Changes in step time variability, not changes in step length and width, are associated with lower-trunk sway during dual-task gait in older adults

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ABSTRACT

Individuals are exposed to repetitive dual-task-like situations in daily life, particularly while walking, and falls among community-dwelling older adults typically occur in such situations. Thus, understanding how individuals adapt their walking-related motion under dual-task conditions is of clinical importance. The present study was conducted to investigate the association between dual-task-related changes (DT-changes) in lower-limb gait parameters and DT-changes in lower-trunk sway. We hypothesized that DT-changes in both spatial- and temporal-lower-limb gait parameters would be associated with DT-changes in lower-trunk sway. Participants were older adults aged > 60 years who lived independently in communities (n = 43, 73.7 [6.1] years old), and younger adults (n = 28, 22.7 [5.1] years old). Participants were asked to walk while performing an additional cognitive task, or with no additional task. During walking, lower-limb gait parameters (step time, step length and width) and lower-trunk sway were measured using a photoelectric cell system and inertial sensors. In older adults, DT-changes in step time variability was significantly associated with DT-changes in lower-trunk sway (standard beta = 0.683, p = 0.003), and DT-changes in lower-trunk sway variability (standard beta = 0.493, p = 0.029). In younger adults, DT-changes in step width were significantly associated with DT-changes in lower-trunk sway (standard beta = 0.395, p = 0.041). The current results partially supported our hypotheses. The association between DT-changes in lower limb and DT-changes in lower-trunk sway varied according to age group.

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1. Introduction

The dual-task paradigm is an experimental method for estimating how the brain deals with two competing tasks performed simultaneously (Amboni, Barone, & Hausdorff, 2013; Pashler, 1994; Yogev-Seligmann, Hausdorff, & Giladi, 2008). In geriatric research, walking tasks have been widely used as motor primary tasks because the influence of aging commonly leads to declining gait performance; reduced gait speed, increased fluctuation of lower-limb motion, and increased trunk sway (Yogev-Seligmann et al., 2008). Dual-task-related changes (DT-changes) in gait are considered an important predictive sign for the occurrence of falling in older adults, including community-dwelling older adults, frail older adults, and older adults with Parkinson's disease and multiple sclerosis (Etemadi, 2017; Heinzel et al., 2016; Lundin-Olsson, Nyberg, & Gustafson, 1997; Muir-Hunter & Wittwer, 2016; Yamada et al., 2011). Individuals are often exposed to repetitive dual-task-like situations in daily life, especially while walking. Importantly, falls among community-dwelling older adults typically occur in such situations (Springer et al., 2006; Yogev-Seligmann et al., 2008). Thus, understanding how older adults adapt their walking-related motion under dual-task conditions is of clinical importance. In addition, considering younger individuals show smaller dual-task related gait pattern changes (Priest, Salamon, & Hollman, 2008; Yogev-Seligmann et al., 2008), we hypothesized that the strategy of mutual postural control between step placement and trunk varies in the process of aging. Elucidating this question could help extend current understanding of the underlying mechanisms of postural control in dual-task gait.

During normal gait, the lower-trunk segment provides a stable platform for vision, and its control is prioritized (Winter, 1995a). To achieve this postural control, stabilization of head movements, lower-limb motion and lower-trunk sway are mutually coordinated while walking (Winter, 1995a, 1995b). Several previous studies have reported that dual tasking involves fluctuation of lower-limb gait parameters and lower-trunk sway (Asai, Doi, Hirata, & Ando, 2013; Asai, Misu, Doi, Yamada, & Ando, 2014; Brach et al., 2011; Doi, Asai, Hirata, & Ando, 2011; Kavanagh & Menz, 2008; van Iersel, Ribbers, Munneke, Borm, & Rikkert, 2007). In addition, a previous study in our laboratory reported that stride time variability, as a temporal-lower-limb gait parameter, is significantly associated with lower-trunk sway (Asai et al., 2014). Although it is possible that other spatial-lower-limb gait parameters (step length and step width) are also associated with lower-trunk sway in the dual-task condition, to our knowledge, these associations have not been investigated in detail. Furthermore, the values of changes in gait parameters from the normal task condition to the dual-task condition have not been examined in previous studies. These values should be used to investigate the associations between changes in gait parameters (i.e., lower-limb gait parameters vs lower-trunk sway) related to dual tasking.

