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Association between Peripheral Vision and Walking Ability in Older Adults

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Abstract

Purpose: This study aimed to clarify how vision influences walking ability and provide fall prevention recommendations for older adults. **Methods:** Forty-four community-dwelling older adults (10 men and 34 women; mean age: 75.79 years) and 45 healthy younger adults (22 men and 23 women; mean age 20.32 years) without visual function or walking difficulties were included. The peripheral vision of both the younger and older adults was evaluated. The Timed Up and Go (TUG) and 10-m obstacle walking tests were conducted to assess the walking ability of the older participants. **Results:** The comparison of hand-eye coordination movements between the younger and older adults showed that the older adults had significantly longer execution times ($p = 0.001$). Age ($r = 0.51$, $p < 0.01$), TUG test ($r = 0.46$, $p < 0.03$), and 10-m obstacle walking speed test ($r = 0.43$, $p < 0.04$) had positive correlations with the execution times of hand-eye coordination movements for older adults. The multiple regression analysis using eye-hand coordination as the dependent variable demonstrated that age and 10-m obstacle walk time were significant explanatory variables. **Conclusions:** A significant association was indicated between hand-eye coordination movements and gait speed in older adults. In the future, combining a visual function assessment with training for enhancing peripheral vision may offer a novel and effective fall prevention approach for older adults.

Keywords

Fall, Hand-Eye Coordination, Gait Speed, Peripheral Vision

1. Introduction

In daily life, walking requires acquiring and processing visual information whether moving outdoors, indoors, or while doing tasks such as shopping. When walking, individuals selectively focus on relevant visual cues, particularly those in their forward field of vision. This focus enables quick detection of potential hazards and adjustments to stride length, walking speed, or trajectory in response to environmental information. In this context, vision serves as a crucial sensory function for maintaining stable walking [1] [2]. Complex real-world environments, characterized by pedestrian and vehicle traffic, uneven terrain, and obstacles, can increase the risk of falls among healthy older adults [3].

Although numerous factors contribute to falls in older adults, age-related deterioration of visual function, particularly in peripheral vision, directly affects walking ability and increases fall risk. Older adults experiencing greater declines in visual attention and gait adaptability are more prone to falls than their non-falling counterparts [4] [5]. Vision plays an essential role in critical movements such as postural control, changing direction, and avoiding obstacles during walking. Disruptions in these visual processes can significantly increase the risk of falls.

Recent studies have revealed a strong relationship between visual function and gait, with particular emphasis on the role of peripheral vision in obstacle avoidance and stride adjustment [6] [7]. Those studies examined the effects of visual function decline on walking stability and showed that the rapid acquisition of visual information through peripheral vision is crucial for avoiding obstacles. Their results highlight the importance of vision in obstacle avoidance among older adults. Thus, visual deterioration may negatively affect walking performance and increase fall risk. Real-world environments demand visual attention and gait adaptation, which involve adjusting walking patterns to meet the environmental demands.

However, many of these studies only suggest the importance of peripheral vision, and few quantitatively measured peripheral vision and directly assessed its impact on walking ability.

The study aimed to clarify how peripheral vision influences walking ability and provide recommendations for fall prevention. The effects of hand-eye coordination on gait were compared between older and younger adults. Furthermore, the Timed Up and Go (TUG) test and 10-m obstacle walking were performed by a local cohort of older adults to examine the relationship between visual function and walking.

2. Methods

2.1. Participants

The study included 44 community-dwelling older adults (10 men and 34 women; mean age 75.79 ± 6.22 years) and 45 healthy younger adults (22 men and 23 women; mean age 20.32 ± 0.46 years) without visual function or walking difficulties. The older adult group participants were selected from residents who participated in community-based physical fitness measurement events. They were required to walk independently, have visual function that did not interfere with daily life, and not have physical and cognitive impairments. The younger adult group participants were primarily recruited from the local area university. Before being invited to participate in the study, their health status was confirmed; they did not have visual impairments affecting daily life or a history of conditions that could impact motor function.

This research was reviewed by an independent ethical review board and conforms with the principles and applicable guidelines for the protection of human participants in biomedical research. This study was approved by the Ethical Review Board of the International University of Health and Welfare (approval number: 23-Ig-12). Prior to the study initiation, the purpose and methods were explained in writing to the participants, and their written consent was obtained.

