Published in final edited form as:

Gait Posture. 2014 July ; 40(3): 415–419. doi:10.1016/j.gaitpost.2014.05.062.

A COMPARISON OF TWO WALKING WHILE TALKING PARADIGMS IN AGING

Clara Li, M.A.,

Ph.D. Candidate, Clinical Psychology, Health Emphasis, Ferkauf Graduate School of Psychology, Yeshiva University, Tel: (516) 519-0663, pochingclarali@gmail.com

Joe Verghese, M.B.B.S., M.S., and

Associate Professor of Neurology, Director of the Division of Cognitive and Motor Aging, Saul R. Korey Department of Neurology, Albert Einstein College of Medicine, Yeshiva University, Tel: (718) 430-3877, Fax: (718) 430-3829, joe.verghese@einstein.yu.edu

Roe Holtzer, Ph.D.

Associate Professor of Psychology and Neurology, Ferkauf Graduate School of Psychology, Department of Neurology, Albert Einstein College of Medicine, Yeshiva University, Tel: (718) 430-3962, Fax: (718) 430-3960, roee.holtzer@einstein.yu.edu

Abstract

Background—Our study aimed to (1) compare dual-task costs in gait and cognitive performance during two dual-task paradigms: walking while reciting alternate letters of the alphabet (WWR) and walking while counting backward by sevens (WWC); (2) examine the relationship between the gait and cognitive interference tasks when performed concurrently.

Scope—Gait and cognitive performance were tested in 217 non-demented older adults (mean age 76 ± 8.8 years; 56.2% female) under single and dual-task conditions. Velocity (cm/s) was obtained using an instrumented walkway. Cognitive performance was assessed using accuracy ratio: [correct responses] / [total responses]. Linear mixed effects models revealed significant dual-task costs, with slower velocity ($p < .01$) and decreased accuracy ratio ($p < .01$) in WWR and WWC compared to their respective single task conditions. Greater dual-task costs in velocity ($p < .01$) were observed in WWC compared to WWR. Pearson correlations revealed significant and positive relationships between gait and cognitive performance in WWR and WWC ($p < .01$); increased accuracy ratio was associated with faster velocity.

Conclusions—Our findings suggested that dual-task costs in gait increase as the complexity of the cognitive task increases. Furthermore, the positive association between the gait and cognitive tasks suggests that dual-task performance was not influenced by task prioritization strategies in this sample.

© 2014 Elsevier B.V. All rights reserved.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Keywords

dual task; walking while talking; attention; elderly; walking

Introduction

The walking while talking protocols are widely used to study how attention and motor-control processes affect walking in normal aging and in various disease populations (1). Poor dual-task gait performance has been linked to adverse clinical outcomes such as frailty, falls (2), disability, and mortality (3) in older adults supporting its clinical utility. Under these dual-task conditions, individuals are asked to walk while performing a cognitive interference task such as repeating digits (4) or reciting names (5). Changes in cognitive and gait performance during dual compared to single-task condition is quantified as a measure of dual-task costs, and is considered to reflect the effect of increased attention demands on walking (6). Previous researchers have reported that dual-task costs in walking were greater among older adults compared to young adults, indicating an aging or disease effect (7, 8). More recently, increasing evidence suggests that such age-related dual-task costs in gait performance are task-specific (9, 10).

Cognitive tasks used in walking while talking paradigms include, but are not limited to, reciting alternate letters of the alphabet and counting backwards by sevens (11). While both of these cognitive tasks have been shown to cause significant gait changes among healthy older adults, their effect on gait has not been directly compared (12). Previous research has suggested that increasing the level of complexity on cognitive tasks in walking while talking paradigms induced greater decline in gait, and showed a stronger relationship with risk of falls (2). Thus, defining and contrasting different dual task paradigms may have practical implications for the design of fall-risk assessments. The comparison between counting-backwards and reciting-the-alphabet tasks, in particular, might provide important information regarding the nature of dual-task effects. Specifically, while reverse sequences (i.e. counting backwards) is cognitively more challenging than forward sequences (i.e. reciting the alphabet) (13), the differential effect of these two tasks on gait is not well understood. Moreover, the cortical networks for linguistic (i.e. superior part of Broca's area and the premotor cortex) and numeric tasks (i.e. temporo-parietal regions) are distinct (14). Hence, investigating the differential effect of the counting and letter tasks on gait control could also help advance our understanding of the localization of brain substrates of gait.

