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From Stumble to Stride: Harnessing Sensory Re-Weighting for Post Stroke Mobility – A Literature review

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ABSTRACT :

Background: The present review was conducted to critically evaluate the existing body of literature on the application of sensory re-weighting strategies in rehabilitation program for stroke survivors to offer evidence-based insights that can lead more individualised, sensory focused rehabilitation interventions, potentially reducing the risk of fall and improving the quality of walking in stroke survivors.

Methods: Databases including PubMed, Cochrane Library, and Pedro were searched for published papers from 2014 to 2024. We evaluated the effect of different sensory re-weighting techniques on balance and walking independence in sub-acute and chronic stroke survivors.

Results: 8 articles described the results following the application of different sensory re-weighting techniques such as perturbation-based balance exercise, galvanic stimulations, optokinetic stimulations and gaze stability exercises on balance and walking independence in patients with stroke that met our inclusion criteria were found. Among these studies, one study described the results in subacute and seven in chronic stroke patients. The results indicated that balance and walking independence can be improved with sensory re-weighting techniques.

Conclusion: The results of this study strengthen the idea that sensory re-weighting techniques has the potential to become an effective adjacent to routine rehabilitation treatments for improving balance and walking independence post-stroke. However, research gap exists in the understanding of implementing a clinical protocol involving all the three phases of stroke recovery (Acute, Subacute & Chronic). Hence appropriate studies need to be conducted to understand the importance of sensory reweighting.

Keywords: Clinical Protocols, Neurological Rehabilitation, Stroke Survivors, balance training, sensory re-training.

Introduction :

Strokes are the world's second biggest cause of mortality and third largest cause of disability[1] According to statistics, the global cost of stroke is more than $721 billion (0.66% of global GDP), and the incidence of stroke (70%), mortality (43%), morbidity (102%), and disability (143%) is increasing from 1990 to 2019.[1] Stroke causes a wide range of sensorimotor abnormalities, including muscular weakness, diminished selective muscle control, stiffness, and a proprioceptive deficit that impairs balance and walking. Sensorimotor impairments are widespread and frequent symptoms, with a reported incidence of 50 to 80% of stroke survivors.[2] Patients with stroke (PWS) have altered gait, balance, and asymmetric walking, which increases their risk of falling.[3] The most prevalent physical dysfunction in stroke patients is impaired balance, which has been demonstrated in studies to have a frequency of up to 61-83%, and even in the chronic stage, the prevalence can reach 22-43%.[3,4] Stroke patients typically experience decreased balance as a functional sequela, which raises their risk of falling while standing and walking during recovery.[5,6]Therefore, neurorehabilitation with the goal of increasing postural stability, balance, and walking independence has gained a lot of curiosity in clinical practice.

Complex sensory adaptations are necessary to preserve postural stability and walking independence. These modifications must integrate different sensory inputs and synchronize diverse motor outputs to muscles all around the body.[7] Balance requires the integration of three major systems. The sensory system (vision, somatosensory, and vestibular) processes sensory information that evaluates the body's position and movement in space. Second, the musculoskeletal system provides the ability to generate forces that control body position. Finally, the central processing system determines effective and timely respons[8]. Visual, vestibular, and somatosensory inputs, in particular, are crucial components of the body's sensory system in terms of postural stability. [9] Constant reweighting of these three sensory signals is essential to maintain postural stability, balance, and walking independence, hence lowering the danger of falling.[7]

