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Age-related differences in dual task performance: A cross-sectional study on women

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Aim: Simultaneous performances of motor and attention-demanding tasks are common in activities of everyday life. The present cross-sectional study examined the changes and age-related differences on mobility performance with an additional cognitive or motor task, and evaluated the relative dual-task cost (DTC) on the motor performance in young, middle-aged and older women.

Methods: A total of 30 young (mean age 25.12 ± 3.00 years), 30 middle-aged (mean age 47.82 ± 5.06 years) and 30 older women (mean age 72.74 ± 5.95 years) were recruited. Participants carried out: (i) single task: Timed Up & Go Test; (ii) cognitive dual-task: Timed Up & Go Test while counting backwards by three; (iii) manual dual-task: Timed Up & Go Test while carrying a glass of water. A repeated measures ANOVA with between-factor as age groups and within-factor as tasks was carried out to assess the effect of aging on the performance of mobility tasks. DTC was calculated as ([performance in single-task – performance in dual-task] / performance in single task) × 100%. One-way ANCOVA were carried out to compare the DTC among the three age groups.

Results: A significant interaction between age groups and task ($F_{4,172} = 6.716$, $P < 0.001$, partial $\eta^2 = 0.135$) was observed. Specifically, older women showed a worse mobility performance under dual-task condition compared with young and middle-aged groups. Furthermore, DTC differences in cognitive task were observed in older women compared with younger and middle-aged women ($F_{2,86} = 7.649$, $P < 0.001$, partial $\eta^2 = 0.151$), but not in manual task.

Conclusion: Dual-task conditions might affect mobility performance differently across the lifespan, and could be particularly challenging in older women. **Geriatr Gerontol Int 2017; 17: 315–321.**

Introduction

In everyday life, mobility tasks are rarely carried out alone. However, these tasks are often associated with a less or more difficult additional activity, such as talking and walking or crossing a road and paying attention to the environment. In previous studies, dual-task paradigms have been used to evaluate the simultaneous performance of an attention-demanding and motor task.[1,2] In particular, the principle of dual-task methodology requires division of attention between the motor task (e.g. gait, postural task) and simultaneous additional attention task, usually a cognitive or motor task.[3]

In particular, mobility, which is defined as the ability of a person to move in the environment safely and independently,[4] is essential for independence in aging people.[5] In particular, women presented a greater impairment in mobility function than men.[6] For instance, a higher decrease in spatio-temporal gait parameters,[7] as well as a higher risk of falling[8] have been observed in older women compared with older men.

Furthermore, mobility might be particularly challenging in dual-task conditions for older adults. In particular, a dual-task condition might compromise a range of spatio-temporal gait parameters, such as reduction in speed,[9,10] increase in stride-to-stride variability[9,11] and in swing time variability, resulting in an increased difficulty in maintaining balance and consequently to a greater risk of falling.[3,12] Furthermore, this different in gait pattern was observed especially in older women because of the influence of the additional attention task.[11] These changes support the idea that the motor performance in older adults is a complex task requiring more cognitive

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resources because of higher attention and control of executive processing.[2,3,13]

The Timed Up & Go (TUG) Test is a valid test to identify the mobility function and falling risk in aging people.[14] TUG testing requires a person to carry out common movements of everyday life, including standing, sitting, walking and turning strategies. It can be considered an objective test and includes neuromuscular components, such as power, agility and dynamic balance.[4,15,16] Slow performance in a TUG test is associated with poor step test performance,[17] slow gait speed and poor balance performance.[15] Furthermore, TUG testing has also been associated with executive function and attention.[14,18]

Previous studies have used TUG tests in dual-task conditions, both with cognitive and additional motor task, to assess aging people,[19–21] individuals with neurodegenerative diseases (e.g. Parkinson's disease)[22] and people suspected of prefrailty syndrome.[23] However, to the best of our knowledge, no studies have examined TUG tests under dual-task conditions in a sample of young, middle-aged and older women to evaluate age-related differences. Assessing and interpreting the difference across the lifespan in dual-task performance both with cognitive and motor additional tasks might provide novel insights on aging people, especially in vulnerable persons, such as older women. Indeed, this might be useful to better understand the possible onset of aging-induced decline in the dual-task performance.[10] Furthermore, exploration of age-related differences in aging women with mean mobility task testing, similar to the common everyday life activities (e.g. standing, walking, turning and sitting), under dual-task conditions might be useful to guide the development of specific physical interventions in aging people.

