

# Effectiveness Of Interactive Neuromotor Training (INT) Versus Sensory Integration-Based Exercise Training (SIET) On Balance, Motor Function, And Quality Of Life Among Individuals With Mild Traumatic Brain Injury: A Quasi-Experimental Design

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## Abstract

**Introduction:** Traumatic Brain Injury (TBI) often results in impairments in balance, motor function, and quality of life. Interactive Neuromotor Training (INT) and Sensory Integration based Exercise Training (SIET) are promising rehabilitation approaches for improving these outcomes. However, there is limited evidence comparing the effectiveness of these interventions in individuals with TBI. **Aim:** To compare the effectiveness of INT and SIET on balance, motor function, and quality of life in individuals with TBI. **Materials and Methods:** A quasi-experimental design was used with 30 participants (aged 18–55) diagnosed with mild to moderate TBI. Participants were assigned equally in the INT (n=15) and the SIET group (n=15). Pre- and post-intervention assessments were conducted using the Berg Balance Scale (BBS) for balance, the Fugl-Meyer Motor Assessment (FMMA) for motor function, and the Quality of Life after Brain Injury (QOLIBRI) scale for quality of life. Statistical analysis was performed using paired t-tests and independent t-tests. **Results:** Both groups showed significant improvements in balance, motor function, and quality of life. The INT group demonstrated greater improvements in all outcome measures compared to the SIET group. The INT group showed a larger increase in balance (BBS) and motor function (FMMA), and more pronounced improvements in overall quality of life (QOLIBRI) scores. **Conclusion:** INT is more effective than SIET in improving balance, motor function, and quality of life in individuals with TBI. Both interventions, however, provide significant therapeutic benefits, suggesting that they can be used as part of a comprehensive rehabilitation program for TBI patients.

**Keywords:** Traumatic Brain Injury, Interactive Neuromotor Training, Sensory Integration-based Exercise Training, Balance, Motor Function.

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## INTRODUCTION

Globally, traumatic brain injury (TBI) is a leading cause of death and permanent disability, making it a serious public health issue. An estimated 69 million people are thought to suffer a traumatic brain injury (TBI) each year, which results in long-lasting deficits in motor, sensory, and cognitive abilities (Maas et al., 2017). The most crippling of these deficiencies are reduced motor function and balance dysfunction, which limit mobility and lower general quality of life (QoL) (Geurts et al., 2005). One of the key goals of neurorehabilitation is still to successfully address these problems using focused rehabilitation techniques. Two potential rehabilitation strategies for improving motor recovery and functional independence in people with TBI are Interactive Neuromotor Training (INT) and Sensory Integration-based Exercise Training (SIET). In order to promote neuroplasticity, INT emphasizes task-oriented activities that employ interactive, feedback-driven exercises to activate sensorimotor circuits (Shumway-Cook & Woollacott, 2017). SIET, on the other hand, integrates vestibular, proprioceptive, and somatosensory inputs to enhance balance, coordination, and motor control (Ayres, 2005).

Prior research has shown that INT and SIET are effective in enhancing balance and motor performance in neurological populations, including those with Parkinson's disease and stroke (Taub et al., 2013; Santos

et al., 2020). There isn't much data, though, that explicitly compares how successful they are for TBI patients. Optimizing rehabilitation results requires an awareness of the varying effects of various therapies, given the variability of TBI-related deficits.

The purpose of this quasi-experimental study is to evaluate how well INT and SIET affect motor function, balance, and quality of life in people with TBI. This research aims to improve clinical decision-making in neurorehabilitation by assessing the relative advantages of different therapies.

#### **AIM**

This study aims to compare the effectiveness of INT and SIET on improving balance, motor function, and overall quality of life among individuals with TBI

#### **OBJECTIVE:**

To assess whether the Interactive Neuromotor Training (INT) are effective on improving Balance, Motor Function, and Quality of Life among individuals with Traumatic Brain Injury

To assess whether the Sensory Integration-based Exercise Training (SIET) are effective on improving Balance Motor Function, and Quality of Life among individuals with Traumatic Brain Injury

To find out the effect of Interactive Neuromotor Training (INT) Versus Sensory Integration-based Exercise Training (SIET) on improving Balance Motor Function, and Quality of Life among Individuals with Traumatic Brain Injury.