In the present study, we investigated the association between DT-changes in lower-limb gait parameters and DT-changes in lower-trunk sway in community-dwelling older adults and younger adults. In normal and dual-task gait conditions, the lower-limb gait parameters and lower-trunk sway were measured, and the magnitude of the difference between conditions (the value of dual-task condition − the value of normal task condition) in gait parameters was computed as DT-changes. We hypothesized that DT-changes in both spatial- and temporal-lower-limb gait parameters would be associated with DT-changes in lower-trunk sway. Thus, we predicted that greater changes in lower limb movements would be mutually linked to greater changes in lower-trunk sway, especially in older adults, but that this association would be less clear in younger adults.

2. Methods

2.1. Subjects

Subjects were 43 adults aged > 60 years (age range 62–87 years) who lived independently in communities as an older adults group (no cognitive impairment and no severe motor deficits), and 28 adults aged < 45 years (age range 19–41 years), including university students, teachers, and physical therapists in hospital as a younger adults group (Table 1). Individuals who did not

Table 1
Demographic data, gait speed in normal and dual-task condition, counting speed in the dual-task condition.

	Older adults group (n = 43)	Younger adults group (n = 28)	p-value#
Sex, Female, n, %	27, 63	16, 57	–
Age, y	73.7 (6.1)	22.7 (5.1)	–
Height, cm	155.0 (7.3)	164.3 (9.0)	–
Weight, kg	53.3 (8.1)	57.3 (10.5)	–
Hypertension, n, %	9, 21	0, 0	–
Respiratory disease, n, %	1, 2	0, 0	—
Heart disease, n, %	2, 5	0, 0	–
Diabetes, n, %	2, 5	0, 0	–
Gait speed in normal condition, m/s	1.39 (0.20)	1.59 (0.18)	< 0.001
Gait speed in dual-task condition, m/s	1.29 (0.26)	1.62 (0.21)	< 0.001
DT-change of gait speed, m/s	− 0.10 (0.20)	0.02 (0.12)	< 0.005
Counting speed in the dual-task condition, n/s	1.4 (0.3)	1.8 (0.3)	< 0.001

