Journal of Sport Sciences and Physical Education,, Vol. 13, January (1), pp1-12 , king Saud Univ., Riyadh (2023 /1444H.)

Assessing the Effects of Dual Tasking on Spatiotemporal Parameters of Gait in Older Adults: Exploring Age and Task Demands

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(Received 26/7/2019 ; Accepted for publication 20/10/2019)

Keywords: Dual task, Elderly, Task demands, Cognitive task, Motor task, Gait parameters, Falling.

Abstract: this study was aimed to assess the spatiotemporal parameters of gait when different age groups of older adults (young-old adults and old adults) perform different types of dual tasks. A total of 31 participants (71.97 years old) were recruited in this study. The results of this study showed that there was a significant difference between age groups on the stride length of the left leg when they walk on the level surface. Furthermore, there was a significant difference on the spatiotemporal parameters of gait for the age groups when they walked and walked while engaging in a secondary task. Additional, there was a significant difference on the spatiotemporal parameters of gait for the age groups when they walked while engaging in different secondary task (fine motor skill, gross motor skill, and cognitive skill).

تقييم مدى تأثير ثنائية المهارة على أنماط الخطوات لكبار السن: لاكتشاف الفرق العمري والمهاري

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(قدم للنشر في 2019/7/26م ؛ وقبل للنشر في 2019/10/20م)

الكلمات المفتاحية: ثنائية المهارة، كبار السن، متطلبات المهارة، المهارة العقلية، المهارة الحركية، أنماط الخطوات، السقوط.

ملخص البحث: هدفت هذه الدراسة إلى تقييم أنماط الخطوات لفئتين من كبار السن (صغار كبار السن و كبار السن) عندما يؤدون أنواع مختلفة من المهارات الثنائية. واحد وثلاثون شخصاً شاركوا في هذه الدراسة بمتوسط عمري 71.97 سنة. وأظهرت نتائج الدراسة إلى أن هناك تغيير بشكل واضح في طول الخطوة للقدم اليسرى بين الفئتين العمريتين. بالإضافة إلى أن هناك تغيير بشكل واضح في أنماط الخطوات للفئتين العمريتين عند مقارنة المشي مع المشي وأداء مهارة أخرى. أضف إلى ذلك بأن هناك تغيير بشكل واضح في أنماط الخطوات بين الفئتين العمريتين عند استخدام أنواع متغيرة من المهارات (المهارة الحركية للعضلات الصغيرة ، المهارة الحركية للعضلات الكبيرة، و المهارة العقلية) أثناء المشي.

Introduction

In 1970, the percentage of the baby boomers in the US was 9.8%, increasing to 13.4% in 2011. The percentage of the baby boomers is expected to increase to 20% by 2030 (Colby & Ortman, 2014). Nine percent of the elderly population aged 65 years and older die from injuries caused by falling (Rubenstein, 2006). Falls are considered a global problem due to the increased rates of falls and the costs associated with treating impairments resulting from falls. The elderly population's psychological reaction to falls and falling includes social isolation, loss of confidence, decrease in activities of daily living function, depression, and feelings of helplessness (Rubenstein & Josephson, 2002). Many would argue that to address the physical and the psychological costs of fall effectively, we must understand the causes of falling. Falling can be caused by extrinsic and intrinsic factors (Chen, Ashton-Miller, Alexander, & Schultz, 1994; Rubenstein et al., 2002). As we independently function within our world, we effortlessly negotiate many obstacles during walking using minimal cognitive awareness that requires to use two different strategies when faced with obstacles in one's walking path: either changing the walking direction or changing the limb's trajectory to negotiate the obstacle (Patla, Prentice, Robinson, & Neufeld, 1991). Aging - considered one of the intrinsic factors that causes falls - can be described as a singular or multiple process that occurs in humans, resulting in functional impairment or loss of adaptability and eventually death (Haibach & Collier, 2011). A closer look at the aging process shows that the elderly people face many challenges to their physiological abilities, such as declines in their perception, cognition, and physical abilities (Haibach et al., 2011; Smith & Kosslyn, 2006). Given that the integration of sensory information is essential for assessing the surface for walking and altering one's gait parameters to meet the needs of the environment, increased fall rates are again seen in those with declines in sensory perception (Stevens et al., 2006). With the lower levels of sensory integration than young adults, elderly people require greater attention to task demands while walking (Hawkins et al., 2011). In daily living, some activities require the performance of dual tasks simultaneously, such as walking and engaging in conversation. Performing a dual task is considered more challenging because of attentional misallocation and capacity sharing, especially for elderly people (Magill, 2007). As we seek to understand why we see changes in one's motor performance when performing dual tasks, several theories have been explored: bottleneck models, capacity sharing, and cross-talk models. These theories have been proposed to explain attentional limitation, misallocation, and interference that can affect the performance of a dual tasking (Kanheman, 1973; Pashler, 1994). The bottleneck model proposes that for some mental operations, it might be impossible to process parallel information at the same time, which can cause impairment or delay in performing of multiple tasks concurrently due to processing one mechanism at a time. In contrast, the capacity sharing theory suggests that a human's processing capacity is shared between tasks. Therefore, performance will be impaired when one of the tasks occupies excessive attentional capacity. Finally, the cross-talk models relate to the operation of information processing. On one hand, if the content of the information is different, then no interference will occur. On the other hand, if the information content is too similar, people can experience interference, making it difficult to perform them together (Pashler, 1994). Several studies have reported that performing dual tasking changed the spatiotemporal parameters of gait for the elderly. Nevertheless, to date the effects of performing different types of dual tasking on different age groups of the elderly has received less attention. Therefore, this study sought to assess the hypothesis that when different age groups of older adults (young-old adults and old adults) perform different types of dual tasks, the spatiotemporal parameters of gait will be changed. Therefore, the research questions driving this study were a) are there differences in spatiotemporal parameters of gait between young-old adults and old adults when walking on a level surface?, b) are there differences in spatiotemporal parameters of gait between walking without engaging in a secondary task and walking while engaging in a secondary task?, c) are there differences in spatiotemporal parameters of gait between walking without engaging in a secondary task and walking while engaging in a secondary task?, and d) is there an interaction between age classification and dual tasking performed concurrently in older adults?

