 2008).

In total, 6 articles reported outcomes on SB *(table 4).* All studies besides Mayo et al. (2013) and Vahlberg et al. (2017) showed within group improvement of IG and CG in static balance (P=n/a). As for Vahlberg et al. (2017), the study reports decrease in BBS score compared to baseline in CG. Two studies showed significant difference of improvement in between-group comparison (Cabanas Valdes et al. 2017, Liu et al. 2020) after one month (short-term). On three months (short-term), two studies (Vahlberg et al. 2017, Cabanas Valdes et al. 2017) showed a significant improvement in outcomes between groups (IG=52, CG=48.4; P<0.05), and (IG=34.86; CG=20.62; P<0.05) respectively. After six and twelve months (long term), none of the studies showed a significant difference (P<0.05) in improvement between IG and CG.

Walking ability: 6-minute walking test (6MWT)

In total, 4 articles reported outcomes on WA *(table 5)* by means of the 6-minute walking test**.** The six-minute walk test (6MWT) is a rehabilitation outcome measure of walking ability that is validated and recommended for persons with stroke (Regan et al. 2019). This test has a good test-retest reliability (ICC=0.99) and concurrent validity with Berg Balance Score. The distance achieved during 6MWT was found to be in direct connection with walking ability. The longer the distance covered, the better the walking ability is. A distance of 304 m during this test can be used for determining the walking independence in stroke patients (Kubo et al. 2019).

All articles showed within group improvement in walking ability compared to the baseline in IG and CG (P=n/a). 2 authors (Vahlberg et al. 2017, Van de Port et al. 2012) showed a significant improvement between IG and CG (IG=361.7, CG=366.9, P<0.05 and IG=412, CG=354, P<0.05 respectively) after 3 months (short-term). Vahlberg et al. (2017) and Van de Port et al. (2012) did not show significant difference (P>0.05) in improvement between the IG and CG after 6 to 12 months (long-term). Nave et al. (2019) did not provide the data about significance of improvement (P=n/a) between the IG and CG after 6 months (long-term).

ADL-activities: Barthel Index (BI)

In total, 7 articles reported about outcomes about ability to perform ADL *(table 6).* Most authors (Cabanas Valdes et al. 2015, Koç et al. 2015, Liu et al. 2020, Nave et al. 2019, Park D et al. 2018) included the Barthel Index (BI), a scale indicating the ability to perform activities of daily living (ADL) (Musa et al. 2018), with the modified BI being applied by Dubey et al. (2017) and Park H et al. (2019). Its outcomes address stroke survivor's ability to feed, take a bath, groom, dress, control bowel and bladder, toileting, chair transfers, stair climbing and ambulation (Musa et al. 2018).

All studies besides Liu et al. 2020, showed the improvement in ability to perform ADL compared to the baseline measurements within the group (P=n/a). 3 studies (Cabanas Valdes et al. 2015, Koç et al. 2015, Park H. et al. 2019) showed a significant improvement in IG compared to CG (IG= 68.50, CG= 54.23, P<0.05; IG= 72.3, CG= 69.4, P<0.05; IG= 73.00, CG= 57.87, P<0.05 respectively) after 1-2 months (short-term). After 3-6 months (mid-term) only one study (Koç et al. 2015) showed significant improvement between IG and CG (IG=82.0, CG= 69.5, P<0.05). Other articles reported within and between group improvements without providing a P value.

