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Original Article

Effects of single and dual tasks during walking on spatiotemporal gait parameters of community-dwelling older

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Abstract. [Purpose] This study aimed to investigate the effects of single and dual motor tasks on walking in the elderly. [Subjects and Methods] Data of 308 community-dwelling elderly people were analyzed. Spatiotemporal gait data were obtained using the OPTO Gait system. The gait ability test was conducted under single- and dual-task conditions. [Results] Age and task main effects showed significant difference. Interaction did not show any significant difference. [Conclusion] Our results showed that gait performance decreased during dual task compared to single task. Moreover, we found that the higher the age, the greater the effect on dual tasks. Further research is needed to determine how to improve dual task abilities in older adults.

Key words: Dual task, Gait, Elderly

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INTRODUCTION

Performing multiple tasks while walking becomes increasingly difficult with age[1)]. Walking in activities of daily living is usually required at the same time as movements of the upper extremities. Performing multiple tasks at the same time results in the loss of performance for individual subtasks[2)]. Therefore, performing dual tasks can affect an elderly person's ability to walk[1)]. Changes in cognitive and motor functions due to aging increase balance instability when walking with dual-task[3)]. Unstable equilibrium increases the risk of falls by reducing walking speed and increasing stride velocity variability[2, 4)].

The effect of walking on dual task performance in the elderly has been studied[2, 4, 5)]. A dual task is a combination of a single task such as balancing or walking and a cognitive task such as speaking or a motor task such as carrying objects. Most of the research on dual tasks has focused on cognitive tasks[2, 4, 6)].

Cognitive dual tasks have a significant impact on gait speed in younger people but less a dramatic effect in elderly people[7)]. Elderly individuals reportedly decrease their walking time when performing dual motor tasks such as transporting goods or pressing a button[8, 9)]. However, there is little research on dual motor tasks[8, 10)].

Dual motor tasks are frequently required in everyday life. Many routine activities, such as walking with coffee, involve dual motor tasks[11)]. Yang et al.[12)] reported that dual motor tasks had greater impact on gait reduction than dual cognitive tasks.

A study suggesting that elderly people are affected by performing dual motor tasks while walking did not provide a spatial and temporal gait variable[13)]. In addition, since it was a small sample collected from an independent living facility, its findings cannot be generalized to the walking characteristics of all elderly individuals.

Therefore, the purpose of this study is to investigate the effects of single and dual motor tasks on walking in the elderly. We also sought to contribute to the normative database of gait parameters during dual tasks in older able-bodied adults.

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SUBJECTS AND METHODS

The study included 308 elderly people (mean age, 74.65 ± 5.32 years; range, 65–85 years). Subjects were recruited through community organizations and local newspaper advertisements. Older people who met these inclusion criteria were recruited:≥65 years; and ability to walk 50 m without an assistive device. Subjects were excluded if they had other neurological, cardiovascular, or musculoskeletal symptoms affecting walking or vision or scored <24 on the Mini-Mental State Examination (MMSE). Each study participant provided written informed consent. All procedures were approved by the Institutional Ethics Committee of Sahmyook University.

Power analyses were performed using G*Power Software version 3.1 with gait speed considered the main variable. We calculated that a minimum of 248 (n=62 in each group) results would be required to achieve an alpha of 0.05, effect size of 0.90 (based on a pilot study), and power of 0.95.

An OPTOGait system (Optogait, Microgate, Italy, 2010) was used to evaluate spatiotemporal gait parameters. The OPTOGait system consists of transmitting and receiving bars, with two bars placed parallel to each other 1 m apart. The transmitting and receiving bars each have 96 communication light-emitting diodes (LEDs). The LEDs are placed 1 mm above the floor level of 3 mm. When the subject passes between the transmitting and receiving bars, the system detects the interruption of the optical signal and automatically calculates the spatiotemporal gait parameters because there is a foot in the recording area. The OPTOGait system provides images to users through small synchronized cameras during the detection and testing of all events. The data were extracted at 1,000 Hz and stored on a PC using OPTOGait version 1.6.4.0 software. The OPTOGait system is widely used in clinical and research environments and features high efficacy and test-retest reliability.