Methods

Design

The study is cross-sectional and quasi-experimental.

Variables

The outcome measure was the gait parameters, including velocity, cadence, double support, and stride length. The independent variables were (a) age classifications groups, with two levels: (1) 65-74 years old and (2) 75-84 years old and (b) dual tasking, with four levels: (1) walking without engaging in a secondary task, (2) walking while engaging in a secondary task, (3) walking while engaging in a secondary task, and (4) walking while engaging in a secondary task.

Subjects

Thirty-three older adults whose age between 65-84 years old consented to participate in the study (Table 1). Two participants were excluded from the study (one has a stroke, the another one has the cognitive impairment). Therefore, thirty-one older adults met the inclusion criteria of the study.

Instruments

Three standard, valid, and reliable measurements were used in this study. First, the Mini Mental State Examination (MMSE), which assessed cognitive abilities for the elderly. So, the maximum possible score on the MMSE is 30/30, while a score of 23 or lower is considered as a cognitive impairment (Folstein et al., 1975). Second, Dynamic Gait Index (DGI) was developed by (Shumway-Cook & Woollacott, 1995) to predict falling for the elderly by assessing the dynamic postural control and ability to respond to changing task demands while walking. If the total score is 19 or less, it will be predicted to an increased incidence of falls (Shumway-Cook & Woollacott, 2011). Third, the Time Up and Go (TUG), which assessed balance (Nordin et al., 2016). Shumway-Cook, Brauer, and Woollacott (2000) pointed out that the perfect time to complete the test has to be fewer than 14 seconds. The old people who take longer than 14 seconds will have a high risk of falls.

Procedure

This study was approved via Institutional Review Board (IRB). The participants were given a code number based upon their arrival to the testing session to maintain anonymity. Participant's legs length were measured from the top of the greater trochanter (hip joint) to the floor. The GAITRite software system needed these data to address differences across participants. The participant performed 3 trials for each condition, and the average of the trials was taken resulting in a total of 12 condition trials.

A tape was attached to the floor 5 feet before and after the edge of the electronic walkway mat (GAITRite) to establish a constant gait speed prior to data recording and at the end of the recording period. The participant stood at the start marker tape and heard "ready, go." After which the participant started to walk over the GAITRite walkway at their preferred/comfortable speed until the participant reached the stop marker tape. To ensure safety and control the risk of falling, the participant wore a standard safety gait belt placed around the participant's waist.

For task A: the participant walked on the electronic walkway mat (GAITRite), listened to the polar questions (known as yes or no questions) via speaker, and answered them loudly while walking to the end walking line. There was a three seconds lapse between questions. If participant could not hear the question clearly or did not understand it, the participant could say the word "SKIP" loudly. The participant answers were writing down. For task B: the participant held a large flat plastic calculator using two hands. The participant was asked to walk along the electronic walkway mat (GAITRite), to the end, while listen for the calculation questions, which was verbalized over a speaker and then to solved the problem using the calculator, and say the result loudly when achieved. There was five seconds between each calculation questions posed. The participant answers were writing down. For task C: the participant was asked to walk on the electronic walkway mat (GAITRite) and negotiated an obstacle (small 6 in high) that was placed in the middle and off the walkway. The obstacle; however, was not placed on the walkway but was anchored off of the walkway. If the participant cleared the obstacle, hit the obstacle with any part of their shoe (foot), or knocked over the obstacle while walking along the walkway, their action was noted. At the end of completing all walking trails associated with the study, the participant was asked to sit on a comfortable, stable chair. After 2 minutes, the participant was asked to listen again to the speaker. The speaker repeated the same yes or no questions that the participant heard while they walked (the same volume was also used). The participant was asked again to answer the questions out loud to confirm the correct answer while the participant was not engaged in the primary task of walking. The participants could say "SKIP" if the participant could not hear the question or did not understand it The participant answers were writing down. At the end of the testing period, the participant was asked to respond to three additional questions that it was believed to help providing further clarity about the participant's perspective on dual-tasking. Each question was read to the participant one time. The participant's answer was recorded with paper and pen. The questions were,

1. What do you usually do when you walk?
2. How often do you walk and do something else at the same time?
3. Which part of experiment was the most challenging for you during the study? And WHY?

After the participants answered these questions, they thanked for participating in the study and it was given a gift card ($25).

