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Effect of Cognitive Sensory Motor Training on Cognition among Community-Dwelling Older Adults with Mild Cognitive Impairment: a Quasi-Experimental Study

Dr. Sirat Kaur Gill[1], Dr. Jaspinder Kaur[2], Dr. Shilpy Jetly[3]

[1]Masters of Physiotherapy, Neurology Department, DAVIPTR, Jalandhar, Punjab, India
[2]Associate Professor (MPT, Neurology), Neurology Department, DAVIPTR, Jalandhar, Punjab, India
[3]Professor (MSPT), DAV Institute of Physiotherapy and Rehabilitation, Jalandhar, Punjab, India

Abstract

Background: Mild Cognitive Impairment (MCI) is a common condition among older adults characterized by cognitive decline beyond that expected with normal aging. Cognitive Sensory Motor Training (CSMT) integrates cognitive, sensory, and motor stimulation and may enhance cognitive function in individuals with MCI.

Objective: To determine the effect of Cognitive Sensory Motor Training on cognition among community-dwelling older adults with Mild Cognitive Impairment.

Methodology: Twenty community-dwelling older adults aged 60-80 years with Mild Cognitive Impairment were recruited according to predefined inclusion and exclusion criteria. Participants were assessed using the Montreal Cognitive Assessment (MoCA) and allocated into two groups: Group A (Experimental Group, n=10), which received Cognitive Sensory Motor Training, and Group B (Control Group, n=10), which received Conventional Physical Therapy. Outcome measures were recorded at baseline and after six weeks of intervention.

Results: Participants in the experimental group demonstrated a statistically significant improvement in cognitive function compared to those receiving conventional physical therapy, as measured by MoCA scores following six weeks of intervention.

Conclusion: Cognitive Sensory Motor Training was effective in improving cognition among community-dwelling older adults with mild cognitive impairment. The findings suggest that CSMT may be incorporated as an adjunctive intervention in cognitive rehabilitation programs for older adults with MCI.

Keywords: Mild Cognitive Impairment (MCI); Cognitive Sensory Motor Training (CSMT); Cognition.

1. Introduction

The World Health Organization (WHO) defines older adults as those over 65 in developed nations and 60 in developing nations. The United Nations predicts that the global population of older individuals over 65 will double between 2021 and 2050 [1]. Population aging is an unavoidable consequence of the demographic shift toward longer lifespans and smaller families. Population aging reflects our tremendous collaborative achievement of improving the lives of billions of individuals around the world. In practically every society, women outlive males on average, while the wealthy outlive the poor. These disparities are due in part to poor nutrition and exposure to environmental and occupational dangers, which are more prevalent among males and those with low income and education [2].

Growing old is very normal and everybody must go through this stage of life at their own pace and at their own time. Ageing, in its broadest definition, is a reflection of all the changes that occur throughout life. These changes begin at birth and continue as a person matures, grows, and develops. Brain imaging abnormalities occur in normal aging without obvious clinical deficits or symptoms; neuropsychological testing can reveal mild cognitive problems [3]. Healthy ageing is defined as the process of acquiring and maintaining functional abilities that allow for well-being in later years [4]. Growing older is exciting to young people. People start to notice age-related changes including wrinkled skin, greying hair, and a fair bit of physical decline in their middle years. These changes are unavoidable for even the healthiest, most attractive people. Increased reliance during old age is the result of gradual physical decline and functional inability. Ageing is a biological phenomenon that begins at conception and concludes with death, according to the World Health Organization. Its dynamics are entirely independent of human control. The age of 60 is regarded as the start of old age and as the equivalent of retirement age in the majority of developed nations [5].