2.2. Peripheral Vision

The peripheral vision of both the younger and older adults was measured.

The vision training system V-training (Tokyo Megane Co., Ltd., Tokyo, Japan) was used to measure the hand-eye coordination (**Figure 1**).

In the hand-eye coordination task, 10 circular targets appeared at random positions on a 50-inch touchscreen monitor. The targets were placed in both the central and peripheral visual fields. The participants were required to detect and quickly respond to stimuli appearing outside their direct line of sight. They were instructed to touch and eliminate all 10 targets as quickly as possible; the task was repeated three times. The total completion time for the three trials was recorded as the performance measure.

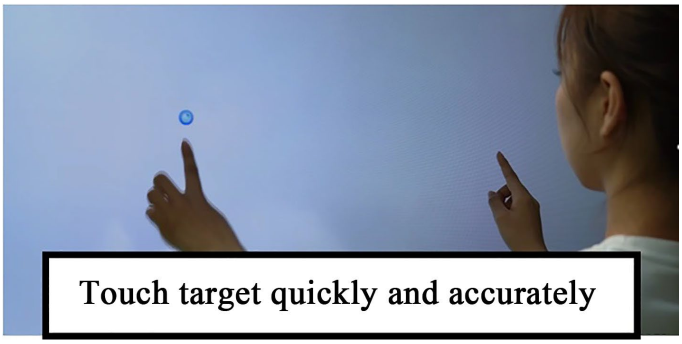

Figure 1. Eye-hand cooperative action.

2.3. Assessment of Walking Ability

The TUG and 10-m obstacle walking test were conducted to assess the walking ability of the older participants.

2.3.1. Timed Up and Go Test

For the TUG test, a 3 m walking path was prepared with a cone placed at the 3 m mark. A participant stood up from a chair at the start signal, walked to the cone, walked around it, and returned to sit back down in the chair. The time taken to complete the task was recorded [8] (**Figure 2**).

2.3.2. 10-m Obstacle Walk Test Procedure

For the 10-m obstacle walk test, six Styrofoam obstacles (100 cm (width) × 20 cm (height) × 10 cm depth) were placed at 2 m intervals from the start to the finish line. The minimum walking time was recorded. If the participants ran or jumped over an obstacle, they were required to restart the task. However, if an obstacle was knocked down, they were allowed to continue without restarting [9] (**Figure 3**).

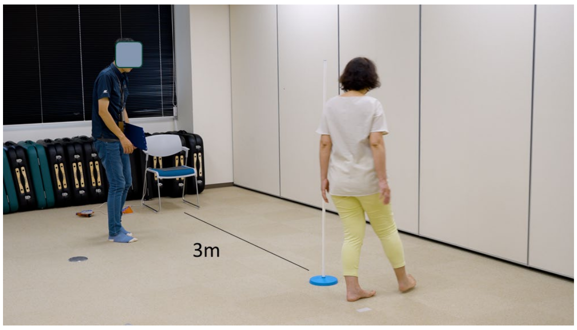

Figure 2. Timed Up and Go Test.

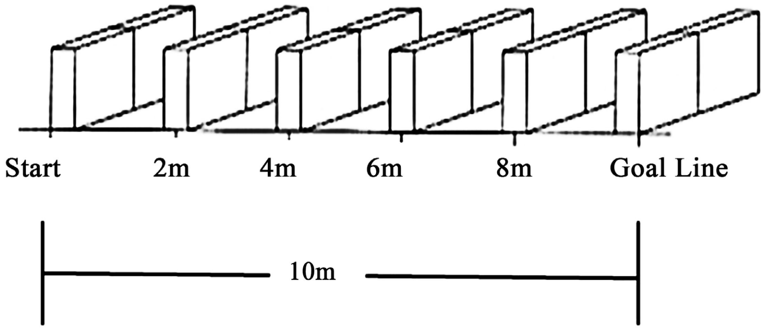

Figure 3. 10 m obstacle walk.

Instructions for this test:

1) Draw a 10 meter line on the floor with vinyl tape.

2) Place obstacles at 2 m intervals from the start to the finish line.

