

**“EFFECT OF MOTOR COGNITIVE TRAINING VS MOTOR DUAL-
TASK TRAINING ON EXECUTIVE FUNCTION IN YOUNGER ADULTS
- A RANDOMIZED CLINICAL TRIAL”**

Dissertation Submitted to the

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MASTER OF PHYSIOTHERAPY (M.P.T)

In

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Under the guidance of

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2021-2023



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I hereby declare that this dissertation entitled “**EFFECT OF MOTOR COGNITIVE TRAINING VS MOTOR DUAL-TASK TRAINING ON EXECUTIVE FUNCTION IN YOUNGER ADULTS**” is a bonafide and genuine research work carried out by me under the guidance of DR. Sonali Soumyashree Assistant Professor, Abhinav Bindra Sports Medicine and Research Institute, Odisha

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LIST OF ABBREVIATIONS

1. **ABSMARI** – Abhinav Bindra Sports Medicine and Research Institute
2. **TMT** - Trail Making Test
3. **DTT** – Dual-Task Training
4. **SPSS** – Statistical package for social science
5. **BMI** – Body Mass Index
6. **DST**– Digit Span Test
7. **IQR** – Interquartile Range
8. **MMSE** – Mini-Mental State Examination

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ABSTRACT

“EFFECT OF MOTOR COGNITIVE TRAINING VS MOTOR DUAL-TASK TRAINING ON EXECUTIVE FUNCTION IN YOUNGER ADULTS”

A RANDOMIZED CLINICAL TRIAL

Background: Dual-task training (DTT) is a kind of exercise program that combines cognitive and physical components. It is separated into motor cognitive dual-task training (mCdtt) and motor dual-task training (mMdtt). DTT can both delay and improve cognitive abilities. However, research on the Dual task training program with younger persons is limited. Because motor cognitive dual-task training and motor dual-task training are beneficial in increasing executive function, younger individuals have been reported to have worse executive function as a result of increased smartphone usage and a sedentary lifestyle. As a result, the goal of this research is to determine which of the following training methods is optimal for restoring or improving executive function.

Methods: This study comprised 44 young individuals (21 males and 23 females) with MMSE scores more than or equal to 24, Beck Depression Inventory scores greater than or equal to 28, and not having trouble with visual ability or hearing. Participants were randomly allocated to either Group A (mCdtt) or Group B (mMdtt). while accomplishing physical activities, participants in Group A counted back from a two-digit number, whereas participants in Group B held half-filled glasses with both hands near the trunk with 90-degree elbow flexion while conducting physical exercises. The intervention program continued for four consecutive weeks. Trail Making Test (TMT) parts A and B, as well as the Digit Span Test (DST) Forward and Backward, were utilized for assessing the executive function.

Results: Our study demonstrated that the 4-week mCdtt Group A and mMdtt Group B programs in TMT (A) Group B performed better than Group A, while in TMT (B) Group A performed better than Group B. In both the forward and backward Digit span tests, both groups improved significantly.

Conclusion: According to the findings of this study, motor cognitive training and motor dual-task training both improved executive function in young adults. A

systematic dual-task training program, a longer intervention duration, and a follow-up period in younger individuals should be developed for future studies comparing motor cognitive training with motor dual-task training.

Keywords: Dual-task training, motor cognitive dual-task training, motor dual-task training, executive functions younger adults

INTRODUCTION

Executive functions are defined as higher-order cognitive abilities that include working memory, inhibitory control, reasoning, planning & problem-solving categorized as higher-order cognitive functions.^[1] The term executive functions refer to the higher-level cognitive skills that are used to control and coordinate other cognitive abilities and behaviors. These skills are used every day to adapt to daily life situations and manage social interactions. Though studies have shown the frontal and prefrontal cortex to be associated with executive functions, recent studies have shown the involvement of posterior and subcortical regions in the processing of executive functions via the dorsolateral prefrontal–subcortical circuit.^[1]

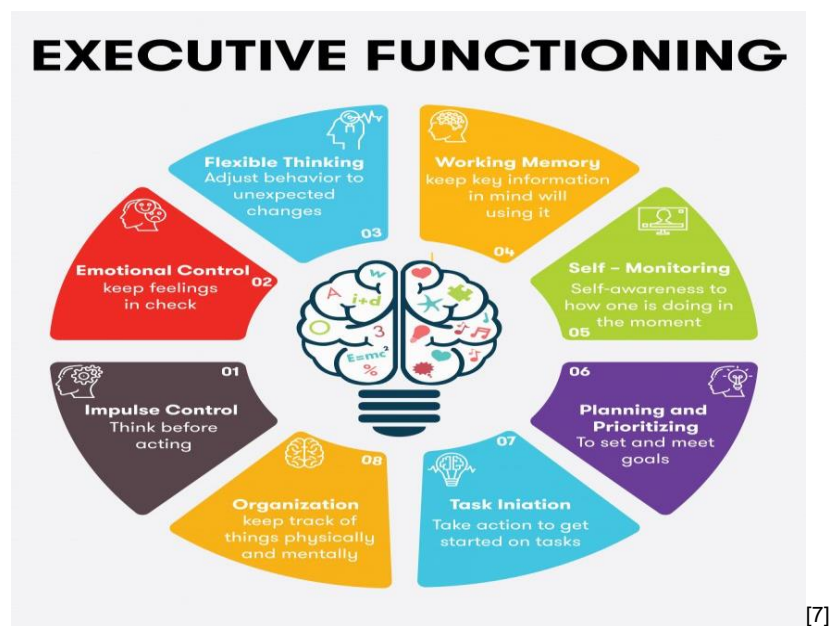


FIGURE 1.1: Components of Executive function

The executive function consists of three domains including inhibitory control, working memory, cognitive flexibility, planning, and reasoning.^[1] Inhibitory control is the ability to ignore distractions and resist temptations and is related to selective attention.

Working memory is the ability to store and process initial information and use it during everyday activities. Cognitive flexibility is the ability to think about one thing in more than one way. The identification and arrangement of the processes and elements required to carry out a purpose or achieve a goal is referred to as planning. Planning involves making choices. Reasoning is the ability to continuously solve problems of all kinds and establish causal relationships between them. Impairment of executive functions may lead to difficulty in focusing, following directions, and handling emotions and may affect performance in daily tasks.^[1]

Young adults usually spend a great amount of sitting time at work or studying in addition to other forms of sedentary behaviors. A study has found a high prevalence of smartphone addiction in medical students.^[2] A new kind of health hazard among the young population is termed smartphone addiction. The COVID pandemic in recent times has made everyone homebound making all learning activities online necessitating increased usage of smartphones.^[2] This addiction to smartphones leads to physiological health hazards including visual disturbances, ear problems, headaches, fatigue, disturbed sleep cycle, and other musculoskeletal symptoms.^[3] Studies in previous literature have found impairment in the brain's ability to retain

new information and form new memories due to smartphone addiction. Smartphone addiction also has a negative psychological effect leading to increased anxiety and depression reducing the performance of the individual in personal and professional life.^[3]

The term dual tasking is a neurophysiological process of performing two different tasks at the same time. Dual tasks can be divided into motor-cognitive dual tasks(mCdt) and motor dual tasks(mMdt).^[4] Motor cognitive dual task refers to the performance of a cognitive task & a motor task at the same time when a disturbance in any one might affect the other. Motor dual-task refers to the performance of two motor tasks, one primary & other secondary at the same time. Both tasks might be completed as a single task with distinct and distinctive goals. Dual tasking assesses one aspect of executive function since participants must pay attention to both activities at the same time. Dual-task training is designed by the principles of motor learning and task specificity, to improve dual-task performance.^[4] The beneficial effects of dual-task training have been demonstrated in several populations with different clinical conditions. Everyday life consists of a broad and continuous variety of multitasking activities such as counting coins while queuing up, and walking while answering a phone call.

