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

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DEDICATION

This humble work is dedicated to my lovely queen, Haya Albaqi, who has supported me during this journey. Furthermore, my warmest gratitude goes to my parents, Dad and Mom, and to my kids - Majed, Issa, Alwaleed, Fahad, and Laura- to whom I dedicate this dissertation.

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Finally, I must say that I have been fortunate to study in a department with lovely and wonderful professors, friends, and staff.

"Old age is far more than white hair, wrinkles, the feeling that it is too late and the game finished, that the stage belongs to the rising generations. The true evil is not the weakening of the body, but the indifference of the soul" (André Maurois, [1885-1967])."

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ABSTRACT

The percentage of the senior citizens is expected to be 20% of the US population by 2030. Falls are considered a global problem due to the increased rate of falls and the costs associated with treating impairments resulting from falls. To date, the effects of performing different types of dual tasks among different age groups of the elderly has received less attention. Therefore, this study sought to assess the impact on spatiotemporal parameters of gait when differing age groups of older adults performer dual tasks that require differing motor and cognitive demands.

Three standard measurements were used in this study: (a) the Mini Mental State Examination, (b) Dynamic Gait Index, and (c) The Time Up and Go test. Thirty-one participants walked on (GAITRite) and randomly performed a total of three trials for each of the four tasks: (a) walking, (b) walking while calculating, (c) walking while stepping over an obstacle, and (d) walking while talking. The spatiotemporal parameters of gait — velocity, cadence, stride length, and double supports —were analyzed by using a mixed design analysis of variance (ANOVA). Furthermore, if the main effect within participants was significant, a pairwise comparison (Bonferroni correction) was used to determine where the difference lied.

The results of this study showed a significant difference in the main effect for the age classification of stride length of the left leg. Furthermore, there were significant differences in the main effect for the single task and dual tasking of velocity, cadence, double support for left and right legs, and stride length for left and right leg. Additionally, there were significant differences in the main effect for the dual tasking of velocity, cadence, double support for left and right legs, and stride length for left and right leg.

The observations showed that the elderly decreased velocity, cadence, and stride length while increasing double support when the complexity of dual tasking increased, in order to provide more stability. Additionally, this study made the elderly concentrate on their balance rather than on the task itself. Therefore, it is important that employees in senior housing be aware of this study when giving instructions to elderly people while they are walking, because the elderly will either concentrate on their walking or ignore the instructions, or they will follow the instructions and increase their rates of falling.

CHAPTER 1

INTRODUCTION

BACKGROUND

In the United States, 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 Centers for Disease Control and Prevention (CDC, 2005) reported that every 17 seconds, an elderly person will be treated in the emergency department for injuries due to falling, and every 30 minutes, an elderly person dies because of injuries related to a fall. Stevens, Corso, Finkelstein, and Miller (2006) reported that in 2000, there were 10,300 fatalities associated with falls, resulting in a cost of $200 million for elderly persons. Not surprisingly, the number of people who suffered nonfatal injuries from falling was significantly higher, 2.5 million (CDC, 2016). Regardless of the degree of injury sustained, the direct medical cost of falling among the elderly was noted to be $34 billion in 2013 (CDC, 2016). Although the rising costs associated with managing physical impairments resulting from a fall are supported by data, physical impairments are not the only impairments observed.

The elderly population's psychological reaction to falls and falling includes social isolation, loss of confidence, decrease in activity daily live function, depression, and feelings of helplessness (Rubenstein & Josephson, 2002). The psychological impairments resulting from falling in the elderly often leads them to a more sedentary, less social, and functional life style, thereby negatively impacting their quality and quantity of life (CDC, 2005).

Understanding what causes people to fall is necessary in order to address the physical and psychosocial costs of falls effectively. Falling can be caused by extrinsic and intrinsic factors

(Chen, Ashton-Miller, Alexander, & Schultz, 1994; Rubenstein et al., 2002). Environmental hazards are an example of extrinsic factors that might result in a fall, such as stepping over obstacles (Rubenstein et al., 2002). Not surprising the rate of falls inside the home due to extrinsic factors is higher, as the elderly spend more time indoors and often do not have someone around to take care of them (Rubenstein et al., 2002). Hestekin et al. (2013) investigated the prevalence and risk of falls for the elderly in six countries: China, Ghana, India, Mexico, Russia Federation, and South Africa, and reported that the percentages of falls that happened in the home environment were 46%, 41.3%, 69.6%, 85.3%, 46%, and 70.5%, respectively. Outdoor falls (46.7% of total home-environment falling), though less frequent than indoor falls (53.3%; Kelsey et al., 2010), are usually a result of everyday hazards or environmental conditions that require people to adjust their movement. Rubenstein et al. (2006) noted that the percentage of falls due to the environment was 30%–50% of the total number of falls. The environmental conditions that frequently resulted in falls were wet floors, poor lighting (Rubenstein et al., 2002), or obstacles (Kovac, 2005). However, the question remains: Why do these everyday environmental characteristics around which we routinely adjust our movements along our life's journey pose problems for us as we age?

As we independently function within our world, we effortlessly negotiate many obstacles during walking using minimal cognitive awareness. In fact, a key to one's ability to successfully live independently is the ability to negotiate many different obstacles while walking. Patla, Prentice, Robinson, and Neufeld (1991) noted the use of two different strategies when faced with obstacles in one's walking path. The first strategy is an obstacle avoidance strategy, where one changes the walking direction and thus moves around the obstacle, whereas the second is obstacle scaling strategy, where one changes his or her limb trajectory to negotiate the obstacle differently. In the literature, some studies have suggested that it might be more of a challenge for the elderly to negotiate obstacles compared to young people regardless of the strategy used, as they are less flexible in their movements and often have decreased joint range of motion, muscular strength, coordination, and control due to the reduction in their physiological abilities (Galna, Peters, Murphy, & Morris, 2009; Haibach, Reid, & Collier, 2011).

Aging is considered one of the intrinsic factors that causes falls, and it 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 et al., 2011). Spirduso, Francis, and MacRae (2005) and Chen et al. (1994) reported that physiological changes due to aging are considered intrinsic factors that might cause falls. Changes that occur in the elderly over time often limit their movement abilities and strategies. In the literature, these changes are defined as part of the aging process and are frequently viewed as negative factors impacting functional independence. Conversely, the changes that expand our movement flexibility and strategies as we move from infancy to childhood to young adulthood are referred to as part of the developmental process and are viewed as positive factors (Haibach et al., 2011).