Table 4 - Static balance outcomes over time of included studies (n=6)

Study (year)	Static Balance Measurement Tool	IG (SD) [Median]	CG (SD) [Median]	P - value
Cabanas Valdes et al. (2015) a,b	BBS			
1 month		28.45 (17.75)	17.03 (15.11)	**< 0.05**
3 months		34.86 (18.03)	20.62 (15.35)	**< 0.05**
Liu et al. (2020)	BBS			
1 month		5 [3.5,13.5]	4 [2.0, 5.5]	**< 0.05†**
Mayo et al. (2013)	BBS			
1 month		51.9 (4.5)	51.6 (4.6)	n/a
1 year		50.7 ± 6.9	51.0 ± 5.0	n/a
Park D et al. (2018)	BBS			
1 month		44.43 (3.65)	46.93 (3.58)	>0.05
Park H et al. (2019)	BBS-3L			
1 month		21.50 (3.65)	22.73 (3.60)	>0.05
Vahlberg et al. (2017)	BBS			
3 months		52 (9.1)	48.4 (2.8)	**< 0.05**
6 months		50.2 (9.5)	49.8 (7.9)	>0.05
1 year		49.2 (5.4)	48.4 (3.4)	>0.05

Abbreviations: Bold, statistically significant (p<0.05); BBS, Berg Balance Scale; BBS-3L, 3-level Berg Balance Scale; †, evaluated by non-parametric comparison.

Table 5 -Walking ability outcomes over time of included studies (n= 4)

Study (year)	Walking Ability Measurement Tool	IG (SD)	CG (SD)	P - value
Marsden et al. (2016)	6MWT (meters)			
3 months		493.5 (89.6)	470.9 (105.7)	>0.05
Nave et al. (2019)	6MWT (meters)			
1 month		175 (126) ‡	185 (115) ‡	n/a
3 months		201 (153) ‡	203 (128) ‡	n/a
6 months		239 (152) ‡	233 (149) ‡	n/a
Vahlberg et al. (2017)	6MWT (meters)			
3 months		361.7 (82)	366.9 (47.8)	**< 0.05**
6 months		380.8 (119.4)	381.8 (56.3)	> 0.05
1 year		299.2 (114.2)	361.1 (85.9)	> 0.05
Van de Port et al. (2012)	6MWT (meters)			
3 months		412 (117)	354 (145)	**< 0.05**
6 months		416 (118)	366 (151)	> 0.05

Abbreviations: Bold, statistically significant (p<0.05); 6MWT, 6 Meter Walk Test; †, participants were unable to walk for entire time of 6 minutes; ‡, for those participants distance walked until stopping is used.

Table 6 - Capacity to perform ADL outcomes over time of included studies (n=7)

Study (year)	Capacity to perform ADL measurement tool	IG (SD)	CG (SD) [median]	P - value
Cabanas Valdes et al. (2015)	BI			
1 month		68.50 (22.37)	54.23 (23.32)	**< 0.05**
3 months		79.30 (20.43)	60.78 (22.55)	> 0.05
Dubey et al. (2017)	MBI			
1 month		80.42 (7.8)	78.62 (14)	> 0.05
Koç et al. (2015)	BI			
1 month		67.9 (5.4)	68.5 (4.3)	> 0.05
2 months		72.3 (5.6)	69.4 (4.1)	**< 0.05**
3 months		82.0 (5.2)	69.5 (4.4)	**< 0.05**
Liu et al. (2020)	BI			
1 month		15[5.0, 27.5]	15[5.0, 25.0]	> 0.05†
Nave et al. (2019)	BI			
1 month		73 (21)	75 (22)	n/a
3 months		77 (22)	79 (19)	> 0.05
6 months		82 (20)	84 (18)	n/a
Park D et al. (2018)	K-BI			
1 month		65.43 (8.61)	69.07 (4.7)	> 0.05
Park H et al. (2019)	MBI			
1 month		73.00 (13.00)	57.87 (17.92)	**< 0.05**

Abbreviations: Bold, statistically significant (p<0.05); BI, Barthel Index; MBI, Modified Barthel Index; K-BI, Korean version Barthel Index; †, evaluated by non-parametric comparison.

