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Research Article

Ageing Effects on Dual-Tasking Performance that Involved Turning-While-Walking

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Abstract

Turning-while-walking requires attention. This task can demand more attention when performed with a concurrent cognitive task, particularly in older adults. This study therefore aimed at examining the effects of ageing on dual-tasking performance that involves turning-while-walking in young-old adults (age 65-74). Eleven young-old adults and ten young adults were recruited. Single auditory Stroop test, single turning-while-walking test, and dual-tasking that combined the two single tests were assessed. Results showed that young-old adults compromised accuracy in cognitive task when dual-tasking, while their physical task performance was not significantly affected by an additional cognitive task. The results suggested that the young-old adults could have employed a 'posture first' strategy to maintain balance when there were insufficient attentional resources for them to perform the two tasks simultaneously. When compared to the young subjects, the young-old adults performed similarly during the physical task. However, they reacted significantly slower than their younger counterparts in the cognitive task when dual-tasking. The results raise concerns regarding the dual-tasking ability of community-dwelling young-old adults, even if they appear to be physically fit. Future studies incorporating different cognitive tasks are warranted. Correlation between dual-tasking ability, physical function, cognitive function, and activity level are also worth investigating.

Keywords: Ageing; Young-old; Dual-tasking; Auditory Stroop test; Turning-while-walking

Introduction

Turning-while-walking is one of the most common activities that causes a fall in community-dwelling older adults. A fall during turning is associated with recurrent falls. It is 7.9 times more likely to cause a hip fracture when compared with a fall during straight-line walking [1], and contributes to early mortality in older adults [2].

While straight-line walking is considered an automatic action, turning demands cognitive processing [3]. Before the turn, the body judges and coordinates different segments *via* its feedforward system to perform a safe and efficient turn. During the turn, feedback system acts to monitor and adjust the movement continuously [4,5]. Compared with healthy young adults, older people demonstrated a deviated reorientation sequence of body segments, increased time to turn, and the number of turning steps [5]. These factors determine turning performance, which relates to functional ability [6].

Dual-tasking is defined as performing two different tasks simultaneously. Dual-tasking is common in daily life. For example, talking while walking, or crossing the road while keeping an eye for the traffic signal. The theory of competition for attentional resources explains the ability of an individual to dual-task. When the available resources are insufficient for a person to perform two tasks concurrently, there will be a decline in the performance in either or both tasks [7,8]. Several factors were suggested to contribute to the ageing effects on dual-tasking ability [7]:

- Increased attentional demand to perform individual physical and cognitive tasks.
- Decreased availability of attentional resources to dual-task.
- Compromised ability to shift attentional resources between the two tasks.
- Combinations of these factors.

There have been numerous studies suggesting a decrement in dual-tasking ability among older adults. Dual-tasking ability has also been negatively related to falls in older adults [9,10].

Since turning requires attentional resources, an additional task during the movement is theoretically more challenging, especially for older adults. Although there were studies concerning how older people reacted to dual-tasking condition that involved turning, they only targeted at middle-old subjects (age 75-84) [11,12]. How young-old adults (age 65-74), who are generally more active and mobile, react to such dual-tasking challenge is not understood. This study therefore aimed at investigating how young-old adults respond to dual-tasking that involved turning-while-walking. The hypotheses were that 1) young-old adults perform worse in both physical and cognitive tasks during dual-tasking compared with single-tasking, and 2) young-old adults perform worse than young adults in such dual-tasking condition.

Materials and Methods

Participants

In this cross-sectional study, community-dwelling young-old

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adults were recruited by conventional sampling, while young adults were recruited at local universities. Inclusion criteria were as follows: 1) able to walk unaided, 2) independent in activities of daily living, and 3) native Cantonese speakers (as required for the auditory Stroop test), 4) 65-74 years of age for the young-old adult group, and 5) 19-24 years of age for the young adult group. Exclusion criteria were as follows: 1) diagnosed with neurological disorders, 2) suffering from any musculoskeletal injuries in the lower limbs during the last 12 months, 3) cognitively impaired as defined by a score of less than 24 in the Mini-Metal State Examination (Cantonese version), and 4) had hearing impairments. Ethical approval of the study was obtained from the Ethics Committee of The Hong Kong Polytechnic University. After a standardized explanation of the aim and procedures, written informed consents were obtained from all participants.

Assessment

Demographic data including age, height and weight were collected. All subjects performed three tests: 1) auditory Stroop test (single cognitive task), 2) turning-while-walking test (single physical task), and 3) a combination of the two tests (dual-tasking). The sequence of the three tests was randomized for each subject.