Sensory re-weighting is the subconscious ability to enhance the influence of one type of sensory input to compensate for a decrease or absence of information from another sensory centre.[5,6] In sensory re-weighting, the nervous system adjusts the relative importance of visual, vestibular, and somatosensory stimuli to maintain balance. When one sensory input becomes unreliable, such as stepping on an uneven surface, the brain decreases its

influence and increases dependence on other dependable signals.[10] Sensory re-weighting is crucial for the recovery of balance control in pathological situations, particularly in stroke patients.[6] These patients display combinations of sensory, motor, cognitive and emotional deficits.[2] Inadequate postural control can impair their ability to perform daily tasks on their own and, more specifically, impact their gait, which is a good indicator of future self-reliance achievement or maintenance and, as a result, a tool that allows for precise assessment of the patient's perceived disability following rehabilitation.[11] Sensory re-weighting approaches such as optokinetic stimulation, galvanic vestibular stimulation, perturbation-based balance exercises, and gaze stability exercises have been demonstrated to improve stroke survivors' reactive stepping balance, postural asymmetry, and walking independence.[1,3,5,6]The objective of this study is to examine the current evidence on the effectiveness of sensory re-weighting on improving postural stability, walking and reducing the risk of fall in stroke survivors.

Materials and Methods :

Study design: Literature review

Study setting: St Johns Medical College Hospital, Bangalore

Study criteria

The eligible studies were required to have the following criteria:

1. To be published in English
2. Investigating any form of sensory re-weighting techniques aimed at improving post stroke balance control and walking independence.
3. Full-text articles available
4. Study comparing pre-intervention and post intervention outcome measures.

Search strategy

We searched several electronic databases including, PubMed, Cochrane Library, and PEDro, and published papers from 2014 to 2024. For further relevant studies, we manually reviewed references from the collections. To decide whether the studies met the predetermined inclusion requirements, we checked authors, titles, and abstracts. The following keywords were used, “balance training”, “sensory re-training”, “stroke”, “neurorehabilitation”, and “gait”.

REVIEW OF LITERATURE :

1. **Cui, Zhe PT et al (2024)[12]**

This study evaluated the effect of a 4-week gaze stability exercises on balance, gait ability, and fall efficacy among 30 chronic stroke patients. The patients were randomly divided into 3 groups. Group 1 performed balance exercises accompanied by gaze stability exercises. Group 2 performed gaze stability exercises, and group 3 performed balance exercises. The study concluded that gaze stability exercise is an effective arbitration method to improve balance and gait ability and fall efficacy.

2. **Oluwole O. Awosika et al (2023)[13]**

This study aimed to prove that Insufficiencies in sensory reweighting is associated with walking impairment severity among 58 ambulatory chronic stroke patients. 76% of participants showed sufficient sensory reweighting with visual and somatosensory deprivation for maintaining postural stability. Findings suggest that survivors with insufficient reweighting demonstrated markedly slower overground walking speeds, greater spatiotemporal asymmetry, and limited acceleration potential.

3. **Nama Mizrachi et al (2020)[14]**

This study aimed to evaluate the effects of mechanical perturbation on gait and balance Performance among 25 chronic stroke patients. The outcomes were measured using the Performance -oriented mobility assessment (POMA) and two-minute walk test (2MWT). The findings revealed that proprioceptive training enhanced balance function, balance confidence and reduced incidence of fall in stroke patients.

4. **Vahid Esmaeli et al (2020)[15]**

This study investigated the effects of a 3-week intense and unpredictable perturbation-based balance training (PBBT) on balance, gait abilities, maximal knee strength, balance confidence and community integration among 21 chronic stroke patients**.** Patients were randomly assigned to PBBT group or non-perturbation group. The findings revealed that Intense and unpredictable gait perturbations have the potential to be an efficient component of training to improve balance abilities and community integration in individuals with chronic stroke.

5. **Handelzalts et al (2019)[16]**

This study investigated the effects of a 2.5-week perturbation-based balance training (PBBT) on static and dynamic balance among 34 subacute stroke patients. Patients were randomly assigned to PBBT group or a combined weight shifting and gait training group. Results indicated that PBBT enhanced balance function, balance confidence and reduced incidence of fall in stroke patients.

6. **Schinkel et al (2019)[17]**

This study aimed to check if PBBT Improve Control of Reactive Stepping among 16 Chronic Stroke patients. The patients were randomly assigned to either perturbation-based or traditional balance training, and underwent 6-weeks of training. Findings provide insight into the mechanism by which PBT improves reactive balance control poststroke, and support the use of PBT in balance rehabilitation programs poststroke.

