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Effect of Trunk Training to Improve Balance and Gait Performance Among Stroke Patients: A Review

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Abstract
Background: Stroke significantly impacts motor functions, including balance and gait, due to trunk weakness, leading to compromised postural control and reduced functionality. Rehabilitation approaches like core stability exercises, dance therapy, Tai Chi, interactive gaming, and robotic assisted therapies are examined for their effectiveness in enhancing trunk function, balance, and gait among stroke survivors.
Aims and Objectives: The study aims to evaluate the impact of different trunk training methods on balance and gait in stroke patients, specifically assessing core stability exercises, dance therapy, sitting Tai Chi, interactive gaming, robotic-assisted therapy, and cycle ergometry.
Materials and Methods: A comprehensive literature review of studies from 2022 was conducted, focusing on stroke patients aged over 18 with more than six months of recovery. Six articles meeting the criteria were analyzed, evaluating interventions such as core stability exercises, Tai Chi, dance therapy, interactive gaming, robotic therapy, and cycle ergometry.
Results: The selected studies reported improvements in trunk control, balance, and gait across interventions. Core stability exercises, sitting Tai Chi, and dance therapy delivered via telerehabilitation improved postural stability. Robotic-assisted therapy and gaming enhanced motor functions, while cycle ergometry promoted balance in acute stroke patients.
Conclusion: Trunk training through core stability exercises, Tai Chi, and robotic-assisted rehabilitation shows promise in enhancing functional outcomes in stroke patients. However, long-term adherence to home-based exercises and intervention optimization remains challenges.

Keywords: Stroke, Trunk Control, Balance, Gait, Rehabilitation, Core Stability, Dance Therapy, Tai Chi, Robotic-Assisted Therapy, Telerehabilitation.

Introduction

Stroke is the second leading cause of death worldwide and the second most common cause of disability-adjusted life-years. As referring to the year 2020 indicate the global prevalence of 10 % ischemic stroke and 3%hemorraghic stroke [1]. Stroke is a clinical syndrome characterized by rapidly developing signs of focal or global disturbance of cerebral functions, lasting for more than 24 hours or leading to death, with no apparent causes other than vascular origin. Stroke can affect vision, cognition, communication, and sensorimotor function. Stroke can induce a wide range of deficits, from none or very minor deficits, to a complete paralysis of the affected side of the body, and even bilateral impairments [2]. Reduction of trunk function is one of major issue faced by stroke patients in their daily living. Persons with stroke suffer from weakness of the trunk and impairment of proprioception, resulting in decreased balance and postural control, reduced weight- bearing ability, and increased postural fluctuations.[3]

Trunk plays a central role in postural response and control; all functional movements and trunk control are important in activities of daily living. Sensory-motor impairment of the trunk interferes with functional performance, thus decreasing balance ability and affecting movement. Increased sway during quiet standing, uneven weight distribution with increased weight bearing on the unaffected limb, decreased weight-shifting ability while in stance, and abnormalities in postural responses have been documented. It also affects the gait and mobility of an individual. So, it is very essential to improve the trunk function of stroke

patients in all phases of rehabilitation [4]. Several studies proves that trunk function can be improved by approaches like core stability exercise, dance therapy, tailored sitting tai chi program, gaming system, robotic assisted rehabilitation, early bed arm and leg cycle ergometry.

CSE also known as lumbopelvic stability exercise is the isometric strengthening of trunk muscles. This approach recommended in the guidelines of good practice and it is not only for the recovery of trunk muscles but also exerts a great influence on balance and gait.[4]

Dance therapy, which offers aerobic benefits similar to jogging and walking, has been shown to improve gait and balance in individuals with neurological conditions like stroke and Parkinson's disease. Recent studies support its effectiveness, particularly excluding Parkinson's disease. Given the COVID-19 pandemic's emphasis on reducing person-to-person contact, telerehabilitation—providing rehabilitation services remotely using technology—has become increasingly important. Therefore, dance therapy delivered through telerehabilitation may be a practical and effective approach for improving trunk control in stroke patients.[2]