Values are mean (standard deviation). #: p-values were obtained by unpaired t-test. Dual-task condition: Subjects were asked to walk while counting backward aloud from a number chosen at random from 70 to 100. DT-change of gait speed: Gait speed in normal dual-task condition minus gait speed in normal condition.
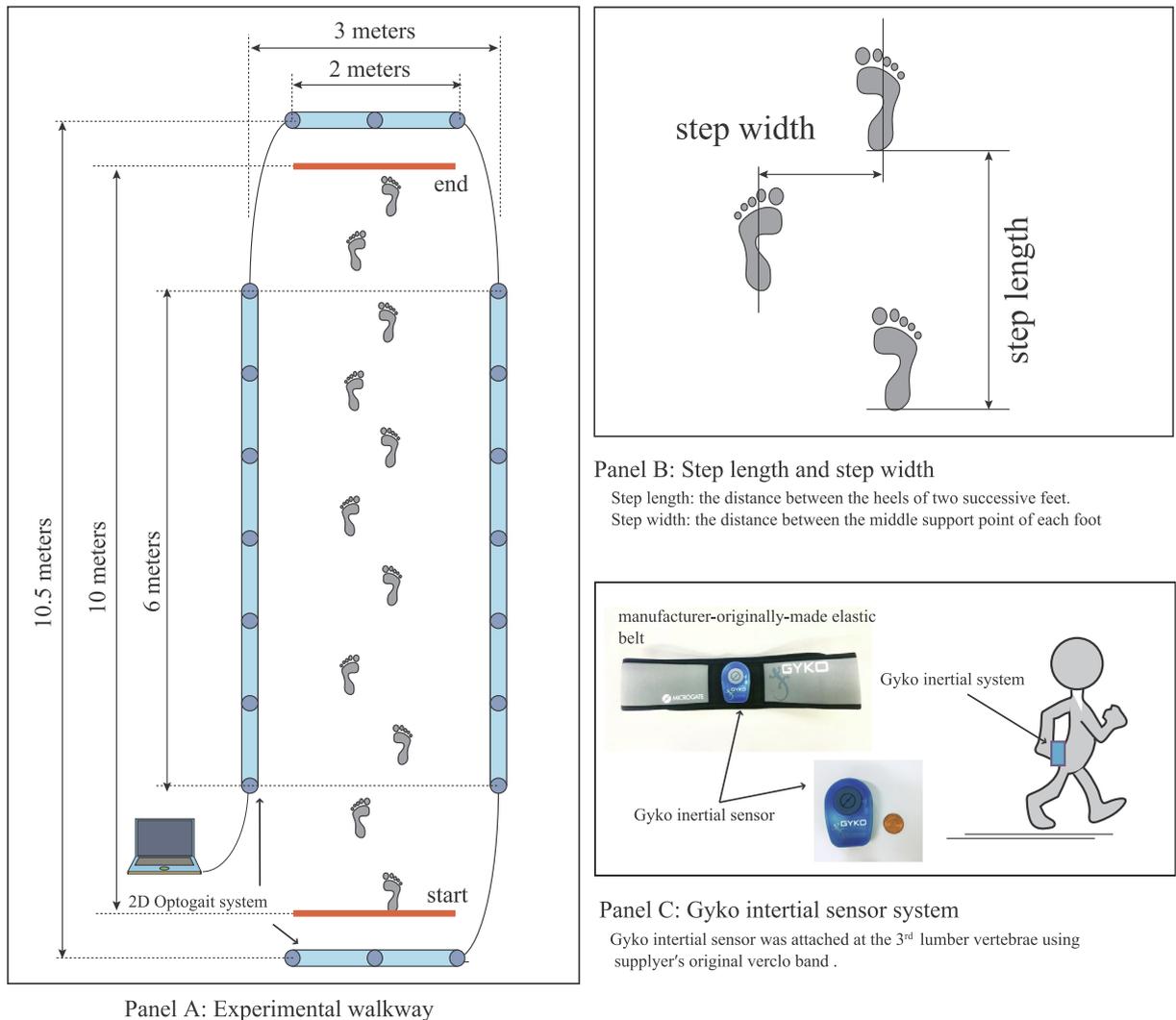
Panel A: Experimental walkway

Panel B: Step length and step width
Step length: the distance between the heels of two successive feet.
Step width: the distance between the middle support point of each foot

Panel C: Gyko intertial sensor system
Gyko intertial sensor was attached at the 3rd lumber vertebrae using supplyer's original verclo band .

Fig. 1. Experimental settings for gait measurements: Optogait System and Gyko intertial system.

complete the gait measurement because of equipment failure were excluded (n = 7). The background characteristics of older adults were assessed using a questionnaire that included questions about age, sex, and medical conditions (hypertension, respiratory disease, heart disease, and diabetes mellitus [yes/no]). This study was carried out in accordance with the principles of the Declaration of Helsinki. The Research Ethics Committee of Kobe Gakuin University approved the study (Approval No. HEB100806-1). Informed consent was obtained from all participants prior to participation.

2.2. Gait measurement

Participants were asked to walk along a 10 m (length) × 2 m (width) smooth horizontal walkway, including a 2 m space at both ends of the 10 m walkway for acceleration and deceleration, while wearing appropriately-sized shoes that were checked beforehand (Fig. 1, panel A). After familiarization with the task and measuring system (OptoGait system and Gyko system, as described below), participants were instructed to walk in two conditions, using the following instructions: (i) walk at your normal speed (normal condition); (ii) walk while serial counting backwards by one aloud from a number chosen at random from 70 to 100 (dual-task condition). The last number reported by each participant was recorded. Using this number, we computed the backward counting speed during the dual-task condition. Backward counting speed (n/s) was equal to the difference between the initial chosen number and the last number counted during walking in the dual-task condition divided by the time taken to complete walking during the dual-task condition. We used the counting backward task as an additional cognitive task because it is relatively easy compared with other cognitive tasks, and the effect of dual tasking can be observed consistently during dual-task walking. Two trials were performed per condition, with the normal condition first, followed by the dual-task condition, with a short break between them. The average values in each condition were computed and used for further analyses.