Discussion

The primary objective of this study was to determine the effect of a well-structured, reproducible, and physiologically based, progressive exercise program on subacute stroke patients' physical functionality. Previous research (Van Duijnhoven et al. 2016, Zhang et al. 2020) demonstrated that exercise improved physical functionality of the patients during the rehabilitation from stroke. This literature review confirmed that additional exercises (core stability; sling exercise therapy; FIT stroke programme) in combination with CP, can help to improve physical functionality significantly in people suffering from subacute stroke on short-term, and another important finding was that the land-based and aquatic trunk exercises aimed at improving mainly core stability, were also effective in improving the capacity to perform ADL where according to Brogardh et al. (2012), the task-specificity of exercise therapy had to be the aim at the first place.

Studies focusing on the analysis of a particular phase of stroke rehabilitation were scarce, which resulted in inclusion of acute, subacute, and chronic phases of stroke rehabilitation. Together with different variety and duration of treatment modalities, these phases presented challenges for combination and synthetization of findings. Results of different types of physiotherapeutic treatment programs effecting SB, WA and capacity to perform ADL were therefore grouped in short term (from 1 months up to 3 months), midterm (3 to 6 months) and long term (from 6 months to 1 year) outcomes for better representation.

Exercises focused on improving the endurance of the core muscles stabilizing the trunk and pelvis, complemented with neuromuscular activation via unstable supporting surface implementation (Cabanas-Valdes et al. 2015, Liu et al. 2020) lead to significant improvements in SB of subacute stroke patients on short-term. This result was consistent with a theory stating that core muscles endurance was associated with balance performance in older population, where exercising the core musculature on an unstable surface could improve stability, reaction times, balance, and proprioceptive capabilities (Cabanas-Valdes et al. 2015). Core stability exercises induce co-contraction of the trunk musculature and improve intersegmental coordination of the body which allows more selective movement control of the lower limb (Cabanas-Valdes et al. 2015). Furthermore, observed short-term improvements in SB could have been facilitated due to optimized compensatory balance control strategies such as improvement of trunk control, nonparetic side hip and ankle strengthening, general motor responses adjustment to changed dynamics and sensory input of body and optimization of stepping strategies (van Duijnhoven et al. 2016). Absence of long-term significant improvements in SB in IG as well as in CG may be based on restriction of the favorable treatment effects beyond 6 months from the stroke onset (van Duijnhoven et al. 2016).

The findings regarding exercise program improving meaningful tasks related to walking competency in subacute phase of stroke rehabilitation (Van de Port et al. 2012) go in hand with the theory according to which the brain plasticity as well as genetic factors facilitate functional recovery, motor rehabilitation efficacy and response to interventions up to 6 months from stroke onset, and decline gradually, reaching the limit at one year (Hara et al. 2015). However, due to context specific nature of the training, noticeable gains in walking distance on 6MWT appeared to be insufficient to result significant improvements in gait performance in the patients' perception. On top of that, the patients receiving the intervention suffered only from mild to moderate stroke, which limited the overall generalizability of the study (Van de Port et al. 2012).

The improvements achieved in IG receiving only CP (Koç et al. 2015) and improving capacity to perform ADL raise a suspicion, as the CG did not receive any type of treatment at all. As for Park H. et al (2019), land-based and aquatic trunk exercises improved the capacity to perform ADL compared to CP alone, even if the population was in chronic phase of stroke. This proves that the improvements in capacity to perform ADL might still take place even after the brain plasticity is not as capable for adaptations as it was in acute or subacute phase. The recovery could also not have happened spontaneously, as it generally appears in first 2 to 3 months after the stroke onset (van Duijnhoven et al. 2016).