A closer examination of the aging process shows that the elderly face many challenges to their physiological abilities, such as declines in their perception, cognition, and physical abilities (Haibach et al., 2011; Smith & Kosslyn, 2007). Their physical changes include functional activities and changes to the skeletal system, muscular system, body composition, and fundamental movement patterns. The deterioration of the muscular system includes decreases in muscle mass, diminution in the size of type II muscle fibers, and a decrease in muscle strength. Aging also brings reductions in heart rate and maximum oxygen volume. Other physiological changes associated with aging might include stiffness of the connective tissues and joint pain

(Haibach et al., 2011; Spirduso et al., 2005; Whipple, Wolfson, & Amerman, 1987). Consequently, decreases in strength, flexibility, and speed in the elderly play a critical role in altering their movement patterns, especially those associated with efficient and effective gait (Haibach et al., 2011). The literature has noted that reducing gait speed, decreasing stride length (Himann, Cunningham, Rechnitzer, & Paterson, 2002; Spirduso et al., 2005), taking short steps, and increasing time spent in a double stance are the most significant changes the elderly make as they seek to reduce their risk of falling (Haibach et al., 2011). Physiological changes associated with aging are not the only factors that result in changes to one's gait parameters. In fact, one's ability to perceive effectively with all sensory systems declines with age. Specifically, as people age, their vision and hearing are negatively impacted and affect their functional independence. A decrease in sensory system acuity can cause failure in information selection, slow walking, and increased cadence (Haibach et al., 2011; Smith et al., 2007). Additionally, changes in the vestibular system might impact balance and lead to difficulties with standing and walking (Haibach et al., 2011). 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).

Given the presence of lower levels of sensory integration when compared to young adults, the elderly require greater attention to task demands while walking (Hawkins et al., 2011). Due to the aging process, the brain loses thousands of cells every day and becomes less efficient; the shrinkage in elderly people's brains affects cognitive function and information processes that involve the capacity of working memory, speed of processing, inhibitory function, and long-term memory (Haibach et al., 2011; Park & Reuter-Lorenz, 2009). As the brain becomes less efficient, its attention and memory capacities are further challenged. Hence, in a situation such as dual tasking where individuals are required to do more than one thing at a time and thus maintain a large quantity of information in working memory, older people might not have enough working memory, accurate sensory information, effective motor control, or coordination to carry out concurrent tasks successfully, or they may misallocate attentional resources and negatively impact their output (Berger, 2011). In fact, fear of falling may be the primary concern for the elderly while walking and engaging in conversation (Spirduso et al., 2005).

In daily living, some activities require the performance of dual tasking, such as walking and engaging in conversation. Dual tasking is a technique that refers to the performance of two tasks concurrently (Coker, 2004; Magill, 2007; Smith et al., 2007). There are three types of performing dual tasks: cognitive-cognitive tasks (Shumway-cook et al., 1997), motor-motor tasks (Lundin-Olsson et al., 1997), and motor-cognitive tasks (Hollman et al., 2011; Kolawole, 2014; Lajoie et al., 1996; Pinto-Zipp et al., 2013; Springer et al., 2006; Teasdale et al., 1993). Based upon the literature, dual tasking research employs two paradigms: the interference and probe paradigms. In the dual tasking probe paradigm, the primary task is performed in conjunction with a discrete secondary task (Goh, Gordon, Sullivan, & Winsteln, 2014; Magill, 2007). Coker (2004) and Schmidt et al. (2007) defined discrete skill as a task with clear beginning and ending points. In contrast, the dual tasking interference paradigm requires the performance of the primary task in conjunction with a continuous secondary task. The secondary task in the dual tasking interference paradigm has to be a continuous task to create a stable conjunction for the primary task, which requires more attention. Continuous skill is defined as a task without recognizable beginning and ending points because it is done in a repetitive fashion (Coker, 2004; Schmidt et al., 2007). Thus, the primary task will be compared to the secondary task while performing the dual tasking to assess the degree of interference. Interestingly, if the primary task requires less attention, the secondary task is expected to be performed better (Goh et al., 2014; Magill, 2007; Woollacott & Shumway-Cook, 2002). On the other hand, if the primary task requires an excessive amount of attention, the secondary task is expected to deteriorate due to misallocation of the attentional resources (Magill, 2007; Goh et al., 2014; Woollacott & Shumway-Cook, 2002). When performing two tasks simultaneously, many variables affect gait parameters, such as age (Shumway-Cook, Woollacott, Baldwin, & Kerns, 1997; Springer et al., 2006; Teasdale, Bard, LaRue, & Fleury, 1993), environment (Kolawole, 2014; Pinto-Zipp et al., 2013; Teasdale et al., 1993), and complexity of the dual tasking (Gentile, 1987).

Gentile (1987) proposed a taxonomy of tasks that examined performing tasks individually as well as simultaneously. She used two dimensions of taxonomy: the environmental context and the function of action. The environmental context includes (a) regulatory conditions that consider the stationary or in-motion environment and (b) inter trial variability, which includes the object in the environment being absent or present. The function of action involves the body being stable or transported during the task and the manipulation of the object, which requires maintaining or changing the object during the task. The purpose of providing the taxonomy of the task in this study is to provide a comprehensive and systematic guide to assess dual tasking performance. Furthermore, it provides a structure to identify the difficulty of information processing related to the environmental context or the function of the action of the task.

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).

Statement of the Problem and Purpose

Not surprisingly, given the impact of falls and the need to maintain functional independence, examining the impact of performing dual tasking has been and continues to be an interesting area of concern for researchers. Recently, several studies have reported the effects of performing a dual task on gait parameters in healthy older adults while negotiating an obstacle (Chen et al., 1996; Da Rocha et al., 2013; Gerin-Lajoie et al., 2006; Guadagnin et al., 2015; Harely, Wilkie, & Wann, 2009; Plummer-D'Amato et al., 2012). However, based on a review of the literature, there is limited evidence which assesses the effects of dual tasking, or tasks requiring differing cognitive and motor demands as identified by Gentile's Taxonomy, on spatiotemporal parameters of gait in older adults. This study sought to address this limitation in the literature as the results from this study will provide insight regarding how spatiotemporal parameters of gait will be changed when the participants (young-old adults and old adults) perform differing dual tasks. This information will further inform healthcare providers as they work with the elderly to reduce the incidence of falls when performing dual tasking and avoiding obstacles in the environment.