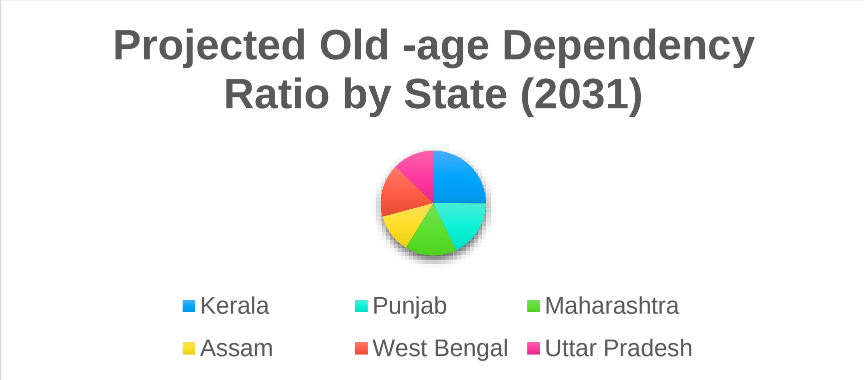
Human aging is a universal, pervasive, and unavoidable phenomenon. Every physiological function is steadily declining [6]. Aging should be viewed as a natural process rather than a disease. The natural changes that bring transitioning from one stage of life to another can bring subtle changes [7].

1.1 Demography of Ageing

Much of the world's population is increasingly getting older. Since 1950, the number of older adults has more than tripled, rising from around 130 million to 419 million in 2000, with the aged population share increasing from 4% to 7% [8]. Population aging affects both developed and developing countries worldwide, particularly Europe, North America, Southeast Asia, and South America. However, the extent of population aging varies internationally. Aging occurs at a significantly faster rate in nations with limited resources than in industrialized nations. The overall percentage of individuals aged 60 and beyond has grown from 5.4% in 1950 to 7% in 2009, and is projected to reach 20% by 2050 [9].

According to the United Nations (2022), the elderly population is expected to increase from 10% in 2022 to 16% by 2050. By 2050, the elderly population is predicted to outweigh youngsters under the age of five. The population aged 60 years and above was 8.61% in 2011, expected to increase to 13.13% in 2031. In India, the aging process varies by area, with the southern states leading the way as they are more economic and socially developed. Between 2001 and 2031, the old age dependency ratio (the ratio of elderly individuals to those of working age) will be increased. The percentage of old-age people compared to working-age people is expected to increase in each state, with Kerala leading the way (12.2% to 22.4%), followed by Punjab (10% to 15.8%), Maharashtra (10% to 14.2%), Assam (6.6% to 10.8%), West Bengal (8.1% to 14.6%), and Uttar Pradesh (8.3% to 10%) [10].

Figure 1: Projected Old-age dependency ratio by State (2031)



1.2 Ageing and its associated Physiological Changes

Ageing triggers irreversible loss of physical function across all organ systems due to the accumulation of damage that occurs in reaction to various stresses. As individuals age, they often develop various comorbidities, particularly around the age of 60 [11]. Aging is a spontaneous process of getting older that describes a wide range of physiological changes in the human system. It is a biological complex that allows people to age without succumbing to the illness [12]. Aging involves the process of gradual, progressive and spontaneous deterioration of most physiological functions [13]. Individuals age at varying speeds, and physiological responses fluctuate significantly. Age-related physiological function declines in most organ systems, but the rate varies by system and individual. Function redundancy is minimized, as is repairability [14]. The major physiological changes affecting certain systems in the elderly population are summarized in Table 1.

Table 1: Age-Related Physiological Changes Across Different Body Systems

Body System	Common Age-Related Changes
Neurological System	Stroke, Parkinsonism, Alzheimer's disease
Respiratory System	Impaired gas exchange, Decreased vital capacity, Slower expiratory flow rates
Cardiovascular System	Decreased cardiac output, Increased blood pressure, Arteriosclerosis
Auditory System	Presbycusis, Imbalance and Vertigo
Musculoskeletal System	Osteoporosis, Osteopenia, Osteoarthritis
Integumentary System	Epidermal atrophy, Reduced skin tone and elasticity
Gastrointestinal System	Atrophic gastritis
Hepatic System	Altered drug metabolism
Special Senses	Age-related decline in sensory functions

1.3 Impact of Age on the Mental and Cognitive Function

Cognition plays a crucial role in maintaining functional independence as individuals age, including the ability to handle finances, take medications appropriately, and drive safely. Intact cognition is essential for effective communication, including sensory processing, integration, and appropriate response to others [15]. Elderly individuals typically experience cognitive loss and disability. Early life experiences, including cultural, physical, and social factors, might impact cognitive development and functioning [16].