Data Analysis

For all quantitative gait parameters data, the GAITRite system secured and processed the data. The chosen data (velocity, cadence, double support, and stride length) were exported to SPSS (Version 22) via Excel files. For the purpose of this study, a mixed design analysis of variance (ANOVA; one dependent variable [gait parameters with four levels]) was employed to analyze the data because it compared several means when there are two independent variables, one has been measured using the same entities (dual tasking with four levels) and the other has been measured using different entities (age with two levels; Field, 2013). Furthermore, an independent t-test was used

to analyzed the data with two means. Mixed design ANOVA is a parametric test that includes the assumptions of one-way independent ANOVA and the assumptions of one-way repeated measures ANOVA.

If the main effect within participants (dual tasking with four levels) was significant (p > .05), a pairwise comparison was used to determine where the difference lies. Bonferroni was an appropriate post-hoc test for this study.

For the three additional questions, the quantizing technique was used to analyze the data. Quantizing is a process that transforms the qualitative data to quantitative data (Sandelowski, 2000). To determine the relative change between single task and dual tasking in this study, the dual tasking cost was calculated for each subject and task based on this formula: Dual tasking Cost (%) $= \frac{\text{Single task} - \text{Dual tasks}}{\text{Single task}} \times 100$ (Bock, 2008).

Results

Participants Demographic

An independent samples t-test by comparing the mean scores of the age for the young-old adults group and old adults group found a significant difference between the means of the two groups (*t* (29) = -9.51, *p* = .001) (Table 1).

Eligibility Test

An independent samples t-test comparing the mean scores of young-old adults group and old adults group found a non-significant difference between the means of the two groups on MMSE (*t* (29) = 1.43, *p* =.16) and on DGI (*t* (29) = .009, *p* =.99). On the other hand, there was a significant difference between the means of the two groups on TUG (*t* (29) = -2.05, *p* =.018) (Table 2).

Velocity

The results of this study showed significant differences in the main effect for the single task and dual tasking of velocity [*F (*3, 87) = 41.64, *p* =.001, partial *η2* = .6], cadence [*F (*3, 87) = 13.69, *p* =.001, partial *η2* = .32]. The pairwise comparison of velocity showed that there was a significant difference in velocity between walking and walking while calculating, *p* =.001, and between walking and walking while talking, *p* =.001.

The results showed significant differences in the main effect for the dual tasking of velocity [*F (*2, 58) = 30.93, *p* =.001, partial *η2* = .52]. The pairwise comparison for the dual tasking showed that there was a significant difference in velocity between walking while calculating and walking while stepping over an obstacle, *p* =.001, and between walking while calculating and walking while talking, *p* =.001.

Cadence

The results of this study showed significant differences in the main effect for the single task and dual tasking of cadence [*F (*3, 87) = 13.69, *p* =.001, partial *η2* = .32]. The pairwise comparison of cadence showed that there was a significant difference in cadence between walking and walking while calculating, *p* =.001, between walking and walking while stepping over an obstacle, *p* =.003, and between walking and walking while talking, *p* =.014.

The results showed significant differences in the main effect for the dual tasking of cadence [*F (*1.81, 52.43) = 5.8, *p* =.007, partial *η2* = .17]. The pairwise comparison for the dual tasking showed that there was a significant difference in cadence between walking while calculating and walking while talking, *p* =.001.

Double Support of the right and left legs

The results of this study showed significant differences in the main effect for the single task and dual tasking of double support for left leg [*F (*1.87,54.22) = 17.55, p =.001, partial *η2* = .38], double support for right leg [*F (*1.876,54.39) = 11.94, p =.001, partial *η2* = .3]. The pairwise comparison of double supports of the left leg showed that there was a significant difference in double support for the left leg between walking and walking while calculating, *p* =.001, and between walking and walking while talking, *p* =.016. The pairwise comparison of double supports for the right leg showed that there was a significant difference in double support for the right leg between walking and walking while calculating, *p* =.001, and between walking and walking while talking, *p* =.0014.

The results showed significant differences in the main effect for the dual tasking of velocity [*F (*2, 58) = 30.93, *p* =.001, partial *η2* = .52], cadence [*F (*1.81, 52.43) = 5.8, *p* =.007, partial *η2* = .17], double support for left leg [*F (*1.44, 44.91) = 16.5, *p* =.001, partial *η2* = .36], double support for right leg [*F (*1.712, 49.637) = 10.47, *p* =.001, partial η2 = .26]. The pairwise comparison for the dual tasking showed that there was a significant difference in double support for the left leg between walking while calculating and walking while stepping over an obstacle, *p* =.001 and between walking while stepping over an obstacle and walking while talking, *p* =.006. The pairwise comparison for the dual tasking showed that there was a significant difference in double support for the right leg between walking while calculating and walking while stepping over an obstacle, *p* =.001and between walking while stepping over an obstacle and walking while talking, *p* =.007.