Different exercise modalities can be implemented for the purpose of increasing the physical functionality for the patients rehabilitating from stroke. This literature review did not provide the ultimate answer to the question asking for the best exercise improving the physical functionality in general of the subacute stroke patients in long run as such, but provided a suggestion about the type of exercises which might lead to improvements in SB, WA and capacity to perform ADL on short and mid-term. Improvements in PF can be reached earlier in IG compared to CG which means that the healthcare resources can be saved by reaching the treatment goals sooner, although the outcomes will be similar at the end. Moreover, this literature review provided evidence that a different variety of physical activities in boundaries of physiotherapy can be used to improve the physical functionality in population rehabilitating from stroke in different phases. The findings might therefore be incorporated into materials for teaching and information provision during each phase of stroke rehabilitation process.

Strengths and Limitations

All articles included in this study were of good methodological quality. Besides, the articles all fulfilled the mandatory extra grading items that guaranteed concealed allocation, key outcome acquisition from at least 3/4 of the participants and reporting of statistical comparison about at least one key outcome. Additionally, the search string together with the Prisma flowchart allows for replicability of this review study.

The heterogeneity of the included studies for phases of stroke rehabilitation and heterogeneity of measurement tools in outcome measurement hampered the analysis of the results. Inclusion of articles with a variety of conditions makes it hard to combine and synthesize the findings.

Some studies included participants which were significantly younger (Dubey et al. 2017, Liu et al. 2020, Marsden et al. 2016, Park D et al. 2018, Park H et al. 2019, Van de Port et al. 2012) than the ones in other studies which could affect the adherence and effect of intervention, as a younger population might improve its functional performance sooner. Another limitation to the research is that some studies did not provide any intervention in the control group (Koç et al. 2015, Vahlberg et al. 2017), which would affect the outcomes in intervention group. Moreover, several studies (n = 2) did not provide the P value for within-group comparisons as well as for between-group comparisons. Bringing in a third independent grader in the quality appraisal process, which could have helped deciding in case there was a disagreement in quality appraisal, could have helped for increasing the internal validity of the literature review. The external validity of the review may be negatively impacted due to the small number of participants in several research groups. Functional recovery is influenced by stroke severity and its location (van Duijnhoven et al 2016), which was not systematically reported in included randomized clinical trials. Therefore, it was impossible to determine the impact of stroke location on functional recovery. Another point to be taken into consideration is that it was not consistently defined how the conventional physiotherapy treatment was structured and what was training frequency and intensity. This could have served as a possible effect modifier for the intervention and control groups. Finally, the use of BBS for assessing the SB came with limitation due to its ceiling effect in subacute and chronic phases of stroke. This might have resulted in an under-estimation of therapeutic effect and training-induced gain in individuals with better functionality.

Conclusion

Subacute-stroke patients' optimization of PF on short term was achieved by conventional physiotherapy with core stability exercises, conventional physiotherapy with sling exercise therapy, and FIT stroke programme rehabilitation. None of the interventions in IG proved to achieve significant improvement in any domains of PF compared to CG in subacute stroke patients on midterm and long-term, suggesting that there is no additional benefit from additional exercise modalities next to CP on long run.

Recommendations for future research

The conducted RCT’s should be consistent in providing the description of the types of interventions which they implement, by exactly stating frequency, intensity and duration of each session. It is also recommended to narrow down the search to only one particular phase of rehabilitation for extracting more specific results, as rehabilitation strategy and final outcomes differ from each other in acute, subacute, and chronic phases of stroke. Furthermore, it is suggested to focus on the same age group in the literature review, and to be consistent in the use of the measurement tools of dependent variables. Next to that, it is important to provide not only between-group statistical significance of results, but also within-group on each measurement time point. Additional determination of the effect size will lead to better understanding of the magnitude of the difference between different findings. Moreover, it is recommended to set identical measurement time points and use different outcome variable for SB and capacity to perform ADL determination, such as mini-Balance Evaluation System Test (mini-BESTest), and Nottingham Extended Activities of Daily Living (NEADL) instead of using BBS and BI respectively. Mini-BESTest and NEADL have lower ceiling effect and higher reliability than the BBS and BI respectively in stroke survivors (van Duijnhoven et al 2016, Sarker et al. 2012).

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