Cognitive capacities frequently deteriorate with aging. It's crucial to distinguish between cognitive changes that occur naturally with aging and those that may indicate a brain disease [17].

Cognitive abilities are classified into categories such as attention, memory, executive function, language, and visuospatial. Each of these categories exhibits measurable deterioration with age [18]. Each domain requires a person to recognize the stimulus, analyze the information, and respond. As people age, their sensory perception and processing speed deteriorate, affecting their test performance across various cognitive areas [17].

1.3.1 Attention

As we age, our ability to do sophisticated attentional activities like selective or divided attention decreases significantly. Selective attention involves focusing on pertinent information while dismissing extraneous information. Divided attention refers to the capacity to focus on numerous tasks concurrently, such as completing an obstacle course and completing questionnaires. As people age, their ability to conduct complicated attentional tasks decreases whereas simple attention tests such as digit span persist in normal persons until the age of 80 [18]. Although there is a gradual loss in overall accuracy in the early 60s, healthy older adults maintain high sustained attention [15].

1.3.2 Memory

While some components of memory remain steady with age, there is a loss in new learning abilities and retrieval of previously learned data [18]. Older adults may struggle with tests that need more than typical primary storage capacity (e.g., six to seven items), whereas immediate or “sensory memory” remains stable with age. Although historical and autobiographical memories remain stable with age, source memory accuracy and episodic memory detail decrease. Delayed free recall, a measure of new learning, reduces with age. Older adults may struggle with learning when tests require mental manipulation (working memory) or multitasking (divided attention). Working memory, which needs active manipulation of material to learn, declines with aging. As people age, their ability to retain new information remains largely steady. However, retrieving information may require additional cues or recognition formats to maintain stability. As we get older, our ability to remember future actions, such as taking medication after breakfast, decreases. Older individuals retain procedural memories, such as how to play the piano or ride a bike [17].

1.3.3 Executive Functions

Executive cognitive functions include decision-making, problem-solving, response planning, and multitasking. With aging, each of these domains of executive cognitive performance declines [18]. The prefrontal cortex plays a crucial role in executive cognitive function, especially for novel tasks when habitual reactions may not be optimal. Age-related reductions in performance on innovative, complicated, or timed examinations, as well as tasks requiring selective inhibition or differentiating between important and irrelevant information [17]. In addition, there are age-related declines in concept formulation, abstraction, and mental flexibility, particularly among those over 70 years old [18].

1.3.4 Speech and Language Functions

As people get older, their speech and language skills remain mostly intact [18]. Normal conversational skills, including vocabulary, verbal reasoning, and speech comprehension, remain steady as we age. Speech comprehension declines with age, especially in noisy and ambiguous environments. Speech comprehension requires both peripheral nervous system sensitivity to sense and central nervous system speech-specific cognitive capacities [19]. These cognitive capacities of the central nervous system are crucial in challenging listening situations and might vary with aging. Recent research indicates a correlation between aging-related changes in left frontal lobe architecture and speech-in-noise test performance [20]. Verbal abilities, including fluency, retrieval or confrontational naming, may deteriorate with aging [17]. Critchley found that older adults tend to be less verbose, repetitious, and vague in their spontaneous speech than younger adults [21].

1.3.5 Visuospatial Processing

Aging can lead to impairments in visuospatial processing and constructional praxis [18]. Visual identification of objects, forms, gestures, and signs stays steady even in elderly person age. Nevertheless, our visuo-perceptual judgment and perception of spatial orientation decrease as we age. Age does not influence a person's ability to reproduce simple figures, but the ability to duplicate complicated designs, such as the Rey figure, decreases with age. Although age-related losses in traditional IQ tests like block design and item assembly can be attributed to time, there is still a decline in test performance with increasing age. As people become older, their free sketching skills tend to become more simple and less defined [17].