Current literature suggests that dual-task activity also may be an effective tool to prevent the decline of overall cognitive function. Erickson et al. showed that improvements in dual-task performance correlate with measured changes in brain activation neuroimaging studies have revealed increased brain activity in the prefrontal cortex during dual-task activity.^[1] Isabelle Hoang et al. showed that young adults had greater cognitive workload in the complex dual-task walking conditions compared to usual walking.^[5] Also, several recent research findings indicate that in male older adults, motor-cognitive dual-task training has a more positive impact on working memory and balance performance than motor-motor dual-task training.^[6]

Since motor cognitive dual-task training and motor dual-task training are effective in improving executive function and younger adults have been found to have decreased executive function owing to greater smartphone usage and having a sedentary lifestyle. This study aims to check which of the above training is best for restoring or improving executive function.

NEED OF STUDY

- Many studies have been done that show smartphone addiction and its' hazardous effect on mental health among young Indian adults^[3], but no studies have been done on the management of the same.
- Lack of research in providing a protocol that improves cognition performance in younger adults.
- Negligence of physical therapist in recognizing cognition aspect in our rehabilitation approach.
- Therefore, to improve the holistic approach of the patient and for clinical implementation, this research is needed.

STATEMENT OF QUESTION

- Does motor cognitive training versus motor dual-task training have an effect on executive functions in younger adults?

AIM OF THE STUDY

- To find the effect of motor cognitive training versus motor dual-task training on executive functions in younger adults.

OBJECTIVES OF THE STUDY

- To observe the effect of motor cognitive training on executive functions in younger adults.
- To observe the effect of motor dual-task training on executive functions in younger adults.
- To observe the effect of anxiety on executive functions in younger adults.
- To observe the effect of motor cognitive training versus motor dual-task training on executive functions in younger adults.

HYPOTHESIS

- Alternate hypothesis
 - There will be a significant effect of motor cognitive training on executive functions in younger adults.
 - There will be a significant effect of motor dual-task training on executive functions in younger adults.
 - There will be a significant effect of motor cognitive training versus motor dual-task training on executive functions in younger adults.
- Null hypothesis
 - There will be no significant effect of motor cognitive training on executive functions in younger adults.
 - There will be no significant effect of motor dual-task training on executive functions in younger adults.
 - There will be no significant effect of motor cognitive training versus motor dual-task training on executive functions in younger adults.

REVIEW OF LITERATURE

1. Hayrunnisa Akin et.al (January 2021)

Conducted a study on **“The effect of motor-cognitive DTT (mCdt) and motor-motor DTT (mMdt) on balance, fear of falling, walking functionality and muscle strength in older adults”** in Istanbul. It is a randomized control study where 25 participants in each group. The primary outcome measure was the Berg balance test to assess balance, Charlson Comorbidity Index (CCI) used to measure the comorbidity status of participants, Falls Efficacy Scale International (FES-I) to evaluate falling, Time Up and Go, and Muscle testing used. The results of the study showed that the 8-week Motor -cognitive dual-task training and motor-motor dual-task training program did not differ in fear of falling, balance, walking functionality, and muscle strength in older adults. While both the training improves balance ability only the motor cognitive dual-task training enhanced the walking functionality in older adults. Limitations of this study were there was no follow-up period and the intervention period was shorter than most of similar studies.

2. Clarissa Theodora Tanil et.al (August 2020)

Conducted a study **“To examine the effect of smartphone’s presence on learning and memory among undergraduates”** in Malaysia. It is an experimental study where 119 undergraduate female students were recruited from a private university. Outcome measures used were the working memory span test, positive and negative affect scale (PANAS), and smartphone addiction scale (SAS). Participants were randomly assigned to one of two conditions: low-phone salience (LS) and high-phone salience (HS). participants in the HS condition were asked to place their

smartphones on the table with the screen facing down. Participants with LS were asked to hand their smartphone to the researcher and showed and researcher kept the phone at a distance between 50cm to 300cm from the participant. They conclude that the presence of smartphones and frequent thoughts of their smartphones significantly affected memory recall accuracy. There were several limitations in this study first they did not ask the phone conscious thought at specific time points during the study. Second, they did not include the simple version of the tasks. Third, the task may have been complex and unfamiliar, which may have caused some disadvantages for some participants. Future studies can determine which aspects of memory processes are more susceptible to smartphone presence.

3. Isabelle Hoang et.al (November 2020)

Conducted a study **“to examine cognitive workload in young adults during walking conditions varying in complexity”** in France. Twenty–five young adults performed 4 conditions:

- a) Usual walking
- b) simple dual-task walking
- c) complex dual-task
- d) standing while subtracting

The cognitive workload was measured through changes in cerebral activity of the DLPFC, using the fNIRS and mental demand score from the NASA-TLX questionnaire. The study explored the association between subjective and neurophysiological measures will also be explored. The study showed that young adults had greater cognitive workload in the two DT walking conditions compared to

usual walking. The study findings could improve the detection of cognitive workload changes during walking under different levels of difficulty in young adults. Limitations of this study were the small sample size and only the activity of the DLPFC cortex was recorded. Future studies can assess other cerebral regions while walking and dual tasking.

4. Ebrahim norouzi et.al (June 2019)

Conducted a study **“to investigate whether two different dual-task interventions improved both working memory and balance performance”** in Iran. It is a randomized control study where 60 male adults 65 years old or older were recruited for this study. In each group, 20 participants were assigned either to a motor-cognitive dual-task condition, a motor-motor dual-task condition, or to a control condition. This study used outcome measures like an n-back task to assess working memory and the Berg balance scale (BBS) to assess balance. The resistance training was carried out in both motor-motor dual-task condition and motor-cognitive dual-task condition groups. In motor-motor dual-task training condition participants were asked to perform activities like throwing a ball up and down, balancing the cup on the palm, and holding a medicine ball in both hands. In the motor-cognitive dual-task training condition, participants were asked to perform 12 different cognitive tasks simultaneously with resistance training. In the control group participants held informal meetings to discuss issues related to everyday life and how to overcome them. This study showed that in male older adult's motor cognitive dual-task training condition group had a more positive impact on working memory and balance performance than the motor-motor dual-task training condition group. The impact

was seen even after 12 weeks after completion of the intervention program.

Limitations were participants were not blinded about treatment and the sample size was small.

5. Saravanan Murugan et.al (Nov 2018)

Conducted a study **“to determine the prevalence of smartphone addiction in young college-going adults and exploring the possible effect it has on health and factors associated with it “**, in India. it is a cross-sectional study that included 306 female college students who participated in this study. The mean age of the participants ranged from 17 years to 26 years. Demographic information including smartphone usage and SAS was used to evaluate the level of addiction to smartphones. SAS scores were calculated based on the 6-point Likert-type scale with 48 items and six subscales (daily-life disturbances, positive anticipation, withdrawal, cyberspace-oriented relationship, overuse, and tolerance). The common symptoms reported by participants caused by mobile overuse were head and neck pain (12.1%), low back pain (9.2%) followed by upper back pain (8.5%). Around 80% reported excessive use of mobile phones affected their sleep habits and their sleep pattern. Addiction to mobile phones led to physiological health hazards and had a negative psychological effect on them. Studies showed a higher rate of addiction to smartphones is associated with negative effects on health and social life and might face difficulties performing in education. Further studies can compare if differences exist between genders in smartphone addiction and its usage. The effects of various possible methods to overcome smartphone addiction among younger generations can also be big scope for further studies.