7. **Hannekke JR Van et al (2018)[18]**

This study investigated the effects of a 5-week PBBT on step quality among 20 chronic stroke patients. The outcomes were measured using the 6-item Activity-specific Balance Confidence (6-ABC) scale, Berg Balance Scale (BBS), Trunk Impairment Scale (TIS), 10-Meter Walking Test (10-MWT), and Timed Up and Go-test (TUG). Results indicated that PBBT on a movable platform appears to improve reactive step quality in people with chronic stroke.

8. Isabelle Bonan et al (2015)[6]

This study aimed to investigate the postural effect of optokinetic (Okn) and galvanic vestibular (Gv) stimulation among 35 chronic patients with a left hemispheric lesion (LHL) or right hemispheric lesion (RHL). This study concluded that both GV and Okn stimulations can modulate hemi-paretic's Centre of Pressure and their postural effects are correlated.

RESULTS :

This review highlights the effect of different sensory re-weighting techniques on balance and walking independence in the sub-acute and chronic phases of stroke. Techniques like perturbation-based balance exercises (PBBT), gaze stability exercises, galvanic and optokinetic stimulations shown positive results in terms of both walking independence and postural stability in sub-acute and chronic stroke patients. There is a limited knowledge and understanding of sensory re-weighting methods in Neuro-rehabilitation field due to the paucity of research in this topic, which recommends us that further studies have to be conducted to bridge this gap.

DISCUSSION :

In stroke patients, the dynamic and static stability is impaired due to muscle weakness and sensory impairment leading to an increased risk of fall based on a prospective cohort study conducted by **Kelly Bower et al 2019**. Impairments in balance can be a consequence of changes in the motor, sensory and integrative aspect of motor control. Abnormal sensory re-weighting, i.e the ability to select the most appropriate sensory information to achieve postural stability may contribute to balance impairment as suggested by **Clarissa B Oliveria et al 2023.**

Techniques such as perturbation-based balance exercises, optokinetic stimulation, galvanic vestibular stimulation, and gaze stability exercises have been studied for their effects on improving postural balance and gait in both chronic and subacute stroke populations. In this study, we have reviewed 8 studies on the effect of different sensory re-weighting techniques on balance and walking independence of chronic and subacute stroke patients. RCTs performed by **Shirley Handelzalts et al. 2019, Nama Mizrachi et al 2020** and **Vashid Esmaeli et al. 2020** summarises that, perturbation-based balance training **(PBBT)** plays a pivotal role in enhancing balance function, confidence and reduces the risk of fall in both sub-acute and chronic stroke patients. Additionally, gaze stability exercises were found to be an effective intervention for improving both balance and gait abilities based on the 2-week follow up RCT conducted by Cui, **Zhe et al 2024.** RCT conducted by **Isabell Bonan et al. 2015** suggest that both galvanic and optokinetic vestibular helps to modulate centre of pressure in stroke patients to main static stability.

The primary limitation of our review is the limited availability of research on the topic. we have reviewed only 8 studies performed on chronic and subacute stroke patents, there are no enough articles to support effectiveness of sensory-reweighting techniques during the early phases of stroke. In the light of the 8 articles, we reviewed we can suggest that these sensory re-weighting techniques enhances walking independence, balance confidence and reduces the incidence of falls in both chronic and sub-acute stroke patients.

CONCLUSION :

In conclusion, sensory re-weighting techniques, particularly perturbation-based balance training and gaze stability exercises, show promising results in improving balance and walking independence in stroke patients. The reviewed studies highlight the effectiveness of perturbation-based training in enhancing balance, reducing fall incidence, and boosting balance confidence, particularly in chronic stroke populations. As in stroke rehabilitation, offering potential for improving functional independence and quality of life for stroke survivors. Further research exploring the combined effects of these interventions and their long-term benefits would be beneficial in advancing stroke recovery strategies.

CONFLICT OF INTEREST :

The authors declare no conflict of interest related to this study.

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