1.4 Incidence & Prevalence of Cognitive Decline which progresses to Alzheimer’s Disease

Even after controlling for age, gender, and education, cognitive impairment is more prevalent in India (4.3%) compared to China (0.8%). Among the total participants, 24.6% of Indian participants had any cognitive impairment, with dementia constituting 1.2% [22]. In 2006, 26.6 million persons worldwide were affected by Alzheimer's disease (AD), with an estimated yearly cost of $156 billion for dementia care [23]. By 2050, the disease's prevalence is projected to double, with one in every 85 individuals living with it and 43.0% requiring advanced care (e.g., nursing homes) [24].

1.5 Cognitive Sensory Motor Training (CSMT) Therapy

Cognitive Sensory Motor Training Therapy is a unique holistic rehabilitation therapy that involves systematic retraining and coaching of sensory-guided motor control. It is widely applied in many European nations, such as Italy, Germany, and Austria. Professor Carlo Perfetti's Cognitive Sensory Motor Training Therapy is characterized by its focus on sensory retraining, particularly joint position perception [25]. CSMT is a highly specialized program of comprehensive rehabilitation, which re-educates sensory-caused motor control and cooperative systematic guidance [26]. It has been discovered that training in a multi-component cognitive rehabilitative program for individuals with mild cognitive dysfunction is helpful in enhancing their capacity to perform daily activities and focus [27]. Furthermore, internal as well as external sensory input stimuli are also advantageous in motor recovery [28]. The learning theory-based CSMT aims to cause recovery of motor function and enable patients to engage their cognitive processes, which will lead to effective healing from injury [29].

Mild cognitive impairment is a common condition among community-dwelling older adults and is associated with progressive cognitive decline, affecting independence and quality of life. Although many articles have been published regarding the application of CSMT in the upper and lower extremities for cognitive sensory rehabilitation among stroke patients, no articles have been published regarding the application of CSMT in the lower extremity for mild cognitively impaired individuals. The efficacy of CSMT on enhancing cognition in patients with mild cognitive impairment is unknown. Therefore, the present study was undertaken to evaluate the effect of Cognitive Sensory Motor Training on cognition in this population and to provide evidence for its use as a non-pharmacological rehabilitation approach.

Although Cognitive Sensory Motor Training has shown promising benefits in enhancing cognitive function, the available evidence regarding its effectiveness in community-dwelling older adults with mild cognitive impairment remains limited.

2. Methodology

2.1 Study Design

This Study was conducted using a quasi-experimental design, and participants were enrolled through convenient sampling method.

2.2 Protocol

The patients meeting the inclusion criteria were recruited for the study. After explaining the need and the procedure of the study, written informed consent was obtained from the subjects. A minimum of 20 subjects were taken and divided into two groups using a convenient sampling method. Two groups were taken including Group A (Experimental Group) receiving Cognitive Sensory Motor Training (CSMT) for a duration of 30 minutes, 5 times weekly, for 6 weeks and Group B (Control Group) receiving Conventional Physical Therapy Training for a duration of 30 minutes, 5 days in a week, for 6 weeks. Each selected participant was assessed for cognition using the outcome measure at the baseline (Day 1) and after 6 weeks (post-intervention).

2.3 Procedure

Experimental Group (Group A) Intervention

Cognitive Sensory Motor Training

The objective of using CSMT was to improve the motor performance of the lower limb, and cognitive and physical functions in older adults thereby decrease the symptoms of depression. In this study, the participants received 30 minutes of cognitive sensory motor training in a sitting position five times weekly for six weeks. To improve the effectiveness of exercise training, the training was conducted in a quiet, unobstructed setting while keeping a suitable temperature. During the training, subjects were offered five minutes of rest if they felt fatigued, reported pain, or had breathing abnormalities. The same investigator carried out the training with the same contents from commencement through the completion of the research project.