6. Masato Kawabata et.al (August 2021)

Conducted a study **“to examine the acute effects of a home-based online square stepping exercise (SSE) trial on cognitive and social functions in sedentary young adult.”** In this study, a total of 18 young adults (6 males, 12 females) were recruited. Two groups underwent the SSE first and then the active control exercise, whereas the other two groups underwent the exercises in the opposite sequence. 2-4 days interval was given between two exercise conditions across the four groups. The exercise sessions were conducted online through Zoom. All the participants attended three sessions per week over two weeks. 5min warmup activities, 30 min of the main exercise (SSE or active control exercises), and 15 min of cool-down exercises were included in each session. The SSE program included multi-direction movements including forward, backward, lateral, and oblique step patterns. Active control exercises included walking on the spot at a similar intensity level. Outcome measures used in this study were The Modified Card Sorting Task (MCST) to assess executive functions and The Physical Activity Group Environment Questionnaire (PAGEQ) to assess the participant's perception of cohesion in their exercise groups. This study's results showed that SSE was effective to improve executive functions such as abstract reasoning, mental flexibility, and problem-solving skills in sedentary young adults. No such improvements were observed in the active exercise group although the intensity and bodily movements of the two exercises were similar.

7. Hsiang -Tsen Kuo et.al (May 2022)

Conducted the study **“to determine the effects of cognitive and motor dual-task walking training on dual-task walking performance and the**

responding brain changes in older people with mild cognitive

impairment,” in Taiwan. This study was a three-arm parallel, randomized controlled trial which included Thirty-one participants. Participants were randomly assigned to 3 groups: conventional physical therapy group (n=10), cognitive dual-task training group (n=10), or motor dual-task training group (n=11). The outcome measure was gait performance under dual-task conditions, single walking performance, brain activation during walking, and cognitive function. The gait performance was assessed by the Gait Up system by wearing two wearable Physilog sensors attached to the lateral side of each shoe. The cortical hemodynamic response to indicate brain activation during walking was assessed through a multichannel wearable functional spectroscopy (fNIRS) imaging system. Trail making test (TMT A& B) and digit span test were used to assess cognitive function. Participants received 24 sessions of 45 -min -on one training given to them according to their assigned group. This study provides the first evidence about different dual-task training on dual-task walking performance and related to brain changes in individuals with MCI. This study concluded that both cognitive and motor dual-task training for 24 sessions improved walking performance under simple and dual-task conditions, while the CPT did not have significant changes in gait performance.

8. Takehiko Doi et.al (August 2013)

Springer International Publishing Switzerland 2013

Conducted a study **“to examine brain activation during Dual-task walking among older adults with mild cognitive impairment during using functional near-infrared spectroscopy.”** Sixteen older adults performed gait experiments under normal walking and dual-task walking conditions. To assess executive function Stroop test was used and to record the hemodynamic response in the PFC 16-channel Spectratech OEG-16 system was used. Two walking conditions were used normal walking and dual-task walking. In normal walking conditions, participants were instructed to walk at their preferred speed and in the dual task walking participants were asked to walk while performing a verbal letter fluency task. This study found that prefrontal activation was increased during dual-task walking, and this increase was correlated with executive function. They also found that exercise involving dual tasks may be useful for stimulating brain activation in older adults with MCI.

9. Teresa Liu – Ambrose et al (2010)

Compared **“the effect of once -weekly and twice-weekly resistance training with twice weekly balanced and tone exercise training on the performance of executive functions in senior women.”** This study is a single-blinded randomized trial with 155 community-dwelling women aged 65 to 75 years who were randomly allocated to once-weekly (n=54) or twice-weekly (n=52) resistance training or twice-weekly balance and tone training (control group). The primary outcome measure was the specific executive cognitive function like selective attention was measured by the

Stroop test. Secondary measures were Trail making tests Part A & B to assess set-shifting, and verbal digit span forward & backward tests to assess working memory. Gait speed, muscular function, and while the results showed that 12 months of progressive resistance training once or twice weekly improved selective attention and conflict resolution and simultaneously improved muscular function in senior women. The limitation of the study was they included women aged 65 to 75 years only, so it cannot be generalized to men or women of other ages.

10. Vojislava Bugarski Ignjatovic et.al (2015)

Conducted a study” **to determine whether cognitive stimulation using the tasks available at the site may indeed promote cognitive efficiency in young healthy subjects**”. The study included 12 healthy volunteers divided into two groups: (experimental and control) with six subjects university students in each group (six men and six women) mean age of 21 years. The study was carried out at the Department of Neurology, in Serbia. Both groups had to undergo neuropsychological tests like the trail making Test parts A and B, The Rey Auditory verbal learning test (RAVLT), The Rey – osterrieth complex figure test (ROCF), Wisconsin Card Sorting Test (WSCT) and The Wheelchair Memory Scale-Revised (WMS-R). The subtest included mental control, digit span, and spatial span. They concluded that cognitive stimulation in the young and healthy population may produce short-term improvements in cognitive performance, primarily in the stimulated cognitive domains, and contribute to the transfer of the effect of stimulation to other related cognitive functions.

Methods

- Study design- randomized clinical trial
- Study population- younger adults
- The sample size was calculated by using the formula – $2K \times sd^2 / d^2$
- Sample size- 44
- Sample technique- purposive sampling
- Study setting- ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE
- Study duration- 6 months
- Materials- pen, paper, stopwatch

Inclusion criteria

- Age -17-26 ^[3]
- Gender- male and female
- Literate should know to read and write English
- Score > or equal to 24 on MMSE.
- Score > or equal to 28 on Beck Depression Inventory
- Willing to participate in the study

Exclusion criteria

- History of specific balance problems (i.e., diagnosed neurological musculoskeletal or vestibular disorder)
- Subjects having problems with visual ability and hearing
- Score below 28 in the Beck depression inventory
- Self-reported use of medication (sedatives and hypnotics, anti-depressants)

Outcome measures

- Trail marking test

The Trail Making Test (TMT) is a widely used neuropsychological assessment tool that is used to assess cognitive function, particularly attention, visual-motor skills, and executive functioning. It is often employed in clinical and research settings to evaluate various neurological and psychological conditions.

The test consists of two parts: Part A and Part B.

- I. Trail Making Test Part A (TMT-A): In this part, the participant is presented with a sheet of paper containing circles with numbers (usually from 1 to 25) scattered randomly across the page. The task is to connect the numbers in sequential order by drawing lines between them as quickly as possible. The goal is to complete the task accurately and efficiently.
- II. Trail Making Test Part B (TMT-B): This part is more complex and challenging. Instead of connecting numbers, the participant is presented with circles containing both numbers (1-13) and letters (A-L), and they must alternate between connecting numbers and letters in ascending order (1-A-2-B-3-C, and so on). The goal is to complete this task as quickly and accurately as possible.

The time taken to complete each part is typically measured. Longer completion times or errors in sequencing can indicate difficulties in attention, mental flexibility, and executive functioning. The difference in completion time between Part A and Part B (sometimes referred to as the "TMT B-A difference") is often used as a measure of cognitive flexibility and set-shifting ability. In clinical practice, TMT scores are often compared to an individual's baseline performance to help assess cognitive function, attention, and executive skills.

- Digit span test

The Digit Span Test is a common neuropsychological assessment tool used to evaluate a person's short-term memory and attention span. It is often included as part of a comprehensive cognitive assessment battery to assess various cognitive functions. The test measures the individual's ability to repeat back a series of digits in the same order as presented or in reverse order.

There are two main components to the Digit Span Test:

- I. Digit Span Forward: In this component, the examiner reads a sequence of digits (numbers) aloud to the participant at a rate of about one digit per second. The participant is then required to repeat the sequence back exactly as they heard it. The sequence length starts with a relatively short span (e.g., three digits) and gradually increases in length. The test continues until the participant consistently fails to recall the sequence correctly.
- II. Digit Span Backward: This component assesses a person's working memory and cognitive flexibility. Similar to the forward component, the examiner reads a sequence of digits to the participant, but this time, the participant is required to repeat the sequence in reverse order. The sequence length again starts short and increases over trials.

The scores for the Digit Span Test are typically recorded as two separate numbers: the highest sequence length that the participant was able to correctly recall for both forward and backward components. For example, if a participant correctly recalls sequences of lengths 7 and 5 for forward and backward, respectively, their Digit Span scores would be recorded as "7 forward, 5 backward."