2.3. Optogait system

In the present study, the Optogait photoelectric cell system (Microgate, Bolzano, Italy) was used as a 2-dimensional step measurement device (Fig. 1, Panel A). The Optogait photoelectric cell system involved a bar 1 m in length, consisting of a transmitter unit and a receiver unit. The transmitter contained 96 light emitting diodes, which were positioned 0.3 cm from ground level (i.e., vertical distance) at 1.04-cm intervals (i.e., horizontal distance). Six bars (i.e. 6 m long) were used for measuring the step placement in the travel direction and step timing, and two bars (i.e., 2 m long) were used for measuring the lateral direction (Fig. 1, Panel A). When subjects entered the measurement-zone enclosed by the Optogait photoelectric cell system, transmission and reception were blocked by the feet and the data for foot placement and step timing were transferred via Bluetooth to a personal computer (Let's note, CF-N9, Panasonic, Japan). Data were extracted at 1000 Hz and saved on a PC using the manufacturer's software (OptoGait Version 1.11 software, Microgate S.r.I, Italy), and mean values for step time, step length, and step width (Panel B) and the coefficient of variance of these lower-limb gait parameters (step time variability, step length variability, step width variability) were automatically calculated. The reliability and validity of the Optogait photoelectric cell system have previously been confirmed in a range of settings (step time; ICC (3,1): 0.911, ICC (2,1): 0.995, step length; ICC (3,1): 0.917, ICC (2,1): 0.996) (Healy, Linyard-Tough, & Chockalingam, 2019; Lee et al., 2014; Lienhard, Schneider, & Maffiuletti, 2013).

2.4. Gyko inertial sensor system

The Gyko inertial sensor system (Gyko sensor, 32 bit, Microgate, Bolzano, Italy) contains a three-dimensional accelerometer (range: ± 2 G), a gyroscope (range: 250°/s), and a magnetometer (range: ± 4800 μT), enabling recording at a sampling frequency of 500 Hz (Fig. 1, panel C). The Gyko sensor (dimensions: 50 × 70 × 20 mm, mass: 35 g) was perpendicularly fixed over the level of the third lumbar spinous process using the elastic belt provided by the manufacturer. The third lumbar spinous process was selected to represent the lower-trunk at the approximate center of mass during walking (Moe-Nilssen, 1998). During measurements, accelerometer and gyroscope signals were transferred via Bluetooth to the same PC for the OptoGait system and saved on the PC using OptoGait software. OptoGait software automatically calculated the dimensions of how much the subject moved their lower-trunk (lower-trunk sway and lower-trunk sway variability). The algorithm in the software estimated the orientation of the Gyko sensor with respect to gravity using an inertial reference system. The antero-posterior and medio-lateral inclination of the Gyko sensor were projected to the ground as 2D cloud points. The obtained trajectories represent the 2D cloud points. Using these 2D cloud points, the algorithm estimates trunk sway and trunk sway variability (Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996). In numerical terms, lower-trunk sway represents the area of the ellipse of confidence (95%), which is an ellipse containing approximately 95% of the points of the trajectory. Greater lower-trunk sway indicates broader antero-posterior and medio-lateral rotation. The software computed the lower-trunk sway for each stride, and lower-trunk sway variability was obtained by considering all lower-trunk sway values in each gait measurement.

2.5. Statistical analysis

We compared gait speed in normal and dual-task conditions, and counting speed in the dual-task condition between groups using unpaired *t*-tests. We compared gait parameters between the normal and dual-task conditions using paired *t*-tests, and calculated the effect sizes (Cohen's d) (Cohen, 1988). The differences of all gait parameters between the dual-task and normal conditions were calculated as the value of the gait parameter in the normal condition minus the value of the gait parameter in the dual-task condition. These values were used as DT-changes in lower-limb gait parameters (step time, step time variability, step length, step length variability, step width, and step width variability) and DT-changes in lower-trunk sway (lower-trunk sway and lower-trunk sway variability). After the confirmation of associations between DT-changes in lower-limb gait parameters that were significant in paired *t*-tests, using Pearson's correlation coefficient r to avoid multicollinearity, forced-entry multiple linear regression models were constructed to investigate the following two associations: 1) between DT-changes in lower-trunk sway and DT-changes in lower-limb gait parameters that were significant in paired *t*-tests, and 2) between DT-changes in lower-trunk sway variability and DT-changes in lower-limb gait parameters that were significant in paired *t*-tests in each age group. Sex was included as a covariate in all models, because it has been reported that the value of "sex" exert a strong effect on gait parameters (Callisaya, Blizzard, Schmidt, McGinley, & Srikanth, 2008; Mazzà, Iosa, Picerno, & Cappozzo, 2009). We did not include gait speed because the components of gait speed, including step time or step length, were included in the model. The level of statistical significance for all analyses was set at $p < 0.05$. All statistical analyses were performed using commercially available software (JMP13.0; SAS Institute Japan, Tokyo, Japan).