CSMT group training included proprioceptive, tactile stimulation, pressure stimulation, and spatial task training. Each of these was applied for an overall duration of 30 minutes, 5 minutes each in an upright position. The training was halted if it could not be sustained for 30 minutes due to the subjects' motor abilities. After consulting the senior physical therapists, we modified and supplemented the program based on comments from Chanubol et al. (2012), Cappellino et al. (2012), and Kim et al. (2021). The ultimate Cognitive Sensory Motor Training Protocol used in this research is broken into six segments, each lasting five minutes.

Proprioceptive Training: It serves to improve sensation of position and movement. Proprioception training was conducted in both the starting position and terminal position after applying pressure to the ankle joint. (Figure 2) During the exercise, the patient was blindfolded and instructed to concentrate on perceiving the position of the limb that is being moved passively by the therapist. Initially, only one joint was shifted at a time. After the therapist had finished relocating the joint, the subjects were asked to describe their perception of its location. At first, each participant had to choose between only two points. If they could consistently answer effectively, they were challenged to distinguish between three, four, and five positions. During this level of training, patients were told not to try any movement actively, but to relax and feel the position of the joint. Training for joints with several planes of movement was done independently for each plane. For example, plantarflexion and dorsiflexion of ankle joint were trained separately from inversion and eversion of the ankle.

Tactile Stimulation Training: It included a tactile activity to differentiate between surface materials and improve friction perception. Subjects utilized visual and somatosensory strategies to distinguish between the senses. (Figure 3) At this point, the therapist places a portion of the patient's limb, usually the sole of the foot, on an external object (such as a tennis ball or a stick) and instructed the patient to actively make an effort to move his or her limb over the object and try to detect the shape, position, or size of the object. The training material was then moved, and another object of an alternate shape or size was presented. Patients had to distinguish amongst the two things. Once they had mastered this, they were given an increasing number of objects (up to five in total).

Pressure Stimulation Training: Subjects demonstrated a cognitive challenge in distinguishing the difference in the degree of sponge pressure in the sitting posture, and the patient was asked to discriminate between the visual and somatosensory senses while performing an activity. (Figure 4)

Spatial Tasks: For the training employing spatial tasks, exercise regimes were given to differentiate distance and direction. It is further divided into three segments.

a) A spatial task was assigned to determine where the foot of the individual was situated in four different zones. A vertical line was drawn on the ground straight from the individual's knee and then horizontally divided into half, such that the floor was now split into four sections. (Figure 5.1)

b) A spatial task training to recognize distinct positions on a straight line with the patient's heel in contact with the bearing surface, with three lines drawn on the floor based on the knee angle. Training was carried out to determine whether the distance had changed. If this was carried out fully, the task was then accomplished by adding a line. (Figure 5.2)

c) For Spatial Cognition training, a movement was executed to recreate an ellipse in the forefront of the body. The movement was produced by starting from a relatively small point on a drawing board and progressing to larger circles. (Figure 5.3)

Control Group (Group B) Intervention

Conventional Physical Therapy Training

The Control Group received exercises to improve the range of motion of lower limb joints, stretching and strengthening of the lower extremity muscles, gait training, balance training, and super-dynamic tasks including Dual tasks like catch and throw a ball while walking, Cone Drills and Step over obstacles while carrying something. For six weeks, the subjects received conventional physical therapy training for 30 minutes, five days a week. During the training, subjects were offered five minutes of rest if they felt fatigued, reported of pain, or had breathing abnormalities.

Figure 2: Proprioceptive Training

Figure 3: Tactile Stimulation Training

Figure 4: Pressure Stimulation Training

Figure 5.1: Spatial Task with a Quadrant

Figure 5.2: Spatial Task with a Straight Line

Figure 5.3: Spatial Task with an Ellipse

3. Results

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) software, Version 18.0. Descriptive statistics were used to summarize the demographic characteristics and Montreal Cognitive Assessment (MoCA) scores of the participants. Within-group comparisons of pre-test and post-test MoCA scores were performed using the paired *t*-test, whereas between-group comparisons were conducted using the independent *t*-test. A 95% confidence level was adopted, and a p-value of <0.05 was considered statistically significant. For the effective presentation and interpretation of the findings, the study data were arranged in the form of tables and graphs.