The Digit Span Test provides insights into a person's ability to maintain and manipulate information in short-term memory, as well as their attention span.

- Generalized Anxiety Disorder Assessment (GAD-7)

The GAD-7, or Generalized Anxiety Disorder 7, is a self-report questionnaire designed to assess the severity of generalized anxiety disorder symptoms. It's a widely used tool in clinical and research settings to screen for and monitor symptoms of anxiety. The questionnaire consists of seven questions that ask about common symptoms of anxiety experienced over the past two weeks. Each question is scored on a scale from 0 to 3, with higher scores indicating greater symptom severity.

Here are the questions from the GAD-7, along with the scoring:

For each question, choose the response that best describes how often you have experienced the symptom over the past two weeks:

1. Not at all (0 points)
2. Several days (1 point)
3. More than half the days (2 points)
4. Nearly every day (3 points)

The questions are as follows:

1. Feeling nervous, anxious, or on edge
2. Not being able to stop or control worrying
3. Worrying too much about different things
4. Trouble relaxing
5. Being so restless that it's hard to sit still
6. Becoming easily annoyed or irritable
7. Feeling afraid as if something awful might happen

To score the GAD-7:

1. Add up the scores for each question.
2. The total score can range from 0 to 21.

Interpretation of the total score is typically as follows:

- 0-4: Minimal anxiety symptoms
- 5-9: Mild anxiety symptoms
- 10-14: Moderate anxiety symptoms
- 15-21: Severe anxiety symptoms

The GAD-7 is useful for identifying individuals who might be experiencing symptoms of generalized anxiety disorder. It can also be used to track changes in symptoms over time, evaluate the effectiveness of interventions, and assist in treatment planning.

PROCEDURE

The institutional Ethical Committee evaluated and approved the current study. A total of 50 samples were selected by using purposive sampling. Where 44 subjects were selected based on inclusion criteria and exclusion criteria and 6 subjects were excluded. They were chosen for this study based on certain criteria, such as being younger adults who know to read and write English and should have an MMSE score of more than 24 scores and a Beck depression score of less than. Everyone who participated in the study was informed of the protocol and their informed consent was taken.

Group allocation was done by using Research Randomizer. 1 set for group A and 1 set for group B, each box containing 22 participants.

22 subjects were placed in Group A (Motor Cognitive Group)

22 subjects were placed in Group B (Motor Dual Task Group)

All groups did a warm-up that comprised active movement of all joints and dynamic stretching for 10 minutes before the intervention and a cool-down that included static stretching for 5 minutes following the intervention.

All groups took intervention for a total of 60 minutes from which 10 minutes are for Warm-up and cool down and 5 minutes for the intervention.

- Group A performed Motor–cognition tasks
- Group B performed Motor Dual tasks

Group A and B subjects took intervention 1 session per day 3 days a week for 4 weeks

At the end of 4th week, post-intervention data were assessed,

For both groups data were analyzed. The difference between the two groups was Assessed by independent t-test and the difference between pre-intervention and post-Intervention within the group was assessed using paired t-test.

Intervention

- Group A

Motor cognition tasks

Participants are required to count backward from two-digit numerals while standing, straight walking, or side walking. ^[4]

- Group B

Motor dual tasks

Participants have to hold half-filled glasses with both hands near the trunk, the elbows should be at 90degree flexion, and have to perform in a standing position, straight walking, side walking

Basic warm-up and cool-down exercises will be given to both groups ^[4]



FIGURE 1.2: Participants performing Trail making tests Part A and B



FIGURE 1.3: Motor Cognitive and Motor Dual-Task Training Program

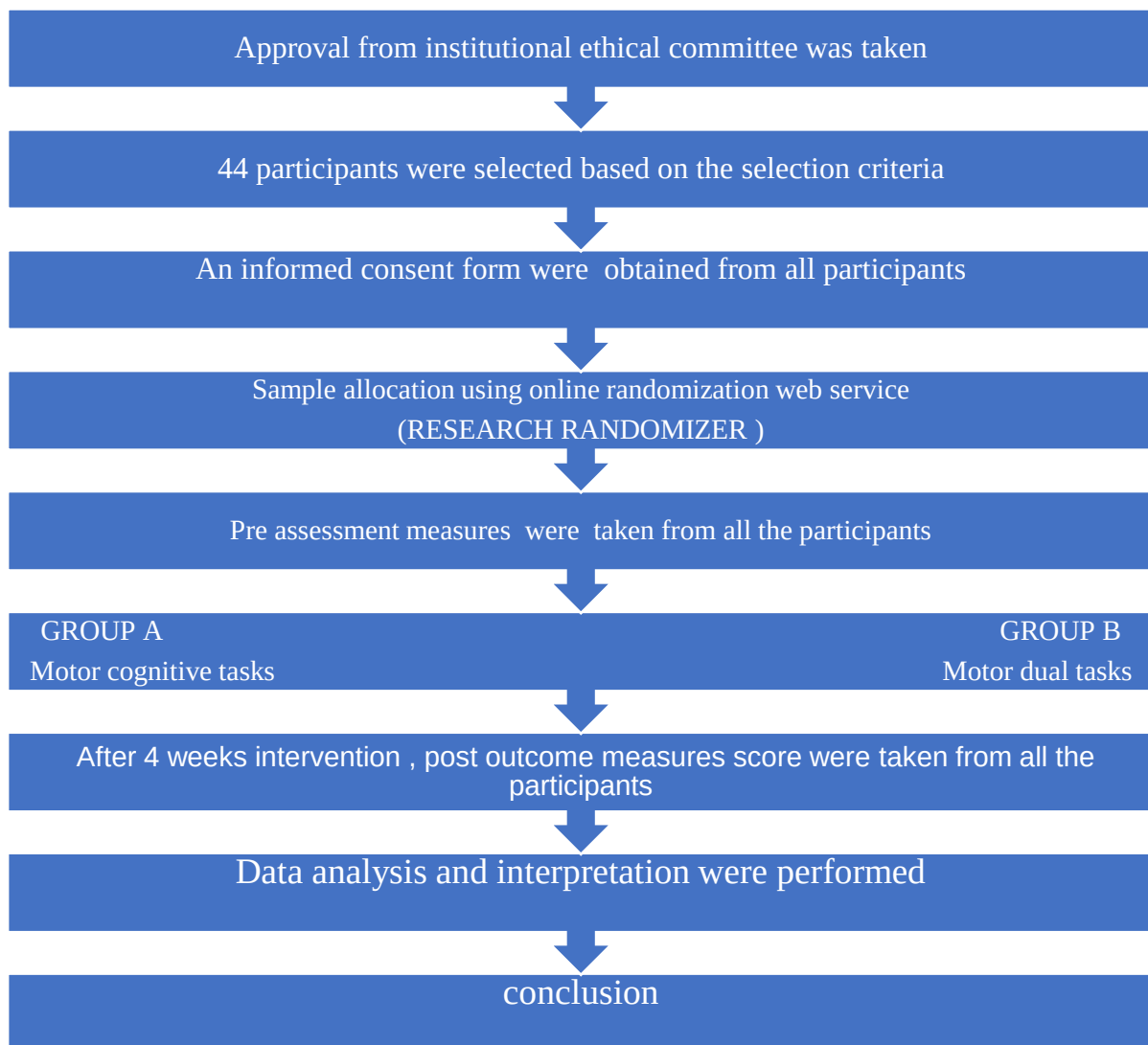


FIGURE1.4: Flowchart of Study Procedure

SAMPLE SIZE ESTIMATION

A sample size of 44 subjects was estimated using a larger effect size of 1.0, a power of 0.90, and a level of significance set at 0.05. participants were randomly assigned to either Group A or Group B.

Statistical Analysis

Data was analyzed using the statistical package SPSS 29.0 (SPSS Inc, Chicago, IL), and the level of significance was set at $p < 0.05$. Descriptive statistics was performed to assess the mean and standard deviation of specific groups. The normality of the data was assessed using the Shapiro-Wilk test. Inferential statistics to find out the difference between groups was done using Wilcoxon Signed rank test and the analysis between two groups was done using the Mann-Whitney U test to find out the difference between two groups.

