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ORIGINAL ARTICLE

Exploring the Association among Executive Attention, Fine Motor Skills, and Fall Risk in Elderly Individuals

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ABSTRACT

Executive attention refers to a supervisory system that suppresses inappropriate responses and triggers appropriate ones and may summoned to compensate for age-related declines in motor skills. The objective of the research was to investigate the connection between executive attention, fine motor performance, and the risk of falls in elderly individuals. This cross-sectional study involved 76 elderly participants aged 60 years and above, recruited from old age homes and Non-Government Organizations in Delhi-NCR (National Capital Region), India. The outcome measures included Executive Attention, assessed using Trail Making Test (TMT) parts A and B; Fine Motor Performance, evaluated using the Minnesota Manual Dexterity Test (MMDT); and Risk of Falls, determined using the Morse Fall Scale (MFS). Karl Pearson's coefficient of correlation (r) was used to analyze the correlation, and univariate regression was applied to evaluate the association. The mean age of the participants was 67.91±4.98 years, and their Body Mass Index (BMI) was 26.07±1.92 kg/m^2. The executive attention test, TMT-part A, showed positive correlations with risk of fall scale and fine motor performance test: it correlated positively with MFS ($r = 0.30$, $p = 0.007$) and with MMDT ($r = 0.40$, $p = 0.000$). TMT-part B exhibited a positive correlation with MMDT ($r = 0.309$, $p = 0.006$). In conclusion, the relationship between executive attention, fine motor performance and risk of fall among the elderly underscores the intricate interplay between cognitive and motor functions in aging populations.

Key Words: *Executive attention, fine motor function, fall risk, old aged.*

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INTRODUCTION

The aging process is accompanied by various cognitive and physical changes, posing significant challenges to older adults, particularly in maintaining motor function and preventing falls. Among the cognitive abilities that play a crucial role in daily activities and fall prevention, executive attention stands out as a critical factor. Executive attention encompasses higher-order cognitive processes responsible for directing attention, inhibiting irrelevant information, and facilitating goal-directed behavior, all of which are integral to successful motor performance and fall prevention in older adults [1]. Executive attention may be enlisted to compensate for the age-related decline in motor performance, which can affect executive function due to changes in the prefrontal cortex associated with aging. The ability of older adults to manage complex everyday situations, such as walking while simultaneously performing other motor and cognitive tasks, may be impacted by these alterations [2]. As the population continues to age globally, understanding the relationship between executive attention, fine motor performance, and the risk of falls becomes increasingly important for promoting healthy aging and enhancing quality of life. Recent studies have highlighted the intricate interplay between executive attention and motor control, suggesting that deficits in executive attention may contribute to declines in fine motor skills and increase the susceptibility to falls among older adults [3,4].

Furthermore, emerging evidence suggests that interventions targeting executive attention could potentially mitigate the risk of falls by enhancing motor coordination and balance control in older adults [5]. However, the precise mechanisms underlying the association between executive attention, fine motor performance, and fall risk remain incompletely understood, necessitating further research to elucidate these relationships and inform targeted interventions for fall prevention in older adults.

Therefore, this study aims to explore the association between executive attention, fine motor performance, and the risk of falls in older adults, drawing upon recent empirical findings and theoretical frameworks in cognitive psychology and gerontology. By elucidating the underlying mechanisms linking executive attention with motor function and fall risk, this research endeavors to inform the development of effective interventions and strategies for promoting healthy aging and reducing the burden of falls among older adults.

MATERIAL AND METHODS

This cross-sectional study comprised 76 elderly individuals aged 60 years and older, selected from old age homes and Non-Governmental Organizations in Delhi-NCR (National Capital Region), India. The sample size was determined using G-Power 3.1.9.4 software, with a significance level of 0.05 and a power of 80%. The estimated sample size was 68. Factoring in a 10% dropout rate, the final sample size was set at 76 individuals. All procedures strictly adhered to ethical standards and followed the guidelines outlined in the Helsinki Declaration of 2013. Both male and female participants who were capable of independent walking, understanding, and adhering to commands, and comprehending the English language were included in the study after obtaining informed consent. The eligibility criteria encompassed the ability to understand inquiries, follow instructions, walk without assistance, and comprehend English letters. Participants with neurological conditions like stroke, Parkinson's disease, or head injury, as well as those with medical conditions that could affect walking ability, a history of alcohol consumption, issues of dizziness or fainting, visual impairments, acute illnesses, or a history of brain surgery, were excluded from the study. The assessment included Executive Attention measured through Trail Making Test parts A and B; Fine Motor Performance assessed via the Minnesota Dexterity Test; and Risk of Falls determined by the Morse Fall Scale.