A total of 20 community-dwelling older adults with mild cognitive impairment were included in the study. The participants were equally allocated to Group A (Cognitive Sensory Motor Training; $n = 10$) and Group B (Conventional Physical Therapy Training; $n = 10$). An identical gender distribution was observed in both groups, with 4 males (40%) and 6 females (60%) in each group, thereby ensuring baseline comparability and minimizing gender-related bias. Cognitive function was assessed using the Montreal Cognitive Assessment (MoCA).

Within-Group Comparison of MoCA Scores

A statistically significant improvement in cognitive function was observed within both groups following the intervention. In **Group A**, the mean MoCA score was increased from **21.70 ± 1.16** at baseline to **26.10 ± 1.20** after the intervention ($t = 14.402$, $p < 0.001$), indicating a highly significant improvement (Table 2, Graph 1). Similarly, in **Group B**, the mean MoCA score was increased from **21.80 ± 1.23** to **24.00 ± 0.94** ($t = 11.000$, $p < 0.001$), demonstrating a statistically significant improvement (Table 3, Graph 2).

Table 2: Within-Group Comparison of MoCA Scores in Group A (Paired t-test)

Paired T Test	**Group A**	
	MoCA	
Table No 5.3	Pre	Post
Mean	21.70	26.10
S.D.	1.160	1.197
Number	10	10
Mean Difference	4.40	
Paired T Test	14.402	
P value	0.0000	
Table Value at 0.05	2.26	
Result	Significant	

Graph 1: Within-Group Comparison of MoCA Scores in Group A (Paired t-test)

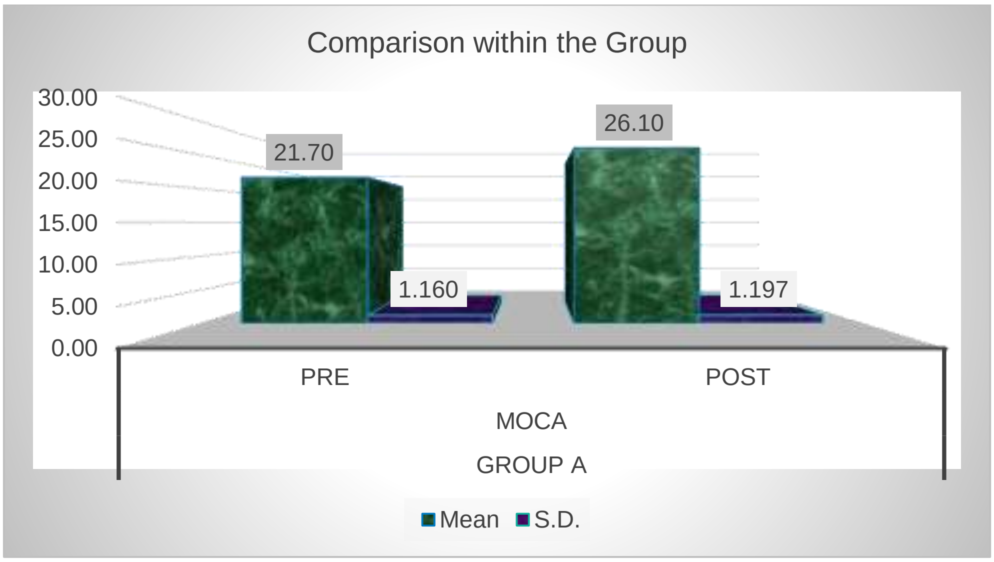
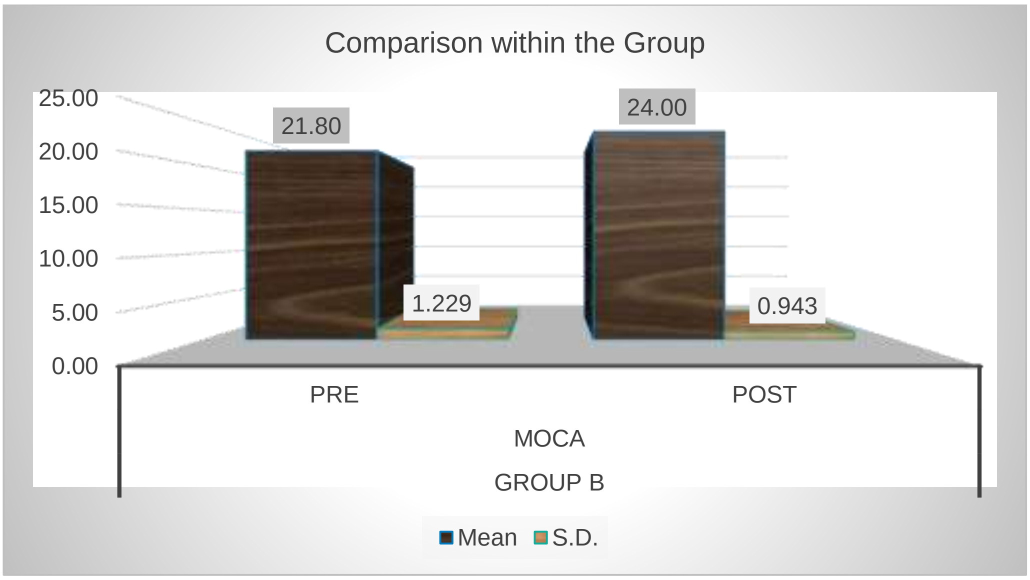