Table 1: Mean age analysis

	Median	IQR
GROUP A	21	5.25
GROUP B	21	6.5

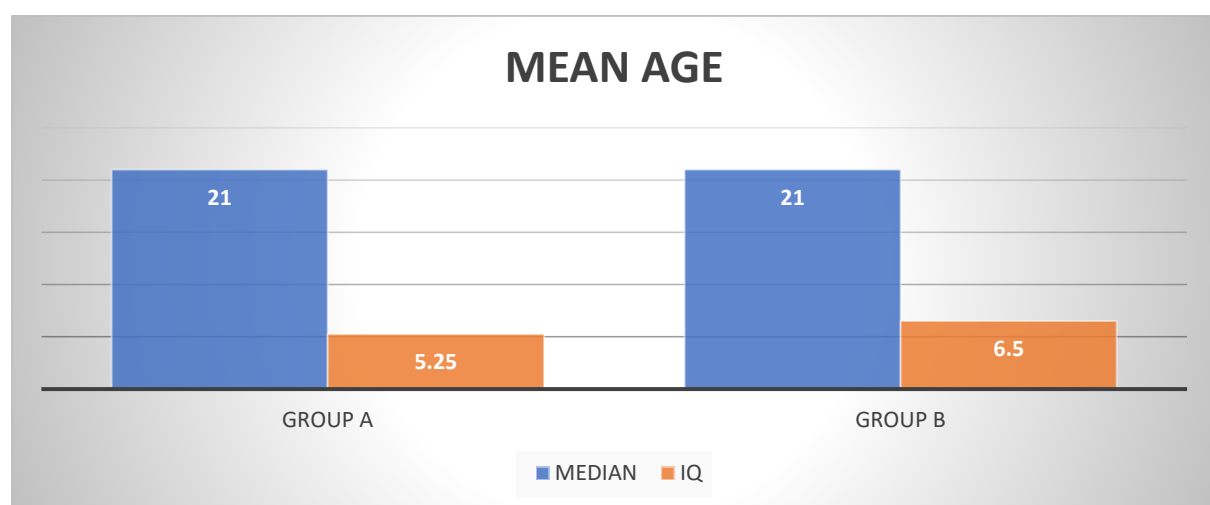


FIGURE 2.1: Graphical Presentation of Mean Age Analysis

Table 2: Mean BMI analysis

	Median	IQR
GROUP A	22.4	4.57
GROUP B	24	5.45

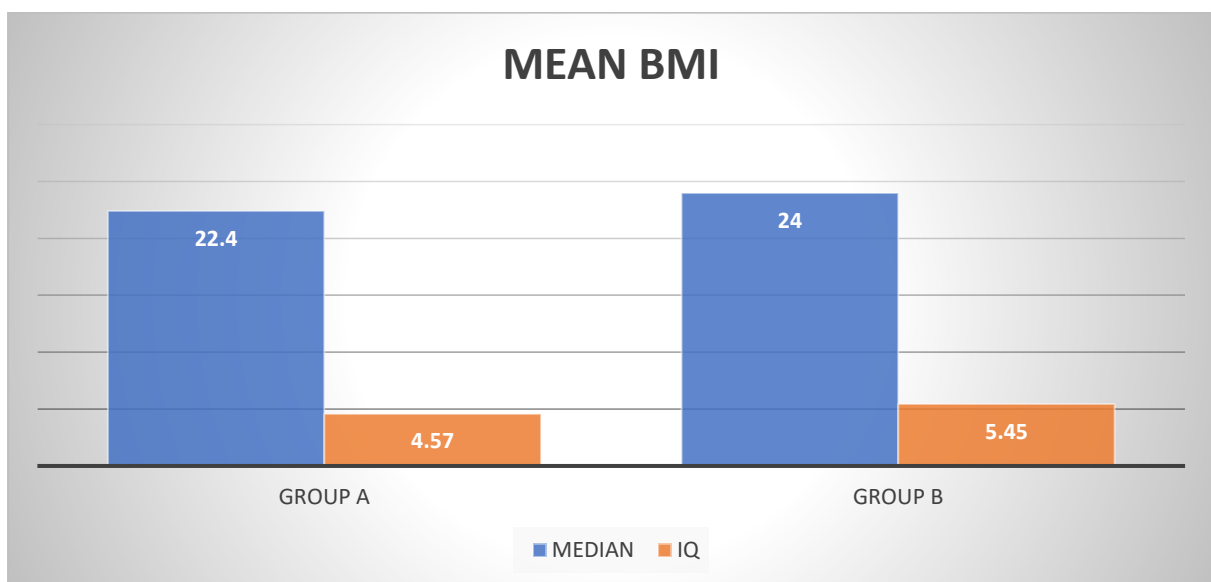


FIGURE 2.2: Graphical Presentation of Mean BMI Analysis

Table 3: TMT(A) TEST WITHIN GROUP ANALYSIS

	PRE	POST	P VALUE	MEAN DIFFERENCE
GROUP A	30.00	28.50	0.18	1.50
GROUP B	31.50	28.00	0.06	2

TMT(A) test of within-group analysis with Wilcoxon Signed rank test indicates statistically not significant difference between the group in Group A ($p < 0.05$), and Group B ($p < 0.05$). The difference in mean value was reported as follows, Group B > Group A

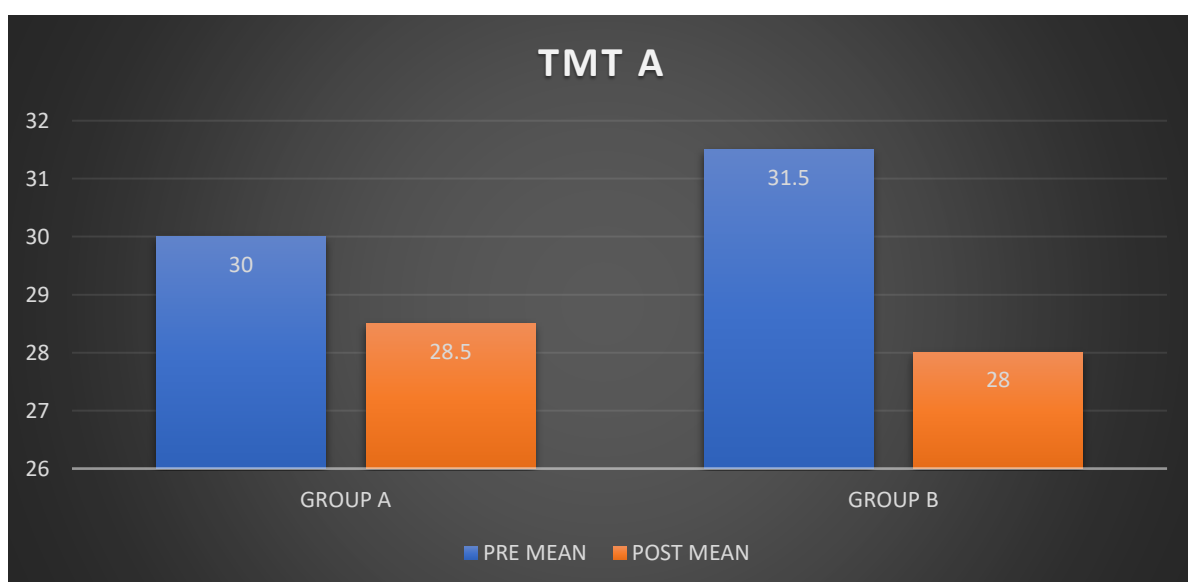


FIGURE 2.3: Graphical Presentation Of TMT(A) within group Analysis

Table 4: TMT(B) TEST WITHIN GROUP ANALYSIS

	PRE	POST	P VALUE	MEAN DIFFERENCE
GROUP A	58.0	50.00	0.00	8
GROUP B	58.0	57.50	0.004	6

TMT(B) test of within-group analysis with Wilcoxon Signed rank test indicates a statistically significant difference between the group in Group A ($p < 0.05$), and Group B ($p < 0.05$). The difference in mean value was reported as follows, Group A > Group B