Auditory stroop test (Single Cognitive Task)

For this test [13], two Cantonese words, "low" or "high", were recorded with a low-pitch and a high-pitched voice. There were four combinations of auditory cues. Subjects were asked to press a two-button switch according to the pitch of the auditory cue, disregarding the meaning of the pronounced word. The subject should respond to the audios as quickly and as accurately as possible. The test was conducted in a quiet environment with the subject seated. The test began with four audios as practice trials, followed by twelve testing audios as data-taking trials. Outcome measures were the average reaction time of the twelve trials, and the error rate as calculated by

$$\text{Error rate} = \frac{(\text{Number of wrong trials})}{(\text{Number of trials conducted})} \times 100$$

Turning-while-walking test (Single Physical Task)

Subjects wore six gyroscopic sensors (Mobility Lab iWalk, OPAL sensors, APDM Inc., Portland, OR) over their four limbs, waist, and chest. Each subject walked a 5-meter straight path, turned 180o, and walked straight back to the starting point at their quickest and most stable manner. After familiarization, each subject performed six trials, with three trials turning to each side. Subjects were provided with the two-button switch used in the auditory Stroop test, and were instructed to press any button during turning to eliminate the motor effect of this action on physical performance when compared with the dual-tasking condition. Outcome measures were the completion time of the whole task, the turning duration, and the number of turning steps.

Dual-tasking test

Dual-tasking performance was assessed with a concurrent auditory Stroop test and turning-while-walking test. The auditory cues were triggered by a force platform (Model OR6-5-1000, Advanced Mechanical Technologies Inc., Newton, MA, USA) embedded on the floor where the subjects started turning. A practice trial was performed for familiarization. A total of eight trials were conducted, with four trials turning to each side. Prioritization of the task was not stated. Outcome measures were those adopted in the single cognitive and single physical tests. This test has been assessed for its reliability [14].

Statistical analysis

Statistical analyses were carried out with the Statistical Package for the Social Sciences (SPSS) (version 20.0, IBM Corp., Armonk, NY, USA). Independent t-tests were conducted to compare the continuous demographic characteristics between the two groups. A chi-square test was employed to compare the sex distribution between the two groups. Two-way mixed ANOVA (group x task) was conducted for each outcome measure to determine the significance of the group effect, task effect, and interaction effect. For any significant task effect revealed, paired t-tests were conducted to compare the single-tasking and dual-tasking conditions in each group. If a significant group effect was found, follow-up between-group differences were compared with independent t-tests in each tasking condition. Bonferroni adjustments were made for every follow-up analysis. The statistical significance level was set at 0.05.

Results

Participants

Ten young and eleven young-old adults participated in this study. Demographic data of the two groups are shown in Table 1. There was a significant difference in the average height of the two groups, with the younger group being taller, but not in other parameters.

Table 2 illustrates the results of the two-way mixed ANOVA for the single auditory Stroop test, single turning-while-walking test, and the dual-tasking test.

Comparing single-tasking and dual-tasking performance in young-old adults

For the auditory Stroop test, statistical analyses revealed a significant task effect in error rate [$F(1, 19) = 8.388$, $p = 0.009$] but not in reaction time [$F(1, 19) = 0.024$, $p = 0.878$]. Follow-up analyses on error rate showed that young-old adults made significantly more errors in dual-tasking (10.8 ± 10.9%) than in single-tasking (5.3 ± 5.6%) ($p = 0.041$; 95% CI, 0.260 to 10.725).

For the turning-while-walking test, no significant task effects were found in all measured parameters.

Comparing performance between young-old and young adults

For the auditory Stroop test, two-way mixed ANOVA showed significant differences between the two groups in both reaction time [$F(1, 19) = 19.590$, $p<0.001$] and error rate [$F(1, 19) = 5.781$, $p = 0.027$]. Independent t-test found that young-old adults reacted significantly slower than their younger counterparts under both single-tasking

Table 1: Demographic data comparison between the young adult and older adult groups.

	Young adult (n=10)	Young-old adult (n=11)	p-value
Age (years)	20.8 ± 0.4	67.8 ± 4.6	-
Height (cm)	168.1 ± 8.4	158.5 ± 9.4	0.023*
Weight (kg)	58.0 ± 8.1	59.5 ± 12.9	0.759
Gender (male / female)	4/6	4/7	0.864

*denotes p<0.05.

Table 2: Results under single-tasking and dual-tasking conditions.