2.4. Statistical Analyses

Prior to statistical analyses, the normality of data was assessed using the Shapiro–Wilk test. For normally distributed data, comparisons of hand-eye coordination movements between the older and younger participants were made using an independent t-test. To evaluate the relationship between performances for the TUG and the 10-m obstacle walk tests and peripheral visual field ability, Pearson's product-moment correlation coefficient was used. To assess the relationship between eye-hand coordination and walking function, a multiple regression analysis (stepwise method) was performed using peripheral vision as the dependent variable and age, sex, and TUG test and 10-m obstacle walking test times as independent variables.

All statistical analyses were conducted using SPSS Statistics 28 (IBM Corp., Armonk, NY, USA). The significance level was set at 5% ($p < 0.05$) for two-sided tests.

3. Results

None of the older adult participants experienced falls (Table 1). The older participants had significantly longer execution times for eye-hand coordination than the younger participants ($p = 0.001$) (Table 2).

Moderate positive correlations were found between eye-hand cooperative movements and the TUG test ($r = 0.46$, $p = 0.03$), 10-m obstacle walking speed test ($r = 0.43$, $p = 0.04$), and age ($r = 0.51$, $p = 0.01$) for the older participants (Table 3).

Table 4 presents the results of the multiple regression analysis that used the total execution time for the hand-eye coordination task as the dependent variable. Age ($\beta = 0.435$, $p = 0.003$) and 10-meter obstacle walking time ($\beta = 0.336$, $p = 0.02$) were identified as significant explanatory variables. The TUG test and sex were not significant, therefore were excluded from the final model. The variance inflation factor of 1.053 was low, which indicated multicollinearity was not an issue. These results suggest that aging and a decline in walking speed may have contributed to decreased visuomotor coordination. (Table 4).

Table 1. Participant characteristics.

	Younger adults (n = 45)	Older adults (n = 44)
Age in years	20.32 ± 0.46	75.75 ± 6.22
History of falls	0	0
TUG test	-	8.26 ± 1.86
10-m obstacle walk	-	10.01 ± 2.14

TUG: Timed Up and Go. The results are presented as mean ± standard deviation.

Table 2. Comparison of eye-hand coordination movements between the younger and older adults.

Trial number	Younger adults (n = 45)	Older adults (n = 44)	95% CI	p-value	Effect size (Cohen's d)
1st	9.30 ± 1.07	15.12 ± 2.79	5.09 - 6.56	0.001	2.77
2nd	9.30 ± 1.07	14.51 ± 2.83	4.46 - 5.95	0.001	2.45
3rd	9.42 ± 1.09	14.82 ± 3.35	4.15 - 6.62	0.001	2.18
Total time	28.04 ± 4.16	44.43 ± 8.26	14.05 - 18.71	0.001	2.51

Total time: from 1st to 3rd. The results include the mean ± standard deviation 95% CI of the distribution for differences, and effect size. CI: confidence interval.

Table 3. Correlation between total time and each item.

Item assessed	Total time	
	r	p-value
Age	0.51	0.01
TUG test	0.46	0.03
10-m obstacle walk	0.43	0.04

TUG: Timed Up and Go.

Table 4. Multiple regression analysis with total time as the dependent variable.

	Multiple regression analysis with total time as the dependent variable				
	Standard regression coefficients	95% CI		p-value	VIF
		Lower limit	Upper limit		
Age	0.435	0.211	0.972	0.003	1.053
10-m obstacle walk	0.336	0.214	2.34	0.02	1.053
Adjusted R2	0.332				
Excluded variables: sex, TUG					

CI: confidence interval; TUG: Timed Up and Go; VIF: variance inflation factor.

4. Discussion

This study revealed the older adults had slower eye-hand coordination and hand-eye movements than the younger adults, and walking speed correlated with eye-hand coordination performance time for older adults.

These findings suggest that the older adults were less able to utilize their peripheral vision when walking compared with younger adults, which can negatively affect their gait, particularly during 10-m obstacle avoidance and TUG tests. Previous studies suggest that a decrease in peripheral vision impairs obstacle recognition and avoidance during walking, thus increases the risk for falls. As people age, they often face challenges in effectively allocating attentional resources, leading to diminished performance on specific tasks [10]. Previous studies on attention and vision have reported slower walking speeds and greater stride length variability in the presence of distractions and visual impairments [11]-[13]. Based on the findings of those studies, the differences in hand-eye coordination movements between older and younger adults observed in this study may have been attributed to age-related declines in attentional and visual functions.