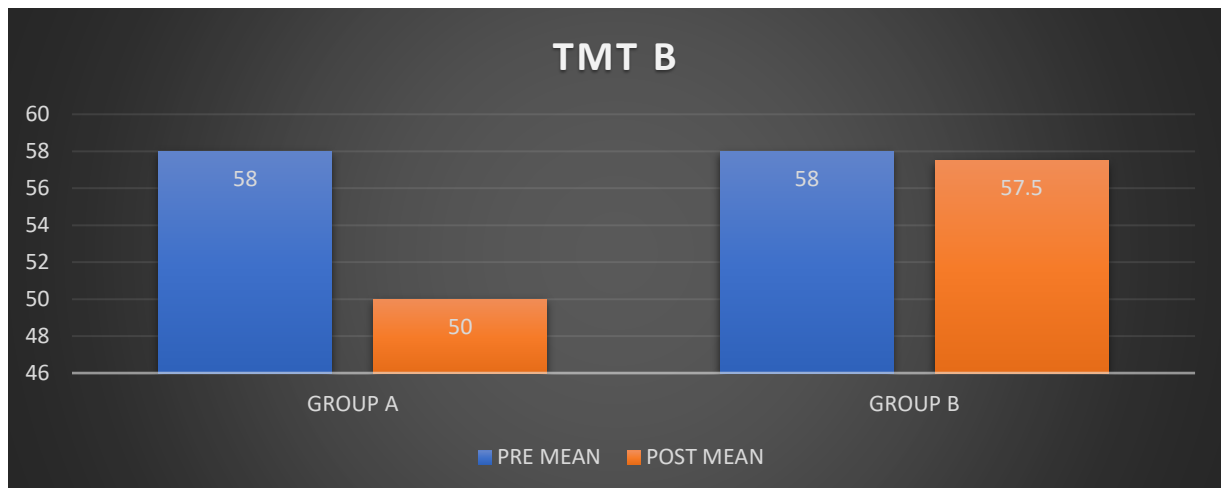


FIGURE 2.4: Graphical Presentation of TMT(B) Within Group Analysis

Table 5: DIGIT SPAN TEST (FORWARD) TEST WITHIN GROUP ANALYSIS

	PRE	POST	P VALUE	MEAN DIFFERENCE
GROUP A	4.00	5.50	0.003	1
GROUP B	5.00	6.00	0.001	1

Digit Span Test (FORWARD) of within-group analysis with Wilcoxon Signed rank test indicates a statistically significant difference between the group in Group A ($p < 0.05$), and Group B ($p < 0.05$). The difference in mean value was reported as follows, Group

A = Group B

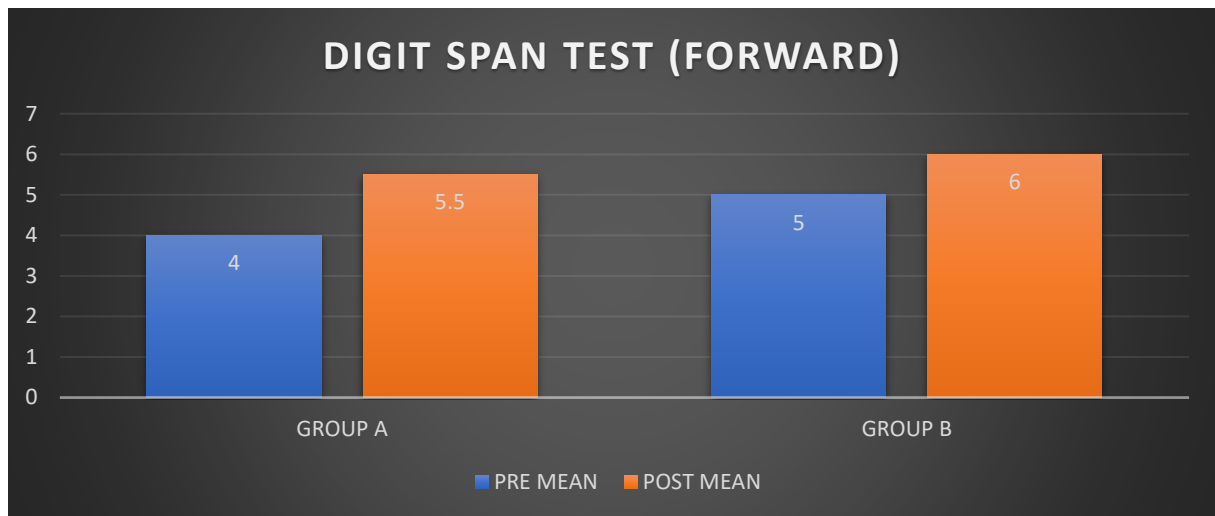


FIGURE 2.5: Digit Span Test (Forward) Within Group Analysis

Table 6: DIGIT SPAN TEST (BACKWARD) WITHIN GROUP ANALYSIS

	PRE	POST	P VALUE	MEAN DIFFERENCE
GROUP A	3.00	4.00	0.000	1
GROUP B	3.00	4.00	0.001	1

Digit Span Test (BACKWARD) of within-group analysis with Wilcoxon Signed rank test indicates a statistically significant difference between the group in Group A ($p < 0.05$), and Group B ($p < 0.05$). The difference in mean value was reported as follows, Group A = Group B

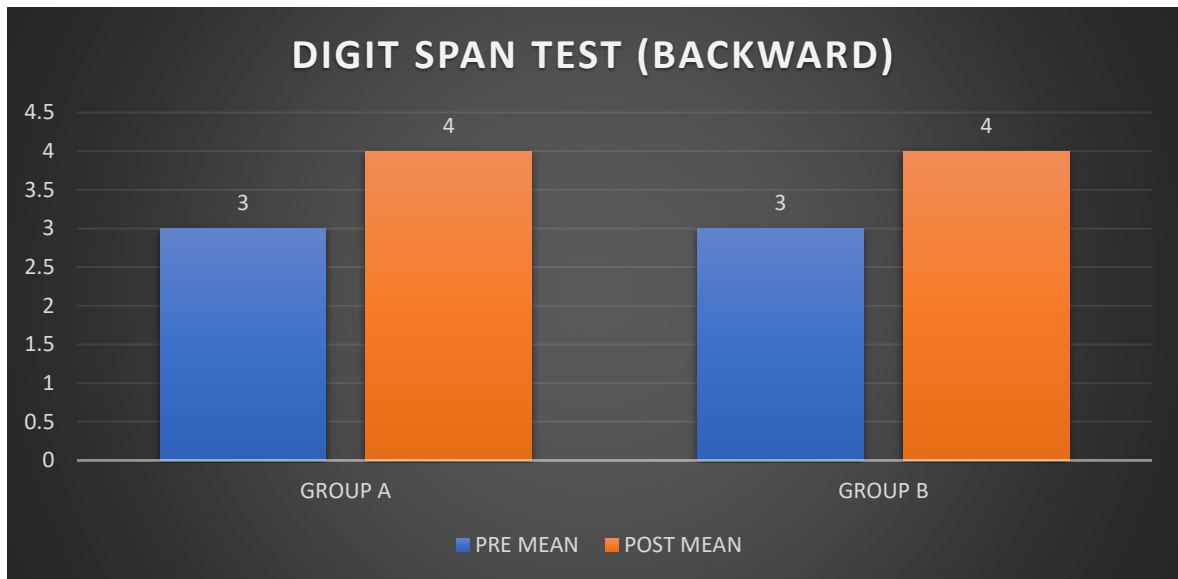


FIGURE 2.6: Digit Span Test (Backward) Within Group Analysis

Table 7: BETWEEN GROUP ANALYSIS OF OUTCOME MEASURES

OUTCOME	POST MEAN	P VALUE	EFFECT SIZE
TMT A	1.553	0.120	
TMT B	0.495	0.621	
DIGIT SPAN TEST (FORWARD)	0.037	0.971	
DIGIT SPAN TEST (BACKWARD)	0.037	0.971	

There was no statistically significant difference in TMT(A), TMT(B), Digit Span Test (forward), and Digit Span Test (backward) outcomes between groups ($P > 0.05$). In TMT (A) Group B showed better results than Group A, and in TMT (B) Group A showed better results than Group B. Both groups showed equal improvement in the Digit span test forward and backward.