Stride length of the right and left legs

The main effect for the age classification groups was significant, *F* (1, 29) = 4.37, *p* =.045, partial *η2* = .131. Additionally, the results of this study showed significant differences in the main effect for the single task and dual tasking of stride length for left leg [*F (*3,87) = 40.58, p =.001, partial *η2* = .58], and stride length for right leg [*F (*3,87) = 37.25, p =.001, partial *η2* = .56]. The pairwise comparison of stride length of the left leg showed that there was a significant difference in stride length for the left leg between walking and walking while calculating, *p* =.001, and between walking and walking while talking, *p* =.001. The pairwise comparison of stride length of the right leg showed that there was a significant difference in stride length for the right leg between walking and walking while calculating, *p* =.001, and between walking and walking while talking, *p* =.001.

The results showed significant differences in the main effect for the dual tasking of stride length for left leg [*F (*2, 58) = 42.02, p =.001, partial *η2* = .59], and stride length for right leg [*F (*2,58) = 35.66, *p* =.001, partial *η2* = .55 The pairwise comparison for the dual tasking showed that there was a significant difference in stride length for the left leg between walking while calculating and walking while stepping over an obstacle, *p* =.001, and between walking while calculating and walking while talking, *p* =.001. Furthermore, there was a significant difference in stride length for the left leg between walking while stepping over an obstacle and walking while talking, *p* =.001. The pairwise comparison for the dual tasking showed that there was a significant difference in stride length of the right leg between walking while calculating and walking while stepping over an obstacle, *p* =.001, and between walking while calculating and walking while talking, *p* =.001. Moreover, there was a significant difference in stride length of the right leg between walking while stepping over an obstacle and walking while talking, *p* =.001.

Dual tasking costs

The dual tasking cost increased as the complexity of the task increased for both groups. The fine motor-motor tasks (walking while calculating) had the greatest dual tasking cost of the spatiotemporal gait parameters compared to gross motor-motor tasks (walking while stepping over obstacle) and cognitive task (walking while talking) for young old people (Figure 1) and old people (Figure 2).

Three Additional Questions

The answers for the three additional questions provided in table 3, 4, and 5.

The Responses to the polar questions and the calculator questions

For the responses of calculating while walking versus sitting, there was no significant difference between the means of the two groups (*t* (20.36) = .41, *p* = .682). Furthermore, for the responses of polar questions while walking versus sitting, there was no significant difference between the means of the two groups (*t* (29) = -3.07, *p* = .761).

Table (1). Age and gender of the participants

Age	Male	Female	means ± SD
Young Old	5	13	68.17 ± 2.72
Old	1	12	77.23 ± 2.45
Total	6	25	71.97* ± 5.22

* significant difference at *p* < .05

Table (2). *Descriptive Statistics for MMSE, DGI, and TUG*

Eligibility test	MMSE (means ± SD)	DGI (means ± SD)	TGU (means ± SD)
Total	28.25 ± 1.26	22.39 ± 1.23	8.94* ± 1.71

* significant difference at *p* < .05

Table (3). *Participants Perception Regarding of Preforming Different Types of Dual tasks*

		age		
		young-old	old	Total
What do you usually do when you walk?	talking on the phone	5	1	6
	talking with friend	4	8	12
	carrying bags	2	1	3
	listening to music	3	2	5
	praying rosary	1	0	1
	just walking	2	0	2
	doing Croshea	0	1	1
	thinking	1	0	1
Total		18	13	31

Table (4). *Participants Perception of Frequency of Preforming Dual tasks*

		age		Total
		young-old	old	
How often do you walk and do something else at the same time?	always	8	8	16
	sometimes	5	3	8
	once a week	1	1	2
	once a month	1	0	1
	rarely	1	1	2
	never	2	0	2
Total		18	13	31

Table (5). *Participants Perception Regarding Which Dual Task Was Challenging During Dual tasking the Experiment*

		age		
		young-old	old	Total
Which part of experiment was the most challenging for you during performing the study?	Walking and Calculating	16	10	26
	Walking and Stepping over obstacle	0	1	1
	Walking and Talking	0	1	1
	none of them	2	1	3
Total		18	13	31

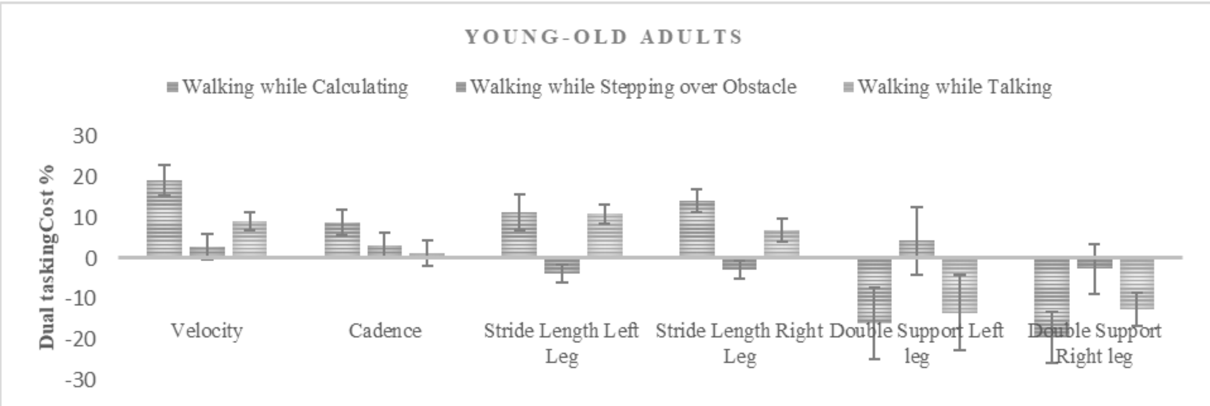

Figure (1). Dual tasking cost on young-old adults.