A. *Executive Attention assessed by Trail Making Test*

In the Trail Making Test, both parts consisted of 25 circles arranged on a sheet of paper. In Part A, the circles were numbered 1 – 25, and the patient was instructed to draw lines to connect the numbers in ascending order. Part B included circles with both numbers (1 – 13) and letters (A – L), requiring the patient to draw lines in an ascending pattern while alternating between numbers and letters (e.g., 1-A-2-B-3-C, etc.). Patients were instructed to connect the circles as quickly as possible without lifting the pen or pencil from the paper. Errors were immediately pointed out and patients were allowed to correct them; however, corrections were included in the completion time for the task. If both parts were not completed within five minutes, the test was discontinued. Scoring was based on the time taken to complete each part, with higher scores indicating greater impairment [6].

B. *Minnesota Manual Dexterity Test*

The test was comprised of 5 tests including the Placing Test, Turning Test, Displacing Test, One-hand Turning and Placing Test, and the Two-Hand Turning and Placing Test. Each test could be repeated for up to four trials. After completing one trial, the board had to be re-set for the following trials. The time in seconds was recorded on the score sheet for each trial. The final scoring was interpreted by the total seconds for all trials. Each trial began as the administrator said, “Put your hand on the first disk. Ready, go!” For each test, all disks had to be fully inserted and inserted into the proper hole if the disk was dropped [7]. The subject performed all tests from a standing position.

- Placing Test: This step assessed the subject's ability to put disks from the top board into the bottom board using their dominant hand.
- Turning Test: This test evaluated the speed at which the subject could pick up disks with one hand, turn them with the other hand, and then replace them into the holes of the board.
- Displacing Test: This step gauged how quickly one could move blocks from one hole to another using either hand.

- One-Hand Turning and Placing Test: This test assessed how fast one could pick up disks from the top board, turn them over, and place them into the holes of the bottom board using only their dominant hand.
- Two-Hand Turning and Placing Test: This test evaluated the speed at which one could pick up disks from the top board, two at a time (one in each hand), turn the disks over, and place them into the holes of the bottom board.

C. The Morse Fall Scale (MFS)

This scale offers a swift and uncomplicated approach to evaluating a patient's risk of falling. Comprising six easily scored variables, it has demonstrated both predictive validity and interrater reliability in research studies [8].

Risk Level	MFS Score
No Risk	0-24
Low Risk	25-50
High Risk	≥ 51

Results

Descriptive statistics were applied using SPSS version 25 to find out the results. Karl Pearson correlation was used to find the correlation executive attention with fine motor performance and risk of fall in older adults. Each of the measures was found to be normally distributed, as determined by the Shapiro-Wilk test.

Table 1: Mean Age and BMI of subjects

	MEAN±SD
AGE (Years)	67.91±4.98
BMI (kg/m^2)	26.07±1.92

The demographic profile of the study participants depicted that the mean age was 67.91±4.98 years. Data constituted almost equal number of males and females males – 42 (55.26%) and females – 34 (44.74%) and mean value of BMI was 26.07± 1.92 kg/m^2 as shown in table 1.

Table 2: Mean of Executive Attention (TMT Part A, TMT Part B) and MFS

	MEAN±SD
TMT PART A(sec)	71.11±38.59
TMT PART B(sec)	128.03±74.22
MFS	30.07±15.10

As evident from table 2, the mean value of two parts of Executive attention test – TMT Part A and TMT Part B were 71.11±38.59 seconds and 128.03±74.22 seconds respectively and for MFS it was 30.07±15.10.

Table 3: Mean of Minnesota Manual Dexterity Test Components

	Mean ± SD
Placing(sec)	198.51±55.93
Turning(sec)	211.38±91.32
Displacing(sec)	167.48±62.79
One hand Turning and displacing(sec)	204.40±60.63
Two hand Turning and displacing(sec)	148.01±57.58
MMDT	929.80±287.94

Above table 3 showed mean of placing test 198.51±55.93 seconds, turning test 211.38±91 seconds, Displacing test 167.48±62.79 seconds, one hand turning and displacing 204.40±60.63 seconds, two hand turning and displacing 148.01±57.58 seconds and mean of total score for MMDT was 929.80±287.94.