Therefore, the purpose of the study was to assess the effects of dual tasking, which requires different levels of cognitive and motor demands, on gait parameters in the community living healthy elderly population. The overarching research questions driving this study were a) are there differences in the spatiotemporal parameters of gait, when community living healthy older adults engage in dual tasking and b) are these differences influenced by the level of cognitive and motor demands required by the secondary task performed and the age of the performer? The overarching research question was broken out by the investigator into four sub-questions:

1. Are there differences in spatiotemporal parameters of gait between young-old adults (65- 74 years old) and old adults (75-85 years old) when walking on a level surface, regardless of the dual tasking performed?
2. Are there differences in spatiotemporal parameters of gait between walking without engaging in a secondary task and walking while engaging in a secondary task (dual tasks: fine motor &cognitive tasks, motor & cognitive tasks, and gross motor (obstacle) & cognitive tasks) regardless of the secondary task requirements and the age of the older adult?

3. Are there differences in spatiotemporal parameters of gait between walking without engaging in a secondary task and walking while engaging in a secondary task (dual tasks: fine motor &cognitive tasks, motor & cognitive tasks, and gross motor (obstacle) & cognitive tasks) and are they influenced by the secondary task requirements in older adults?

4. Is there an interaction between age classification and dual tasking performed concurrently in older adults?

The hypotheses of the study were:

1. There will be difference in spatiotemporal parameters (velocity, cadence, stride length, and double support) of gait between young-old adults (65- 74 years old) and old adults (75-85 years old) when they walk on the level surface.
2. There will be difference in spatiotemporal parameters (velocity, cadence, stride length, and double support) of gait between walking without engaging in a secondary task and walking while engaging in a secondary task (dual tasks: fine motor &cognitive tasks, motor & cognitive tasks, and gross motor (obstacle) & cognitive tasks) when they walk on the level surface.
3. There will be differences in spatiotemporal parameters (velocity, cadence, stride length, and double support) of gait between walking without engaging in a secondary task and walking while engaging in a secondary task (dual tasks: fine motor &cognitive tasks, motor & cognitive tasks, and gross motor (obstacle) & cognitive tasks) and when they are influenced by the secondary task requirements in older adults.

4. There will be an interaction between age classification and dual tasking performed concurrently in older adults specific to spatiotemporal gait parameters (velocity, cadence, stride length, and double support).

CHAPTER 2

Review of the Literature

In the United States, people born between 1946 and 1964 are known as the baby boomer generation (Hogan, Perez, & Bell, 2008). Life expectancy is defined as "the average number of years of life remaining for a population of individuals, all of the same age, usually expressed from birth as the average number of years of life that newborns might expect to live" (Spirduso et al., 2005, pp. 9–10). In 1970, the percentage of the baby boomers was 9.8%, with an increase to 13.4% in 2011. Furthermore, the percentage of the baby boomers is expected to increase up to 20% by 2030 (Colby et al., 2014). By 2060, the life expectancy of the young-old adults (age between 65 and 74 years old) and old adults (age between 75 and 84 years old) of the baby boomer generation will increase, and they will be around 60 million; however, their population numbers will have decreased to 2.4 million due to mortality (Spirduso et al., 2005).

The elderly can be categorized into four subgroups: young-old adults (between 65 and 74 years), old adults (between 75 and 84 years), old-old adults (between 85 and 99 years), and, oldest-old adults (100+ years old; Berger, 2011; Haibach et al., 2011; Spirduso et al., 2005). Each of these groups faces different challenges that affect their perception, cognition, and physical ability, which impacts their levels of independency and physical activities, such as walking (Haibach et al., 2011; Smith et al., 2007).

Walking is the one of the most important aspects of physical activity that we perform in our daily lives. During walking, we perform a repetitive gait cycle, which requires being both flexible and adaptable. One gait cycle is defined as the period when the heel makes the first contact with the ground until the same heel contacts the ground again (Spirduso et al., 2005). The gait cycle is divided into two phases: stance phase and swing phase. The stance phase occupies 60% of one gait cycle, and it is characterized by remaining of the foot in contact with the ground. The stance phase starts when the heel of the right foot makes an initial contact with the ground and ends when the toe of the left foot starts to be off the ground and swings in the air. The point when the stance phase ends is the beginning of the swing phase. The swing phase occupies the remaining 40% of the gait cycle and it is characterized by swinging of the left foot in the air with no contact with the ground until the heel of the right foot contact the ground again and a new gait cycle begins. (Griffiths, 2006).

Gait parameters can be divided into three categories: spatial (distance) parameter, temporal (time) parameter, and spatiotemporal parameter. The first category, the spatial parameter, includes stride length. Stride length is known as the distance when the heel makes contact with the ground until the same heel contacts the ground again (Griffiths, 2006; Spirduso et al., 2005). The second category, the temporal parameter, involves cadence and double support time. Cadence is known as the number of steps per time (step rate), whereas double support time is the time when both feet are in contact with the ground (Griffiths, 2006; Spirduso et al., 2005). The third category, the spatiotemporal parameter, involves velocity. Velocity is the time that a person spends to cover a distance (Hollman et al., 2011).

Gait is considered a complex functional activity that is affected by many factors such as aging (Himann, Cunningham, Rechnitzer, & Paterson, 1988; Tibaek, Holmestad-Bechmann, Pedersen, & Bramming, 2015); surface, especially when stepping over obstacles is required, (Chen et al., 1994; Lu et al., 2006; Shin et al., 2015); performing dual tasking concurrently(Chen et al., 1991; Da Rocha et al., 2013; Guadagnin et al., 2015), lastly performing a dual tasking while negotiating obstacles (Da Rocha et al., 2013; Guadagnin et al., 2015; Soma et al., 2011). The following sections will discuss the effect of these factors on the gait parameters.