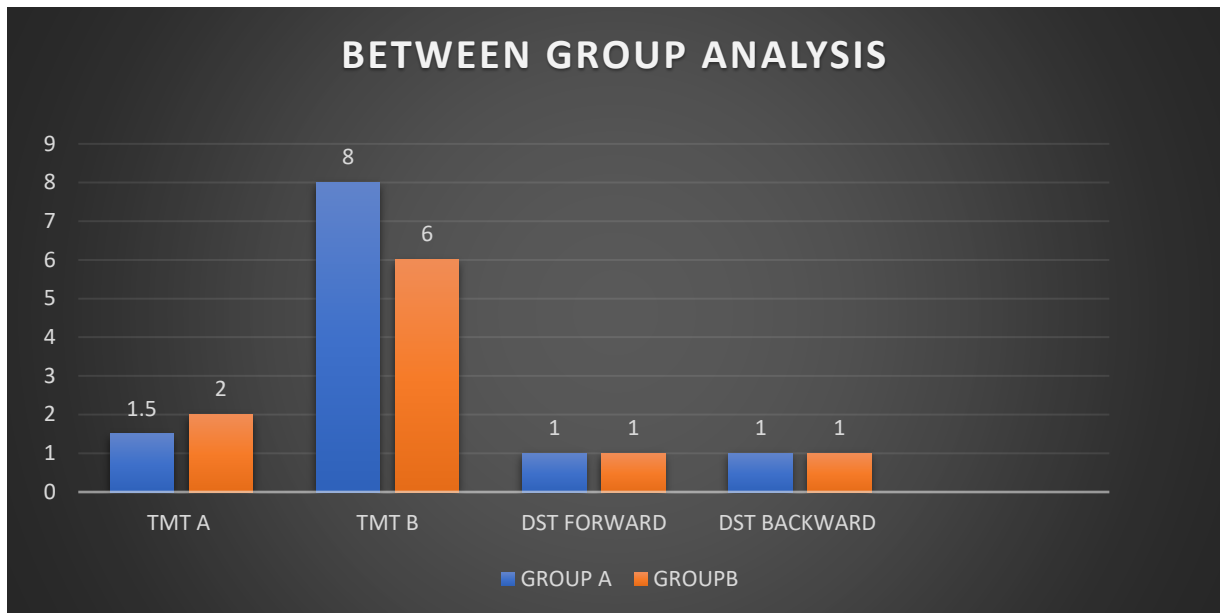


FIGURE 2.7: Graphical Presentation of Between Group Analysis of Outcome Measures

Discussion

The goal of this study was to compare the effects of motor cognitive training and motor dual-task training to see which one should be used to restore or improve executive functioning in younger adults. The results of our study showed that 4-week motor cognitive training and motor dual-task training had equal effects in improving executive function. Our findings demonstrated that 4 weeks of motor cognitive training and motor dual-task training had no difference in improving executive function. However, both types of training have increased attention and working memory in younger individuals.

The first hypothesis hypothesized that motor cognitive training would have a considerable influence on executive functioning in younger individuals, and this prediction was fully verified. According to prior research, combining physical and cognitive activity training supports good executive function, working memory, and the ability to divide attention better than either physical or cognitive training alone.^[6] According to current research, dual-task activity may be a useful approach for preventing the deterioration of general cognitive performance.^[18] Performance on TMT (B) has been associated with pre-frontal cortex-related cognitive functions, including executive function, attention, and working memory.^[18] Participants in motor cognitive training Group A showed better results in TMT (B) outcome measures. As a result, the current study supported several earlier studies by demonstrating that motor cognitive training improved executive function.

With the second hypothesis, we assumed that there would be a significant effect of motor dual-task training on executive functions in younger adults. Based on previous research paying attention to the consequences of motor performance leads to external attention control which results in higher motor control and performance.^[6] Other research has shown that motor dual-task training has a positive impact on divided attention.^[6] Performance on TMT (A) has been linked to complex attention. This may explain why the participants in motor dual-task training Group B had greater results in TMT (A).

In the digit span test, however, we found no statistically significant distinction between the motor cognitive and motor dual-task training groups. The digit span test is connected with short-term memory since both groups were trained to learn exercises and accomplish difficult tasks ^[20]. This explains why individuals in both groups performed better on the Digit span test, both forward and backward.

Individual motor cognitive training and motor dual-task training are extremely important, although neither is superior in younger adults. Prior research, however, found that the motor-cognitive training group had a stronger impact on working memory.^[6] Unlike our study, they coupled exercise training with cognitive activity and examined working memory and balance in older individuals at baseline, four weeks after training completion, and 12 weeks later at follow-up. Furthermore, exercise training has been shown to increase cognitive performance in the elderly via neuroplasticity processes.^[6] This might be another reason why they obtained more relevant findings than our study.

Excessive smartphone use has been linked to detrimental psychological impacts on young people.^[3] According to certain research, smartphone addiction impairs the brain's capacity to remember new information and develop new memories.^[12] In our study, we used the Generalised Anxiety Disorder Assessment (GAD-7) to determine how it impacted executive function, and the results were statistically insignificant in both groups. This might be because neither group used relaxation methods, which could have helped to lower anxiety in younger people. The topic of this study is an ongoing concern in the literature. There has been relatively little research comparing the effects of motor cognitive training and motor dual-task training on executive function in younger persons to our knowledge. We anticipate that the findings of this study will serve as a reference article for future research and will help to create a suitable dual-task training program for young adults.

LIMITATIONS:

The study's limitations must also be taken into consideration. First of all, there was no follow-up period to demonstrate long-term outcomes. Second, this study's intervention time was shorter than that of previous similar trials, which lasted 12 weeks.

FUTURE SCOPE

Further research comparing motor cognitive training with motor dual-task training should be planned, including a systematic dual-task training program, a longer intervention time, and a follow-up period.

CONCLUSION

According to the findings of this study, 4 weeks of motor cognitive training and motor dual-task training both have a positive impact on executive function in younger individuals. If the aim is to focus more on working memory, motor cognitive training should be implemented, but motor dual-task training should be used if complex attention is needed. As a result, our research gives valuable insights into how working these factors might be enhanced in younger individuals.

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ANNEXURES.1
ASSESSMENT FORM

DATA COLLECTION FORM

SUBJECT NUMBER -

DATE-//

AGE/GENDER-

HEIGHT

WEIGHT

|

ADDRESS-

CONTACT NO.-

Name of the test	Pre-test readings	Post-test readings
TRAIL MAKING TEST PART A PART B		
DIGIT SPAN TEST FORWARD BACKWARD		
GAD-7		

ANNEXURES 2

CONSENT FORM

CONSENT FORM

Title of the study –

**“EFFECT OF MOTOR COGNITIVE TRAINING VS MOTOR DUAL-
TASK TRAINING ON EXECUTIVE FUNCTION IN YOUNGER ADULTS
- A RANDOMIZED CLINICAL TRIAL”**

I have been informed by Ms. Haripriya Kumaran; pursuing MPT (Neuro) conducting the above-mentioned study under the guidance of Dr. Sonali Soumyashree Assistant Professor Department of Neuro Physiotherapy ABHINAV BINDRA SPORTS MEDICINE AND RESEARCH INSTITUTE (ABSMARI), BHUBANESWAR.