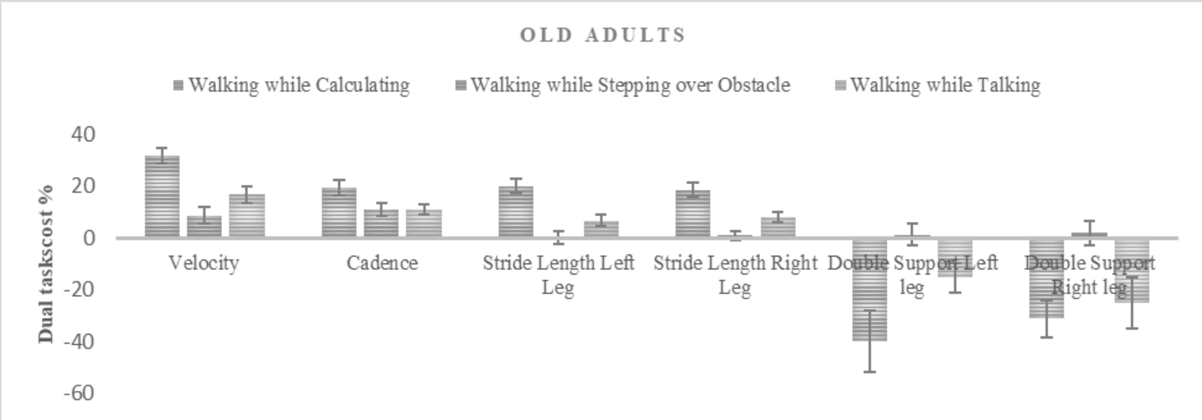

Figure (2). **Dual tasking cost on old adults.**

DISCUSSION

As we seek to understand the findings it is important to confirm that on the baseline/eligibility tests in this study, there were no significant difference between age classification groups on MMSE and DGI. If there was a significant difference between age classification groups on MMSE, it might affect the difficulty of performing the secondary task and hence modify the dual task. Additionally, if there was a significant difference between age classification groups on DGI, it might influence the spatiotemporal parameters of gait and misallocate attentional demands. However, it must be noted there was a significant difference between age classification groups (young-old adults [65-74 years old] versus old adults [75-84 years old]) when the participants were tested on the TUG test at baseline. The TUG test was based upon the instruction and the tools (Bergmann et al., 2017). As outlined in the test protocol, the primary investigator provided these instructions, "On the word GO, you will stand up, walk to the line on the floor, turn around, and walk back to the chair and sit down. Walk at your regular pace." In Bergmann et al. (2017) work it was noted that, TUG test is affected by the speed of the performance and the age of participants. Therefore, the data in the present study showed that 33% of the young-old adults finished the test in fewer than 7 seconds, whereas 47% of the old adults took over 10 seconds to finish the test, which is not surprising. Furthermore, to stabilize balance, the old adults group might reduce their velocity while taking this test and thus resulting in a difference in TUG scores.

However, surprisingly there were no significant changes in the spatiotemporal parameters of gait between the age classification groups (young-old adults and old adults) except for stride length of the left leg.

For velocity, Himann et al. (1988) mentioned that the velocity of walking starts to decline at age 62, and the rate of decrease is about 4.5% for each decade. However, the previous expression disagrees with our observation due to the walking's distance, which was not large enough to detect the effect of walking's velocity between age classification groups. In contrast, the duration of performing physical activity and exercise may improve the velocity of walking for the elderly (Plummer et al., 2014; Rosengren et al., 1998). Based upon the data that 40% of the young-old adults performed an activity less than 75 minutes per week and 50% of the old adults did an activity 150 minutes or more per week, so the velocity of walking for the old adults' group was quite similar to the young adults' group.

For cadence, Harely et al. (2009) pointed out that as age increases, the cadence will decrease to obtain posture protective strategy. The observation of this study did not support Harley et al. (2009) prior findings. Reflecting upon this difference four possible explanations are proposed. First, the walking distance was longer (520 cm). Second, there were two obstacles that were used for their study. Third, the heights of the obstacles were shorter than the height of the obstacle for this study. Fourth, for their study, the participants walked in an 8-shape direction. On the other hand, the cadence was decreased for both groups due to fourth possible explanations. First, the participants tried to stabilize their balance, which agrees with McFadyen et al. (2002), Rosengren et al. (1998), Guedes et al. (2014), Hollman et al. (2011), Guadagnin et al. (2015), and Harley et al. (2009). Second, the participants decreased the swing time and increased the stance time, which concurs with McFadyen et al. (2002) and Springer et al. (2006). Third, the participants were unable to walk with longer steps, which agrees with Galna et al. (2009). Fourth, the sample size was not large enough to reach the statistical power of cadence, which might be another possible explanation for a non-significant difference between groups.