3. Results

Demographic data, gait speed in normal and dual-task gait, and counting speed in dual-task condition were summarized in Table 1. Older adults walked slower than younger adults in both gait conditions: normal and dual-task gait ($p < 0.001$). Counting speed in the dual-task gait was significantly faster in younger adults than in older adults ($p < 0.001$). For comparison of gait conditions, all gait parameters, including lower-trunk sway and lower-limb gait parameters, were summarized in Table 2. The numbers of steps used for computing the gait parameters (average [standard deviation]) in the normal and dual-task gait condition in older adults and younger adults were 5.3 [1.1], 4.9 [1.2], 4.3 [0.7], and 4.2 [0.7], respectively. In older adults, gait speed was

Table 2
Gait parameters in normal and dual-task conditions.

| | Gait conditions | | | | | Effect size | DT-changes | |
| | Normal | | Dual-task | | | | | |
	Mean	SD	Mean	SD	*p*-value#	Cohen's d	Mean	SD
Older adults (n = 43)								
Gait speed, m/s	1.39	0.20	1.29	0.26	0.002	0.43	−0.10	0.20
Lower-trunk sway, cm^2	7.48	3.78	8.98	4.83	0.010	0.35	1.50	3.65
Lower-trunk sway variability, %	18.73	6.39	25.32	11.83	0.002	0.69	6.59	13.12
Step time, s	0.48	0.04	0.55	0.09	< 0.001	1.01	0.07	0.08
Step time variability, %	2.64	0.74	5.84	4.91	< 0.001	0.91	3.20	4.94
Step length, cm	66.62	7.63	69.89	9.22	< 0.001	0.39	3.26	4.51
Step length variability, %	3.38	1.26	4.85	1.56	< 0.001	1.04	1.46	2.04
Step width, cm	10.45	2.79	10.46	2.94	0.981	0.00	0.00	1.23
Step width variability, %	27.95	10.27	31.04	14.06	0.079	0.25	3.09	11.25
Younger adults (n = 28)								
Gait speed, m/s	1.59	0.18	1.62	0.21	0.337	0.15	0.02	0.12
Lower-trunk sway, cm^2	9.82	4.35	10.13	4.25	0.561	0.07	0.31	2.80
Lower-trunk sway variability, %	0.20	0.09	0.19	0.10	0.570	0.11	−1.24	11.44
Step time, s	0.48	0.03	0.49	0.04	0.047	0.28	0.01	0.02
Step time variability, %	2.25	0.58	2.35	1.02	0.562	0.12	0.10	0.90
Step length, cm	76.40	5.95	79.00	5.36	< 0.001	0.46	2.59	2.58
Step length variability, %	2.21	0.95	2.16	0.93	0.752	0.05	−0.05	0.89
Step width, cm	8.15	2.46	9.10	2.82	< 0.001	0.36	0.95	1.10
Step width variability, %	33.60	13.98	33.34	20.77	0.908	0.01	−0.27	12.07

#: *p*-values were obtained by paired *t*-test (Normal vs Dual-task). Dual-task condition: Subjects were asked to walk while counting backward aloud from a number chosen at random from 70 to 100. DT-changes = value in dual-task condition – value in normal condition.