The American Heart Association/American Stroke Association recommends Tai Chi for stroke recovery, but traditional Tai Chi programs are often unsuitable for subacute stroke survivors with hemiparesis or hemiplegia due to fall risks and mobility issues. Sitting Tai Chi, a modified version performed while seated, offers a safer alternative for these individuals. However, there is a lack of randomized controlled trials (RCTs) on the effectiveness of sitting Tai Chi for subacute stroke recovery. Developing a tailored sitting Tai Chi program for this population is essential to provide evidence of its benefits.[5]

Commercial gaming systems are being used for stroke rehabilitation due to their fun, low-cost nature, and ability to provide meaningful and repetitive movements. They can enhance rehabilitation by encouraging self-rehabilitation at home or in hospitals. However, a concern is whether these systems may lead to increased compensatory trunk movements, where patients substitute impaired functions (e.g., elbow extension) with trunk movements. Research by Michaelsen et al. suggests that such compensatory strategies can reduce functional recovery in patients with moderate motor impairment. Thus, while gaming systems may be engaging, they might inadvertently promote compensatory patterns that could negatively impact functional recovery.[6]

Robot-assisted therapy has significantly advanced stroke rehabilitation by providing targeted, intensive, and engaging training. Robot-assisted gait training (RAGT) is particularly notable for its ability to offer high-intensity, repetitive, and task-specific exercises with consistent control over movement patterns, speed, and resistance. This precise control and adaptability surpass what is achievable with traditional manual therapy. Combining robotic treatment with conventional physical therapy has been shown to maximize effectiveness. Robotic systems also allow for personalized adjustments to accommodate the diverse motor impairments caused by strokes, tailoring rehabilitation to each patient's needs [8].

Early bedside cycle ergometer along with routine physiotherapy improves motor function in hospitalized acute stroke survivors . Early mobilization after a stroke is crucial for reducing death and disability, and in ICU rehabilitation, therapists often use positioning, passive movements, bedside sitting, and transfers. Techniques like tilt tables, wheelchair mobilization, and functional electrical stimulation assist in early mobilization. The cycle ergometer, a device for cyclic exercises, is particularly effective as it enables passive, active, and resistance exercises for both arms and legs. This method aids in muscle activation and coordination, and has shown benefits in improving standing and walking abilities in stroke patients, especially in subacute and chronic stages.[7] The study aims to review the effectiveness of trunk training during the rehabilitation of stroke patients.

Methodology

This study encompassed various types of research designs, including randomized controlled trials, clinical trials, and pre-post experimental designs, and focused on participants who had been medically diagnosed with stroke, either cortical or subcortical, and ischemic or hemorrhagic in nature. Participants were required to have completed more than six months of recovery and presented clinical symptoms of hemiplegia or hemiparesis. Additionally, the study included individuals over the age of 18 who were capable of understanding and following simple instructions. To ensure relevance, only articles published in 2022 were considered for inclusion.

Type of intervention: the studies included the techniques of Core-Stability Exercises, Dance therapy program, Sitting Tai Chi, The interactive gaming intervention, Robotic-assisted rehabilitation, cycle ergometry trainings.

The *Core-Stability Exercise Program* targets abdominal, lower back, and hip muscles to improve balance, coordination, and strength in the trunk region. Exercises include planks, bridges, leg raises, pelvic tilts, sit-to-stand movements, and seated trunk rotations, with video demonstrations and step-by-step instructions provided through app (fig 1).