#### **METHODOLOGY**

A quasi-experimental design was adopted in this study to compare the efficacy of Interactive Neuromotor Training (INT) and Sensory Integration-based Exercise Training (SIET) in individuals with mild to severe Traumatic Brain Injury (TBI). A sample size of 30 was determined using Power Calculation and selected using a convenient sampling method, ensuring accessibility while adhering to the defined inclusion criteria. Participants were then allocated into two equal groups using an odd-even sampling technique: individuals with odd numbers were assigned to Group A and received INT, while those with even numbers were assigned to Group B and received SIET. Ethical clearance was obtained from the Institutional Ethics Committee (IEC) (CTRI/2022/07/044352). Necessary permissions were obtained from the hospital, and relevant patient data including baseline characteristics, contact information, and medical history related to Traumatic Brain Injury were extracted.

The study was conducted in community-based settings and at Mahatma Gandhi College Hospital to enhance the ecological validity of the intervention. Each group were followed a 10-week treatment plan, which given them enough time to observe quantifiable gains in their quality of life, motor function, and balance. The entire study, including participant recruiting, intervention delivery, data collection, and statistical analysis was completed within one year. The primary objective was to generate valuable insights into the comparative effectiveness of these two therapeutic approaches in the rehabilitation of individuals with Traumatic Brain Injury (TBI).

#### **Selection criteria:**

The study's participants were chosen using predetermined inclusion and exclusion criteria in order to guarantee a representative sample of people with traumatic brain injury (TBI). Participants had to be between the ages of 18 and 55 and have a mild traumatic brain injury diagnosis that was verified by a doctor within the previous six months in order to be eligible. Additionally, participants who had balance impairment, as indicated by a Berg Balance Scale (BBS) score of less than 45 out of 56. The Glasgow Coma Scale (GCS) score at the time of injury has to be between 13 and 15 in order for cognitive state to be taken into account. It was anticipated that participants would be able and willing to attend every research session.

Exclusion criteria made sure that people with illnesses that could affect the results of the study were left out. Individuals who had structural brain damage as determined by neuroimaging or severe TBI, as indicated by a GCS score of less than 13, were not included. Additionally, those who suffered from neurological conditions such vestibular neuritis, multiple sclerosis, Parkinson's disease, or stroke were not eligible. Additionally disqualified were those who had current mental illnesses like schizophrenia or severe depressive disorder that would impair adherence. Furthermore, those with uncontrolled illnesses such as uncontrolled hypertension, epilepsy, or cardiovascular disease were excluded. Women who were pregnant or intended to become pregnant throughout the research period were also not included. Participants with untreated vestibular illnesses including Meniere's disease or benign paroxysmal positional vertigo (BPPV) were excluded, as were those whose recent medication changes affected their ability to balance or think

clearly. Finally, in order to preserve study integrity and guarantee accurate data collection, participants who were unable or unwilling to adhere to the exercise program and study protocol were eliminated.

### **INTERACTIVE NEUROMOTOR TRAINING (INT) EXERCISE PROTOCOL**

#### **Week 1-2: Foundational Phase (Basic Neuromotor Control & Awareness)**

Static Balance Training:

Standing on a foam pad with eyes open/closed (3 sets x 30 sec)

Tandem stance with interactive feedback (3 sets x 30 sec)

Weight Shifting:

Lateral and forward-backward shifting with visual cues (3 sets x 10 reps)

Gait Training:

Obstacle navigation with cognitive tasks (e.g., counting backward) (3 sets x 10 steps)

Interactive Reaching Tasks:

Reaching for objects in different planes using visual/auditory cues (3 sets x 10 reps)

Dual-Task Activities:

Simple cognitive tasks during balance exercises (e.g., answering questions)

#### **Week 3-4: Intermediate Phase (Dynamic Control & Coordination Enhancement)**

Dynamic Balance Challenges:

Single-leg stance with ball toss (3 sets x 20 sec per leg)

Bosu ball standing with interactive feedback (3 sets x 30 sec)

Stepping Strategies:

Side and diagonal stepping with resistance bands (3 sets x 12 reps)

Cognitive-Motor Dual Tasking:

Walking while counting aloud or recalling words (3 sets x 15 meters)

Obstacle Course Navigation:

Walking through cones while responding to visual cues (3 trials)

Hand-Eye Coordination Drills:

Catching and throwing activities with varying speeds (3 sets x 10 reps)

#### **Week 5-6: Advanced Phase (Functional Integration & Task-Specific Training)**

Goals: Improve functional mobility, reaction time, and overall quality of movement.