significantly slower in the dual-task condition compared with the normal gait condition ($p < 0.01$), and the values of other gait parameters except step width and step width variability were significantly greater in the dual-task condition compared with the normal gait condition ($p < 0.05$). In younger adults, the values of step time, step length, and step width were significantly greater in the dual-task condition compared with the normal condition ($p < 0.05$). These significant gait parameters were used to construct the regression model, revealing a strong association between step time and step time variability in older adults ($r = 0.826$; the others were less than 0.8), and if both parameters were used, multicollinearity would be expected to occur in the regression model (Katz, 2011). Thus, we selected step time variability for the regression model because this parameter has been previously reported to be strongly affected by dual tasking (Springer et al., 2006; Yogev-Seligmann et al., 2008). The results of the regression models for DT-changes in trunk sway and trunk sway variability for each age group are shown in Table 3. The DT-changes in step time variability were significantly associated with the DT-changes in lower-trunk sway (standardized beta = 0.638, $p = 0.003$), and the DT-changes

Table 3
Standardized β values from forced-entry multiple linear regression analyses for dual-task-related changes in lower-trunk sway and lower-trunk sway variability.

	Variables	Standardized β	*p*-value
Older adults			
DT-changes in lower-trunk sway	Sex	−0.426	0.004
	DT-changes in step time variability	0.638	0.003
	DT-changes in step length	−0.061	0.702
	DT-changes in step length variability	−0.228	0.274
DT-changes in lower-trunk sway variability	Sex	−0.008	0.960
	DT-changes in step time variability	0.493	0.029
	DT-changes in step length	0.082	0.639
	DT-changes in step length variability	−0.019	0.935
Younger adults			
DT-changes in lower-trunk sway	Sex	−0.228	0.285
	DT-changes in step time	−0.271	0.269
	DT-changes in step length	0.068	0.791
	DT-changes in step width	0.395	0.041
DT-changes in lower-trunk sway variability	Sex	−0.133	0.558
	DT-changes in step time	−0.357	0.179
	DT-changes in step length	−0.172	0.533
	DT-changes in step width	−0.091	0.646

in lower-trunk sway variability (standardized beta = 0.493, p = 0.029). Other gait parameters, such as DT-changes in step time, DT-changes in step length, and DT-changes in step width, were not significant in either model. In younger adults, DT-changes in step width were significantly associated with DT-changes in lower-trunk sway (standardized beta = 0.395, p = 0.041). DT-changes in step time and DT-changes in step length were not significantly associated with trunk sway, and all gait parameters (DT-changes in step time, DT-changes in step length, and DT-change in step width) were not significantly associated with lower-trunk sway variability.

4. Discussion

The objective of the present study was to investigate the association between DT-changes in lower-limb gait parameters and DT-changes in lower-trunk sway. Older adults and younger adults were instructed to walk while performing an additional cognitive task (counting backward aloud), or no additional task. During walking, lower-limb gait parameters and lower-trunk sway were measured. Our main results were as follows. DT-changes in step time variability were significantly associated with DT-changes in both lower-trunk sway and lower-trunk sway variability in older adults. DT-changes in step width were significantly associated with DT-changes in lower-trunk sway in younger adults. We hypothesized that DT-changes in both spatial- and temporal-lower-limb gait parameters would be associated with DT-changes in lower-trunk sway. Our results showed these lower-limb parameters were significantly associated with lower -trunk sway according to age group, with the spatial-lower-limb parameter showing a significant association in younger adults, and the temporal-lower-limb parameter showing a significant association in older adults. Thus, the current results partially supported our hypotheses.

For older adults, DT-change in step time variability was associated with DT-changes in lower-trunk sway and lower-trunk sway variability. The effect sizes of step time variability in conditional comparisons (normal vs dual-task) were relatively large (i.e., a Cohen's d value greater than 0.8) (Cohen, 1988). These results indicate that fluctuation of temporal lower-limb movement related to dual tasking may lead to fluctuation of lower-trunk motion in older adults. Importantly, inference of a causal relationship between gait parameters (lower-limb and lower-trunk) should be carefully considered, because step placement and trunk motion in gait are strongly coupled (Winter, 1995a, 1995b). Increased fluctuation of lower-trunk motion may lead to irregular limb motion to prevent falls, and both trunk and limb movements may be mutually affected by the same underlying mechanism. To determine the causal relationships between these factors, a further study including movement analysis based on direct measurement of muscle activation using electromyography is needed.

