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INTEGRATING CORE STABILITY WITH TASK-ORIENTED GAIT TRAINING TO IMPROVE FUNCTIONAL AMBULATION POST-STROKE: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background:

Trunk control and ambulation are critical rehabilitation goals for stroke survivors. While core stability training enhances proximal control, task-oriented gait training (TOGT) improves functional mobility through repetition of real-life walking tasks. This study investigated the combined effect of core stability and TOGT on functional ambulation post-stroke.

Objective:

To evaluate whether integrating core stability training with task-oriented gait training leads to superior improvements in trunk control, balance, and gait performance in post-stroke hemiparetic patients compared to conventional physiotherapy alone.

Methods:

This randomized controlled trial included 40 subacute stroke survivors, allocated into two groups: Experimental Group (n = 20) received a combined intervention of core stability and TOGT; Control Group (n = 20) received conventional physiotherapy. Both groups underwent 60-minute sessions, five times per week, for six weeks. Outcome measures included the Trunk Impairment Scale (TIS), 10-Meter Walk Test (10MWT), Functional Ambulation Category (FAC), Berg Balance Scale (BBS), Timed Up and Go (TUG), and Modified Rivermead Mobility Index (MRMI). Pre- and post-intervention assessments were performed by blinded assessors.

Results:

Experimental Group showed significantly greater improvements across all outcomes ($p < 0.001$) compared to Control Group. TIS scores increased by 7.9 ± 1.2 points in Experimental Group versus 3.5 ± 1.0 in Control Group. Walking speed improved by 3.2 ± 0.6 seconds in Experimental Group compared to 1.4 ± 0.5 in Control Group. FAC, BBS, TUG, and MRMI scores also reflected superior gains in the experimental group.

Conclusion:

Integrating core stability training with task-oriented gait training is more effective than conventional physiotherapy in improving trunk control and functional ambulation post-stroke.

This dual-targeted approach offers a promising strategy for optimizing stroke rehabilitation outcomes.
Keywords: *Stroke, Core stability, Task-oriented gait training, Trunk control, Ambulation, Neurorehabilitation*

INTRODUCTION

Stroke remains a major global health concern and is one of the leading causes of adult disability worldwide. It results in a wide range of motor, sensory, and cognitive impairments that significantly compromise the functional independence and quality of life of survivors. Among these, motor impairments such as poor trunk control and impaired ambulation are particularly debilitating, limiting the individual's ability to perform activities of daily living and reintegrate into the community. Functional ambulation, which encompasses the ability to walk safely and efficiently in real world environments, is a primary rehabilitation goal in post-stroke recovery programs and serves as a key determinant of overall recovery potential and independence (1, 2).

Trunk control, defined as the ability to maintain or regain balance during static and dynamic postures, is essential for achieving effective mobility and gait performance. The trunk plays a pivotal role in postural alignment, weight transfer, anticipatory postural adjustments, and the coordination of limb movements. Post-stroke hemiparetic patients often exhibit poor trunk stability, reduced anticipatory postural control, and asymmetrical weight distribution, all of which contribute to poor gait patterns and an increased risk of falls (3-5). Research has demonstrated a strong correlation between trunk impairment and mobility deficits, suggesting that trunk control is a significant predictor of functional outcome in stroke survivors (6, 7).

Core stability training has emerged as a focused intervention aimed at enhancing the strength, endurance, and neuromuscular control of the deep abdominal and back muscles that support the spine and pelvis. These core muscles contribute to the dynamic stability of the trunk and play a critical role in maintaining upright posture and facilitating coordinated limb movements during locomotion. Core training exercises target muscles such as the transversus abdominis, multifidus, internal obliques, and pelvic floor, promoting improved trunk alignment and efficient energy transfer through the kinetic chain (8, 9). Previous studies have suggested that core stability training can improve balance, gait velocity, and overall motor function in patients with neurological impairments, including stroke (10-12). However, core stability is often underemphasized in traditional rehabilitation protocols that prioritize limb-based strengthening.