The gait ability test was conducted under single- and dual-task conditions performed in a random order to minimize the effect of training. Three attempts were made for each of the two conditions. Each participant walked through the tray on which the water cup was placed while flexing the elbow at 90 degrees. All tests were performed by a single tester. All participants wore comfortable shoes.

The data analysis was performed using the SPSS 19.0 statistical package. The data distribution of all measured parameters was tested using the Kolmogorov-Smirnov test. The data of all variables were satisfied with the assumption of normality and subjected to the parameter test.

Repeated-measures analysis of variance (four groups, two conditions) and a post-hoc test with Scheffe's test were used to analyze differences in age, gait speed, stride length, and double limb stance duration. Statistical significance was set at values of $p<0.05$.

RESULTS

The spatiotemporal parameters of single and dual tasks by age group are shown in Table 1. The main effects of age and task differed significantly ($p<0.05$). Interaction did not differ significantly.

DISCUSSION

Various tasks must be performed at the same time in everyday life. Humans can generally perform multiple tasks at the same time, but the dual task performance of elderly individuals with reduced cognitive and physical function decreases balance control and mobility[12].

This study investigated the effects of single and dual motor tasks on walking in elderly individuals. We also comprehensively analyzed the standard spatiotemporal gait data of the elderly participants by task. Gait quality is dependent on age, health status, and physical function; thus, it is used to assess the risk of cognitive impairment, falls, and premature death[14]. Verghese et al.[15] explained the walking ability of the elderly in several areas. The gait parameters associated with the execution function include walking speed and stride[14, 15].

Gait speed is an important index of the physical function of the elderly, and when it is reduced by 0.1 m/s, the risk of falling increases in the elderly[15, 16].

In this study, gait speed decreased with age. The gait speed difference between single and dual tasks is 0.07 m/s for individuals 65–69 years of age, 0.08 m/s for those 70–74 years old, 0.09 m/s for those 75–79 years old, and 0.13 m/s for those 80–84 years old. The difference between the single and dual task was 5.4 cm for those 65–69 years old, 5.8 cm for those 70–74 years old, 8.8 cm for those 75–79 years old, and 11.8 cm for those 80–84 years old. The results of this study show that the risk of falls during the dual task condition is increased, while executive function is decreased.

In a study by Silsupadol et al.[17], elderly individuals>65 years of age showed a decreased gait speed of 0.1 m/s during the dual- compared to the single-task condition. Freire Júnior, et al.[18] reported similar results with a reduction in gait speed of 0.18–0.22 m/s and a decrease in stride length of 5.1–5.2 cm for motor dual tasks in elderly people >60 years of age (mean age, 67 years). Himann et al.[19] reported that the walking speed decreased by 12–16% at 10 years after age 70. Our cross-sectional results suggest that gait speed is not significantly different between subjects aged 70–74 years and those aged 75–79 years but significantly reduced in individuals aged 80–84 years. The gait speed of individuals 80–84 years of age decreased