I have no objection and will be a part of that group. I also understand that the study does not have any negative implications for my health. I understand that the information produced by the study will become a part of the institute's record and will be utilized, as per the confidentiality regulations of the institute. I am also aware that the data might be used for medical literature and teaching purposes, but all my personal details will be kept confidential.

I am well informed to ask as many questions as I can to Ms. Haripriya Kumaran either during the study or later.

I understand that my assent is voluntary and I reserve the right to withdraw or discontinue the participation from the study at any point of time during the study.

I have explained to MR/MISS/MRS _____ the purpose of the research, and the procedure required in the language he/she could understand to the best of my ability.

(Investigator)

(Date)

ANNEXURES.3

ETHICAL COMMITTEE CLEARANCE CERTIFICATE

 **ABHINAV BINDRA**
Sports Medicine & Research Institute
A Unit of the Abhinav Bindra Foundation Trust
Recognized by DMRT, Health & PW Dept., Govt. of Odisha, Affiliated to Utkal University
Recognized by Odisha State Council for Occupational Therapy and Physiotherapy

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Reference No. – ABSMARI/IRB/05/2023
Date: 22nd June 2023

INSTITUTIONAL REVIEW BOARD

To
Ms Haripriya Kumaran,
Post Graduate student, Department of Physiotherapy,
Abhinav Bindra Sports Medicine and Research Institute (ABSMARI).

This is to certify that your proposal for the study titled “Effect of Motor Cognitive Training VS Motor Dual-Task Training on Executive Functions in Younger Adults: A Randomized Clinical Trial” has been taken for discussion in the meeting held on 20th May 2023. Following the meeting, the committee approves the proposal and it has no objection on the study being carried out.

You are advised to familiarize yourself with the ICMR guidelines on biomedical research in human subjects and also adhere to the principles of Good Clinical Practice. You are hereby directed to submit the final report to the committee, on completion of the study. Any case of adverse reactions should be informed to this ethics committee and action will be taken thereafter.

Any such adverse reactions during the course of the study are the sole responsibility of the Principal Investigator and there is no onus on the Ethical Committee members resulting thereof.

We wish you all the best for your study.


Member Secretary




Chair Person

Utkal Signature, Plot No 273, NH-5, Pahal, Bhubaneswar, 752101
Phone: 6370703650, 6370703651

ANNEXURES.4

MASTER CHART

SUBJECT	AGE	GENDER	HEIGHT	WEIGHT	BMI	GROUP	TMT (A)			TMT (B)			DST (FORWARD)			DST (BACKWARD)			GAD-7		
							PRE	POST	Mean	PRE	POST	Mean	PRE	POST	Mean	PRE	POST	Mean	PRE	POST	Mean
1	24	F	163	71	26.7	A	30	28	-2	60	60	0	5	7	2	3	4	1	4	4	0
2	26	M	160	55	21.5	A	60	58	-2	120	60	-60	4	5	1	2	4	2	3	2	-1
3	22	F	154	50	21.1	A	40	42	2	56	50	-6	6	7	1	5	6	1	9	7	-2
4	21	F	164	46	18.2	A	24	18	-6	40	38	-2	5	7	2	2	6	4	3	3	0
5	20	F	159	65	25.7	A	29	26	-3	70	58	-12	5	6	1	3	4	1	11	9	-2
6	25	M	171	61	20.9	A	28	26	-2	48	40	-8	5	6	1	3	4	1	1	1	0
7	25	M	165	82	30.1	A	17	17	0	32	29	-3	4	7	3	4	6	2	1	1	0
8	24	F	164	65	24.2	A	30	29	-1	56	53	-3	5	6	1	3	4	1	1	1	0
9	20	F	161	56	21.6	A	24	21	-3	34	40	6	6	5	-1	3	4	1	10	8	-2
10	21	F	150	41	18.2	A	38	37	-1	60	56	-4	6	4	-2	3	4	1	6	6	0
11	19	M	175	60	19.6	A	36	29	-7	68	60	-8	4	4	0	2	4	2	7	6	-1
12	19	F	153	52	22.2	A	22	29	7	62	60	-2	7	7	0	2	4	2	6	6	0
13	21	M	180	83	25.6	A	17	17	0	45	38	-7	4	6	2	2	3	1	5	6	1
14	17	F	158	56	22.4	A	30	31	1	58	46	-12	2	4	2	3	3	0	1	1	0
15	24	M	171	73	25	A	26	26	0	90	60	-30	3	4	1	3	4	1	0	0	0
16	19	F	162	59	22.5	A	58	60	2	160	120	-40	3	4	1	4	4	0	2	1	-1
17	20	M	168	69	24.4	A	26	24	-2	48	40	-8	3	5	2	4	5	1	2	1	-1
18	18	F	154	49	20.7	A	38	30	-8	50	46	-4	4	5	1	4	3	-1	0	0	0
19	26	M	172	87	29.4	A	30	28	-2	58	50	-8	5	7	2	3	5	2	1	1	0
20	19	F	157	60	24.3	A	50	44	-6	60	50	-10	3	6	3	4	6	2	2	5	3
21	18	M	160	54	21.1	A	48	30	-18	90	68	-22	4	3	-1	4	5	1	1	1	0
22	25	F	165	78	28.7	A	28	28	0	58	50	-8	3	4	1	4	5	1	2	1	-1
23	26	F	162	61	23.2	B	38	30	-8	58	60	2	4	6	2	3	4	1	1	1	0
24	20	M	160	51	19.9	B	35	30	-5	62	60	-2	5	5	0	2	4	2	7	7	0
25	21	M	171	64	21.9	B	22	22	0	35	32	-3	5	6	1	4	5	1	3	3	0
26	26	F	152	67	29	B	28	27	-1	70	58	-12	5	6	1	4	4	0	16	15	-1
27	24	M	176	65	21	B	33	28	-5	44	41	-3	6	7	1	2	4	2	9	8	-1
28	26	M	173	81	27.1	B	29	27	-2	60	62	2	5	6	1	5	4	-1	4	3	-1
29	20	F	156	51	21	B	22	18	-4	42	38	-4	6	7	1	2	5	3	10	10	0
30	23	F	157	53	21.5	B	22	24	2	49	40	-9	6	7	1	4	5	1	5	4	-1
31	18	F	161	59	22.8	B	48	30	-18	90	66	-24	6	7	1	3	5	2	5	5	0
32	18	F	150	67	29.8	B	38	30	-8	58	50	-8	6	6	0	2	3	1	6	7	1
33	18	M	150	54	24	B	22	20	-2	78	68	-10	6	7	1	2	4	2	5	3	-2
34	22	F	149	54	24.3	B	30	28	-2	56	44	-12	3	3	0	2	3	1	12	10	-2
35	17	M	160	52	20.3	B	38	28	-10	48	44	-4	5	4	-1	3	3	0	3	3	0
36	25	M	173	75	25.1	B	28	38	10	44	58	14	3	6	3	4	4	0	8	9	1
37	20	F	158	60	24	B	38	30	-8	58	57	-1	3	7	4	5	4	-1	12	12	0
38	21	M	158	56	22.4	B	58	60	2	120	90	-30	2	4	2	4	4	0	2	2	0
39	26	F	155	67	27.9	B	18	20	2	48	40	-8	4	5	1	5	6	1	9	9	0
40	18	M	170	80	27.7	B	29	18	-11	60	68	8	4	4	0	3	5	2	4	0	0
41	25	F	161	88	33.9	B	30	28	-2	48	44	-4	4	7	3	3	5	2	0	0	0
42	19	M	152	59	25.5	B	38	30	-8	68	58	-10	5	7	2	2	5	3	1	1	0
43	20	M	163	72	27.1	B	40	38	-2	90	68	-22	4	7	3	3	5	2	1	4	3
44	26	M	184	78	23	B	38	36	-2	50	48	-2	4	4	0	5	6	1	0	0	0