On the other hand, task-oriented gait training (TOGT) is a motor-learning-based approach that emphasizes repetitive practice of functional and goal-directed walking tasks. It incorporates context-specific activities such as walking over uneven surfaces, stair climbing, changing direction, and negotiating obstacles, which stimulate motor recovery through neuroplastic adaptations. The underlying principle of TOGT is that practicing meaningful, real-life tasks enhances neural reorganization and promotes carryover to everyday activities (13, 14). This approach is supported by substantial evidence showing improvements in gait parameters, balance, and functional ambulation when TOGT is integrated into stroke rehabilitation (15).

Although both core stability training and task-oriented gait training have independently demonstrated beneficial effects on functional outcomes in stroke rehabilitation, there is limited literature exploring their combined application. The biomechanical and neuromuscular synergy between trunk control and gait function suggests that the integration of these two approaches could yield greater improvements in postural alignment, weight shifting, and dynamic balance during ambulation. Proximal trunk stability acts as a foundation for distal limb mobility, and enhancing this stability may improve the efficiency and effectiveness of task-specific gait training (16, 17). Moreover, core training may reduce the compensatory movement patterns often seen in stroke survivors, thereby promoting a more energy-efficient and symmetrical gait pattern.

The integration of core stability training into a task-oriented rehabilitation framework represents an innovative and clinically feasible strategy to address multiple aspects of stroke-related disability. By strengthening the trunk and promoting functional gait, this dual approach targets both static and dynamic components of balance and mobility. However, empirical evidence on the effectiveness of this combined intervention remains scarce, particularly in the subacute phase of stroke recovery, which is considered a critical window for rehabilitation due to heightened neural plasticity (18).

Therefore, this study aims to evaluate the effectiveness of combining core stability training with task-oriented gait training in improving trunk control and functional ambulation among subacute stroke survivors. We hypothesize that this integrated approach will produce significantly greater improvements in gait speed, trunk coordination, and overall mobility compared to conventional physiotherapy alone. This research has the potential to contribute valuable insights to clinical practice by establishing a more holistic, trunk-to-limb rehabilitation strategy for optimizing functional outcomes in stroke rehabilitation.

Methodology

Study Design and Setting

This randomized controlled trial was conducted at the Department of Physiotherapy, Nisar Medical Complex, between June 2024 and November 2024. Ethical approval was obtained from the institutional review board prior to the commencement of the study (Reference No. HRS/ERC/205 of 2024). All participants provided written informed consent before enrolment.

Participants and Sample Size

A total of 40 participants with post-stroke hemiparesis were recruited using purposive sampling based on predefined eligibility criteria. The sample size was calculated using G*Power software with an effect size of 0.8, alpha value of 0.05, and power of 0.80, resulting in a minimum requirement of 34 participants. To account for potential dropouts, 40 participants were included.

Inclusion Criteria

Participants who met the following criteria were included: Aged between 40 and 75 years, First ischemic or hemorrhagic stroke confirmed by imaging, Subacute stage of stroke (2 weeks to 6 months post-onset), Hemiparetic presentation with ability to sit independently for at least 30 seconds, Mini-Mental State Examination (MMSE) score ≥ 24 and Medically stable and cleared for participation in physical therapy

Exclusion Criteria

Participants were excluded if they had: Recurrent or bilateral strokes, Cerebellar or brainstem involvement, Severe musculoskeletal or orthopedic disorders affecting trunk or lower limb mobility, Uncorrected visual impairments, vestibular disorders, or spatial neglect and Severe aphasia or cognitive deficits precluding following instructions.

Randomization and Blinding

Participants were randomly assigned to two groups using a computer-generated random number sequence: Experimental Group: Core Stability + Task-Oriented Gait Training and Control Group: Conventional Physiotherapy.

Allocation was concealed using sealed opaque envelopes. Due to the nature of the intervention, therapist blinding was not feasible. However, outcome assessors were blinded to group allocation.

Intervention Protocols

Experimental Group: Core Stability + Task-Oriented Gait Training

Participants in the experimental group received a structured program combining core stability training and task-oriented gait training. Each session lasted 60 minutes, five times a week for six weeks.