Attentional functioning involves allocating attentional resources as needed when performing multiple tasks simultaneously [14] [15]. For example, while walking, more attention is required in real-world environments than in laboratory settings, thus increases the risk of falls. In the real world, visual attention, gait adaptability, and the ability to modify gait according to environmental demands are essential. One key aspect of gait adaptability in such environments is the ability to perform dual tasks. In daily life, individuals must visually scan for obstacles and distinguish between necessary and unnecessary elements to complete the desired action. This decline in visual search ability, combined with age-related changes in gaze behavior and working memory, are critical factors in fall prevention among older adults [16].

Considering this background information, we hypothesized that the differences in hand-eye coordination movements between older and younger adults may emerge as a result of age-related changes. Aging also affects gaze patterns during obstacle negotiation and dual task performance [17]. Dual-task walking is frequently discussed in studies that investigated fall risk in older adults. Walking while performing tasks such as calculation and word recall increases trunk sway, causes instability, and slows walking speed [18]-[20]. Age-related decline in gait adaptability is a main challenge associated with performing gait and cognitive tasks simultaneously, impacts walking performance [13] [21]. In addition, age-related decline in visual attention and gait adaptability is more pronounced in older adults who fall than in those who do not [4] [5].

Those studies suggest that older adults who fall exhibit poorer performance on cognitive tasks involving walking and vision. Hence, we believe older adults who are slower in executing hand-eye coordination movements require more time to avoid obstacles while walking, changing direction appropriately during the TUG test, and performing preparatory movements to sit in a chair.

Studies on obstacle avoidance and gaze behavior have demonstrated that individuals tend to focus on the final target position when avoiding obstacles [6]. To avoid obstacles, real-time information about the body's trajectory in relation to the obstacle's location is acquired from peripheral vision [6] [22]. External information must be accurately processed through vision during walking to create a precise route [6] [23]. In other words, visual information must be integrated to design an accurate walking route during task performances such as the TUG and 10-m obstacle walking tests. However, a previous study reported that older people at high risk for falls tend to shift their gaze away from a target more quickly while walking compared with those at low risk for falls [24].

Older adults who exhibit slower execution of hand-eye coordination movements may have difficulty effectively acquiring visual information, which subsequently leads to a reduction in walking speed. Older adults are more reliant on visual input for postural control than younger individuals [25]. Additionally, poor vision leads to increased postural sway [26], highlighting the critical connection between walking and visual function. Therefore, walking and visual function are closely linked. Based on the results of this study, the slower acquisition of visual information during hand-eye coordination movements in older adults may affect their ability to adjust acceleration, deceleration, and direction changes during walking.

This study confirmed the relationship between hand-eye coordination and the TUG and 10-m obstacle-stepping walking speed test results. We believe training aimed at improving peripheral vision could enhance walking safety and prevent falls. A previous study demonstrated that peripheral vision training, commonly used by athletes, can improve performance [27]. In the future, the application of such visual training for older adults may further reduce fall risks.

This study has several limitations. First, as this study was a cross-sectional survey, causal relationships cannot be determined. Second, the walking assessment was limited to the TUG and 10-meter obstacle walking tests. Future studies should incorporate more detailed gait analyses beyond time-based measurements. Furthermore, a long-term perspective is needed to investigate the intervention effects of visual function training. Third, visuomotor coordination in the peripheral visual field was evaluated using the V-training system standardized perimetry tests were not included. Future research should integrate standardized peripheral vision assessments to provide a more comprehensive evaluations of the relationship between peripheral vision function and walking ability. Finally, although the results suggest a potential relationship between hand-eye coordination and peripheral vision processing ability, direct evidence linking these two functions remains limited. Future studies should incorporate measurements of peripheral vision sensitivity and dynamic visual processing to conduct more detailed analyses.

5. Conclusion

A significant association was found between hand-eye coordination movements and gait speed in older adults. In the future, combining a visual function assessment with training for enhancing peripheral vision may offer a novel and effective fall prevention approach for older adults.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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