Table 3: Within-Group Comparison of MoCA Scores in Group B (Paired t-test)

Paired T Test	Group B MoCA	
Table No 5.4	Pre	Post
Mean	21.80	24.00
S.D.	1.229	0.943
Number	10	10
Mean Difference	2.20	
Paired T Test	11.000	
P value	0.0000	
Table Value at 0.05	2.26	
Result	Significant	

Graph 2: Within-Group Comparison of MoCA Scores in Group B (Paired t-test)



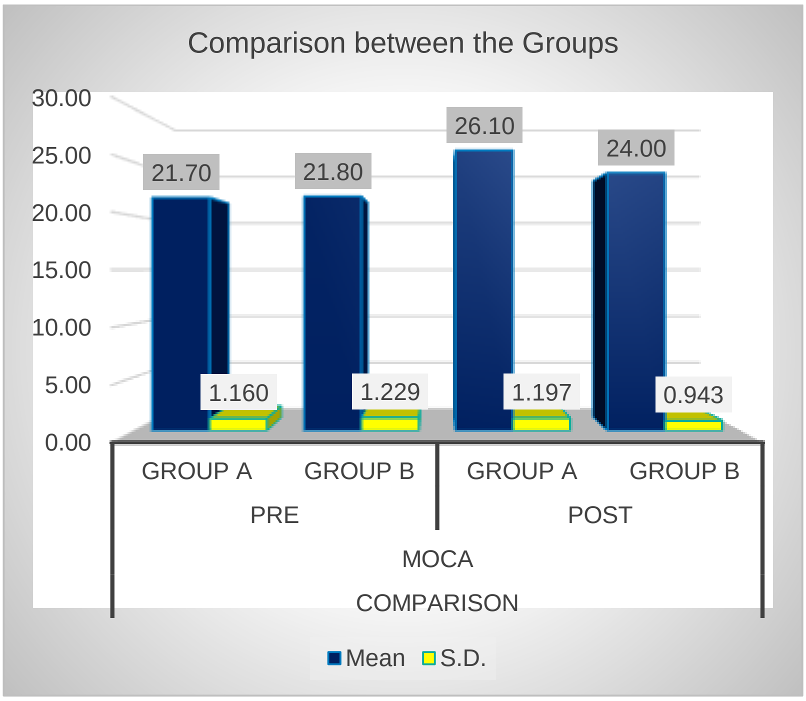
Between-Group Comparison of MoCA Scores

No statistically significant difference was observed between the two groups at baseline (**Group A: 21.70 ± 1.16; Group B: 21.80 ± 1.23**; t = 0.187, p = 0.8536), indicating that comparable levels of cognitive impairment were present before the intervention. Following the intervention, a statistically significant difference was observed between the groups, with **Group A** demonstrating a higher post-test mean MoCA score (**26.10 ± 1.20**) than **Group B** (**24.00 ± 0.94**) (t = 4.358, p = 0.0004) (Table 4, Graph 3).