Impact of Aging on Gait Parameters

For elderly people, gait may be used to assess many factors, such as health status, quality of life, and physical functions. Thus, researchers have considered gait speed a major area of concern because it reflects a decrease in stride length (Hollman et al., 2011; Spirduso et al., 2005), a decline in step length (Himann et al., 1988; Oberg, Karszania, & Oberg, 1993) and an increase in stride frequency (Himann et al., 1988; Oberg et al., 1993) due to aging. Hollamn et al. (2011) examined the effect of old age classification (70–74 years old, 75–79 years old, 80–84 years old, and 85–89 years old) on gait parameters. They reported that there were significant differences in stride length and gait speed between 70-74-years-old and 80–84-years-old; and between 75–79-year-olds and 85–89-year-olds. For double support limb, the only significant difference was between 70–74 years old and 85–89 years old. In addition, for double support time, the significant differences were between 70–74 years old and 85–89 years old and between 75–79 years old and 85–89 years old.

In general, the most significant parameter affected by aging is gait speed (Spirduso et al., 2005; Steffen, Hacker, & Mollinger, 2002; Tibaek et al., 2015). Himann et al. (1988) pointed out that gait speed starts to decline at age 62, and the rate of decrease is about 4.5% for each decade; however, Hollman et al. (2011) found that the rate of decline in gait speed is 12%–16% per decade starting at age 70. A common explanation for the decline in gait speed and stride length in the elderly is the decrease in joint flexibility, joint kinematics, biomechanical changes (Tibaek et al., 2015), loss of body mass, and loss of motor neurons (Himann et al., 1988). Therefore, the elderly may take a short swing time and long stance phase to have maximum stability and security during walking (Himann et al., 1988), which leads them to walk slowly, which increases their double support limb and double support time (Hollman et al., 2011). Over time, these changes in gait parameters will affect their ability to walk independently and negotiate obstacles (Spirduso et al., 2005).

Impact of Aging on the Gait Parameters When Negotiating Obstacles

Negotiating obstacles requires rapid adjustments of gait parameters (Spirduso et al., 2005) to avoid them safely. Many studies have measured gait parameters and foot placement while negotiating obstacles in the elderly (Lowery et al., 2007; Sparrow, Shinkfield, & Begg, 1996). Foot placement includes the step length of the trial limb before stepping over an obstacle, the distance from the trial limb to the obstacle before stepping over it, the toe clearance of the lead limb, the stride length of the lead limb, the toe clearance of the trial limb, and the distance of the lead limb after stepping over an obstacle. Factors that affect gait parameters and foot placement while stepping over obstacles include aging (Lowery et al., 2007); stepping strategies (Chen et al., 1994); health status, such as whether the person is active or sedentary (Rosengren, McAuley, & Mihalko, 1998); the number of obstacles (Lowrey et al., 2007); and the height of the obstacles (Patla et al., 1991).

Some adjustments to gait parameters and foot placement were different between the elderly and young adults. On one hand, the significant differences between the elderly and young adults manifested as decreasing the step velocity prior to the obstacle (Chen et al., 1994; Lowery et al., 2007; McFadyen & Prince, 2002; Patla et al., 1991; Shin et al., 2015), using a conservative step strategy (Chen et al., 1994; Shin et al., 2015), decreasing the step length of the trial limb before stepping over the obstacle (Chen et al., 1994; Lowery et al., 2007; Lu, Chen, & Chen, 2006; Patla et al., 1991), increasing the distance of the trial limb before stepping over the obstacle (Lu et al., 2006; Patla et al., 1991), increasing the toe clearance of the lead limb (Lu et al., 2006; Patla et al., 1991; Shin et al., 2015) or decreasing the toe clearance of the lead limb

(McFadyen et al., 2002), shortening the stride length of the lead limb (McFadyen et al., 2002), and shortening the distance of the lead limb after stepping over the obstacle (Chen et al., 1994; Lowery et al., 2007; Lu et al., 2006; McFadyen et al., 2002) or lengthening the distance of the lead limb after stepping over the obstacle (Patla et al., 1991). The common explanation of the differences between older adults and young adults in gait parameters and foot placement was their physical differences (McFadyen et al., 2002), which led to decreasing the risk of a fall while crossing the obstacle (Lu et al., 2006). On the other hand, there were no significant differences between older and younger adults in the distance of the trial limb before stepping over the obstacle (Chin et al., 1994; Lowery et al., 2007; McFadyen et al., 2002) and the toe clearance of the lead limb (Chin et al., 1994; Lowery et al., 2007). The reason for the previous findings were related to the height of the obstacle that was used—30 mm for Chin et al. (1994), 25 mm for Lowery et al. (2007), and 1220 mm for McFadyen et al. (2002)—which was not high enough to affect the lead limb or the trial limb.

A study performed by Weerdesteyn, Nienhuis, and Duysens (2008) compared young and elderly, and among four old-age groups (65–69, 70–74,75–79, and 80+ years old) assessing stride strategy and foot placement of the left foot while negotiating the obstacle. Specifically, they measured the stride length and the foot placement of the left foot, which included toe distance, foot clearance, and heel distance. The participants were asked to walk on a treadmill at a speed of 3 km/h and avoid an obstacle that was dropped 30 times. The obstacle’s height, width, and length were 1.5, 30, and 40 cm, respectively. Toe distance and heel distance were smaller for older people compared to younger when using the short stride strategy. Furthermore, the foot clearance was larger in older adults compared to younger adults. For the longer stride strategy, there were no significant differences between younger and older adults in foot clearance and heel distance. However, the heel distance was twice as large for younger adults compared to older. For stride length, the older adults had a shorter stride length than younger. The success of negotiating the obstacle was lower in the elderly compared to younger people. The important result of the elderly subgroups was that the success rate of negotiating the obstacle between people 65–69 years old and that of young adults showed no significant difference, whereas the other three subgroups showed a significant decrease in the success of negotiating the obstacle due to increasing the long stride strategy. Weerdesteyn et al. (2005) explained the shorter stride length in older adults compared to young adults was because the height of the obstacle was the same for all groups. Additionally, they suggested that the older adults had a lower success rate avoiding the obstacle was due to the increase in reaction time for the elderly. In fact, increasing the complexity of the tasks while performing dual tasking concurrently impacted gait parameters in the elderly.

Impact of Aging and Dual tasking on the Gait Parameters When Negotiating the Obstacle

In daily life, performing a dual task such as walking and talking is often challenging for the elderly, particularly when the environment has an obstacle that requires them to adjust their foot placements and gait parameters to avoid or decrease the risk of falling. In addition, many factors impact foot placement and gait parameters, including types of cognitive tasks such as Stroop task (Chen et al., 1996; Da Rocha et al., 2013; Guadagnin et al., 2015); age of participants (Hegeman et al., 2012); walking distances (Da Rocha et al., 2013; Guadagnin et al., 2015; Soma et al., 2011); walking surfaces, such as a treadmill (Hegeman et al., 2012; Soma et al., 2011); and complexity of the dual tasking (Da Rocha & Carpes, 2015).