Table 4: Correlation Coefficient of outcome measures for Elderly Subjects

ELDERLY SUBJECTS (N=76)		MMDT	MFS	Executive Attention-Trail Making Test-Part A	Executive Attention-Trail Making Test-Part B
Executive Attention-Trail Making Test-Part A	r (p-value)	0.405 (0.000) **	0.298 (0.009) **		
Executive Attention-Trail Making Test-Part B	r (p-value)	0.309 (0.007) **	0.108 (0.355)		
MFS	r (p-value)	0.21 (0.06)			
MMDT	r (p-value)				

****Correlation is significant at the 0.01 level**

The correlation of outcome variables (Executive Attention-Trail Making Test - Part A & B, MMDT & MFS) for elderly subjects are depicted in table 4. There was a statistically significant positive correlation of TMT-Part A with MMDT (r = 0.405, p = 0.000) and MFS (r = 0.298, p = 0.009) and MMDT (r = 0.405, p = 0.000). There also existed significant positive correlation between TMT-Part B and MMDT (r = 0.309, p = 0.007). TMT-Part B was also significantly positively correlated with MMDT (r = 0.309, p = 0.007). There was insignificant correlation of TMT part B with MFS. In addition, among elderly subjects, insignificant correlation was also found between MFS and MMDT.

Table 5: Regression Analysis

Regression Statistics	
Multiple R	0.34
R Square	0.11
Adjusted R Square	0.07
Standard Error	14.58
Observations	76

ANOVA					
	Df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2014.33	671.44	3.15	0.029
Residual	72	15310.33	212.64		
Total	75	17324.67			

	Coefficients	*Standard Error*	*t Stat*	*p-value*	*Lower 95%*	*Upper 95%*
Intercept	18.47	5.80	3.18	0.002	6.90	30.04
MMDT	0.006	0.006	0.96	0.338	-0.006	0.01
Trail Making test part A	0.13	0.05	2.35	0.021	0.02	0.25
Trail Making test part B	-0.03	0.02	-1.06	0.288	-0.09	0.02

- df: Degree of Freedom, SS: Sum of Squares, MS: Mean Squares

As depicted in table 5, the multiple R value was 0.34 that suggested a reasonably linear association between the predictors (Executive Attention and MMDT) and the response variable (Morse Fall risk score). The p-values for MMDT and Trail Making Test part B were 0.33 and 0.28, respectively, whereas the p-value for Trail Making Test part A was 0.021.

DISCUSSION

The findings from the study suggest a relationship between executive attention, risk of falls, and fine motor performance in older adults. Executive attention, encompassing aspects such as planning and cognitive flexibility, has been shown to influence both fall risk and fine motor skills, although the strength of these correlations varies across different measures. Firstly, the moderate positive correlation observed between Executive Attention (EA) as assessed by Trail Making Test (TMT) Part A and fall risk suggests that interventions targeting executive attention and cognitive planning could potentially reduce the incidence of falls among older adults. This finding aligns with the understanding that cognitive processes related to planning and attention play a crucial role in maintaining balance and preventing falls in this population [9]. Regression analysis suggested that Executive Attention (Trail Making Test part A) is a significant predictor of fall risk, whereas MMDT and Trail Making Test part B are not significant predictors. Conversely, the weak positive correlation between TMT Part B and fall risk indicates that while cognitive flexibility is relevant to fall prevention, it may not be the sole predictor of fall risk [10]. Other factors such as muscle strength, sensory function, and environmental hazards likely contribute to fall risk as well. Therefore, interventions focusing solely on cognitive flexibility may not be sufficient to address the multifactorial nature of falls in older adults.

Fine motor performance exhibits a moderate positive correlation with Executive attention (Trail Making Test Part A) and the Placing test, as well as with Trail Making Test Part B. Moreover, Corti et al. (2017) highlighted the strong positive correlation between TMT Part B and fine motor performance, underscores the interconnectedness of cognitive and motor abilities in aging individuals [11]. This suggests that interventions aimed at enhancing executive attention and cognitive flexibility, such as cognitive training or physical exercise programs, may not only impact fall prevention but also contribute to maintaining or improving fine motor skills [12].