Table 1. Gait parameter by age and task

Parameter	65–69 (n=85)		70–74 (n=80)		75–79 (n=71)		80–84 (n=72)	
	Single	Dual	Single	Dual	Single	Dual	Single	Dual
Temporal parameter								
Velocity (m/s)	1.3 ± 1.1	1.2 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	1.2 ± 0.1	1.1 ± 0.1	1.0 ± 0.1	0.9 ± 0.1*†
Cadence (steps/min)	98.0 ± 6.3	96.5 ± 6.4	96.2 ± 6.4	94.1 ± 5.6	95.4 ± 5.8	94.7 ± 6.5	95.0 ± 7.3	92.3 ± 8.3*†
Stride time (sec)	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0*†
Step time (sec)	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.5 ± 0.0*†
Double limb stance (%GC)	29.4 ± 3.4	30.5 ± 3.6	29.9 ± 2.8	30.7 ± 3.0	29.9 ± 4.1	32.0 ± 3.7	32.9 ± 3.5	34.9 ± 4.1*†
Single limb stance (%GC)	70.5 ± 3.4	69.4 ± 3.6	70.0 ± 2.8	69.2 ± 3.0	70.0 ± 4.1	67.9 ± 3.7	67.0 ± 3.5	65.0 ± 4.1*†
Spatial parameter								
Stride length (cm)	134.0 ± 12.7	128.6 ± 12.0	129.6 ± 14.0	123.8 ± 12.0	127.1 ± 15.1	118.3 ± 12.2	112.2 ± 15.2	100.4 ± 11.4*†
Step length (cm)	66.8 ± 6.3	64.2 ± 6.0	64.6 ± 6.9	61.7 ± 5.9	63.4 ± 7.5	59.0 ± 6.1	56.0 ± 7.5	50.1 ± 5.6*†

Values are expressed as mean ± standard deviation.
*Means significant difference between age.
†Means significant difference between task.

by 14.5% in single tasks and by 19.9% in dual tasks compared to individuals 70–74 years of age. This result suggests that even a healthy elderly person can not avoid gait performance deterioration due to aging and that the decrease may cause an executive function deficit. Additionally, there is greater functional loss and a greater risk of falls in the dual task condition than in the single task condition.

According to Verghese et al.[15], cadence and temporal parameters are associated with memory impairment and dementia. Therefore, it is important to understand the normative value of these variables. Cadence in the present study was 0.02 steps/min for those 65–69 years of age, 0.02 steps/min for those 70–74 years old, 0.01 steps/min for those 75–79 years old, and 0.03 steps/min for those 80–84 years old. In this study, cadence did not differ significantly between age groups or tasks. The subjects of this study were healthy elderly people with normal cognition (MMSE score ≥24 points), and it was difficult to confirm the relationship between cadence, memory, and dementia.

Double limb stance is a variable that reflects balance disturbance during walking[20]. The increase in double limb stance affects the decrease in gait speed and stride length and is associated with an increase in age and double limb stance[21, 22]. When people simultaneously perform dual tasks, attention should be distributed between them[13]. At this time, if the available resource capacity is exceeded, the performance of one or both of the tasks becomes hindered[23]. In this study, the difference in dual limb stance between single and double tasks was 3.8% in individuals 65–69 years of age, 2.6% in those 70–74 years old, 7.2% in those 75–79 years old, and 6.0% in those 80–84 years old. These findings suggest that attention to balance and the dual task was reduced during walking.

Since double limb stance is a variable that reflects disturbances during walking, the increase in double limb stance also affects the decrease in gait speed and stride length[21, 24]. The results of this study show that double limb stance was increased in the dual task condition, while gait speed and stride length were decreased compared to those of the single task condition. Double limb stance increased with age, while gait speed and stride length decreased. Our results showed that gait performance decreased during the dual task condition compared to the single task condition. We also found that the more advanced the age, the greater the effect on the dual tasks.

The limitation of this study was that the subjects walked at their own selected speed rather than at maximum speed. Thus, the results of this study should not be interpreted as those of the subjects' maximum walking ability.

This study has several strengths. First, the study sample was large and the participants were all healthy community-dwelling elderly adults. Thus, our results are expected to be generalizable to the larger elderly population. Second, the data in this study were collected from an average of 18 ± 4 steps (nine strides) per person. We believe that our data are reliable because they were collected from more strides than those of previous studies. Third, test variability was minimized by the use of a single evaluator.

Despite our findings, further studies are needed to determine how to improve dual task abilities in older adults.

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