Core Stability Training (30 minutes):

- Exercises focused on activation of deep core muscles including transversus abdominis, multifidus, and obliques
- Progressed from static (bridging, abdominal draw-in) to dynamic (Swiss ball, plank variations, pelvic tilts)
- Emphasis on proper breathing, posture, and movement control

Task-Oriented Gait Training (30 minutes):

- Activities included overground walking, obstacle negotiation, stair climbing, direction changes, and uneven surface walking
- Tasks were designed to mimic real-life ambulation challenges and were progressively intensified over the six weeks

Control Group: Conventional Physiotherapy

The control group received conventional physiotherapy focused on limb strengthening, range of motion exercises, and basic balance training without targeted core or task-oriented gait components. Session duration and frequency matched that of the experimental group.

Outcome Measures

All participants were evaluated at baseline (pre-intervention) and after 6 weeks (post-intervention) using the following outcome measures:

Primary Outcomes:

- **Trunk Impairment Scale (TIS):** to assess static and dynamic sitting balance and trunk coordination.
- **10-Meter Walk Test (10MWT):** to measure gait speed.
- **Functional Ambulation Category (FAC):** to classify the level of walking independence.

Secondary Outcomes:

- **Berg Balance Scale (BBS):** to assess balance performance.
- **Timed Up and Go Test (TUG):** to assess functional mobility
- **Modified Rivermead Mobility Index (MRMI):** to evaluate general mobility abilities.

Assessments were performed by a physiotherapist who was blinded to group assignment.

Statistical Analysis

Data were analysed using SPSS version 27. Descriptive statistics were used to summarize demographic and baseline characteristics. The Shapiro-Wilk test was used to check normality of data distribution.

- **Within-group differences** were analysed using paired t-tests or Wilcoxon signed-rank tests, depending on normality.
- **Between-group comparisons** were conducted using independent t-tests or Mann-Whitney U tests.
- A p-value < 0.05 was considered statistically significant.

Results

Participant Flow and Baseline Characteristics

A total of 40 participants were enrolled and randomly assigned to Experimental Group (n = 20) and Control Group (n = 20). All participants completed the 6-week intervention and post-treatment assessments. There were no dropouts or adverse events reported during the study.

The demographic and baseline clinical characteristics of both groups were comparable, with no statistically significant differences in age, gender distribution, time since stroke, or baseline outcome scores ($p > 0.05$). The mean age of participants in Experimental Group was 61.4±6.7 years, and in Control Group was 60.2 ±7.1 years.

Primary Outcome Measures

1. Trunk Impairment Scale (TIS): Experimental Group showed a significant improvement in TIS scores post-intervention (mean change: 7.9 ± 1.2, $p < 0.001$), compared to Control Group (mean change: 3.5 ± 1.0, $p = 0.002$). Between-group comparison revealed a statistically significant difference favouring Experimental Group ($p < 0.001$).

2. 10-Meter Walk Test (10MWT): Experimental Group demonstrated a greater reduction in time to complete the 10MWT (mean improvement: 3.2 ± 0.6 seconds) compared to Control Group (mean improvement: 1.4 ± 0.5 seconds). The between-group difference was statistically significant ($p < 0.001$), indicating faster walking speed in the experimental group.

3. Functional Ambulation Category (FAC): Post-intervention FAC scores increased significantly in Experimental Group (median improvement from 2 to 4, $p < 0.001$), whereas Control Group showed a modest improvement (median change from 2 to 3, $p = 0.04$). The difference between groups was significant ($p = 0.002$), suggesting superior functional ambulation in Experimental Group.

Secondary Outcome Measures

4. Berg Balance Scale (BBS): Experimental Group exhibited a substantial improvement in BBS scores (mean increase: 14.6 ± 2.3, $p < 0.001$), compared to Control Group (mean increase: 6.2 ± 2.0, $p = 0.003$). The between-group difference was statistically significant ($p < 0.001$).

5. Timed Up and Go (TUG):
The mean reduction in TUG time was significantly greater in Experimental Group (4.8 ± 1.1 seconds) than in Control Group (2.1 ± 0.9 seconds), with a p-value of < 0.001, indicating improved functional mobility in the experimental group.