Smith et al. (2023) has stated in their studies that executive attention deficit is a sole pathophysiology of clinical manifestations like increased risk of fall, not a by-product of specific cognitive deficits which really do increase the risk of fall in parallel process [13]. During active engagement in mobility tasks of daily life, distractions should be inhibited otherwise they will compete for the attention and often appear to reduce the capability to quick respond to loss of balance. So executive attention being an integral part of daily life activities, underlines poorer accuracy, more error and longer reaction time on the executive function (EF) tests indicates future predisposition of increased risk of fall among geriatric populations.

Spedden et al. (2017) has suggested that in healthy older adults, a decline in fine motor control corresponds with diminished planning abilities, indicating a significant predictive relationship between planning and sequencing performance [14]. This finding substantiates the proposed hypothesis, suggesting that as planning abilities diminish with age, so too does the execution of movement and the capacity for fine motor control. Executive attention, which encompasses planning, plays a contributory role in motor control. Dopamine appears to control both motor functions and cognition, and perhaps a disruption in dopamine could lead to both executive functioning and fine motor control declines. Also according to a study of Karrer TM et al. (2017) has suggested that both functions may decline concurrently because they rely on the dopamine system [15]. Research indicates that low levels of dopamine transporters are associated with compromised motor control, such as impaired gait, and with diminished executive functioning, including working memory. This pathophysiology has been estimated as an attribute of the decline in executive attention to cause increased risk of fall, leading to a strong association between executive attention and risk of fall. The main results bolster the hypothesis and indicate that within older adults living in the community, future falls can be predicted by executive attention and attention tests. This suggests that a lower executive attention score may precede a higher risk of falls. The connection between executive attention and future falls could be interpreted through various avenues. The results of the survival analyses also imply that higher levels of executive attention might act as a protective barrier for older adults against falling [16]. This allows individuals to effectively allocate cognitive resources to maintain balance while walking, thereby preventing or recovering from any disruptions. On the other hand, it's possible that lower levels of executive attention hinder the ability to compensate for age-related alterations in gait and balance, consequently elevating the risk of falls [17]. This outcome aligns with recent studies indicating decreased connectivity in the frontal lobe to other cortical areas and diminished performance on tasks related to executive attention, even in older adults without evident cognitive decline. These results coincide with the frontal aging hypothesis, suggesting that dysfunction in the frontal lobe could signify a reduction in cognitive reserve due to distinct brain changes [18]. Both these reports and the current findings suggest that as cognitive reserve diminishes with age, the influence of executive attention on falls becomes more pronounced.

Brauer et al. (2002) investigated the impact of attention on posture and gait in older adults by having participants stand on a balance and posture mat while engaging in a digit memory task [19]. Results revealed that when participants divided their focus between balancing and the digit memory task, there was an uptick in the number of sways (errors) during the balancing task. This suggests that cognitive processes play a crucial role in maintaining proper motor control as an individual's age. The main finding is further supported by the 'dual task cost' theory which suggests that older adults increasingly depend on executive functions for movement. Studies have shown that additional prefrontal areas are activated during movement in older adults compared to younger adults, aligning with this theory [20].

CONCLUSION

In conclusion, the correlation between executive attention, fine motor performance, and fall risk among the elderly highlights the intricate relationship between cognitive and motor functions in aging individuals. As executive attention diminishes, individuals may encounter difficulties in coordinating fine motor tasks, potentially heightening their susceptibility to falls and associated injuries. Recognizing and addressing this connection is crucial for devising targeted interventions aimed at preserving cognitive and motor capabilities in older adults, thereby enhancing their overall quality of life, and reducing fall risks. By integrating approaches to sustain executive attention and fine motor skills, healthcare professionals and caregivers can collaborate to promote independence and safety in the aging population. The study's limitations include analysis of other factors contributing to the risk of falls among the elderly. Future interventional studies focusing on enhancing executive attention and its impact on fall risks warrant exploration.

Ethical Approval: Ethical clearance was obtained from the Institutional Ethics Committee (IEC) of Manav Rachna International Institute of Research & Studies, Faridabad, Haryana, India under reference number IEC/MPT-NEURO/21-23.

Authors' Contribution: MA: Conception or design of the work, data acquisition. MK: Conception or design of the work, data analysis and final approval of the manuscript. AKS: Drafting of the work. PA: Data interpretation, revising it critically.

Conflict of Interest: The authors declared no conflict of interest.

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