When examining walking while talking paradigms, a potential methodological issue is whether dual-task costs in gait performance can be attributed to limited attention resources or to task preference (for instance, prioritizing the cognitive task over the walking task). Our recent study indicates that attention/executive resources moderate dual-task costs in gait and cognitive performance (15). While prior studies suggested that older adults may have an innate preference for preserving walking over talking during a walking while talking task (7), greater decrements in gait performance have been noted when older adults were instructed to pay more attention to the cognitive task than when they were instructed to pay equal attention to both concurrent tasks (12). These initial reports raise interesting questions

regarding the influence of explicit instructions on dual-task performance. Available studies on walking while talking paradigms generally emphasize on their impacts on gait, and relatively few studies have examined the effect of walking on cognitive performance (16). The relationship between gait and cognitive interference task, when assessed simultaneously, can shed light on the possible influence of task prioritization strategies on dual-task performance.

Herein, we propose to examine the following two aims in 217 non-demented older adults. First, we compared dual-task costs in gait and cognitive performance using two dissimilar paradigms: walking while reciting alternate letters of the alphabet (WWR) and walking while counting backwards by sevens (WWC). We hypothesized that older adults would show dual-task performance costs in both conditions. Since we predicted that subtracting serial sevens is a cognitively more challenging task than reciting alternate letters of the alphabet, it was also expected that WWC would result in greater dual-task performance costs than WWR. Second, we examined whether performance on the two concurrent tasks was related. Our experimental protocols require participants to equally prioritize the walking and cognitive interference tasks. Although previous works showed that dual-task performance costs indeed varied as a function of task instruction (12, 17), it was of interest to determine the existence and directionality of the relationship of the two tasks when performed concurrently. Negative correlations between the gait and cognitive interference tasks would suggest task prioritization, while positive correlations would imply that better attention resource but not task preference influenced dual-task performance.

Methods

Study population

Participants were enrolled in a longitudinal research study entitled “Central Control of Mobility in Aging” (CCMA). The primary aim of the CCMA study is to determine the role of cognitive control processes on mobility and mobility decline in aging. Potential participants (age 65 and older) were identified from a population-list of residents of Yonkers town in lower Westchester County (New York). They were first contacted by letter and then by telephone. A structured telephone screening interview was administered to potential participants to assess eligibility. Exclusion criteria included: inability to speak English, inability to independently ambulate (18), presence of dementia (AD8 Dementia Screening Interview > 2 and the Memory Impairment Screen by telephone < 5) (19), significant loss of vision and/or hearing, current or history of neurological or psychiatric disorders, medical procedures (recent or anticipated) that may affect mobility, and receiving hemodialysis. After completing the telephone interview, eligible individuals were scheduled for the first of two three-hour in-person visits at our research center within a four week window. During the in-person visits, participants received comprehensive neuropsychological and mobility assessments by research assistants as well as a structured neurological and gait examination by the study clinician. Following the evaluations, cognitive status (dementia, mild cognitive impairment syndrome, or cognitively normal) was determined at consensus clinical case conferences as described in our previous study (20). CCMA participants are followed longitudinally at annual intervals. The current study included the initial 217 non-demented

participants enrolled in the CCMA study during the 9-month period between July 2011 and March 2012. Written informed consent was obtained from the participants in person according to study protocols approved by the institutional review board.

Walking Protocol

Participants were asked to walk at their "normal pace" on an instrumented walkway with embedded pressure sensors (GAITRite; CIR Systems, Havertown, PA). The participants walked for one trial under three different task conditions: (1) normal pace walking (NW), (2) WWR (i.e. reciting a, c, e...), and (3) WWC (i.e. counting 100, 93, 86...). In WWR and WWC, the participants were asked to pay equal attention to both the walking and cognitive tasks to minimize task prioritization effects as previously described (6).