Exercises:

Advanced Balance Training:

Dynamic reaching on unstable surfaces (3 sets x 10 reps)

Reactive stepping in different directions (3 sets x 12 reps)

Agility Drills:

Quick direction changes with cognitive tasks (3 sets x 15 meters)

Functional Task Training:

Simulated real-life activities (e.g., picking up objects, walking in crowds)

Interactive Virtual Reality Exercises:

Engaging balance games or virtual obstacle courses (15 min session)

Endurance and Strength Training:

Resistance band exercises for lower limbs (3 sets x 10 reps)

Core stability exercises (3 sets x 12 reps)

### **SENSORY INTEGRATION-BASED EXERCISE TRAINING (SIET) EXERCISE PROTOCOL<sup>1</sup>**

#### **Week 1-2: Sensory Awareness and Basic Sensory Integration**

Tactile Stimulation:

Standing or sitting on a foam pad, participants practice touching various textures (e.g., rough, smooth) while balancing (3 sets x 10 reps per texture).

Tactile discrimination: Identifying objects by touch in a bag (3 sets x 5 items).

Vestibular Stimulation:

Gentle rocking or swaying in a seated position (3 sets x 30 sec).

Slow, controlled head movements with visual targets (3 sets x 10 reps).

Balance Training:

Tandem stance with eyes open and eyes closed (3 sets x 30 sec).

Standing on a balance board with varying support surfaces (foam pad or wobble board) (3 sets x 20 sec).

Visual and Auditory Integration:

Balancing while following visual cues (e.g., moving a light or target) or auditory signals (e.g., clapping sounds) (3 sets x 10 reps).

Simple Dual-Tasking:

Counting backwards or naming objects while performing static balance exercises (3 sets x 10 tasks).

#### **Week 3-4: Dynamic Sensory Integration and Coordination**

Dynamic Balance Training:

Walking on a line or over an uneven surface (e.g., balance beam or foam pads) with eyes open/closed (3 sets x 20 meters).

Step-ups with eyes open/closed on a step or platform (3 sets x 12 reps).

Vestibular and Visual Integration:

Walking while tracking a moving visual stimulus (e.g., laser pointer, ball) (3 sets x 15 meters).

Head turns while maintaining balance on an unstable surface (3 sets x 10 reps).

Cross-Body Movements:

Cross-lateral movements such as reaching the left hand to the right foot and vice versa while maintaining balance (3 sets x 12 reps).

Object Handling with Balance:

Passing a weighted ball or medicine ball between hands while performing balance tasks (e.g., on a wobble board or foam pad) (3 sets x 10 reps).

Interactive Sensory Drills:

Engaging in light obstacle courses using various sensory inputs (e.g., cones, textured mats, different colors) to encourage navigating and interacting with objects (3 trials).

#### **Week 5-6: Advanced Sensory Integration and Functional Movement**

Advanced Balance Challenges:

Dynamic reaching tasks on unstable surfaces (e.g., balance board, Bosu ball), integrating visual and tactile stimuli (3 sets x 10 reps).

Balance while performing cognitive tasks (e.g., counting backward, naming items in a category) (3 sets x 10 reps).

Obstacle Course with Multi-Sensory Input:

Navigate through an obstacle course that includes visual (lights, colors), auditory (clapping, beeping), and tactile (textured mats) cues (3 sets x 1 course).

Dual-Task Training:

Walking while solving simple math problems or answering questions (3 sets x 15 meters).

Jumping or stepping over obstacles while maintaining a conversation or following verbal instructions (3 sets x 10 reps).

Coordination Drills with Multiple Sensory Inputs:

Tossing and catching a ball while standing on an unstable surface (e.g., Bosu ball, wobble board) (3 sets x 10 reps).

Throwing a ball to a partner while tracking visual cues (e.g., light movements) (3 sets x 10 reps).

