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EFFECT OF SENSORY INTEGRATION TRAINING ON BALANCE AMONG STROKE PATIENTS

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Abstract
This study explores how sensory integration training influences balance recovery in stroke patients by evaluating muscle activity and the limit of stability (LOS). Twenty-eight individuals participated and were randomized via computer into either a control (CON; n=15) or sensory integration training (SIT; n=13) group. Each group underwent interventions five days per week over four weeks. Both received standard physiotherapy, but the CON group also performed 30 minutes of general balance exercises, while the SIT group engaged in 30 minutes of sensory integration training.
Results showed that the SIT group had significantly greater improvements in the activity of the erector spinae (ES) and gluteus medius (GM) muscles compared to the CON group. Additionally, LOS gains—both forward and toward the affected side—were notably higher in the SIT group. These findings suggest that sensory integration training enhances balance in stroke patients by boosting activation in trunk extensors (ES) and stance-limb muscles (GM) and expanding stability limits.

Keywords: sensory integration training, balance, muscle activity, limit of stability, stroke

1. Introduction

Balance impairments in stroke survivors often stem from limited mobility, muscle weakness or tone changes, sensory deficits, abnormal postural responses, and cognitive issues[^1]. These impairments hinder daily activities and amplify fall risk[^2]. A crucial factor is the inadequate central integration of somatosensory, visual, and vestibular inputs, which normally helps compensate for a weakened sense[^3].

In healthy individuals, standing posture relies heavily on somatosensory feedback from foot pressure, ankle mechanoreceptors, and muscle proprioceptors[^4]. Yet, stroke often damages these inputs in the lower limb, making central integration essential for maintaining balance[^1,^5].

Sensory integration can be improved through tailored exercises that alter the sensory environment, such as standing on foam or performing tasks with occluded vision[^5].
Assessment tools for stroke-related balance issues include EMG of trunk extensors and stance-limb muscles, and measurements of LOS, which reflects how far the center of pressure (COP) can move without losing balance[^6–8]. Although balance training under sensory-conflicted conditions is thought to strengthen multisensory integration and improve balance[^3], little research has examined its effects on muscle activity and COP stability in stroke patients.

This study, therefore, investigates how sensory-integration-based balance training affects trunk and stance-limb muscle activity and LOS in individuals who have had a stroke.

2. Methods

2.1 Subjects

Patients hospitalized in with stroke confirmed by CT or MRI within the last 12 months, and who could stand unaided for 30 minutes with normal vision and cognition, were eligible. Exclusions included additional neurological disorders, brainstem or cerebellar stroke, vestibular issues, lower-limb orthopedic injuries, hemineglect, or pusher syndrome. All participants provided informed consent.

2.2 Design

Demographic data were collected before randomization. Participants were stratified by gender and hemiplegic side, then randomly assigned to the CON (n=15) or SIT (n=13) group.

2.3 Intervention

Over four weeks, both groups received standard physiotherapy: 30 minutes of routine therapy, 20 minutes of ergometer training, and 20 minutes of functional electrical stimulation. The CON group performed 30 minutes of general balance exercises, while the SIT group performed 30 minutes of sensory integration exercises adapted from Smania et al. (2008) and Gandolfi et al. (2015).
Three progressive levels were used:
1. **Level 1**: Standing with external COP perturbations on firm ground.
2. **Level 2**: Weight shifting forward on the affected side—CON on firm ground; SIT with eyes closed or on compliant surface.
Level 3*: External perturbations while stepping forward on the affected side—CON on solid ground; SIT with eyes closed or on compliant surface*

2.4 Outcome Measures

LOS was measured in the forward and affected-limb directions using the Biorescue pressure platform. Participants repeated each test three times, with rest intervals, and averaged the results.
Simultaneously, EMG data were collected for the ES (during forward reach) and GM (on the affected side) using Biopac MP150. After processing, signals were converted to RMS and standardized to a reference voluntary contraction (RVC) from a sit-to-stand task.

2.5 Statistical Analysis

Within-group changes (pre- vs. post-) were analyzed with paired t-tests, and between-group differences in improvement were assessed using independent t-tests. Significance was set at $p<0.05$.