6. Modified Rivermead Mobility Index (MRMI):
Experimental Group showed a greater mean increase in MRMI scores (8.7 ± 1.9) as compared to Control Group (4.2 ± 1.3), and the difference was statistically significant ($p < 0.001$).

Summary of Key Findings

- All within-group changes were statistically significant ($p < 0.05$), with Experimental Group consistently showing larger improvements.
- Between-group comparisons revealed statistically significant differences in favor of Experimental Group across all outcome measures.
- The combination of core stability and task-oriented gait training led to superior outcomes in trunk control, walking speed, balance, and overall functional mobility.

Table 1: Descriptive Statistics of Participant Demographics (n = 40)

Variable	Experimental Group (n = 20)	Control Group (n = 20)	p-value
Age (years, mean ± SD)	61.4 ± 6.7	60.2 ± 7.1	0.54
Gender (M/F)	12 / 8	11 / 9	0.75
Time Since Stroke (weeks, mean ± SD)	9.2 ± 2.4	9.5 ± 2.6	0.66
Affected Side (Left/Right)	10 / 10	9 / 11	0.76
MMSE Score (mean ± SD)	26.1 ± 1.3	25.8 ± 1.4	0.43

Table 2: Normality Test Results (Shapiro-Wilk Test)

Outcome Measure	Experimental Group (p-value)	Control Group (p-value)	Normal Distribution?
Trunk Impairment Scale	0.191	0.237	Yes
10-Meter Walk Test	0.112	0.154	Yes
Functional Ambulation Category	0.034	0.049	No (used non-parametric tests)
Berg Balance Scale	0.210	0.188	Yes
Timed Up and Go	0.067	0.093	Yes
MRMI	0.141	0.189	Yes

Table 3: Within-Group Comparisons (Pre- and Post-Intervention)

Outcome Measure	Experimental Group (Mean ± SD)	p-value	Control Group (Mean ± SD)	p-value
TIS	Pre: 10.1 ± 1.8 Post: 18.0 ± 1.5	<0.001	Pre: 10.3 ± 1.7 Post: 13.8 ± 1.5	0.002
10MWT (sec)	Pre: 12.6 ± 2.1 Post: 9.4 ± 1.7	<0.001	Pre: 12.8 ± 2.3 Post: 11.4 ± 2.2	0.004
FAC	Pre: 2 (IQR 2–3) Post: 4 (IQR 4–5)	<0.001	Pre: 2 (IQR 2–3) Post: 3 (IQR 3–4)	0.04
BBS	Pre: 34.2 ± 4.5 Post: 48.8 ± 5.2	<0.001	Pre: 35.1 ± 4.9 Post: 41.3 ± 5.4	0.003
TUG (sec)	Pre: 18.9 ± 3.4 Post: 14.1 ± 2.8	<0.001	Pre: 18.7 ± 3.6 Post: 16.6 ± 3.1	0.005
MRMI	Pre: 23.4 ± 3.1 Post: 32.1 ± 3.3	<0.001	Pre: 24.1 ± 3.0 Post: 28.3 ± 2.9	0.004

Table 4: Between-Group Comparisons (Post-Intervention)

Outcome Measure	Experimental Group (Post Mean ± SD)	Control Group (Post Mean ± SD)	p-value
TIS	18.0 ± 1.5	13.8 ± 1.5	<0.001
10MWT (sec)	9.4 ± 1.7	11.4 ± 2.2	<0.001
FAC	Median: 4 (IQR 4–5)	Median: 3 (IQR 3–4)	0.002
BBS	48.8 ± 5.2	41.3 ± 5.4	<0.001
TUG (sec)	14.1 ± 2.8	16.6 ± 3.1	<0.001
MRMI	32.1 ± 3.3	28.3 ± 2.9	<0.001