Thus, the purpose of the present cross-sectional study was to assess the relationship of cognitive and manual tasks on the mobility performance in young, middle-aged and older women. In particular, the aims of the present study were to examine changes and age-related differences on the mobility performance with an additional cognitive or motor task, and to evaluate the relative dual-task cost on the motor performance in young, middle-aged and older women.

We hypothesized that we would find a larger decrease in mobility performance under dual-task performance. Furthermore, considering the relative dual-task cost, we expected to observe an increase in dual-task cost with age increase.

Methods

Participants

A total of 90 women were recruited for the study, including 30 young women (age 20–35 years; mean age 25.12 ± 3.00 years), 30 middle-aged women (age 45–55 years; mean age 47.82 ± 5.06 years) and 30 older women (age 65–85 years; mean age 72.74 ± 5.95 years). All participants lived independently. All of the participants were enrolled through public advertisements. Inclusion criteria were: Mini-Mental State Examination score ≥24 or higher, ability to walk without assistant device, no history of a previously fall, comprehension of simple instructions, ability to carry out simple arithmetic exercises and ability to carry a glass of water.[24] Exclusion criteria were the presence of certain medical conditions, such as an acute disease (e.g. myocardial infarction) or a chronic disease (e.g. Alzheimer's disease, Parkinson's disease) or a musculoskeletal condition affecting mobility or balance. All of the participants were informed that participation in the study was voluntary and confidential. All of the selected participants provided written informed consent, according to Italian law. The Ethical Committee of Torino University approved the study.

Data collection

The test procedure took approximately 60 min for each participant. Participants initially completed a sociodemographic questionnaire. The demographic and social data, age, family condition and level of education were self-reported. After this, each participant completed a TUG test under three different task conditions: (i) TUG (single task); (ii) TUG while counting backwards by three (TUGC); and (iii) TUG while carrying a glass of water (TUGM).

TUG requirements were to stand up from a chair, walk 3 m, turn 180°, walk back and sit down on the chair.[25] In TUGC, the participants were instructed to carry out the TUG while counting backwards by three from a given number between 80 and 99 randomly selected using a computerized randomization.[23] The numbers given to each participant were in a randomized order. In TUGM, the participants were instructed to carry out the TUG and simultaneously carry a glass of water without spilling with their preferred hand.[12] The intrarater reliability for the TUG, TUGC and TUGM was 0.95,[16] 0.94 and 0.99,[20] respectively.

After giving standardized instructions and a visual demonstration, the participants were instructed to complete one trial each of TUG, TUGC and TUGM at their preferred speed, and to carry out both tasks as well as possible.[19] No prioritization instruction between TUG and the additional task performance was given. The same investigators collected the data. To avoid performance bias of TUG, TUGC and TUGM, the order of the tests were chosen randomly.[19] The performance time was the time in seconds taken to complete the TUG, TUGC and TUGM.

Data analysis

Using the standardized education years as a covariate, a repeated measures analysis of variance, with between-factor as age groups (younger, middle-aged, older adults) and within-factor as tasks (TUG, TUGC, TUGM), was carried out to assess the effect of aging on the performance of mobility tasks.

To quantify the relative dual-task cost (DTC) in the mobility performance, the following formula DTC = ([performance in single-task – performance in dual-task] / performance in single task) × 100% was used.[19] The time in single (TUG) and dual-task performance both in TUGC and in TUGM was used to calculate DTC. Performance in a single task indicated performance in TUG alone, whereas performance in dual task indicated the performance in TUGC or TUGM. Specifically, the DTC of TUGC was calculated as ([TUG – TUGC] / TUG) × 100% and the DTC of TUGM as ([TUG – TUGM] / TUG) × 100%. Thus, a lower value in DTC indicated a poor performance in the dual-task condition. One-way analyses of covariance, with standardized education years as a covariate, were carried out to compare DTC between young, middle-aged and older adults. Bonferroni post-hoc correction was used to identify specific age group differences. The level of significance was set at $P < 0.05$. All data were analyzed using SPSS 20.0 for Windows (SPSS, Chicago, IL, USA).