Researchers have investigated the combination of different types of cognitive tasks in the elderly population when walking and crossing over an obstacle including; the Stroop task (Chen et al., 1996; Da Rocha et al., 2013; Guadagnin et al., 2015; Hegeman et al., 2012); counting down by seven from 100 (Soma et al., 2011); and demonstrating the Stroop task while repeating days of the week (Da Rocha et al., 2015). While walking distances of most studies were different—6 m (Da Rocha et al., 2013; Da Rocha et al., 2015), 8 m (Guadagnin et al., 2015), and 9 m (Soma et al., 2011)—the obstacle to be avoided has been consistently placed in the middle for all walking distances. Only Chen et al. (1996) and Hegeman et al. (2012) used treadmill walking at a pace of 3 km/h while avoiding obstacles. Not surprising the findings of the previous studies when a dual tasking was included and compared to a single task situation were that the success rate for avoiding the obstacle decreased (Hegeman et al., 2012; Soma et al., 2011), gait speed decreased (Guadagnin et al., 2015; Soma et al., 2011), the pre-obstacle trail limb step length was higher (Da Rocha et al., 2013), the pre-obstacle trail limb distance was higher (Guadagnin et al., 2015), the lead limb toe clearance and the lead limb stride length were higher (Da Rocha et al., 2013), the post-obstacle lead limb distance was higher (Da Rocha et al., 2013) and lower (Guadagnin et al., 2015; Soma et al., 2011), and the cadence and stride length were shorter (Soma et al., 2011). The results of Guadagnin et al. (2015) were different from others due to: (a) the height of the obstacle was adjusted to be 20% of the leg's height, (b) the participants were asked to walk barefoot, and (c) half of the participants did regular exercise at least three times per week.

Harely et al. (2009) examined the effect of differing age classifications and dual tasking (verbal fluency and walking) on foot placement and gait parameters while stepping over obstacles. The participants were divided into three groups: 20–29 years old, 60–69 years old, and 70–79 years old. The participants engaged in three randomly ordered trails: (a) verbal fluency with walking simultaneously while crossing an obstacle, which was considered a dual task; (b) walking and crossing the obstacle, considered a motor task; and (c) verbal fluency with walking simultaneously without crossing the obstacle, which was considered a baseline single task. The results of the pre-obstacle trail limb distance during step approach showed that the younger participants 20–29 years old had more variation in the single task performance than older aged groups. Furthermore, the interaction between age and cognitive task was found to be significant and showed that verbal task decreased the variability of the pre-obstacle trail limb distance for both the 20–29 and 60–69 years groups; however, it increased for the oldest group who were 70–79 years old. For the post-obstacle lead limb step crossing distance, there was a main effect for age, with the 70–79 years group landing closer than the other groups to the obstacle. Furthermore, an interaction effect was found between age and tasks on the post-obstacle lead limb distance with the cognitive task increasing the post-obstacle lead limb distance for the 70–79 years group. An interaction effect was found between age and tasks such that the cognitive task increased the trail limb toe clearance for the 20–29 years group and the 60–69 years group, but it was decreased for the 70–79 years group. Therefore, there was a main effect of the cognitive task on lead limb toe clearance. For step velocity, there was a main effect of age, tasks, and the height of obstacles. For age classification, the 20–29 years group was faster than the other two groups, whereas the 60–69 years group was faster than the 70–79 years group. For dual tasks, the cognitive task decreased the crossing velocity more than the single task. For the height of obstacles, higher obstacles decreased the velocity more during crossing compared to smaller obstacles. As we seek to understand these dual tasking findings we look to theories that have been proposed in the literature to explain the outcomes.

Dual tasking Theoretical Framework

Bottleneck, capacity sharing, and cross-talk are the primary theories that have been applied to explain attentional processing for performing a dual task (Pashler, 1994; Kahneman,1973). The first theory is bottleneck theory, also known as the filtering attention theory, which refers to an internal stage of processing that operates on only one response or stimulus at a time, even when two tasks need to be processed, which leads the human information processing system to perform them in serial order (Pashler, 1994). Kahneman (1973) pointed out that the filter theory has two models. The first model of the bottleneck theory assumes that the sensory information is filtering the stimulus at or before the stage of perceptual analysis, which perceives only one stimulus at a time. However, when two stimuli require sensory information to be perceived, one of the stimuli will be held briefly until the perceptual analysis stage completes the analysis of another stimulus. Therefore, attention controls perception (as cited in Broadbent, 1957, 1958). The second model of the bottleneck theory assumes that the sensory information is filtering the stimulus at or before the response selection, which perceives two parallel stimuli without interference. The bottleneck filters the information by selecting the response that fits the situation and inhibits the other (as cited in J. Deutsch & D. Deutsch, 1963). Posner and Boies (1971) pointed out that attention has three components: selectivity, processing capacity, and alertness. In other words, the components of attention include orienting events to the sensory perception, detecting signals for processing, and maintaining an alert state. In fact, the attention selects some information to be processed (successes of selection) and inhibits other information (failures of selection). Failure of selection happens when the system receives a great deal of information simultaneously and cannot process all of it at once or more time is needed for processing. Failure of selection is divided into failure of selection in space and failure of selection in time. Failure of selection in space may occur when two sources of information present simultaneously (divided attention), so the ability to process the information of these sources is impaired compared to the processing of information from one source alone (focused attention). One of the reasons for failure of selection is related to sensory perception (Smith & Kosslyn, 2007). A common example of the bottleneck theory considers a person at a cocktail party with many loud conversations in the room. According to the first model, all the conversations are filtered before the perceptual analysis stage, which means a person is not affected by and does not hear any of them. However, according to the second model, when the person hears someone saying his or her name in a conversation, he or she will respond to that (response selecting) while inhibiting other conversations in the room (Kahneman, 1973). The bottleneck theory was popular for many years until scientists realized that the filter theory of attention did not explain all the movement situations and thus the capacity theory began to gain popularity (Magill, 2007).