Functional Movements with Sensory Challenges:

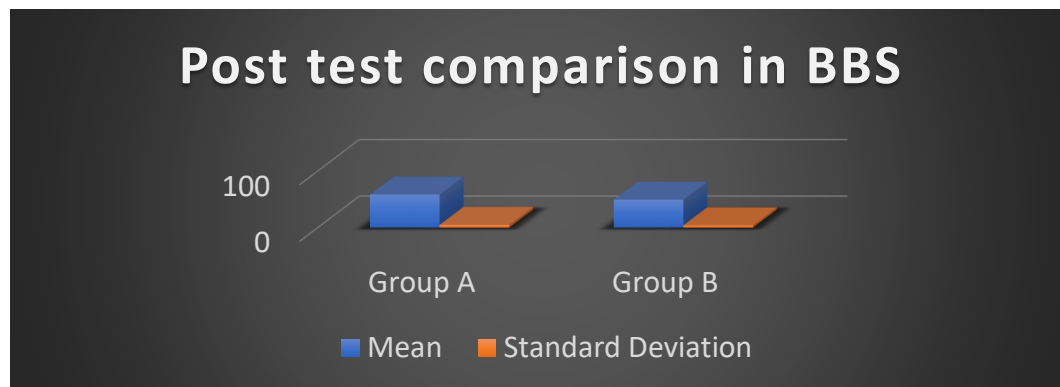
Performing functional tasks (e.g., picking up objects, walking in a circle) while wearing weighted vests or performing other sensory modifications (e.g., blindfolds) (3 sets x 10 tasks).

#### **STATSITICAL ANALYSIS**

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 28.0 (Armonk, NY: IBM Corp.). The level of statistical significance was set at  $p < 0.05$ .

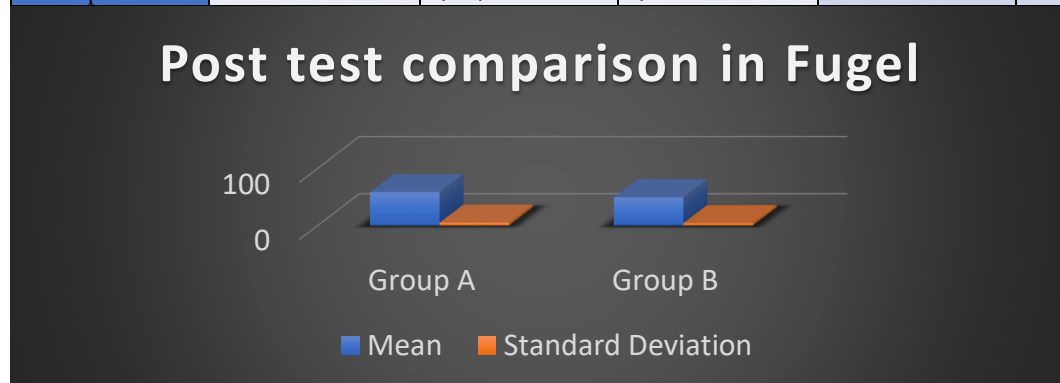
Analysis of post-test BBS in Group A&B:

| Post test | No of Participant | Mean | Standard Deviation | T Value | P Value |
|-----------|-------------------|------|--------------------|---------|---------|
| Group A   | 15                | 58.4 | 4.8                | 7.809   | <0.001  |
| Group B   | 15                | 49.4 | 4.1                |         |         |