For double support, both groups adjusted their foot placement to enhance balance, which concurs with Galna et al. (2009). Therefore, the old adults group increased their double support more than the young-old adults group when they were walking and calculating by decreasing the swing time to stabilize the balance and reduce falling. This observation is consistent with Harley et al. (2009) and Springer et al. (2006). Additionally, the statistical power of double support for both legs was not large enough to detect the significant differences for both groups, which requires more sample size. The statistical power for the left leg was .07 while the statistical power for the right leg was .01.

Both groups increased their stride length in order to successfully step over the obstacle and to avoid stepping on an obstacle or falling. A possible explanation for left leg stride length significance between age classification groups could be that the participants used this leg as the non-preferred leg when they stepped over the obstacle, which supports De Rocha et al. (2013) findings. Conversely, one could argue that the sample size was not large enough to reach the statistical power of .8 for the stride length of the right leg.

Significant changes in the spatiotemporal parameters of gait were observed when the participants walked while engaging in a secondary task versus just walking. The velocity and the cadence were decreased as the participants performed the dual tasking concurrently. This observation supports the findings of McFadyen et al. (2002), Rosengren et al. (1998), Guedes et al. (2014), Hollman et al. (2011), Guadagnin et al. (2015) and Harley et al. (2009) who all reported that the decrease in velocity and cadence while performing dual tasking resulted in stabilization of balance for old people aged 65 years old to 85 years old. Double support increased when the participants performed walking while calculation and walking while talking versus just walking. In contrast, double support decreased when the participants were walking while stepping over an obstacle. One possible explanation for this observation might be that an increased stance time and decreased swing time can reduce the risk of falling (Huffman et al., 2009) (Harley et al., 2009).

Stride length decreased when participants performed walking while calculation and walking while talking versus just walking. This observation concurs with the finding of Da Rocha et al. (2013) and Guedes et al. (2014) who reported that the participants may prefer to decrease their stride length to be safer while walking. However, participants' stride length increased during walking while stepping over an obstacle. This observation was contrary to the findings of McFadyen et al. (2002), who reported that the participants decreased the swing time and increased the stance time to step over a high obstacle. Thus, leaving us with further questions to explore.

Not surprising, significant changes were observed in spatiotemporal parameters of gait based upon the secondary task performed. When the participants were walking while calculating, they adopted "protective" gait parameters to decrease the risk of accidents. Furthermore, walking while calculating, required additional visual attention that may have further impacted the gait parameters (Krasovky, Weiss, & Kizony, 2017). Impacting the situation further was that the participants could not see their feet when they performed this type of dual task (walking while calculating), and thus further negatively impacting the elderly who often depend on seeing their feet when walking (Beurskens & Bock, 2013). For the obstacle avoidance task, the participants walked and stepped over the obstacle, thus requiring visual information to provide feed-forward information in conjunction with kinesthetic sensory feedback to be successful (Di Fabio, 1997). As we seek to understand the impact of the obstacle we must further note that as Schrodt, Mercer, Giuliani, and Hartman (2004), identified the height of the obstacle to be avoided could have further impacted the elderly gait parameters (Schrodt et al., 2004). Yet, the height in this study did not appear to negatively impact successful obstacle negotiation as all the participants avoided it successfully (Chen et al., 1994) and it can be further explored in future work.

Specifically, while many researchers have neglected to look at the secondary tasks performance success, we believe it was imperative to do so as it provided additional insight regarding the participants' solution to meeting the challenges set for the dual tasking. Therefore, we analyzed the participants' responses while performing dual tasking to capture any changes in their secondary task (i.e. cognitive function) (Plummer & Eskes, 2015).

In summary, no significant interaction was observed between age classifications and tasks. For velocity, a few explanations are offered to clarify these observations. First, when the participants performed the single task, the velocity of walking was quite similar because both groups performed intensity exercise (Table 5) (Plummer et al., 2015). Second, when the participants performed dual task, the velocity of walking decreased compared to single task for both groups. The lowest velocity was when the participants performed walking while calculating because the participants exceed the capacity of attention (Chen et al., 1994; Guadarnin et al., 2015; Hall et al., 2011; Hausdoff et al., 2008; Plummer et al., 2015; Springer et al. 2006). The highest velocity for both groups was when the participants performed walking while stepping over an obstacle because it did not require more attention to perform it and it decreased stance time and increased swing time (Guadagnin et al., 2015).

For cadence, the old adults group had higher cadence when performing the single task compared to the young adults group. The old adults group had higher cadence due to safety and balance. On the other hand, the cadence decreased for the old adults group while performing dual task because they exceeded attentional resources and increased the rate of falls. Furthermore, walking while calculating had the lowest cadence for both groups. Additionally, the interaction between groups and cadence was very close to be significant (p =.052) (Table 29). Moreover, no previous study examined the interaction between age groups and cadence while performing different types of secondary tasks.

For double support, there was no difference between groups when they performed the single task. For dual tasking, the double support increased for both groups except for walking while stepping over an obstacle because it required less double support for legs (compared to other dual tasking and single task) to stabilize balance. The highest double support of both legs for both groups was when the participants performed walking while calculating. The possible explanations for the previous observations were due to a) misallocate attentional resources and b) decrease the swing time and increase the stance time. Furthermore, the statistical power for double support of right leg was not large enough (Figure 38). Moreover, no previous study measured the interaction between age groups and double support while performing different types of secondary tasks.