Discussion

The findings of this study demonstrate that integrating core stability training with task-oriented gait training (TOGT) significantly enhances trunk control, gait speed, balance, and functional ambulation in post-stroke hemiparetic patients. Participants in Experimental group, who received the combined intervention, showed greater improvements across all measured outcomes compared to those in the conventional physiotherapy group. These results highlight the synergistic potential of combining proximal stability training with function-specific locomotor practice in stroke rehabilitation. Trunk control plays a pivotal role in achieving independent mobility, and its impairment is a known predictor of poor functional outcomes following stroke (3,19, 20). Stroke survivors often experience deficits in the neuromuscular control of the trunk, resulting in compromised sitting balance, inefficient postural transitions, and impaired gait (6). The significant improvement in the Trunk Impairment Scale (TIS) observed in Experimental Group supports the effectiveness of targeted core muscle activation in restoring trunk coordination. This aligns with prior research indicating that core stability exercises contribute to better trunk alignment and improved anticipatory postural adjustments during voluntary movements (21, 22).

Moreover, the 10-Meter Walk Test (10MWT) results revealed that participants in the experimental group achieved faster walking speeds compared to the control group. Improved gait velocity not only reflects better motor control but is also a critical marker of functional recovery and community ambulation capacity (23-25).

The functional gains observed in this study can be attributed to the dynamic interaction between core stabilization and the motor learning principles inherent in task-oriented gait training. By repeatedly engaging the patient in real-life walking tasks—such as obstacle negotiation and directional changes—TOGT facilitates the reorganization of motor circuits through use-dependent neuroplasticity (26, 27). One of the most compelling findings of this study was the significant improvement in Functional Ambulation Category (FAC) scores in Experimental Group. While both groups improved, those who underwent core + TOGT demonstrated advancement to higher ambulation levels, suggesting enhanced walking independence. The FAC is sensitive to detecting clinically meaningful changes in gait function, and its progression implies better integration of trunk-limb synergy and improved balance reactions during locomotion (28, 29).

Balance, measured through the Berg Balance Scale (BBS), also improved substantially in the experimental group. Core stability training improves the strength and control of deep postural muscles, thereby enhancing the body's ability to maintain equilibrium during both static and dynamic conditions (30, 31). When coupled with TOGT, which mimics real-world challenges to balance (such as turning or navigating uneven surfaces), the intervention creates a dual benefit—stability through strength, and adaptability through task practice. This finding is consistent with the work of Verheyden et al., who showed that trunk-targeted exercises significantly correlate with balance recovery in stroke survivors (3).

The improvements in Timed Up and Go (TUG) test and Modified Rivermead Mobility Index (MRMI) further support the functional relevance of the combined approach. The TUG test evaluates functional mobility, including transitions and walking, and is an established predictor of fall risk (32). The MRMI reflects the patient's ability to perform essential mobility tasks such as rolling, transfers, and stair climbing. Enhancements in these measures suggest that the core + TOGT intervention not only targets isolated impairments but also fosters independence in daily functional tasks.

This study adds to a growing body of literature advocating for multi-component interventions in neurorehabilitation. While previous studies have evaluated the effects of core training (33) or task-oriented therapy in isolation (34), few have examined their integration in a systematic, controlled manner. Our findings suggest that these methods are not only compatible but potentially synergistic, as improved trunk stability provides a foundational platform for executing more efficient and safe ambulatory patterns. As such, the combined intervention represents a more holistic approach, addressing both the biomechanical and neurophysiological aspects of motor recovery.

The observed improvements may also be explained by principles of motor learning and neuroplasticity. Task-oriented training emphasizes repetition, variability, and contextual relevance, all of which are known to promote cortical reorganization after stroke (35). When paired with core stability—providing proximal control and postural readiness—the patient may be better positioned to engage in effective task execution. This interplay between preparatory postural control and functional mobility may accelerate motor relearning, leading to more robust outcomes.

Despite the promising results, this study has several limitations. First, the sample size, while adequately powered, was relatively small and drawn from a single clinical center, which may affect generalizability. Second, the intervention period was limited to six weeks, and long-term follow-up was not conducted. Future studies should examine the retention of functional gains over time and consider including patient-reported outcomes such as confidence in mobility or quality of life. Additionally, incorporating advanced biomechanical assessments or EMG analysis could provide deeper insights into neuromuscular changes underlying the observed functional improvements.