3. Results

3.1 Participant Characteristics

Both groups (CON: n=15; SIT: n=13) were similar in age, gender, hemiplegic side, stroke type, height, and weight (Table 1).

Table-1 General characteristics of the subjects (number or mean±SD)

Variables	SIT (n=13)	CON (n=15)
Gender (male/female)	6/7	8/7
Paretic side (left/right)	8/5	9/6
Type (infarction/hemorrhage)	10/3	12/3
Age (years)	64.77±11.27	67.47±13.00
Height (cm)	162.31±6.56	161.53±8.58
Weight (kg)	58.92±5.86	55.13±9.43

3.2 Muscle Activity

Both groups showed significant increases in ES and GM activity post-intervention, but the improvements were significantly greater in the SIT group (Table 2).

Table 2. Comparison of pre and post muscle activity in the SIT and CON (mean±SD)

Variables		SIT (mean±sd)	CON (mean±sd)	t-value	P-value
ES	Pre	93.72±30.76	101.42±32.63	2.22*	<0.05
	Post	129.12±33.82	118.22±37.82		
	t-test	-6.10*	-2.82*		
	P-value	<0.05	<0.05		
GM	Pre	111.22±31.28	114.70±35.74	2.40*	<0.05
	Post	161.24±39.09	143.63±43.40		
	t-test	-6.82*	5.64*		
	P-value	<0.05	<0.05		

3.3 Limit of Stability

The SIT group—but not the CON group—showed significant improvements in LOS both forward and toward the affected side. The extent of improvement was also significantly higher in the SIT group (Table 3).

Table 3.Comparison of pre and post limit of stability in the SIT and CON (mean±SD)

Variables		SIT (mean±sd)	CON (mean±sd)	t-value	P-value
LF	Pre	483.08±160.64	543.20±307.71	2.67	<0.05
	Post	735.54±210.13	565.07±343.84		
	t-test	4.38	0.34		
	P-value	<0.05	<0.05		
LL	Pre	390.54±162.66	338.40±170.48	2.08	<0.05
	Post	531.77±209.82	375.47±258.35		
	t-test	3.74	1.11		
	P-value	<0.05	<0.05		

4. Discussion

Balance impairments after stroke are multi-factorial, involving muscle weakness, sensory deficits, and decreased motor coordination[^1]. Sensory integration—able to compensate when one sense is compromised—is a key component for balance recovery[^3]. Activities on unstable surfaces or with sensory restrictions can stimulate multisensory adaptation[^5].

The study found that both general and sensory integration training enhance ES and GM activation, which is essential for resisting perturbations and stabilizing posture[^6,11]. However, gains were significantly larger in the SIT group, supporting previous findings that unstable-surface training boosts hip abductor activity[^13].

Moreover, only the SIT group showed improvements in LOS—suggesting enhanced COP control. Given the roles of ES and GM in forward stability and lateral support, increased activity likely contributed to expanded LOS[^6,^13].

The results confirm that multisensory re-weighting—prioritizing reliable sensory inputs—is critical in postural control, especially when one sensory modality is impaired, as is often the case after stroke[^5,^16]. Sensory integration training may facilitate this re-weighting, improving postural responses and fall prevention.

Conclusion

Sensory integration balance training more effectively improves post-stroke balance recovery than general balance exercises. It enhances trunk extensor and hip abductor muscle activity and expands stability limits, supporting its clinical value in stroke rehabilitation

References:

[1].Bonan I. V., Colle F. M., Guichard J. P., Vicaut E., Eisenfisz M.. et al. Reliance on visual information after stroke. Part I: balance on dynamic posturography. Arch Phys Med Rehabil. 2004;85:268–273. doi: 10.1016/j.apmr.2003.06.017. [DOI] [PubMed] [Google Scholar]

[2].Tyson S. F., Hanley M., Chillala J., Selley A., Tallis R. C.. Balance Disability After Stroke. Phys Ther. 2006;86:30–38. doi: 10.1093/ptj/86.1.30. [DOI] [PubMed] [Google Scholar]

[3].Smania N., Picelli A., Gandolfi M., Fiaschi A., Tinazzi M.. Rehabilitation of sensorimotor integration deficits in balance impairment of patients with stroke hemiparesis: a before/after pilot study. Neurol Sci. 2008;5:313–319. doi: 10.1007/s10072-008-0988-0. [DOI] [PubMed] [Google Scholar]