For stride length, the young-old adults group had higher stride length than the old adults group for both legs when they performed the single task. For dual task, the stride length was decreased for both groups. Walking while stepping over an obstacle, had similar stride length of both legs for both groups (Table 53 and Table 63). In addition, the statistical power for stride length of the right leg was not large enough (Figure 59). Furthermore, no previous study measured the interaction between age groups and stride length while performing secondary task.

Upon reflecting upon the contribution of this work we see that our findings support previously findings that, dual task cost increases when the complexity of the task increases (Bock, 2009; McIaas et al., 2015). Specifically in our study, performing the dual task of walking while calculating had the greatest dual task cost because it was incurred and required the greatest degree of attentional control (Bock, 2009; Hall et al., 2011; lindenberger, Marsiske, & Baltes, 2000; Salthouse, Hambrick, Lukas, & Dell, 1996) as well as most visual processing of information (Plummer et al., 2015) and thus resulted in spatial parameter changes which can impact falls and functional independence.

This study has several limitations. The first limitation was the sample size, which required more participants to reach the statistical power of .8. Second, the sampling method was nonprobability sampling (convenience), which limited generalizability of observations. Third, the task variability and complexity was limited; only three types of dual tasking were used. Fourth, this study was not analyzed the performance while stepping over the obstacle such as knowing the preferred leg for the participants (leg cross the obstacle first). Fifth, the information provided by the participants might not be accurate, which leads to self-reported bias. Sixth, the intrinsic factor of the participants (such as mood or effort) could not be measured and it might impact their performance. Nevertheless, this study accurately assessed the hypothesis that the spatiotemporal parameters of gait will be changed based on different types of dual tasking as identified by Gentile's Taxonomy of Task. Furthermore, this study provides direction for future work that can inform and impact the lives of community living older adults.

References

Bergmann, J., Alexiou, C., Howard, N., & Smith, C. (2016, October 14). A normative data-set of Timed Up and Go component times under different conditions. Retrieved from https://www.xsens.com/customer-cases/normative-data-set-timed-go-component-times-different-conditions/

Beurskens, R., & Bock, O. (2013). Does the walking task matter? Influence of different walking conditions on dual-task performances in young and older persons. *Human Movement Science*, *32*(6), 1456–1466. http://doi.org/10.1016/j.humov.2013.07.013

Bock, O. (2008). 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. *Journal of Neuroengineering and Rehabilitation*, *5*, 27. http://doi.org/10.1186/1743-0003-5-27

http://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html

Chen, H.-C, Ashton-Miller, J., Alexander, N., & Schultz, A. (1994). Effects of age and avaliable response time on ability to step over an obstacle. *Journal of Gerontology*, *49*(5), 227-233.

Colby, S. L., & Ortman, J. M. (2014). The Baby Boom Cohort in the United States : 2012 to 2060, 16.

Da Rocha, E. S., Machado, Á. S., Franco, P. S., Guadagnin, E. C., & Carpes, F. P. (2013). Gait Asymmetry During Dual-Task Obstacle Crossing in the Young and Elderly. *Human Movement*, *14*(2), 138–143. http://doi.org/10.2478/humo-2013-0016

Folstein. M., Folstein. S., & McHugh. P. (1975). Mini-mental state: A practical method for
grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12:189-198.

Galna, B., Peters, A., Murphy, A. T., & Morris, M. E. (2009). Obstacle crossing deficits in older adults: A systematic review. *Gait and Posture*.

Gentile, A.M. (1987). Skill acquisition: Action, movement, and neuromotor processes. In J.H. Carr, R.B. Shepherd, J. Gordon, A.M. Gentile, & J.M. Held, Movement Science. Foundations for Physical Therapy in Rehabilitation. MD: Aspen Publishers.

Guadagnin, E. C., da Rocha, E. S., Mota, C. B., & Carpes, F. P. (2015). Effects of regular exercise and dual tasking on spatial and temporal parameters of obstacle negotiation in elderly women. *Gait and Posture*, *42*(3), 251–256. http://doi.org/10.1016/j.gaitpost.2015.05.012

Guedes, R. C., Dias, R. C., Pereira, L. S. M., Silva, S. L. A., Lustosa, L. P., & Dias, J. M. D. (2014). Influence of dual taskingand frailty on gait parameters of older community-dwelling individuals. *Brazilian Journal of Physical Therapy*, *18*(5), 445–52. http://doi.org/10.1590/bjpt-rbf.2014.0034

Haibach, P., Reid, G., & Collier, D. (2011). Motor learning and development. Champaign, IL: Human Kinetics.

Harley, C., Wilkie, R. M., & Wann, J. P. (2009). Stepping over obstacles: Attention demands and aging. *Gait and Posture*, *29*(3), 428–432. http://doi.org/10.1016/j.gaitpost.2008.10.063

Hawkins, K. M., Perry, C. J., Kiriella, J. B., Shanahan, C. J., Moore, A. E., & Gage, W. H. (2011). Attentional demands associated with obstacle crossing while carrying a load. *Journal of Motor Behavior*, *43*(1), 37–44. http://doi.org/10.1080/00222895.2010.530307

Himann, J. E., Cunningham, D. A., Rechnitzer, P. A., & Paterson, D. H. (1988). Age-related changes in speed of walking. *Medicine and Science in Sports and Exercise*, *20*(2), 161–6. http://doi.org/10.1249/00005768-198804001-00010

Hollman, J. H., McDade, E. M., & Petersen, R. C. (2011). Normative spatiotemporal gait parameters in older adults. *Gait and Posture*, *34*(1), 111–118.