On the other hand, for younger adults, DT-change in step width was associated with DT-changes in lower-trunk sway. However, the effect sizes of lower-trunk sway in the conditional comparison were small (i.e., a Cohen's d value less than 0.2) (Cohen, 1988), and the difference in values was almost the same as the resolution of the gait system we used. Thus, although fluctuation of lateral lower-limb movement may be related to fluctuation of lower-trunk motion in dual-task gait in younger adults, the current results did not have sufficient precision to draw conclusions about this question. A future study should be conducted to elucidate this relationship. The discrepancy of the association by age group may be partially explained by postural strategy in dual-task gait. Older adults tend to walk slowly to enhance postural stability under dual-task conditions, using a "posture first strategy", in accord with the current results: (Shumway-Cook, Woollacott, Kerns, & Baldwin, 1997). According to this postural strategy, people change their gait patterns frequently under dual-task conditions, and could potentially lead to an increase in trunk sway. On the other hand, young adults exhibited greater performance on cognitive tasks, and exhibited similar performance in the normal gait and dual-task gait conditions, presumably because young adults have greater attention-dividing ability than older adults.

In addition, the current results provide new insight into postural control during dual-task gait among older adults. Interestingly, in older adults, DT-changes in spatial-lower-limb gait parameters were not associated with DT-changes in lower-trunk sway or lower-trunk sway variability. In contrast, step time variability, which is a temporal lower-limb parameter, was associated with DT-changes in lower-trunk sway and lower-trunk sway variability. In addition, the effect size of gait parameters in conditional comparisons varied widely (see Table 2), and the effect sizes of step time, step time variability, and step length variability were 1.01, 0.91, and 1.04, respectively. These effects were large (i.e., a Cohen's d value greater than 0.8) (Cohen, 1988). Taken together, these results suggest that dual tasking affects both spatial- and temporal-lower-limb gait parameters, but the DT-changes in lower-trunk stability are strongly related to DT-changes in temporal lower-limb parameters more than spatial-lower-limb gait parameters in older adults.

Furthermore, the current results may elucidate why step time variability is reported to be a good predictor of the occurrence of falling in older adults (Hausdorff, Rios, & Edelberg, 2001; Springer et al., 2006). The current results suggest that fluctuation of temporal lower-limb movement related to dual tasking is mutually associated with increased trunk sway. Several previous studies have reported that postural stability is prioritized while walking, and that trunk instability is a strong risk factor for the occurrence of falling in geriatric populations (Asai et al., 2013; Doi et al., 2013; Howcroft, Kofman, & Lemaire, 2013; Kavanagh & Menz, 2008; Yogev-Seligmann et al., 2008). Taken together, these findings indicate that the increase in step time variability may be strongly linked to fluctuation of lower-trunk motion, particularly in dual-task situations in which falls commonly occur. Thus, step time variability appears to be a valuable indicator for the occurrence of falling. Finally, it is also possible that a third, unmeasured variable, such as fear of falling, affected both lower-limb and lower-trunk gait parameters (Asai et al., 2014; Sawa et al., 2014). Further research is needed to examine this hypothesis in more detail.

The current study involves several limitations that should be considered. First, the results may have been affected by selection bias: the older participants in our sample appeared to be generally healthy compared with older adults in the general population, with an average gait speed: 1.39 m/s. Thus, the external validity of our sample may be limited. Second, the order of experiments may have affected the gait parameters. In the present study, the order of experiments was fixed, so systematic bias may not have been controlled. Third, we did not assess the effects of other types of additional task, such as manual motor tasks and visual tasks. Previous

studies have reported that the effect of an additional task on the primary task differs with the type and difficulty of the additional task (Asai et al., 2014; Shumway-Cook et al., 2007; Yogev-Seligmann et al., 2008). Studies using a different secondary task may provide additional insight into postural control during dual-task gait. Finally, the activity of the lower-limb muscles may have been a confounding variable in the current study. It is possible that dual tasking affects muscle activity, and postural changes in dual-task gait may have occurred because of muscle activity changes.

5. Conclusions

The association between DT-changes in spatiotemporal gait parameters and DT-changes in lower-trunk sway differed according to age group. In older adults, DT-changes in a temporal-lower-limb gait parameter (step time variability) were mutually associated with DT-changes in lower-trunk sway. In younger adults, the association between DT-changes in a spatial-lower-limb gait parameters and DT-changes in lower-trunk sway were small, and their relationships were non-significant.

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