Table 4: Between-Group Comparison of MoCA Scores (Unpaired t-test)

Unpaired T Test	**Comparison**			
	MoCA			
	Pre		**Post**	
	Group A	**Group B**	**Group A**	**Group B**
Mean	21.70	21.80	26.10	24.00
S.D.	1.160	1.229	1.197	0.943
Number	10	10	10	10
Mean Difference	0.10		2.10	
Unpaired T Test	0.187		4.358	
P value	0.8536		0.0004	
Table Value at 0.05	2.10		2.10	
Result	Not-Significant		Significant	

Graph 3: Between-Group Comparison of MoCA Scores (Unpaired t-test)



Statistically significant improvements in cognitive function were observed following both Cognitive Sensory Motor Training and Conventional Physical Therapy Training. However, significantly greater improvements in MoCA scores were observed in Group A than in Group B. These findings indicate that

Cognitive Sensory Motor Training was more effective than Conventional Physical Therapy Training in improving cognitive function among community-dwelling older adults with mild cognitive impairment.

4. Discussion

The present study demonstrated a significant improvement in cognitive function in both groups, with greater improvement observed in the Cognitive Sensory Motor Training (CSMT) group compared to the conventional physiotherapy group. These findings suggest that CSMT is more effective in enhancing cognition among community-dwelling older adults with mild cognitive impairment.

The results are consistent with the findings of **Tao et al. (2023)**, who reported that motor–cognitive interventions improve cognitive function in older adults with mild cognitive impairment by combining physical activity with cognitive challenges. A possible explanation for these findings lies in the principles of the Perfetti Method, which considers movement as a cognitive process. By requiring participants to interpret proprioceptive, tactile, and spatial information rather than relying on visual input, CSMT promotes active cognitive engagement and sensory integration.

Furthermore, **Quispe Arias et al. (2023)** suggested that sensory-motor interventions facilitate neuroplasticity by promoting adaptive changes in brain function. These neuroplastic adaptations may explain the superior cognitive improvements observed following CSMT. Therefore, the findings of the present study support the use of Cognitive Sensory Motor Training as an effective non-pharmacological intervention for improving cognition in community-dwelling older adults with mild cognitive impairment.

5. Future Scope

Future research should include larger and more diverse samples to enhance the generalizability of the findings. Studies with longer intervention durations and extended follow-up periods are recommended to evaluate the long-term sustainability of cognitive improvements. Furthermore, randomized controlled trials incorporating comprehensive neuropsychological assessments are warranted to strengthen the evidence regarding the effectiveness of Cognitive Sensory Motor Training. Future investigations may also explore the applicability of this intervention in different neurological populations and community-based settings, including structured home-based rehabilitation programs.

6. Conclusion

The findings of the present quasi-experimental study demonstrate that Cognitive Sensory Motor Training (CSMT) is an effective intervention for improving cognition among community-dwelling older adults with Mild Cognitive Impairment (MCI). Participants who received CSMT showed significant improvement in cognitive function following the intervention, indicating its potential as a beneficial rehabilitation strategy for this population.

Although both intervention groups demonstrated positive outcomes, Cognitive Sensory Motor Training produced greater improvement in cognitive performance compared to conventional physiotherapy. These findings suggest that integrating cognitive, sensory, and motor components within a structured rehabilitation program may enhance cognitive functioning more effectively than conventional approaches alone.

Overall, the study supports the incorporation of Cognitive Sensory Motor Training into routine physiotherapy practice for community-dwelling older adults with Mild Cognitive Impairment to promote cognitive health, functional independence, and quality of life. Further studies with larger sample sizes and long-term follow-up are recommended to confirm these findings and evaluate the sustainability of the intervention's effects.

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