Capacity sharing, the second theory that supports that each movement requires a given portion of capacity to be performed. For dual tasks, the total capacity to perform tasks has to be equal. However, if one of the tasks requires more than the total capacity, the performance of either or both will suffer (Woollacott et al., 2002). Kahneman (1973) pointed out that attention capacity is flexible depending on person, task, and environment. Consequently, he created a model to explain the capacity sharing theory. The top of the attention model is available capacity, which increases or decreases depending on the arousal level of a person. In the middle of the model, there is an allocation policy, which is divided into evaluations of demands on capacity, enduring dispositions, and momentary intentions. The evaluation of demands on capacity of the tasks requires a person to decide to perform some or all of tasks concurrently.

The enduring dispositions are related to the event in the environment that attracts the person's attention involuntarily. In contrast to the enduring dispositions, the momentary intentions mean to direct a person's attention voluntarily. Therefore, people who are required to perform dual tasking concurrently will have some changes on their performance. These changes usually depend on several factors such as the complexity of the task.

The third theory is cross-talk theory, which relates to the operation of information processing. If the content of the information is different, no interference will occur. However, more interference will ensue if the content of the information that needs to be processed is similar. Therefore, when two tasks have similar information, it will be difficult to perform them together (Pashler, 1994). The previous expression means that if the task has similar or confuse order to perform, the interference will occur. When performing a dual task, the previous theories can be applied to explain the limitation of attention that reduce the performance, whereas the taxonomy of tasks provided by Gentile (1987) can be used to analyze the complexity of the motor task by classifying the task based on the environmental context and the function of action.

Taxonomy of the Tasks

Gentile (1987) proposed a two-dimensional taxonomy that provided a comprehensive and systematic evaluation guide for movement and a systematic basis to select functionally appropriate activities. Two general characteristics of the skill have been considered: the environmental context and the function of the action. For this study, participants were asked to perform a single task, a cognitive task, a fine motor-motor task, and gross motor- motor tasks concurrently. The environmental context of the first dimension of this study will be stationary regulatory conditions with no internal variability. Furthermore, the function of the action of this study will be transportation due to walking while stepping over obstacle and walking while talking from one point to another and manipulating an object by calculating the numbers. The two-dimensional taxonomy for this study will be to transport the body with and without manipulating an object with stationary regulatory conditions and no inter-trial variability.

Assessing the effect of performing a dual task compared to a single task is done by calculating the dual tasking cost. In other words, calculating the dual tasking cost proposes the ability of the subject to execute both the primary task alone and simultaneously with the secondary task (Bock, 2008; McIaas et al., 2015). Dual tasking cost can be calculated for each subject and task based on this formula: Dual tasking Cost (%) = $\frac{Single\ task - Dual\ task}{Single\ task} \times 100$. Bock (2008) mentioned that the high cost of the dual tasking reflects the deficits of performing a dual task compared to a single task due to the complexity of the task. Dual tasking cost supports the Gentile’s Taxonomy of tasks, which provided that if the complexity of task increases (by increasing the environmental context and the body function), the dual tasking cost will be increased.

CHAPTER 3

METHODOLOGY

Participants

Thirty-three older adults whose age between 65-84 years old consented to participate in the study. 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**.** The total of sample size is a widely accepted for movement science stduies. Comparing the sample size of this study to similar studies as De Rocha et al. (2013) who had 20 participants, Pinto-Zipp et al.(2013) who had a sample size of 29, and Kolawole (2014) who has 28, we can tell that the sample size of 31 is accpeted.

The participants were recruited either by (1) contacting the primary investigator via phone call or e-mail to set up an appointment to meet based upon their review of the study flyer, which was posted in local senior centers, or (2) following attending a presentation at a senior center by the primary investigator on falling they agreed to participate in the study. The primary investigator notified all participants about the testing location, time, and date via email.

Inclusion criteria. The participant was included if:

- between 65 and 85 years old.
- able to walk in the community independently for 10 feet.
- able to read, write, and speak in English at the 6th grade level (this was confirmed by their ability to read and complete (sign) the consent form, which is in English and at the 6th grade level.)
- complete the study demographic form.

- able to successfully complete the motor and cognitive tests used by Physical therapists to assess balance.

Exclusion criteria. As per participant's statement:

- uncorrected vision or hearing problems.
- presence of pain or stiffness in the lower or upper parts of your body or broken bones in the past 6 months.
- use of an assistive device, such as a walker, cane, or leg brace while walking.
- any medical condition such as a stroke or nerve problems that affect balance, walking, or movement.
- use of a hearing aid.

Design

The study focused on exploring the effects on gait parameters when performing different types of dual tasking across different age categorizations of senior people on gait parameters. The study is cross-sectional and quasi-experimental. A cross-sectional study is used when data are collected on a single point in time. For this study, the data was collected from participants at one point in time. A quasi-experimental approach means that the independent variable is active but without random assignment of participants to groups. For this study, the independent variables were active, and there was no random assignment of participants to groups (no control groups).

Variables

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

Instrumentation

Mini Mental State Examination. The Mini Mental State Examination (MMSE) was developed by Folstein, Folstein, and McHugh (1975) to assess the cognitive aspects of the mental functions. Furthermore, MMSE is considered as a standard tool that is used to assess the individual's attention, orientation, language, recall, and motor tasks.

MMSE is divided into two sections. The first section includes vocal responses, memory, attention, and cover orientation with a maximum score of 21. The second section requires to write a sentence spontaneously, the ability to name, follow verbal and written commands, and copy a polygon shape that is similar to a Bender-Gestalt Figure with a maximum score of 9. 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).

MMSE is reliable and valid for measuring cognitive function for the elderly. The concurrent validity of the MMSE is high when it scores correlated to Wechsler Adult Intelligence Scale ($r = .78$, $p < .001$) and to Performance IQ ($r = .66$, $p < .001$). Additionally, MMSE has a high test-retest ($r = .89$) and inter-rater ($r = .83$) reliability correlation coefficient (Folstein et al., 1975).

Dynamic Gait Index. The dynamic gait index (DGI) was developed by (Shumway-Cook & Woollacott, 1995) to predict falling for the elderly. The DGI is used to assess dynamic postural control and their ability to respond to changing task demands while walking. This tool is appropriated with older people with imbalance and history of falls. The DGI contains of 8-items that includes walking on normal pace, changing walking speeds, walking with horizontal head turns (right and left), walking with vertical head turn (up and down), turning and stopping, walking and stepping over obstacle, walking around the obstacles, and ascending/descending stairs. The scoring of this tool depends on changes in balance and changes in gait parameters while performing each task. Each of these 8-items is scored from zero (indicates the lowest level of function) to three (the highest level of function). The total scores are range from zero (the worst) to 24 (the best). If the total score is 19 or less, it will be predicted to an increased incidence of falls (Shumway-Cook & Woollacott, 2011).