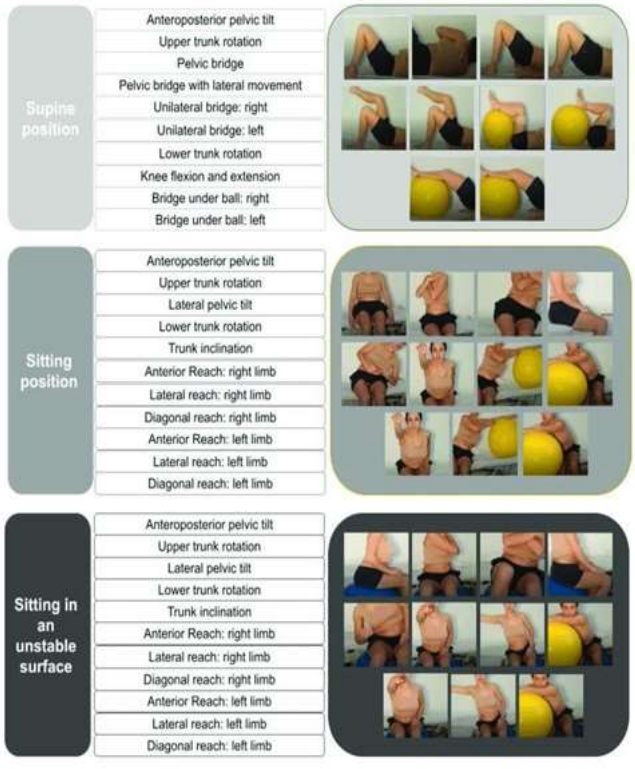

Fig 1: Core Stability Exercise Protocol for Stroke Patients.

Participants perform exercises 3-5 times/week, 30-45 minutes/session, with gradual intensity increases. The app offers real-time feedback via motion-sensing technology or video submissions, regular check-ins for adherence, and progress tracking. Specific exercise instructions include: planks (30-60 seconds), bridges (3 sets of 10-15 reps), leg raises (3 sets of 10-15 reps), pelvic tilts (3 sets of 10-15 reps), sit-to-stand movements (3 sets of 10-15 reps), and seated trunk rotations (3 sets of 10-15 reps).

Dance therapy program is tailored to target trunk and lower body movements aimed at improving postural stability, coordination, and balance. The sessions are conducted remotely via video conferencing platforms, allowing patients to participate from their homes under the guidance of a trained therapist who provides real-time feedback. Each session lasts 30 to 60 minutes and typically occurs multiple times per week. The sessions consist of warm-up exercises, core dance movements focusing on trunk and balance control, and a cool-down phase. Therapists monitor patients' progress using standardized tools, such as the Trunk Impairment Scale and the Berg Balance Scale, to measure improvements over time. Feedback from the patients on the exercises and the telerehabilitation technology is regularly gathered to adjust the program as needed.

Sitting Tai Chi is a modified version of traditional Tai Chi, designed for stroke survivors. The practice begins with the individual sitting comfortably in a chair, feet flat on the floor, back straight, and shoulders relaxed to promote good posture and balance. A typical session starts

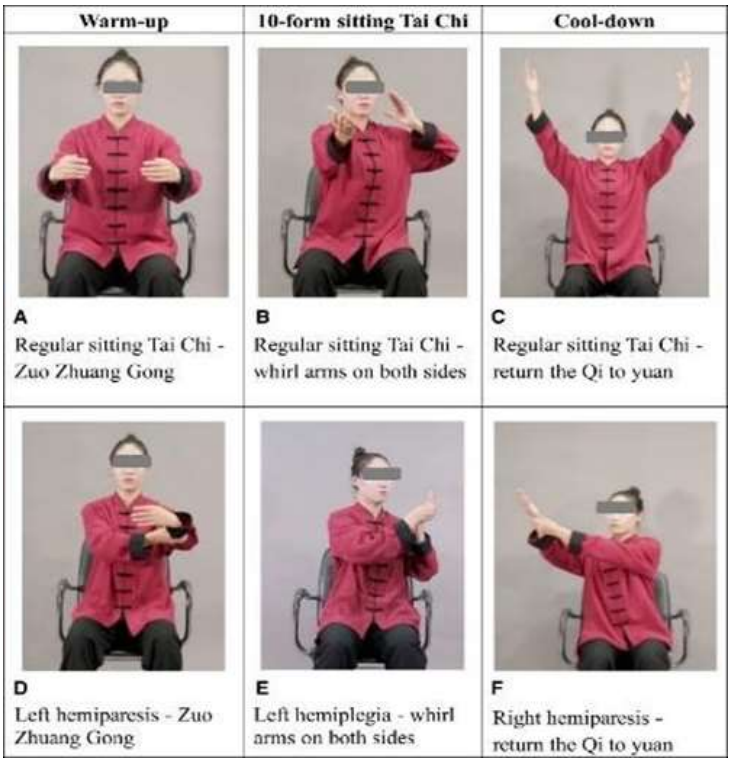

Fig 2: Sitting Tai Chi Movements.