Measures

GAITRite software was used to calculate quantitative gait parameters based on the recorded footsteps. The program has been reported to show excellent reliability and validity (12, 21). The walkway measures 8.5mx0.9mx0.01m (LxWxH) with an active recording area of 6.1mx0.61m (LxW). The present study utilized velocity (in centimeter per second) as the single outcome measure for the following reasons. First, velocity is the most common quantitative gait measure reported in the literature facilitating comparisons with previous studies (11). Second, velocity is a statistically robust measure with excellent test-retest reliability in our (reliability of two repeated trials, $r = 0.96$) (3, 11, 15) and other research centers ($ICC > 0.80$) (22). Third, slow velocity during both normal pace and walking while talking conditions is a risk factor for a range of adverse outcomes, such as higher rates of mortality, increased incidence of hospitalizations, and poor quality of life (11, 19).

Baseline comparators of the cognitive tasks in the two dual-task paradigms was obtained in 10-second blocks when stationary: (1) reciting alternate letters of the alphabet (i.e. a, c, e, ...) while standing and (2) counting Backwards by sevens (i.e. 100, 93, 86,...) while standing. Although postural control studies consider standing while performing a cognitive task as a dual-task condition (23), the present study considered this condition as a single-task condition because standing requires minimal cognitive and mobility demands. In these standing conditions, balance was not assessed and subjects were explicitly instructed to focus on the cognitive task performance only. To assess cognitive task performance in the single task conditions, we recorded all responses (correct + incorrect) that were generated within the 10-second limit. In the dual-task conditions, however, we recorded responses (correct + incorrect) that were generated while walking without imposing a time limit. The accuracy ratio (i.e. correct responses $\div$ total responses) was calculated to allow for a direct comparison between the single and dual-task conditions and across the two dual-task paradigms.

The administration of the two dual-task walking and three single task conditions was counterbalanced to reduce test order and practice effects.

Covariates

Demographic information (i.e. age, race, sex, and education) was obtained from participants by research assistants during the first study visit. Consistent with our prior studies (6, 21), a disease comorbidity summary score (range from 0 to 10) was calculated based on dichotomous ratings (presence/absence) of diabetes, chronic heart failure, arthritis, hypertension, depression, stroke, Parkinson's disease, chronic obstructive lung disease, angina, and myocardial infarction. Clinical gait abnormalities (neurological and nonneurological) were assessed, blinded to dual-task procedures, by the study clinician as described in our previous study (24).

Statistical Analyses

Statistical analyses were performed using IBM SPSS version 20 (IBM, Somers, NY). The level of statistical significance was set at $p = .05$. Linear Mixed Effects Models (LMEs) were used to examine the effect of dual-tasking on gait and cognitive task performance. Specially, task-condition served as the repeated-measure variable, while performance metrics on the gait and cognitive tasks served as the dependent variables in two 3-level and three 2-level LMEM models respectively. The analyses were controlled for age, race, sex, education, disease comorbidity and presence of any clinical gait abnormalities. The covariates were selected to be included in analysis based on prior studies (6, 21, 24). Because the cognitive accuracy ratio was potentially vulnerable to ceiling effect and bias (i.e. low responses may inflate accuracy) we used Pearson correlations to evaluate the association between accuracy ratio and total number of responses (the performance index that is not subject to bias or ceiling effects). To estimate whether dual-task performance was related to limited attention resources or to task preference, additional Pearson correlations were used to assess the association between accuracy ratio and velocity in WWR and WWC. Whereas negative correlations between the cognitive and gait tasks would suggest task preference between the gait and the cognitive sub-tasks, positive correlations would imply that attention resources were directly related to dual-task performance.

Results

Demographics

The sample had a mean age (76 ± 8.8 years), education (14 ± 3.2 years), as well as gender (%female = 56.2) and racial distribution (%white = 88.9) that is broadly representative of the demographic characteristics of individuals in this age group who reside in the study catchment area. The average disease comorbidity summary score (range 0–10) was $1.47(\pm 1.2)$ indicating relatively low disease burden. Gait abnormality was present in 38.2% of the participants. Descriptive statistics of gait velocity and cognitive performance for the entire sample are summarized in Table 1.

Dual-task Performance

As seen in table 2 and 3, older adults showed a significantly slower velocity and lower accuracy ratio during the two dual-task conditions compared to their respective single task conditions.