The DGI has been shown to have excellent inter-rater (ICC = .99), and intra-test reliability (ICC = .98) (Wolf et al., 2001). Herman, Inbar-Borovsky, Brozgol, Giladi, and Hausdorff (2009) pointed out that the DGI has a significant moderate correlation with Berg Balance Scale (BBS), $r = .53$, $p < .001$.

The Timed Up and Go Test. The time up and go test (TUG) is an objective, simple, and inexpensive measurement that was developed to assess basic functionally mobility and dynamic balance for old people. Furthermore, the timed up and go is considered as one of the most measurement to assess the incidence of falls in the elderly (Nordin, Rosendahl, Lundin-Olsson, 2006; Rolenz & Reneker, 2016). TUG test considers basic daily life movements: stand up from a chair, walk 3 meter, turn around, walk back, and sit back again (Nordin et al., 2016). The participant should do a practice trial without record the score (Dawood & Radd, 2010).

The outcome will be the time that it takes to perform the test (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.

TUG test is reliable and valid in community-dwelling elderly population. The inter-rater reliability of TUG test was high (ICC = .98) (Shumway-Cook et al., 2000), and the test-retest reliability of TUG test was also high (ICC = .97) (Steffen, Hacker, & Mollinger, 2002). Additionally, the concurrent validity of TUG test is high when the scores correlated to Functional Gait Assessment ($r = -.84$, $p < .001$) (Wrisley & Kumar, 2010).

GAITRite. The GAITRite® system (CIR System Inc.) is an electronic walkway that examines the temporal and the spatial parameters with embedded pressure activated sensors. The pressure sensors of GAITRite has an interface cable to connect to a computer. The size of the standard GAITRite electronic walkway is 427 cm long and 61 cm wide. The walkway includes seven sensors pads that is connected to a computer by using GAITRite Gold software running on Windows 7 operating system. The sampling rate of the data collection is 80 Hz. The purpose of the GAITRite software is to calculate the temporal and the spatial parameters of the gait, control the functionality of the walkway, and compute the raw data into footfall patterns. Furthermore, the GAITRite software stores the resultant information into data files.

The GAITRite® system is reliable and valid in both adults and the elderly when it measures the spatial and temporal of gait parameters. The literatures reported the reliability (Intra-class Correlation Coefficients (ICC)) is between .92 to .99 (Bilney, Morris, Webster, 2003; McDonough, Batavia, Chen, Kwon, & Ziai, 2011; Van Uden, & Besser, 2004; Webster, Wittwer, & Feller, 2005). The concurrent validity of GAITRite® system is also high (ICC=.09) comparing to Vicon® (Webster et al., 2005) and to Clinical Stride Analyzer® (Bilney et al., 2003).

Calculator. Large flat plastic calculator was used (30 cm X 21 cm) to calculate the numbers during walking while calculating.

Speaker. Tsunami Bluetooth® Speaker was used during walking while calculating and walking while talking. The speaker was connected by Bluetooth® to IPhone 6. The volume of the speaker was adjustable.

IPhone 6. The questions and the numbers, the participants were required to answer it, were saved on IPhone 6. IPhone 6 specifications includes:

- Capacity: 64 GB.
- Version: 2.3.3(13G34).
- Model: MG5A2LL/A
- Auto-Correction: Off
- Auto-Capitalization: Off
- Predictive: Off
- Portrait Orientation Lock: On
- Airplane Mode: ON
- Auto-Brightness: Off
- Volume: Adjustable
- Shake to Undo: Off

Procedure

Following SHU's IRB approval of this study (Appendix K), the primary investigator posted the recruitment flyers at Senior Living Residents in Paterson NJ (Appendix G1), Older Adults Services at Clifton NJ (Appendix G2), and at Seton Hall University (SHU) (Appendix G3). Additionally, the primary investigator had the permission to present the study verbally to

Senior Living Residents in Paterson NJ and to Older Adults Services in Clifton NJ to recruit participants from there.

If a senior was interested in participating in the study, the participant contacted the primary investigator verbally (after the presentation) or via the contact email information on the recruitment flyer. The primary investigator notified the participant about the testing location, (SHU functional movement science lab or senior center), date, and time via email.

When the participant arrived at the testing site, the participant filled out the screening protocol (Appendix B) and the demographic questions (Appendix C). The screening protocol included ten questions and its successful completion is considered part of the inclusion criteria to determine cognitive awareness. For the screening protocol, when a potential participant answered no for the first, second, and last questions or yes to any question from 3 to 9, the participant could not continue with the experiment and the participant was excluded from the study (without receiving any payment). When the participant met the inclusion criteria, then the primary investigator was systematically gave all potential participants a code number based upon their arrival to the testing session to maintain anonymity. There was no indication of the participants' identity on any of these tests; only the participants' code numbers was noted. After this, the participants read, understood, and signed the informed consent form (Appendix A). when the participant asked any question(s), the primary investigator answered the question(s). Then, the primary investigator spent the next 30 minutes determining the participants' eligibility by measuring their mobility, physical and cognitive functions by determining MMSE, DGI, and TUG scores. If a participant did not achieve the cut-off score for at least one of these tests, the participant was excluded from the study (without receiving any payment).

If the participant was eligible, then the participant continued the experiment. Prior to the testing session, the primary investigator provided verbal instructions about what the participant was needed to do via a script. There were two folders available for the participant to choose. Each folder contained the same set of tests but in different orders based on the number of the participant. To ensure the counterbalance of this study, the participants picked one of two folders (A or B) randomly. For example, if the participant picked folder (A), the participant started with walking, walking while calculation, walking while talking, and walking while stepping over obstacle. On the other hand, if the participant picked folder (B), the participant started with walking while calculating, walking while stepping over obstacle, walking, and walking while talking.