Huffman, J. L., Horslen, B. C., Carpenter, M. G., & Adkin, A. L. (2009). Does increased postural threat lead to more conscious control of posture? *Gait and Posture*, *30*(4), 528–532. http://doi.org/10.1016/j.gaitpost.2009.08.001

Kahneman, D. (1973). Attention and effort. Englewood Cliffs, NJ: Prentice-Hall.

Krasovsky, T., Weiss, P. L., & Kizony, R. (2017). A narrative review of texting as a visually-dependent cognitive-motor secondary task during locomotion. *Gait and Posture*, *52*, 354–362. http://doi.org/10.1016/j.gaitpost.2016.12.027

Lindenberger, U., Marsiske, M., & Baltes, P. B. (2000). Memorizing while walking: Increase in dual-task costs from young adulthood to old age. *Psychology and Aging*, *15*(3), 417–436. http://doi.org/10.1037//0882-7974.15.3.417

Magill, R. (2007). Motor Learning. Boston: McGraw-Hill.

McFadyen, B. J., & Prince, F. (2002). Avoidance and accommodation of surface height changes by healthy, community-dwelling, young, and elderly men. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *57*(4), B166–B174. http://doi.org/10.1007/s00221-007-0986-0

McIsaac, T. L., Lamberg, E. M., & Muratori, L. M. (2015). Building a framework for a dual task taxonomy. *BioMed Research International*, *2015*. http://doi.org/10.1155/2015/591475

Nordin, E., Rosendahl, E., & Lundin-Olsson, L. (2006). Timed " Up & Go " Test : Reliability in Older People Dependent in Activities of Daily Living —Focus on Cognitive State. *Physical Therapy*. http://doi.org/10.1093/ptj/86.5.646

Pashler, H. (1994). Dual-task interference in simple tasks: data and theory. *Psychological Bulletin*, *116*(2), 220–44. http://doi.org/10.1037/0033-2909.116.2.220

Patla, A. E., Prentice, S. D., Robinson, C., & Neufeld, J. (1991). Visual control of locomotion: strategies for changing direction and for going over obstacles. *Journal of Experimental Psychology. Human Perception and Performance*, *17*(3), 603–634.

Plummer, P., & Eskes, G. (2015). Measuring treatment effects on dual-task performance: a framework for research and clinical practice. *Frontiers in Human Neuroscience*, *9*(April), 1–7. http://doi.org/10.3389/fnhum.2015.00225

Rosengren, K., McAuley, E., & Mihalko, S. L. (1998). Gait adjustments in older adults: activity and efficacy influences. *Psychology and Aging*, *13*, 375–386. http://doi.org/10.1037/0882-7974.13.3.375

Rubenstein, L. Z. (2006). Falls in older people: epidemiology, risk factors and strategies for prevention. *Age and Ageing*, *35 Suppl 2*(SUPPL.2), ii37–ii41. http://doi.org/10.1093/ageing/afl084

Rubenstein, L., & Josephson, K. (2002). The epidemiology of falls and syncope. *Clinic Geriatric Medicine*, *18*, 141-158.

Salthouse, T. a., Hambrick, D. Z., Lukas, K. E., & Dell, T. C. (1996). Determinants of adult age differences on synthetic work performance. *Journal of Experimental Psychology: Applied*, *2*(4), 305–329. http://doi.org/10.1037/1076-898X.2.4.305

Schrodt, L. A., Mercer, V. S., Giuliani, C. A., & Hartman, M. (2004). Characteristics of stepping over an obstacle in community dwelling older adults under dual-task conditions. *Gait and Posture*, *19*(3), 279–287. http://doi.org/10.1016/S0966-6362(03)00067-5

Shumway-Cook, A., Woollacott, M. (1995). *Motor Control Theory and Applications*, Williams and Wilkins Baltimore, 5: 323-324.

Shumway-Cook, A., Brauer, S., & Woollacott, M. (2000). Predicting the Probability for Falls in Community-Dwelling Older Adults Using the Timed Up & Go Test. *Physical Therapy*, *80*(9), 142–148. http://doi.org/10.1037/0033-2909.86.2.420

Shumway-Cook, A., Woollacott, M. (2011). *Motor Control:* Translating research into clinical practice. (4th ed.). Philadelphia, PA: Wolters Kluwer.

Smith, E., Kosslyn, S. (2006). Cognitive psychology: Mind and brain. (1st ed.). London, Englnad: Pearson.

Springer, S., Giladi, N., Peretz, C., Yogev, G., Simon, E. S., & Hausdorff, J. M. (2006). Dual-tasking effects on gait variability: The role of aging, falls, and executive function. *Movement Disorders*, *21*(7), 950–957. http://doi.org/10.1002/mds.20848

Stevens, J. A., Corso, P. S., Finkelstein, E. A., & Miller, T. R. (2006). The costs of fatal and non-fatal falls among older adults. *Injury Prevention*, *12*, 290–295. http://doi.org/10.1136/ip.2005.011015