with warm-up exercises, including neck rolls, shoulder rolls, and deep breathing to prepare the body. The core of Sitting Tai Chi involves slow, flowing movements coordinated with deep breathing, focusing on the upper body while keeping the lower body stable (fig 2). Examples of these movements include "Wave Hands Like Clouds," where the hands move in a circular motion; "Grasp the Sparrow's Tail," which involves arm extensions and gentle trunk twists; and "Single Whip," extending one arm to the side with a torso turn. Breathing is synchronized with the movements, such as inhaling while raising the arms and exhaling while lowering them, fostering relaxation and mindfulness. At the end of each session, participants perform cool-down exercises, including gentle stretches and controlled breathing to promote relaxation.

The *interactive gaming intervention* involved participants with chronic stroke engaging with a gaming system designed to improve upper-limb and trunk motor function. The rehabilitation-focused games included tasks like reaching, grasping, and trunk rotation, with sessions held several times per week, lasting 30 to 60 minutes, over a period of 4 to 8 weeks. The games were progressively adjusted in difficulty based on the participant's performance and provided real-time visual or auditory feedback to help refine their movements. The intervention emphasized high repetitions of targeted movements to promote motor recovery. Kinematic data was collected before and after the intervention using motion capture to assess improvements in movement accuracy, speed, and coordination. Additionally, functional assessments were conducted to evaluate realworld motor function.

Robotic-assisted rehabilitation for balance in stroke patients involves the use of specialized robotic devices that guide patients through balance exercises while integrating cognitive tasks to enhance motor skills. Patients participate in therapy 2-3 times per week, with some protocols including daily sessions, each lasting 30 to 60 minutes. The total treatment duration generally spans 4 to 12 weeks. Patients usually start in a standing position with robotic support or may begin sitting for initial assessments. Common exercises include standing balance tasks on flat or unstable surfaces and single-leg stances to improve stability and strength. Dynamic movement exercises involve walking in various directions and navigating obstacles to

simulate reallife situations. Functional reach exercises focus on reaching for objects at different heights and shifting weight between legs to strengthen core muscles. Resistance training, including leg strengthening exercises, is also incorporated to build lower limb strength. Finally, task-specific training allows patients to practice daily living activities, tailored to individual needs.

Patients engaged in *cycle ergometry* while positioned in bed or sitting upright, facilitating a safe environment for low-impact cardiovascular exercise. The sessions were conducted daily or several times a week, each lasting between 15 and 30 minutes, based on the patient's individual tolerance and physical condition. The intensity of the cycling was adjusted to match the capabilities of each participant. This structured approach aimed to improve the patients' sitting and standing abilities, encourage early mobilization, and support overall functional recovery during the critical acute phase of stroke rehabilitation.

Type of participants: This study included medical diagnosis of stroke with cortical or subcortical, ischemic or haemorrhagic involvement with more than 6 months of recovery, clinical symptoms of hemiplegia or hemiparesis , being over 18 years of age, have the ability to understand and execute simple instructions.

Outcome Measures: The outcome measures include the Trunk Impairment Scale (TIS) for trunk control, kinematic analysis for upper-limb and trunk movements, the Berg Balance Scale (BBS) and Sitting Balance Scale (SBS) for balance, and the 10-Meter Walk Test (10MWT) and Timed Up and Go (TUG) for gait performance. Cognitive function is assessed using the Montreal Cognitive Assessment (MoCA), and overall functionality with the Functional Independence Measure (FIM).