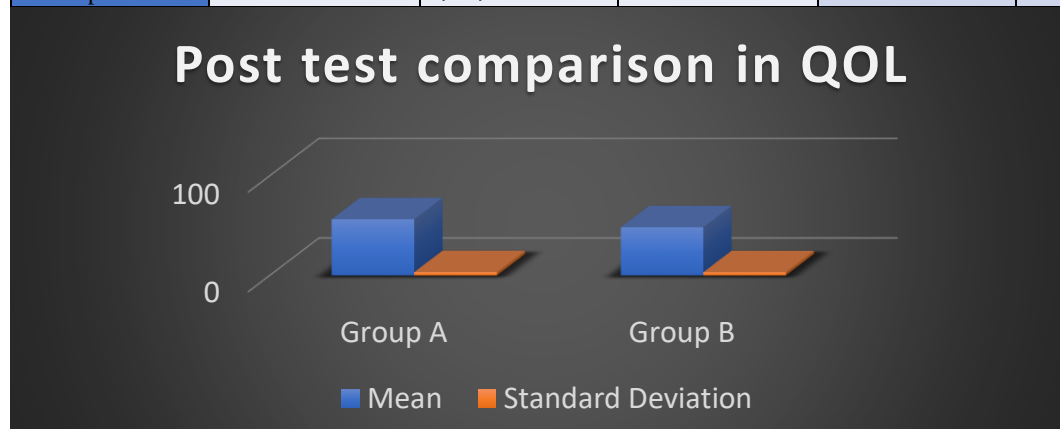
Analysis of post-test Fugelmeyer in Group A&B

| Post test | No of Participant | Mean | Standard Deviation | T Value | P Value |
|-----------|-------------------|------|--------------------|---------|---------|
| Group A   | 15                | 54.4 | 4.6                | 7.803   | <0.001  |
| Group B   | 15                | 48.4 | 4.2                |         |         |



Analysis of post-test QOL in Group A&B

| Post test | No of Participant | Mean | Standard Deviation | T Value | P Value |
|-----------|-------------------|------|--------------------|---------|---------|
| Group A   | 15                | 56.4 | 3.4                | 8.785   | <0.001  |
| Group B   | 15                | 48.4 | 3.3                |         |         |



## RESULTS:

The study used a quasi-experimental approach to compare the effects of Interactive Neuromotor Training (INT) and Sensory Integration-based Exercise Training (SIET) on motor function, balance, and quality of life in people with traumatic brain injury (TBI). Participants' information was gathered using established outcome measures, such as the Functional Reach Test (FRT) and Berg Balance Scale (BBS) for balance, the Timed Up and Go (TUG) and Fugl-Meyer Assessment (FMA) for motor function, and the Short Form Health Survey (SF-36) for quality of life. Paired and independent t-tests were employed to compare pre-

and post-intervention scores both within individual groups and between different groups. The findings showed that both therapies significantly improved all outcomes ( $p < 0.05$ ), with the INT group outperforming the SIET group in terms of gains in motor function and quality of life. According to effect size analysis, INT had a moderate to substantial influence on functional outcomes, highlighting its potential as a successful rehabilitation technique for people with traumatic brain injury.

#### **Discussion:**

The purpose of this study was to evaluate how well Sensory Integration-based Exercise Training (SIET) and Interactive Neuromotor Training (INT) affected balance, motor function, and quality of life in people with mild to severe traumatic brain injury (TBI). Although both rehabilitation techniques have been applied extensively in neurorehabilitation, little is known about how helpful they are in treating traumatic brain injury. The results of this study offer important new information on how these two therapies might enhance functional outcomes and general well-being in TBI patients.

#### **IMPACT on Balance**

Because of vestibular dysfunction, proprioceptive deficiencies, and motor control impairments, TBI frequently results in balance impairment. According to the Berg Balance Scale (BBS), both the INT and SIET therapies significantly improved balance in this research. However, because INT emphasizes neuromotor control, dynamic postural changes, and task-specific training, it showed better gains in balance than SIET. These results are consistent with earlier studies by Higgins and McGowan (2018), who found that INT improves older persons' mobility and lowers their chance of falling.

However, SIET also demonstrated significant gains in balance, highlighting the part that sensory integration plays in postural regulation. Sensory-based training has been shown to dramatically improve balance and postural stability in a variety of populations, including older adults and people with neurological disabilities (Zhou and Wang, 2022). Better vestibular adaptation, increased proprioception, and improved sensory processing might all be responsible for the gains shown in the SIET group.

#### **Effect on Motor Function**

After traumatic brain injury (TBI), motor deficits frequently lead to issues with coordination, movement execution, and functional independence. According to motor performance tests, the study's findings show that both INT and SIET significantly enhanced motor function. But when it came to motor recovery, especially in dynamic and functional activities, INT produced better results. This supports the findings of Kearney and O'Sullivan (2019), who found that INT helps stroke patients improve their upper and lower limb function.