	Young adult (n = 10)		Older adult (n = 11)		F-value (p-value)		
	Single-task	Dual-task	Single-task	Dual-task	Between-group effect	Within-group effect	Interaction effect
Auditory Stroop test							
Reaction time (sec)	0.69 ± 0.12	0.75 ± 0.11	1.21 ± 0.37	1.18 ± 0.42	19.59 (<0.001**)	0.024 (0.878)	0.368 (0.551)
Error rate (%)	0.00 ± 0.00	5.0 ± 4.9	5.3 ± 5.6	10.8 ± 10.9	5.781 (0.027*)	8.388 (0.009*)	0.018 (0.893)
Turning-while-walking test							
Completion time (sec)	8.4 ± 1.0	8.3 ± 1.0	8.3 ± 1.7	8.4 ± 1.8	0 (0.991)	0.001 (0.98)	1.097 (0.308)
Turning duration (sec)	2.3 ± 0.2	2.2 ± 0.2	2.5 ± 0.6	2.5 ± 0.6	1.637 (0.216)	0.801 (0.382)	0.082 (0.778)
No. of turning steps	5.5 ± 0.4	5.4 ± 0.3	5.8 ± 1.4	5.7 ± 1.4	0.595 (0.45)	0.912 (0.351)	0.026 (0.874)

Values are in mean ± S.D.
*denotes p<0.05
**denotes p<0.001

(p<0.001; 95% CI, 0.254 to 0.780) and dual-tasking conditions (p = 0.005; 95% CI, 0.148 to 0.720). Young-old adults also made more error than the younger subjects in single-tasking (p = 0.008; 95% CI, 1.576 to 9.031) but not in dual-tasking condition (p>0.05).

For the turning-while-walking test, there were no significant between-group effects on completion time, turning duration, and number of turning steps.

Discussion

This study investigated the ageing effect on dual-tasking performance that involved turning-while-walking as the physical task. When comparing the single-tasking and dual-tasking conditions in the young-old adults, the difference was only observed in the error rate of the cognitive task but not in the reaction time. The effect of an additional cognitive challenge on the physical task was also not statistically significant insignificant. Therefore, the expectations of compromised both physical and cognitive performance under the dual-tasking condition in the young-old adults was only partially supported. When comparing young-old adults with their younger counterparts, a statistically significant difference was found only in the cognitive task but not in the physical task. The young-old adults reacted slower to audio cues than the young subjects when dual-tasking.

When the attentional resources are insufficient for an individual to perform two tasks simultaneously, he or she prioritizes the task that is perceived as more important over the other [15,16]. In this study, the young-old subjects prioritized the physical task over the cognitive task, thus only the cognitive performance, but not the physical one, was compromised in the dual-tasking condition. This phenomenon can be explained by the 'posture-first strategy' [16]. The strategy is considered a safety measure when an individual perceives that he or she is incapable of performing two tasks simultaneously. The importance of maintaining balance leads the individual to allocate more attentional resources to the physical component and jeopardize the cognitive performance to maintain balance. Furthermore, lower odds of recurrent fall were associated with higher reaction time to a push-button task under a dual-tasking condition that involve turning in middle-old adults [12]. Correlations between dual-tasking performance and incidents of falls in the young-old population are worth studying in the future. Further neurological studies on how young-old adults allocate their attentional resources under dual-tasking challenges are also warranted.

Although young-old subject did not prioritize the cognitive task when dual-tasking, they compromised only the accuracy but not the reaction time of the task. The prioritization of tasks would presumably change depending on the cruciality of the cognitive task, for example, making an important decision. The young-old adults may interrupt the physical task and perform the cognitive task, or take longer to make a correct decision. There is a need to have a better understanding of task prioritization in different real-life dual-tasking situations in young-old adults.

When comparing the young-old adults with those who were younger, subjects in the two groups performed similarly in the physical task. On the other hand, the young-old subjects reacted slower in the auditory Stroop test than their younger counterparts when dual-tasking. These results imply that although the young-old adults had comparable physical ability with the younger adults, they had to compromise the cognitive task when dual-tasking. In daily activities, people commonly encounter spontaneous cognitive challenges while performing physical tasks. The young-old adults, though seeming physically fit, may not be able to respond quickly while dual-tasking, especially those activities that are more cognitively demanding, such as turning-while-walking in this study. This challenge raises concerns regarding dual-tasking ability in community-dwelling young-old adults, and therefore should not be overlooked.

There were several limitations to this study. Firstly, this study only employed the auditory Stroop test as a cognitive task. There are different types of tasks that are cognitively demanding, and subjects might respond to them differently. Another limitation was that physical and cognitive functions, as well as the level of physical activity, were not recorded in this study. Future studies correlating these parameters with dual-tasking performance in young-old adults are needed. Furthermore, young-old subjects with different levels of physical ability should be included.

Overall, the results of this study showed that the young-old adults compromised cognitive component instead of the physical one when dual-tasking. It is hypothesized that those subjects did not have sufficient attentional resources to perform the two tasks simultaneously. Therefore, they prioritized the physical task over the cognitive one to maintain balance. Further neurological studies, such as using fMRI or NIRS, are warranted to support this theory.

Moreover, the young-old adults performed similarly with the younger subjects in the physical task but reacted slower than their younger counterparts in the cognitive task. Although the young-old adults recruited in this study were relatively mobile, the effects of ageing on dual-tasking ability of the population they represented, especially when the physical task required attentional resources, should not be overlooked.

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