Study selection process: The study selection process involved conducting a web-based search in the PubMed database using the keywords "Stroke," "Trunk Control," "Balance," "Daily activities," and "Rehabilitation," which resulted in a total of 26 articles being identified for potential inclusion in the study.

Results

A literature review was conducted using the PubMed database, applying keywords related to stroke rehabilitation: *Stroke, Trunk Control, Balance, Daily Activities, and Rehabilitation*. After applying inclusion and exclusion criteria, 26 articles were identified, of which 6 were included for detailed analysis. The six selected studies involved a total of 284 stroke patients.

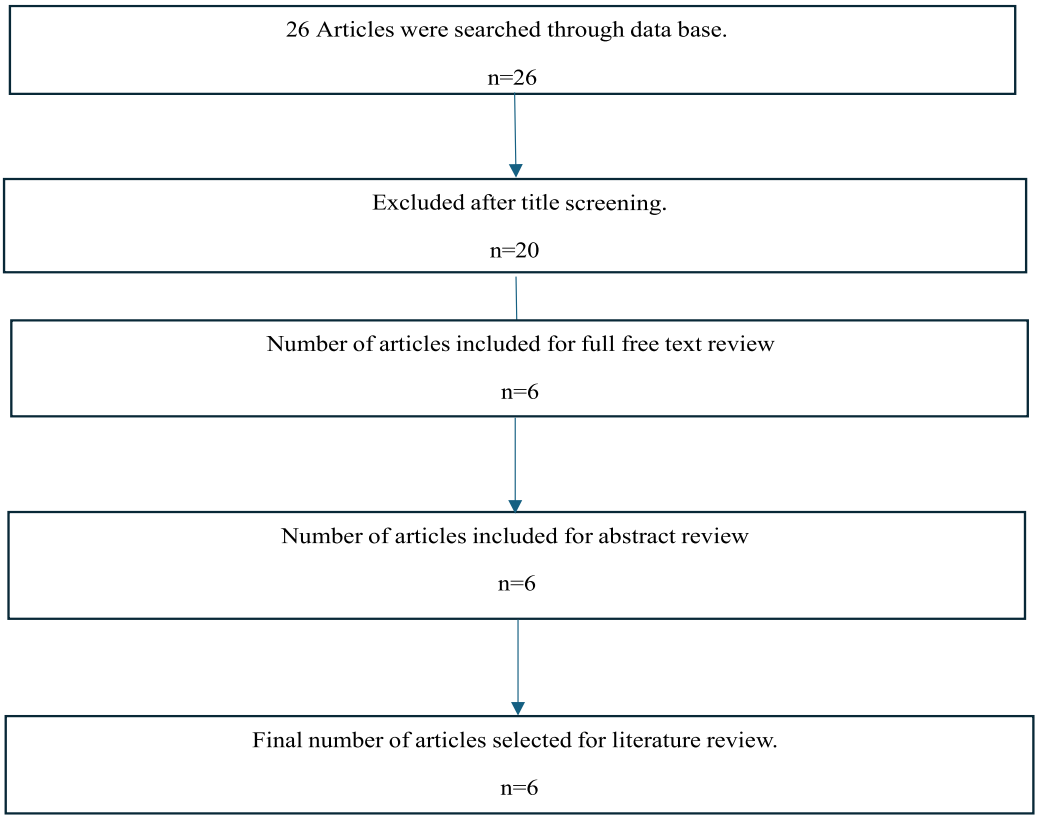

Fig 3: Flowchart Of Data Extraction.

Discussion

The overall study is to find effectiveness of trunk training to improve balance and gait performance among stroke survivors.

The study by Carina Salgueiro et al. Found the effectiveness of telerehabilitation using the Farmalarm App for delivering Core Stability Exercises (CSE) to improve trunk function and sitting balance in chronic stroke patients [4]. Similar to Cabrera-Martos et al. (2023), CSE was found to enhance trunk performance, but challenges like low adherence due to the high exercise demand and app issues were identified [11]. While telerehabilitation shows promise, face-toface therapy still holds higher patient satisfaction. The study emphasizes that long-term success depends on patient adherence and self-responsibility in recovery [4].