Nonetheless, the clinical implications of this study are significant. The integration of core stability with task-oriented gait training is feasible in typical rehabilitation settings and requires minimal additional equipment or cost. It also aligns with contemporary rehabilitation paradigms that emphasize function-based, patient-centered care. Rehabilitation professionals can implement this combined approach to address the foundational deficits in trunk control while simultaneously promoting task-specific walking practice, thereby improving both independence and participation in stroke survivors.

Conclusion

This study demonstrates that a rehabilitation program integrating core stability training with task-oriented gait training yields superior outcomes in trunk control, gait speed, balance, and functional ambulation compared to conventional physiotherapy. These findings underscore the importance of targeting both proximal stability and functional mobility through a synergistic, evidence-based approach. Incorporating such interventions into standard stroke rehabilitation protocols may enhance recovery trajectories and support better long-term functional independence.

REFERENCES

1. Feigin VL, Norrving B, Mensah GA. Global burden of stroke. Circulation research. 2017;120(3):439-48.
2. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. The Lancet. 2011;377(9778):1693-702.
3. Verheyden G, Vereeck L, Truijen S, Troch M, Herregodts I, Lafosse C, et al. Trunk performance after stroke and the relationship with balance, gait and functional ability. Clinical rehabilitation. 2006;20(5):451-8.
4. Karthikbabu S, Verheyden G. Relationship between trunk control, core muscle strength and balance confidence in community-dwelling patients with chronic stroke. Topics in stroke rehabilitation. 2021;28(2):88-95.
5. Ishiwatari M, Honaga K, Tanuma A, Takakura T, Hatori K, Kurosu A, et al. Trunk impairment as a predictor of activities of daily living in acute stroke. Frontiers in Neurology. 2021;12:665592.
6. Winstein CJ, Stein J, Arena R, Bates B, Cherney LR, Cramer SC, et al. Guidelines for adult stroke rehabilitation and recovery: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2016;47(6):e98-e169.
7. Mohan DM, Khandoker AH, Wasti SA, Ismail Ibrahim Ismail Alali S, Jelinek HF, Khalaf K. Assessment methods of post-stroke gait: A scoping review of technology-driven approaches to gait characterization and analysis. Frontiers in Neurology. 2021;12:650024.
8. Willardson JM. Developing the core: Human Kinetics; 2024.
9. Gamble K, Chiu A, Peiris C. Core stability exercises in addition to usual care physiotherapy improve stability and balance after stroke: a systematic review and meta-analysis. Archives of physical medicine and rehabilitation. 2021;102(4):762-75.
10. Moreno-Segura N, Martín-San Agustín R, García-Bafalluy S, Escriche-Escuder A. Effects of core training on trunk function, balance, and gait in stroke patients: A systematic review and meta-analysis of randomised controlled trials. Clinical Rehabilitation. 2022;36(12):1635-54.
11. Mahmood W, Ahmed Burq HSI, Ehsan S, Sagheer B, Mahmood T. Effect of core stabilization exercises in addition to conventional therapy in improving trunk mobility, function, ambulation and quality of life in stroke patients: a randomized controlled trial. BMC Sports Science, Medicine and Rehabilitation. 2022;14(1):62.
12. Park C, Yoon H. The effectiveness of core stabilization exercise using ultrasound biofeedback on motor function, balance control, gait speed and activities of daily living in stroke patients. Technology and Health Care. 2024;32(1_suppl):477-86.
13. Iqbal S, Saeed A, Batool S, Waqqar S, Khattak HG, Jabeen H. Effects of task-oriented balance training with sensory integration in post stroke patients. The Rehabilitation Journal. 2023;7(03):18-23.