[4].Maurer C., Mergner T., Peterka R. J.. Multisensory control of human upright stance. Exp Brain Res. 2005;171:231–250. doi: 10.1007/s00221-005-0256-y. [DOI] [PubMed] [Google Scholar]

[5].Oliveira C. B., Medeiros Í R. T., Greters M. G., Frota N. A. F., Lucato L. T., Scaff M.. et al. Abnormal sensory integration affects balance control in hemiparetic patients within the first year after stroke. Clinics. 2011;66:2043–2048. doi: 10.1590/S1807-59322011001200008. [DOI] [PMC free article] [PubMed] [Google Scholar]

[6].Graham D. F., Carty C. P., Lloyd D. G., Lichtwark G. A., Barrett R. S.. Muscle contributions to recovery from forward loss of balance by stepping. J Biomech. 2014;47:667–674. doi: 10.1016/j.jbiomech.2013.11.047. [DOI] [PubMed] [Google Scholar]

[7].Hakim R. M., Davies L, Jaworski K., Tufano N, Unterstein A.. A computerized dynamic posturography (CDP) program to reduce fall risk in a community dwelling older adult with chronic stroke: A case report. Physiother Theory and Pract. 2012;28:169–177. doi: 10.3109/09593985.2011.577887. [DOI] [PubMed] [Google Scholar]

[8].Cunha B. P., Alouche S. R., Araujo I. M. G., Freitas S. M. S. F.. Individuals with post-stroke hemiparesis are able to use additional sensory information to reduce postural sway. Neurosci Lett. 2012;513:6–11. doi: 10.1016/j.neulet.2012.01.053. [DOI] [PubMed] [Google Scholar]

[9].Gandolfi M., Munari D., Geroin C., Gajofatto A., Benedetti M. D., Midiri A.. et al. Sensory integration balance training in patients with multiple sclerosis: A randomized, controlled trial. Mult Scler. 2015;21:1453–1462. doi: 10.1177/1352458514562438. [DOI] [PubMed] [Google Scholar]

[10].Balasubramaniam R., Wing A. M.. The dynamics of standing balance. Trends Cogn Sci. 2002;6:531–536. doi: 10.1016/s1364-6613(02)02021-1. [DOI] [PubMed] [Google Scholar]

[11].Laughton C. A., Slavin M., Katdare K., Nolan L., Bean J. F., Kerrigan D. C.. et al. Aging, muscle activity, and balance control: physiologic changes associated with balance impairment. Gait Posture. 2003;18:101–108. doi: 10.1016/s0966-6362(02)00200-x. [DOI] [PubMed] [Google Scholar]

[12].Vuillerme N., Pinsault N.. Re-weighting of somatosensory inputs from the foot and the ankle for controlling posture during quiet standing following trunk extensor muscles fatigue. Exp Brain Res. 2007;183:323–327. doi: 10.1007/s00221-007-1047-4. [DOI] [PubMed] [Google Scholar]

[13].Tse Y. Y. F., Petrofsky J., Laymon M., Cavalcanti P., Daher N., Lohman E.. et al. Postural sway and EMG analysis of hip and ankle muscles during balance tasks. Int J Ther Reh. 2013;20:280–288. [Google Scholar]
[14].Pijnappels M., Bobbert M. F., van Dieën J. H.. Push-off reactions in recovery after tripping discriminate young subjects, older non-fallers and older fallers. Gait Posture. 2005;21:388–394. doi: 10.1016/j.gaitpost.2004.04.009. [DOI] [PubMed] [Google Scholar]
[15].Barrett R. S., Cronin N. J., Lichtwark G. A., Mills P. M., Carty C. P.. Adaptive recovery responses to repeated forward loss of balance in older adults. J Biomech. 2012;45:183–187. doi: 10.1016/j.jbiomech.2011.10.005. [DOI] [PubMed] [Google Scholar]
[16].Horak F. B.. Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls? Age Ageing. 2006;35(Suppl 2):ii7–ii11. doi: 10.1093/ageing/afl077. [DOI] [PubMed] [Google Scholar]