Dance therapy (DT) improves balance and gait performance through several mechanisms, as noted by

various authors. Lee et al. (2022) found that DT enhances overall physical engagement and body awareness, leading to improved stability and coordination [2]. Demers et al. (2022)
emphasized that subacute stroke patients benefit more from DT due to increased
neuroplasticity, which allows for better adaptation and recovery of motor functions, enhancing balance [12]. Subramaniam et al. (2022) pointed out that integrating virtual reality into DT boosts patient motivation, encouraging more active participation, which positively impacts balance and gait [13]. Hackney et al. (2022) provided evidence that DT contributes to improved dynamic balance, as demonstrated by better performance in the Timed Up and Go (TUG) test, which assesses mobility and gait [14]. Overall, DT promotes core stability, weight shifting, and coordination through rhythmic movement and social interaction, all of which are essential for improving balance and gait in stroke patients [2].

Tai Chi is used for improving balance and gait performance, as studied by Zhao et al. (2022), who found significant enhancements in balance control and overall recovery among subacute stroke survivors. Their research highlights how Tai Chi's slow, controlled movements foster core stability, coordination, and weight shifting, ultimately leading to improved body awareness and postural control [5]. Supporting these findings, Gao et al. (2022) noted enhancements in balance, emphasizing the importance of social interaction in Tai Chi practice, which can further motivate participation and improve outcomes [16]. And they recognized that the engaging nature of Tai Chi, with its rhythmic movements and focus on mindfulness, enhances patient adherence, contributing to better rehabilitation results. Together, these studies underscore the potential of Tai Chi as an effective intervention in stroke rehabilitation [5].

Maxime Térémetz et al. (2022) studied the effectiveness of Wii gaming versus conventional therapy for chronic stroke patients but found no significant differences in elbow extension or trunk motion, aligning with Michaelsen et al., who noted that task difficulty influences outcomes [17]. The authors attributed the lack of improvement to insufficient therapy duration, as suggested by Tedesco et al. [18] and Tzeng et al. [19], Participants expressed a preference for conventional therapy, indicating that richer interactions enhance satisfaction. Limitations, including low training dosage and late participant selection, support Kwakkel et al.'s emphasis on intensive therapy for meaningful recovery[20]. While the gaming technique did not show significant improvements, it underscores the need for further research on optimizing therapy duration and intensity to enhance gait and balance in stroke rehabilitation.

The study by L Castelli et al. examined the impact of Hunova robotic balance therapy alongside conventional therapy on stroke patients. They found that this combination led to improvements in both motor and cognitive functions. Notably, participants showed enhancements in cognitive skills like executive functioning and processing speed, which support the brain adaptation theory and highlight the role of cognitive reserve in recovery. The robotic therapy also resulted in significant gains in balance and lower limb function, consistent with earlier findings by Aprile et al. (2020) [21]. These improvements indicate that incorporating robotic technology can enhance trunk training by offering targeted and adaptive exercises that help improve balance and motor control, aiding overall recovery in stroke patients. However, the authors noted some limitations, such as a small sample size and the absence of follow-up evaluations[8].

The study by Bharti et al. (2022) Found the effects of early bedside arm and leg cycle ergometry combined with conventional therapy on sitting and standing abilities in acute stroke patients. The results showed significant improvements in these abilities. Supporting this, Katz-Leurer et al. found that cycle ergometry effectively enhances motor function and trunk control in subacute stroke patients[22]. Similarly, Diserens K et al. highlighted that cycle ergometry promotes motor recovery through aerobic exercise and increased cortical activation[23]. Both of these studies support Bharti et al.'s findings, which indicate better improvements in motor function, strength, and balance in the group receiving the intervention. However, the authors noted limitations, including a short intervention duration and no follow-up assessments, suggesting that further research is needed to confirm these results[7].

Clinical Relevance

This study underscores the value of trunk training interventions—such as core stability exercises, dance therapy, and robotic-assisted rehabilitation—in improving balance, gait, and motor function in stroke patients. By enhancing postural control and mobility, these targeted approaches aid in daily functioning, supporting long-term recovery and independence in stroke rehabilitation.