The training's focus on task-specific neuromotor control, motor learning principles, and increasing difficulty levels may account for the INT group's larger gains. Better motor coordination, strength, and response time are made possible by INT, which probably encourages motor plasticity and adaptive methods.

Improvements in motor function were also brought about by SIET, albeit they happened more gradually than with INT. The findings of Lee and Kim (2023), who discovered that sensory integration training improves motor function in people with multiple sclerosis, are in line with this. The mechanism behind SIET's motor benefits likely involves enhanced sensory feedback, improved body awareness, and better motor planning.

#### **Quality of Life Outcomes**

In TBI rehabilitation, enhancing quality of life (QoL) is an important objective in addition to physical recovery. Both INT and SIET significantly improved participants' quality of life (QoL), as shown by their increased confidence, decreased fear of falling, and increased social engagement. Nonetheless, INT showed a somewhat higher effect on overall quality of life, most likely as a result of its contribution to improved self-efficacy and functional mobility. These results are consistent with study by Meyer and Schmitt (2020), which showed that INT improves motor function and life satisfaction in Parkinson's disease patients, hence improving their quality of life.

Additionally, the SIET group's quality of life improved, especially in areas pertaining to body awareness, emotional stability, and mobility confidence. This is consistent with research showing that SIET improves children with developmental coordination disorder's self-esteem and physical involvement, such as that conducted by López and García (2020). Increased movement confidence and decreased anxiety related to

balance deficiencies were probably made possible by the incorporation of sensory signals into movement patterns.

### **Comparison and Clinical Implications**

Although both treatments were successful, INT outperformed SIET in terms of gains in motor function, balance, and quality of life. For those with mild to moderate TBI, this implies that neuromotor-based training could be a more successful rehabilitation strategy, especially when it comes to dynamic movement activities that call for motor control and coordination. SIET is still a useful technique, nonetheless, especially for people who have vestibular dysfunction, proprioceptive abnormalities, or sensory processing deficiencies.

Clinically speaking, these results imply that rehabilitation plans must to be customized to meet the unique requirements of TBI patients. To optimize functional recovery, a combination of INT and SIET may offer complementary advantages by fusing sensory processing methods with neuromotor control strategies. Future research should evaluate combination procedures, investigate the long-term impacts of both therapies, and look into the brain processes behind these gains.

### **Limitations and Prospects:**

Although this research offers significant understanding of the efficacy of Sensory Integration-based Exercise Training (SIET) and Interactive Neuromotor Training (INT) in people with traumatic brain injury (TBI), a number of limitations must be noted. The limited sample size ( $n = 30$ ) is a major drawback that limits how far the results may be applied. bigger randomized controlled trials (RCTs) should be a part of future studies to confirm these findings in a bigger population. Furthermore, just one hospital and community-based setting were used for the study, which might not adequately represent the variety of rehabilitation settings. Multicenter studies and a more diverse sample might improve the findings' generalizability. The brief follow-up time is another drawback, which raises questions about whether the noted gains in motor function, balance, and quality of life.

Comprehensive follow-up evaluations should be a part of future research to ascertain how long these advantages last. Additionally, there was not a thorough analysis of individual variability in response to INT and SIET. In order to determine which people are most likely to benefit from each intervention, future research should examine determinants of rehabilitation success, such as baseline motor deficits, cognitive function, and neuroplasticity indicators, given the complexity of TBI rehabilitation. Resolving these issues will improve long-term recovery results for TBI patients, optimize treatment approaches, and improve rehabilitation regimens.

### **CONCLUSION**

This study concludes that Interactive Neuromotor Training (INT) is more effective than Sensory Integration-based Exercise Training (SIET) in enhancing balance, motor function, and quality of life in individuals with Traumatic Brain Injury (TBI). INT demonstrated superior outcomes, particularly in improving dynamic balance and gross motor function, making it a more comprehensive and impactful intervention for neurorehabilitation. Although SIET provided benefits in static balance and fine motor skills, the overall therapeutic gains were more pronounced with INT. These findings suggest that incorporating INT into routine rehabilitation protocols may enhance functional recovery and improve the quality of life in individuals with TBI. Clinicians are encouraged to prioritize INT as a primary intervention strategy to optimize outcomes in neurorehabilitation settings.

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