Results

The sociodemographic characteristics of the participants and results of the test are summarized in Table 1. The mean body mass index (BMI) was 21.15 ± 2.82 kg/m^2 for young, 23.49 ± 3.95 kg/m^2 for middle-aged and 24.67 ± 4.24 kg/m^2 for older women.

Generally, older women presented a lower education (6.83 ± 2.70 years) compared with young (16.33 ± 1.26 years) and middle-aged women (11.26 ± 3.44 years).

Table 2 contains the results of the TUG performance, both in the single- and dual-task performance, including the relative repeated measures analyses of variance.

The 3×3 repeated measures yielded a significant interaction between age groups and task ($F_{4,172} = 6.716$, $P < 0.001$, partial $\eta^2 = 0.135$), which indicated that the effect of the dual-task performance was not uniform among the age groups (Fig. 1). The main effect of age groups showed that there was a statistically significant difference between the age groups ($F_{2,86} = 38.435$, $P < 0.001$, partial $\eta^2 = 0.472$). A post-hoc analysis, with Bonferroni adjustment, showed a significant difference in older versus young groups ($P < 0.001$) and in older versus middle-aged groups ($P < 0.05$). Finally, the main effect of task showed a statistically significant difference in the TUG performance in the single- and dual-task performance ($F_{2,172} = 52.446$, $P < 0.001$, partial $\eta^2 = 0.379$).

Table 3 provides the results of the analyses of variance in DTC separately for young, middle-aged and older groups. There were statistically significant differences among the age groups in DTC of TUGC ($F_{2,86} = 7.649$, $P = 0.001$, partial $\eta^2 = 0.151$), but not in DTC of TUGM ($F_{2,86} = 2.824$, $P = 0.065$, partial $\eta^2 = 0.062$). A post-hoc analysis with Bonferroni adjustment showed that the DTC of TUGC (Fig. 2) was statistically different in older (-25.83 ± 19.63) versus young groups (-11.54 ± 11.95; $P < 0.001$), and in older versus middle-aged groups (-15.25 ± 10.55; $P < 0.05$).

Discussion

The main purpose of the present study was to assess the relationship of cognitive and manual tasks on the

**Table 1** Sociodemographic characteristics of participants

Characteristics	Age groups Young	Middle-aged	Older
Age (years)	25.12 ± 3.00	47.82 ± 5.06	72.74 ± 5.95
Height (m)	1.67 ± 0.66	1.62 ± 0.59	1.60 ± 0.52
Weight (kg)	59.40 ± 8.54	61.77 ± 11.47	63.77 ± 9.97
BMI (kg m^{-2})	21.15 ± 2.82	23.49 ± 3.95	24.67 ± 4.24
Education years (years)	16.33 ± 1.26	11.26 ± 3.44	6.83 ± 2.70
Family condition			
Never married	30 (100%)	3 (10%)	0
Married	0	26 (86.7%)	18 (60%)
Widow/widower	0	0	12 (40%)
Divorced	0	1 (3.3%)	0

Data presented as mean and standard deviation or percentage. BMI, body mass index.

Table 2 Repeated measures analyses of variance

	Age groups			Task	Age group	Task*Age groups	Bonferroni post-hoc
	Young	Middle-aged	Older				
TUG (s)	6.43 ± 0.69	7.30 ± 0.84	9.00 ± 2.01	$F = 52.446$	$F = 38.435$	$F = 6.716$	Young < older
TUGC (s)	7.13 ± 0.73	8.40 ± 1.21	11.35 ± 3.32	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
TUGM (s)	7.19 ± 0.92	7.94 ± 1.07	10.65 ± 2.72	partial $\eta^2 = 0.379$	partial $\eta^2 = 0.472$	partial $\eta^2 = 0.135$	middle-aged < older
							$P < 0.001$