Conclusion

The study concludes that core stability exercises, dance therapy, Tai Chi, gaming therapy, and robotic-assisted rehabilitation, enhance trunk control, balance, and motor recovery in stroke survivors. Robotic-assisted therapy and early cycle ergometry provide more notable benefits for balance and motor function, especially in elderly and acute stroke patients.

References

1. Castelli L, Iacovelli C, Loreti C, Malizia AM, Barone Ricciardelli I, Tomaino A, Fusco A, Biscotti L, Padua L, Giovannini S. Robotic-assisted rehabilitation for balance in stroke patients (ROAR-S): effects of cognitive, motor and functional outcomes. Eur Rev Med Pharmacol Sci. 2023 Sep;27(17):8198-8211. doi: 10.26355/eurrev_202309_33580. PMID: 37750648.
2. Lee SJ, Lee EC, Kim M, Ko SH, Huh S, Choi W, Shin YI, Min JH. Feasibility of dance therapy using telerehabilitation on trunk control and balance training in patients with stroke: A pilot study. Medicine (Baltimore). 2022 Sep 2;101(35):e30286. doi: 10.1097/MD.0000000000030286. PMID: 36107516; PMCID: PMC9439746.
3. Thijs L, Voets E, Denissen S, Mehrholz J, Elsner B, Lemmens R, Verheyden GS. Trunk training following stroke. Cochrane Database Syst Rev. 2023 Mar 2;3(3):CD013712. doi: 10.1002/14651858.CD013712.pub2. PMID: 36864008; PMCID: PMC9987175.