As seen in table 4, older adults had a significantly slower velocity in WWC than in WWR, while dual-task costs in accuracy ratio were similar between the two dual-task conditions. The Pearson correlations between accuracy ratio and number of correct responses were significant and positive in WWR ($r = .51$, $p < .01$) and in WWC ($r = .47$, $p < .01$) indicating that higher accuracy ratio was associated with higher number of correct responses.

The Pearson correlations between cognitive accuracy and gait velocity were significant and positive in WWR ($r = .166$, $p = .01$) and in WWC ($r = .151$, $p = .03$); higher cognitive accuracy was associated with faster gait velocity in both dual-task paradigms.

Discussion

Our findings confirmed that both WWR and WWC conditions incurred significant dual-task costs in gait and cognitive performance among older adults. The results were consistent with previous studies where subtracting serial sevens (25) and reciting alternate letter of the alphabet (12) compromised gait performance in normal aging. According to capacity sharing (26) and bottleneck (27, 28) theories, attempting to perform two tasks simultaneously will cause performance changes in one or both of the tasks because of limited attention resources. Our results corroborated these theories, and showed that limited attention resources in aging underlie cognitive motor dual-tasking (e.g. WWR and WWC). Furthermore, we found that WWC caused greater decline in gait velocity than WWR. It appeared that the increased difficulty in the counting backwards task caused greater competition for attention resources and therefore induced a greater effect on gait performance. It is possible that the counting backwards task, relative to the reciting alphabet task, shared more cortical networks with walking, and consequently induced greater changes in gait performance. Although dual-task related decline in accuracy was comparable in the two cognitive interference tasks, results of a Paired-Sample t-test showed that accuracy ratio was significantly lower in WWC than in WWR ($p = .01$), supporting the notion that counting backwards by 7s was a more difficult task than reciting alternate letters of the alphabet.

The second aim was designed to evaluate the relationship between the gait and cognitive interference tasks when performed simultaneously. While negative correlations between the cognitive and gait tasks would suggest task preference (e.g., faster gait velocity associated with worse cognitive accuracy), positive correlations would imply that attention resources were more effectively utilized to support the gait and cognitive interference tasks. Indeed, our results revealed that faster gait velocity was associated with higher cognitive accuracy in both dual-task conditions suggesting that older adults with more attention resources were better able to negotiate the demands of the concurrent cognitive and gait tasks. Furthermore, in the context of our task and administration procedures we found no evidence that task prioritization influenced dual-task performance.

Limitations

Although our participants were verbally instructed to pay equal attention to both simultaneous tasks, it is difficult to control whether the participants indeed showed equal attention to both concurrent tasks or if there was a task preference effect. However, previous

data has suggested that participants' attention can be manipulated by verbal instructions in the walking while talking paradigm (12). Additionally, while the accuracy ratio afforded direct comparison of cognitive task performance between the single and dual-task conditions and across the two dual-task paradigms, the possible impact of ceiling effect on cognitive task performance has to be considered. It is noteworthy that 60% and 65% of our participants had a cognitive ratio of one in the alphabet and counting conditions, respectively, when performed alone. However, the impact of the ceiling effect is believed to be relatively limited because (1) our additional analyses show that the correlations between accuracy ratio and total number of responses for WWC and WWR were significant and positive; higher accuracy ratio is associated with higher number of correct responses (the performance index that is not subject to a ceiling effect), and (2) the range of correct response for the four task conditions was not restricted (i.e. 11, 24, 10, and 16 for alphabet alone, counting alone, WWR, and WWC conditions, respectively).

Conclusion

The results of our study indicate that dual-task costs in gait velocity increase as the complexity of the cognitive interference task increases. Additionally, the positive association between the gait and cognitive tasks suggests that dual-task performance was not influenced by task prioritization strategies in our sample. While fall risk is a multidimensional problem, gait velocity in walking while talking has been identified as a risk factor of fall as well as other critical outcomes such as frailty and disability (2, 29, 30). Future research should aim to determine whether increased complexity of the cognitive interference task in walking while talking paradigms results not only in greater dual-task performance cost but also in improved predictability of major geriatric outcomes.