Data presented as mean and standard deviation; TUG, Timed Up & Go Test; TUGC Timed Up & Go Test with cognitive task; TUGM, Timed Up & Go Test with manual task.
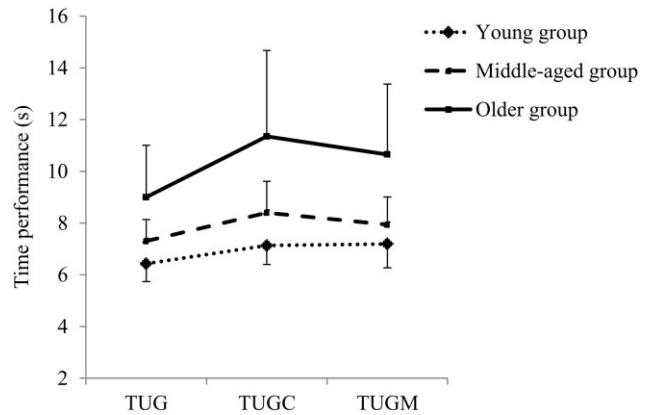
Figure 1 Mean and standard deviation of the Timed Up & Go Test (TUG), TUG while counting backwards (TUGC) and TUG while carrying a cup of water (TUGM) for the young group (dotted line), the middle-aged group (dashed line) and the older group (solid line).

mobility performance. In particular, age-related differences in the mobility performance while counting backwards by three and carrying a cup of water and DTC were examined in a sample of young, middle-aged and older women.

A decline in the TUG test performance was observed in dual-task conditions both with cognitive and manual tasks. In accordance with previous studies on gait performance in middle-aged[9,10] and older women,[11] the present study confirmed that young, middle-aged and older women had a decrease in the mobility performance while carrying out serial subtractions or carrying a cup of water. Furthermore, older women showed a larger decrease in the TUG test performance under dual-task conditions when compared with young and middle-aged women.[10,26] TUG tests assessed a relative multicomponent activity, including sit-to-stand movement, initiation of stepping, acceleration and deceleration, and preparation to turn on two occasions, which required the involvement of cognitive resources (e.g. planning, orientation and organization).[14,18] Therefore, because of the nature of the mobility task, the present study results suggest that everyday life activities, which require dual-task performance, could be challenging for older people. This might reflect the increase in cognitive resources requested to carry out multicomponent activity safely, as seen with the TUG test in dual-task conditions. The present study results were in accordance with previous studies where mobility during the dual-task activity performance took longer[20] and increased the risk of falling in older adults.[19] The larger change in the mobility performance observed in older adults might suggest an inability to share attention resources during the dual-task performance.[26] Consequently, older adults required more attention cognitive resources for motor control when they simultaneously carried out an

Table 3 Analysis of variance

	Age groups			ANOVA	Bonferroni post-hoc
	Young	Middle-aged	Older		
DTC TUGC (%)	−11.54 ± 11.95	−15.25 ± 10.55	−25.83 ± 19.63	F = 7.649, $P < 0.001$, partial $\eta^2 = 0.151$	Young < older $P < 0.001$ Middle-aged < older $P < 0.05$
DTC TUGM (%)	−12.56 ± 15.56	−9.16 ± 11.84	−18.97 ± 20.00	F = 2.824, $P = 0.065$, partial $\eta^2 = 0.062$	NS

Data presented as mean and standard deviation. DTC TUGC, dual-task cost in Timed Up & Go Test with cognitive task; DTC TUGM dual-task cost in Timed Up & Go Test with manual task.
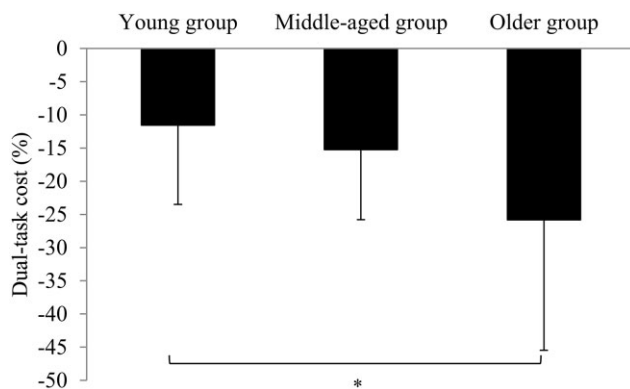
Figure 2 Mean and standard deviation of dual-task cost of cognitive tasks for young, middle-aged and older groups in the Timed Up & Go Test while counting backwards. The statistical significance of the difference between the age groups was calculated by using the Bonferroni post-hoc test. *$P < 0.05$.