4. Salgueiro C, Urrútia G, Cabanas-Valdés R. Influence of Core-Stability Exercises Guided by a Tele-rehabilitation App on Trunk Performance, Balance and Gait Performance in Chronic Stroke Survivors: A Preliminary Randomized Controlled Trial. Int J Environ Res Public Health. 2022 May 7;19(9):5689. doi: 10.3390/ijerph19095689. PMID: 35565084; PMCID: PMC9101754.
5. Zhao J, Chau JPC, Chan AWK, Meng Q, Choi KC, Xiang X, Zhao Y, He R, Li Q. Tailored Sitting Tai Chi Program for Subacute Stroke Survivors: A Randomized Controlled Trial. Stroke. 2022 Jul;53(7):2192-2203. doi: 10.1161/STROKEAHA.121.036578. Epub 2022 Apr 7. PMID: 35387494.
6. Térémetz M, Garcia Alvarez A, Hanneton S, Roby-Brami A, Roche N, Bensmail D, Lindberg P, Robertson JVG. Improving upper-limb and trunk kinematics by interactive gaming in individuals with chronic stroke: A single-blinded RCT. Ann Phys Rehabil Med. 2022 May;65(3):101622. doi: 10.1016/j.rehab.2021.101622. Epub 2022 Feb 26. PMID: 34929355
7. Bharti A, Balaji GK, Agrahara S. Effect of Early Bedside Arm and Leg Cycle Ergometry on Sitting and Standing ability in Hospitalized acute Stroke Patients: A Randomized Controlled Trial. Neurol India. 2022 Sep-Oct;70(5):2065-2071. Doi: 10.4103/0028-3886.359229. PMID: 36352610.
8. Kwakkel G, Kollen BJ, Krebs HI. Effects of robot-assisted therapy on upper limb recovery after stroke: a systematic review. Neurorehabil Neural Repair. 2008 Mar-Apr;22(2):111-21. Doi: 10.1177/1545968307305457. Epub 2007 Sep 17. PMID: 17876068; PMCID: PMC2730506.
9. Salgueiro C, Urrútia G, Cabanas-Valdés R. Telerehabilitation for balance rehabilitation in the subacute stage of stroke: A pilot-controlled trial. Neuro Rehabilitation. 2022;51(1):91-99. Doi: 10.3233/NRE-210332. PMID: 35311721.
10. Ares-Benitez I, Billot M, Rigoard P, Cano-Bravo F, David R, Luque-Moreno C. Feasibility, acceptability and effects of dance therapy in stroke patients: A systematic review. Complement Ther Clin Pract. 2022 Nov;49:101662. Doi: 10.1016/j.ctcp.2022.101662. Epub 2022 Aug 28. PMID: 36084579.
11. Cabrera-Martos I., Ortiz-Rubio A., Torres-Sánchez I., López-López L., Jarrar M., Valenza M.C. The Effectiveness of Core Exercising for Postural Control in Patients with Stroke: A Systematic Review and Meta-Analysis. PM R. 2020;12:1157–1168. Doi: 10.1002/pmrj.12330. [DOI] [PubMed] [Google Scholar].
12. C. Manterola, C. Asenjo-lobos, T. Otzen Jerarquización de la evidencia. Niveles de evidencia y grados de recomendación de uso actual Rev. Chil. Infectol., 31 (2014), pp. 705-718
13. K.K. Patterson, J.S. Wong, T.U. Nguyen, D. Brooks A dance program to improve gait and balance in individuals with chronic stroke: a feasibility study Top. Stroke Rehabil., 25 (2018), pp. 410-416, 10.1080/10749357.2018.1469714
14. L. Micheli Rochetti, I. Salomão Alexandre de Assis, T. Aguiar Caires, M. Mendonça Emílio, R. De Almeida Oliveira, L.A. Pascucci Sande de Souza Effects of Bolero basic steps on balance and functional mobility in post-stroke hemiparesis: a pilot study J. Bodyw. Mov. Ther., 25 (2021), pp. 188-192, 10.1016/j.jbmt.2020.10.016
15. Thompson-Butel AG, Lin G, Shiner CT, McNulty PA. Comparison of three tools to measure improvements in upper-limb function with poststroke therapy. Neurorehabil Neural Repair. 2015;29:341–348. Doi: 10.1177/1545968314547766
16. Gao B, Feng Y, Li Q, Li M, Yang H, Yin X. Effects of 10-form Tai Chi on stroke survivors with hemiplegia. Chinese Manip Rehabil Med. 2012;3:71–72.
17. S.M. Michaelsen, R. Dannenbaum, M.F. Levin Task-specific training with trunk restraint on arm recovery in stroke: randomized control trial Stroke, 37 (2006), pp. 186-192, 10.1161/01.STR.0000196940.20446.c9
18. N.S. Ward, F. Brander, K. Kelly Intensive upper limb neurorehabilitation in chronic stroke:outcomes from the queen square programme J Neurol Neurosurg Psychiatry, 90 (2019), pp. 498-506, 10.1136/jnnp-2018-319954
19. R. Quentin, O. Awosika, L. Cohen Plasticity and recovery of function Handbook Clinical Neurology, Elsevier B.V. (2019), pp. 163-473
20. C. Bushnell, J. Bettger, K. Cockroft, S. Cramer, M. Edelen, D. Hanley, et al. Chronic stroke outcome measures for motor function intervention trials: expert panel recommendations Circ Cardiovasc Qual Outcomes, 8 (6 Suppl) (2015), pp. S163-S169, 10.1161/CIRCOUTCOMES.115.002098
21. Aprile I, Conte C, Cruciani A, Pecchioli C, Castelli L, Insalaco S, Germanotta M, Iacovelli C. Efficacy of Robot-Assisted Gait Training Combined with Robotic Balance Training in Subacute Stroke Patients: A Randomized Clinical Trial. J Clin Med 2022; 11: 5162.
22. Katz-Leurer M, Sender I, Keren O, Dvir Z. The influence of early cycling training on balance in stroke patients at the subacute stage. Results of a preliminary trial Clin Rehabil. 2006;20:398– 405
23. Diserens K, Perret N, Chatelain S, Bashir S, Ruegg D, Vuadens P, et al The effect of repetitive arm cycling on post stroke spasticity and motor control: Repetitive arm cycling and spasticity J Neurol Sci. 2007;253:18–24