Acknowledgments

The Central Control of Mobility in Aging study is funded by the NIA (R01AG036921, PI: Roee Holtzer, PhD.). The funding source had no role in the design or conduct of the study; collection, management, analysis, or interpretation of the data; or preparation, review, or approval of the manuscript.

References

1. Huang H-J, Mercer VS. Dual-Task Methodology: Applications in Studies of Cognitive and Motor Performance in Adults and Children. *Pediatric Physical Therapy*. 2001; 13(3):133–140. [PubMed: 17053670]
2. Verghese J, Buschke H, Viola L, et al. Validity of divided attention tasks in predicting falls in older individuals: a preliminary study. *J Am Geriatr Soc*. 2002 Sep; 50(9):1572–1576. [PubMed: 12383157]
3. Verghese JHR, Lipton RB, Wang C. Mobility Stress Test Approach to Predicting Frailty, Disability, and Mortality In High Functioning Older Adults. *J Am Geriatr Soc*. 2012; 60(10):1901–1905. [PubMed: 23002714]
4. Sheridan PL, Solomont J, Kowall N, Hausdorff JM. Influence of executive function on locomotor function: divided attention increases gait variability in Alzheimer's disease. *J Am Geriatr Soc*. 2003 Nov; 51(11):1633–1637. [PubMed: 14687395]
5. Camicioli R, Howieson D, Lehman S, Kaye J. Talking while walking: the effect of a dual task in aging and Alzheimer's disease. *Neurology*. 1997 Apr; 48(4):955–958. [PubMed: 9109884]
6. Holtzer R, Verghese J, Xue X, Lipton RB. Cognitive processes related to gait velocity: results from the Einstein Aging Study. *Neuropsychology*. 2006 Mar; 20(2):215–223. [PubMed: 16594782]

7. Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: a review of an emerging area of research. *Gait Posture*. 2002 Aug; 16(1):1–14. [PubMed: 12127181]
8. Li KZ, Lindenberger U, Freund AM, Baltes PB. Walking while memorizing: age-related differences in compensatory behavior. *Psychol Sci*. 2001 May; 12(3):230–237. [PubMed: 11437306]
9. Beauchet O, Dubost V, Gonthier R, Kressig RW. Dual-task-related gait changes in transitionally frail older adults: the type of the walking-associated cognitive task matters. *Gerontology*. 2005 Jan-Feb; 51(1):48–52. [PubMed: 15591756]
10. Bock O. Dual-task costs while walking increase in old age for some, but not for other tasks: an experimental study of healthy young and elderly persons. *J Neuroeng Rehabil*. 2008; 5:27. [PubMed: 19014544]
11. Holtzer R, Wang C, Verghese J. The relationship between attention and gait in aging: facts and fallacies. *Motor Control*. 2012 Jan; 16(1):64–80. [PubMed: 22402221]
12. Verghese J, Kuslansky G, Holtzer R, et al. Walking while talking: effect of task prioritization in the elderly. *Arch Phys Med Rehabil*. 2007 Jan; 88(1):50–53. [PubMed: 17207675]
13. Tamura I, Kikuchi S, Kitagawa M, Otsuki M, Tashiro K. [Age-related working memory decline in patients with Parkinson's disease]. *No To Shinkei*. 2003 Apr; 55(4):335–340. [PubMed: 12755037]
14. Piras F, Marangolo P. Word and number reading in the brain: evidence from a voxelbased lesion-symptom Mapping study. *Neuropsychologia*. 2009 Jul; 47(8–9):1944–1953. [PubMed: 19428427]
15. Holtzer R, Wang C, Verghese J. Performance variance on walking while talking tasks: theory, findings, and clinical implications. *Age (Dordr)*. 2013 Aug 13.
16. Strygley JM, Mirelman A, Herman T, Giladi N, Hausdorff JM. When does walking alter thinking? Age and task associated findings. *Brain Res*. 2009 Feb 9; 1253:92–99. [PubMed: 19084511]
17. Hall CD, Echt KV, Wolf SL, Rogers WA. Cognitive and motor mechanisms underlying older adults' ability to divide attention while walking. *Phys Ther*. 2011 Jul; 91(7):1039–1050. [PubMed: 21527384]
18. Harada K, Shimada H, Sawyer P, et al. [Life-space of community-dwelling older adults using preventive health care services in Japan and the validity of composite scoring methods for assessment]. *Nihon Koshu Eisei Zasshi*. 2010 Jul; 57(7):526–537. [PubMed: 20845714]
19. Lipton RB, Katz MJ, Kuslansky G, et al. Screening for dementia by telephone using the memory impairment screen. *J Am Geriatr Soc*. 2003 Oct; 51(10):1382–1390. [PubMed: 14511157]
20. Holtzer R, Verghese J, Wang C, Hall CB, Lipton RB. Within-person acrossneuropsychological test variability and incident dementia. *JAMA*. 2008 Aug 20; 300(7):823–830. [PubMed: 18714062]
21. Verghese J, Wang C, Lipton RB, Holtzer R, Xue X. Quantitative gait dysfunction and risk of cognitive decline and dementia. *J Neurol Neurosurg Psychiatry*. 2007 Sep; 78(9):929–935. [PubMed: 17237140]
22. Brach JS, Perera S, Studenski S, Newman AB. The reliability and validity of measures of gait variability in community dwelling older adults. *Archives of Physical Medicine and Rehabilitation*. 2008; 89(12):2293–2296. [PubMed: 19061741]
23. Huxhold O, Li SC, Schmiedek F, Lindenberger U. Dual-tasking postural control: aging and the effects of cognitive demand in conjunction with focus of attention. *Brain Res Bull*. 2006 Apr 14; 69(3):294–305. [PubMed: 16564425]
24. Verghese J, Lipton RB, Hall CB, Kuslansky G, Katz MJ, Buschke H. Abnormality of gait as a predictor of non-Alzheimer's dementia. *N Engl J Med*. 2002 Nov 28; 347(22):1761–1768. [PubMed: 12456852]
25. van Iersel MB, Kessels RP, Bloem BR, Verbeek AL, Olde Rikkert MG. Executive functions are associated with gait and balance in community-living elderly people. *J Gerontol A Biol Sci Med Sci*. 2008 Dec; 63(12):1344–1349. [PubMed: 19126847]
26. Tombu M, Jolicoeur P. A central capacity sharing model of dual-task performance. *J Exp Psychol Hum Percept Perform*. 2003 Feb; 29(1):3–18. [PubMed: 12669744]
27. Hartley AA, Little DM. Age-related differences and similarities in dual-task interference. *Journal of experimental psychology General*. 1999 Dec; 128(4):416–449. [PubMed: 10650582]
28. Hartley AA. Age differences in dual-task interference are localized to response-generation processes. *Psychol Aging*. 2001 Mar; 16(1):47–54. [PubMed: 11302367]

29. Lundin-Olsson L, Nyberg L, Gustafson Y. "Stops walking when talking" as a predictor of falls in elderly people. *Lancet*. 1997 Mar 1;349(9052):617. [PubMed: 9057736]
30. Lundin-Olsson L, Nyberg L, Gustafson Y. Attention, frailty, and falls: the effect of a manual task on basic mobility. *J Am Geriatr Soc*. 1998 Jun; 46(6):758–761. [PubMed: 9625194]

Highlights

- We compared dual-task performance in two walking while talking paradigms in aging
- Dual-task protocols included walking while reciting letters and counting backwards
- Dual-task costs in gait speed vary depends on the complexity of the cognitive task
- Walking while counting backwards induced higher dual-task costs in gait speed
- Dual-task costs are attributed to limited attention resources not task preference

Table 1

Summary of Characteristics (n=217)