additional task than the young and middle-aged groups, presumably because of competition for central processing resources.[27]

Regarding the second aim of the study, although lower scores in DTC would suggest a poor performance on the individual tasks controlling for the performance of the single task, a higher cost score in DTC would indicate a better performance on the individual task costs. A DTC of −11.54% and of −15.25% was observed in young and middle-aged women, respectively, during TUGC. In contrast, older women had a higher DTC (−25.83%) in comparison with young and middle-aged women, showing that the effect of dual-task cost on the mobility performance was higher in older adults. These results suggest that performance of young and middle-aged women was less affected in dual-task conditions, and that they were able to carry out all tasks with minimal performance decrements. Differently, because of the decline in physical ability,[28,29] in attention and executive function[2] observed in aging people, the present results showed that older women had a larger

cost because of the difficulty in simultaneously managing both mobility and attention demanding tasks.[30] Interestingly, we found a significant difference in DTC among age groups in TUGC, but no difference in TUGM. Indeed, the results showed that the DTC in the TUGM generally required less DTC among the age groups, probably suggesting a different response strategy of the secondary tasks. These findings might suggest that the automaticity of the movements showed a greater degree of decline with cognitive task rather than with manual task.[22] According to this interpretation, it was possible that older women compensated with a slowing gait when carrying out the additional cognitive task required. The nature of the manual task that required additional motor ability rather than cognitive resources[23] was probably not sufficiently complex to reach the threshold attention required to negatively impact the performance.[22] The results show that the additional manual task was less demanding than the cognitive task. Consequently, older women had a similar ability to manage dual-task performance as the other age groups. Nevertheless, the additional manual task might be a screening tool in early identification of prefrailty individuals.[23] Taken together, the present study results confirm that DTC might be dependent on the nature of the attention task.[3,12,13,30]

There were some limitations to the present study. First, the cross-sectional study did not permit us to give a causation of the results. A second limitation was the healthy participants and relatively small sample size, which did not allow us to generalize the results to a larger population of older adults. Indeed, the older adults' population presents a greater heterogeneity, and the results cannot be extended to specific populations, such as older adults living in long-term care facilities, older adults with a history of falling, mild cognitive impairment, or with specific diseases as Parkinson's or Alzheimer's disease. A ceiling effect likely contributed to the results observed. We could hypothesize that, in a more heterogeneous cohort (people at risk of falling or mild cognitive impairment), the results would be more

pronounced. In contrast, even though only healthy participants with good mobility and cognitive function were included, the study showed important findings. Our results show that, among healthy women, age-related differences in dual-task performance exist, and thus might give us added insight into aging and age-associated changes in dual tasks. Further studies are required to extend the present results. A third limitation is given by the quantitative only (time) measurement of the mobility performance. An additional limitation was no evaluation of the secondary task, as well as that no prioritization instruction was given to the participants between TUG and the additional tasks. This did not permit us to investigate the strategy of the participants in dual-task performance.[23]

However, these measures permitted us to test participants quickly in a small space, to assess many groups in different environments without requiring expensive equipment and to provide initial screening on the dual-task performance. Future studies are required to better understand the mobility changes during common movements of everyday life under dual-task performance conditions. It will be important to study these changes not only with quantitative measures, but also with qualitative measurements (video and gait analysis), in relation to different cognitive domains, such as reaction time, visuomotor processing, verbal fluency and decision-making.

In conclusion, despite these limitations, the results of the present study underlined the change in motor patterns with simultaneous tasks of both cognitive and motor tasks. We observed a general decrease in the mobility performances under dual-task conditions in all age groups, but this decrease was more pronounced in older women compared with young and middle-aged groups. Furthermore, the data suggested that the performance, particularly in older women, decreased when the secondary task was a cognitive task. Simultaneous performances of motor and attention-demanding tasks are common in activities of everyday life, and the results of present study might help to clarify changes in dual-task conditions in aging, and might be taken into account to develop specific physical interventions for aging people.

Acknowledgments

Disclosure statement

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