14. Malik AN, Masood T. Task-oriented training and exer-gaming for improving mobility after stroke: A randomized trial. J Pak Med Assoc. 2021;71(1):186-90.
15. Lee KE, Choi M, Jeoung B. Effectiveness of rehabilitation exercise in improving physical function of stroke patients: a systematic review. International journal of environmental research and public health. 2022;19(19):12739.
16. Fukata K, Amimoto K, Inoue M, Sekine D, Inoue M, Fujino Y, et al. Effects of diagonally aligned sitting training with a tilted surface on sitting balance for low sitting performance in the early phase after stroke: a randomised controlled trial. Disability and rehabilitation. 2021;43(14):1973-81.
17. Inoue M, Amimoto K, Shida K, Sekine D, Hasegawa D, Fukata K, et al. Effects of dynamic sitting exercise with delayed visual feedback in the early post-stroke phase: A pilot double-blinded randomized controlled trial. Brain sciences. 2022;12(5):670.
18. Buma F, Kwakkel G, Ramsey N. Understanding upper limb recovery after stroke. Restorative neurology and neuroscience. 2013;31(6):707-22.
19. Hsieh C-L, Sheu C-F, Hsueh I-P, Wang C-H. Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. Stroke. 2002;33(11):2626-30.
20. Iso F, Mitsunaga W, Yamaguchi R, Shimizu N, Ito S, Honda Y, et al. Relationship among trunk control, activities of daily living, and upper extremity function during the first week after stroke in patients with acute cerebral infarction. Journal of Physical Therapy Science. 2022;34(4):315-9.
21. Cabanas-Valdés R, Boix-Sala L, Grau-Pellicer M, Guzmán-Bernal JA, Caballero-Gómez FM, Urrútia G. The effectiveness of additional core stability exercises in improving dynamic sitting balance, gait and functional rehabilitation for subacute stroke patients (core-trial): Study protocol for a randomized controlled trial. International journal of environmental research and public health. 2021;18(12):6615.
22. Chung E-J, Kim J-H, Lee B-H. The effects of core stabilization exercise on dynamic balance and gait function in stroke patients. Journal of physical therapy science. 2013;25(7):803-6.
23. Perry J, Garrett M, Gronley JK, Mulroy SJ. Classification of walking handicap in the stroke population. Stroke. 1995;26(6):982-9.
24. Torres JL, Andrade FB, Lima-Costa MF, Nascimento LR. Walking speed and home adaptations are associated with independence after stroke: a population-based prevalence study. Ciência & Saúde Coletiva. 2022;27(06):2153-62.
25. Tasseel-Ponche S, Delafontaine A, Godefroy O, Yelnik AP, Doutrellot P-L, Duchossoy C, et al. Walking speed at the acute and subacute stroke stage: A descriptive meta-analysis. Frontiers in Neurology. 2022;13:989622.
26. Bayouk J-F, Boucher JP, Leroux A. Balance training following stroke: effects of task-oriented exercises with and without altered sensory input. International Journal of Rehabilitation Research. 2006;29(1):51-9.
27. Karaca O, Kılınç M. Sensory training combined with motor training improves trunk proprioception in stroke patients: a single-blinded randomized controlled trial. Neurological Research. 2024;46(6):553-60.
28. Mehrholz J, Wagner K, Rutte K, Meiβner D, Pohl M. Predictive validity and responsiveness of the functional ambulation category in hemiparetic patients after stroke. Archives of physical medicine and rehabilitation. 2007;88(10):1314-9.

29. DCM de Wit D, Buurke J, Nijlant J, IJzerman M, Hermens H. The effect of an ankle-foot orthosis on walking ability in chronic stroke patients. Co-ordination Patterns & Functional Recovery. 2005;18:79.
30. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. Current sports medicine reports. 2008;7(1):39-44.
31. Mohammed A, Arulsingh W, Kandakurti PK. The effectiveness of core stability exercise program on lower limb performance in athletes— a scoping review. Critical Reviews™ in Physical and Rehabilitation Medicine. 2022;34(1).
32. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. Journal of the American geriatrics Society. 1991;39(2):142-8.
33. Younas F, Shafiq H, Khan S, Saleem S, Mehmood A, Ikram A. Comparison of Task-Oriented and Bobath-Based Trunk Training on Balance, Functional abilities and Walking in Ischemic Stroke Patients. Pakistan Journal of Medical & Health Sciences. 2024;18(01):47-.
34. Robinson-Bert K, Woods AB. Effectiveness of synchronous action observation and mental practice on upper extremity motor recovery after stroke. Occupational Therapy In Health Care. 2024;38(2):196-213.
35. Kleim JA, Jones TA. Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. 2008.