Variables	Value
Mean Velocity + SD:	
Normal Walking (cm/s):	98.79 (22.11)
Walking While Reciting Alternate Letters of the Alphabet (cm/s):	68.63 (25.03)
Walking While Counting Backwards by Sevens (cm/s):	63.65 (25.04)
Mean Total Responses + SD:	
Standing While Reciting Alternate Letters of the Alphabet:	7.64 (1.79)
Standing While Counting Backwards by Sevens:	4.28 (1.93)
Walking While Reciting Alternate Letters of the Alphabet:	9.32 (3.40)
Walking While Counting Backwards by Sevens:	5.27 (2.92)
Mean Total Correct Responses + SD:	
Standing While Reciting Alternate Letters of the Alphabet:	7.04 (2.02)
Standing While Counting Backwards by Sevens:	3.71 (1.94)
Walking While Reciting Alternate Letters of the Alphabet:	7.75 (3.29)
Walking While Counting Backwards by Sevens:	4.21 (2.91)
Mean Accuracy Ratio + SD:	
Standing While Reciting Alternate Letters of the Alphabet:	0.91 (0.13)
Standing While Counting Backwards by Sevens:	0.87 (0.22)
Walking While Reciting Alternate Letters of the Alphabet:	0.83 (0.17)
Walking While Counting Backwards by Sevens:	0.78 (0.26)

Table 2

Dual-task Costs in Gait Performance during Normal Walking (NW) versus Walking While Reciting Alternate Letters of the Alphabet (WWR) and Normal Walking (NW) versus Walking While Counting Backwards by Sevens (WWC)

Outcome	Effect	Lower CI	Upper CI	p Value
NW vs. WWR Velocity	−30.15 *	−32.69	−27.62	< .01
NW vs. WWC Velocity	−35.13 *	−37.67	−32.60	< .01
Age	−.72 *	−1.03	−.41	< .01
Gender	−.49	−5.89	4.91	.86
Race	−.55	−5.31	4.21	.82
Education	.62	−.24	1.48	.16
Disease Comorbidity	−2.29 *	−4.60	.01	.05
Abnormal Gait	−9.01 *	−14.89	−3.14	< .01

p values were calculated using linear mixed effects models, adjusting for age, gender, race, education (years), disease comorbidity, and gait abnormality.

*
p < .05

Table 3

Dual-task Costs in Cognitive Performance during Reciting Alternate Letters of the Alphabet while Standing (Letter Alone) versus While Walking (WWR) and Counting Backwards by Sevens while Standing (Count Alone) versus While Walking (WWC)

Outcome	Effect	Lower CI	Upper CI	p Value
Letter Alone vs. WWR	-.09 *	-.11	-.06	< .01
Age	<-.01	-.00	.00	.40
Gender	-.02	-.05	.02	.29
Race	-.04 *	-.07	-.01	.01
Education	.01 *	.00	.01	< .01
Disease Comorbidity	<.01	-.01	.02	.49
Gait Abnormality	.02	-.02	.05	.37
Count Alone vs. WWC	-.08 *	-.12	-.05	< .01
Age	<.01	-.00	.00	.48
Gender	.04	-.02	.09	.17
Race	-.04	-.09	.01	.09
Education	.01 *	.00	.02	.01
Disease Comorbidity	.01	-.01	.03	.33
Gait Abnormality	.02	-.04	.08	.48

p values were calculated using linear mixed effects models, adjusting for age, gender, race, education (years), disease comorbidity, and gait abnormality.

*
p < .05

Table 4

Comparison of Dual-task Performance between Walking While Reciting Alternate Letters of the Alphabet (WWR) and Walking While Counting Backwards by Sevens (WWC)

Outcome	Effect	Lower CI	Upper CI	p Value
WWR vs. WWC Velocity	-4.98 *	-6.94	-3.03	<.01
Age	-.68 *	-1.04	-.32	<.01
Gender	-1.03	-7.29	5.23	.75
Race	-.60	-6.12	4.92	.83
Education	.52	-.48	1.52	.31
Disease Comorbidity	-2.03	-4.71	.64	.14
Gait Abnormality	-7.41 *	-14.22	-.60	.03
WWR vs. WWC Accuracy Ratio	<-.01	-.05	.04	.91
Age	<.01	-.00	.00	.58
Gender	-.01	-.06	.03	.57
Race	-.01	-.05	.03	.67
Education	-.01	-.01	.00	.10
Disease Comorbidity	-.01	-.03	.01	.51
Gait Abnormality	<.01	-.05	.05	.93

p values were calculated using linear mixed effects models, adjusting for age, gender, race, education (years), disease comorbidity, and gait abnormality.

* p < .05