The primary investigator measured the participant's legs length. Specifically, the primary investigator used a cloth tape measure and measured the participant's legs from the top of the greater trochanter (hip joint) to the floor. The GAITRite software system needed these data to address differences across participants. Before the participant performed walking while talking or walking while calculating, the primary investigator tested the volume of the speaker. The participant heard the phrase "Test: please raise your hand if you can hear my voice." If the participant raised their hand, it signified the participant heard the voice effectively and we proceeded with the study. If the participant did not raise their hand, the primary investigator increased the volume and replayed the phrase again until the participant raised their hand and at volume was then noted and used during the study for that participant. The participant performed 3 trials for each condition, and the average of the trials was taken resulting in a total of 12 condition trials. Adequate rest intervals of 2 minutes between trails were provided to avoid physical and mental fatigue. Participants rested in a secure and comfortable chair. If a participant requested additional rest periods, the participant was provided additional rest periods, but the rest periods were documented.

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 the primary investigator said “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. The standard gait belt allowed the assistant investigator to follow (alongside but behind) and assist the participant if needed while walking without interfering with the participant’s walking pace. There was one assistant investigator per participant. The assistant investigator was instructed by the primary investigator on how to engage in the study protocol prior to the study initiation.

Secondary task descriptions and attentional demands. According to Gentile’s taxonomy of the task (1987), every action we perform is constrained by the complex interaction among the environment, the individual, and the task. Therefore, a single task is categorized by Gentile’s taxonomy (1987) as a body transport, no manipulation, stationary environment, and no intertrial variability regardless of negotiating an obstacle. In contrast, the fine motor-motor tasks are categorized as body transport, manipulation, stationary environment, and no intertrial variability. For the motor-gross motor task and cognitive-motor task, there will be body transport, no manipulation, stationary environment, and no intertrial variability.

Task 1 (single task). The participant walked on the electronic walkway mat (GAITRite) without performing any other tasks (baseline). For this task, based on Gentile’s taxonomy of the task (1987), the participant was required to engage in body transport (i.e., walk) without manipulating any object or limbs in a stationary environment with no intertrial variability of this condition.

Task 2 (dual tasks). For task A: cognitive-motor tasks, the primary investigator asked the participant to walk 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 (Appendix D). 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 primary investigator walked beside the participant and wrote down the answers. For task B: fine motor-motor tasks, 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 veibalized over a speaker and then to solved the problem using the calcultor, and say the result loudly when achived (Appendix H). There was five seconds between each calculation questions posed. The primary investigator walked beside the participant and wrote down the answer. For task C: the gross motor- motor tasks, 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. The primary investigator noted 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(Appendix I).

While the participant rested between trials, the investigator processed the GAITRite data and set up the secondary tools that the participant needed to perform for the next condition. 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 primary investigator asked the participant 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 so that the primary investigator could confirm the correct answer while the participant was not engaged in the primary task of walking (Appendix D1). The participants could say "SKIP" if the participant could not hear the question or did not understand it. The primary investigator sat in front of the participant and wrote down the participnat's answers.

At the end of the testing period, the primary investigator asked the participant to respond to three additional questions that the investigator believed would help to provide further clarity about the participants presepctive on dual-tasking (Appendix J). Each question was read to the participant one time. The primary investigator recorded with paper and pen the participant's responses to the following three questions.

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 **<u>WHY?</u>**

After the participants answered these questions, the primary investigator thanked the participant for participating in the study and gave him/her 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 by the primary investigator. The data was saved on a USB memory drive and kept securely locked in a cabinet in the primary investigator's home office.

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. The assumptions for one-way ANOVA were (a) the independent variable (age) has at least two levels, (b) the dependent variable (gait parameters) is at a continuous level (ratio), (c) the dependent variable (gait parameters) should be normally distributed for each combination of the levels (two levels), and (d) the participants have the same variance (homogeneity).

The assumptions for one-way repeated measures were as follows: (a) there is no dependency between participants, which means the same participant will produce four levels of the dual tasks, (b) the dependent variable (gait parameters) is at a continuous level (ratio), (c) the dependent variable (gait parameters) should be normally distributed for each combination of the levels (four levels), (d) the participants have the same variance (homogeneity), and (e) there is homogeneity of variance of differences (sphericity).

If the assumptions were violated, there is no nonparametric match of mixed ANOVA. The only way to correct the violation of the assumption was by transforming the data. Three common transformations that may be used are inverse transformation, square transformation, and logarithmic transformation.

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 posthoc test because (a) it has more power when the number of comparisons is small (four pairwise comparisons for tasks and three pairwise comparison for the secondary tasks); (b) it has more opportunities to control type I error by dividing the alpha level by the numbers of pairwise comparison, which is known as Holm's correction; and (c) it is a conservative test because it lacks statistical power. If the main effect between participants (age with two levels) was significant ($p > .05$), the primary investigator did not need to use the pairwise comparison because the independent variable (age groups) has only two levels.

The assumptions for an independent t-test were as follow; a) the two groups (young-old adults and old adults) were independent (not related to each other), (b) the dependent variable (gait parameters) is at a continuous level (ratio), (c) the dependent variable (gait parameters) should be normally distributed for each combination of the levels (two levels), (d) the participants have the same variance (homogeneity), and (e) the number for the two groups were quite similar.

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). Therefore, the primary investigator decreased the verbal responses into items / themes and then represented them numerically by tallying the themes. Inter coder agreement (80%) was sought for the themes and percent tally with another researcher. It is the intent that these responses will further inform the primary investigator as he begins to assess the findings and interpret the data.

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).

CHAPTER 4

RESULTS

Participants Demographic

Thirty-one healthy older adults aged between 65-84 years old participated in the study. The total number of participants for the young-old adults group (aged between 65 to 74 years old) was 18, while the total number of participants for the old adults group (aged between 75 to 84 years old) was 13 (Table 1). When looking at gender, the overall number of males who participated in this study were 6, whereas the number of females were 25 (Table 1).

Table 1

Age and gender of the Participants

		Gender		Total
		male	female	
age	Young-old	5	13	18
	Old	1	12	13
	Total	6	25	31

Table 2 showed the mean age of the participants. The mean age of the young-old adults group was 68 years old, whereas the mean age of old adults group was 77 years old. The different age of participants was quite 10 years. 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 3).

Table 2

Age of the participants

age	Mean	Std. Deviation	N
Young-old	68.1667	2.72785	18
Old	77.2308	2.45472	13
Total	71.9677	5.22484	31

Table 3

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Age of participants	Equal variances assumed	.697	.411	-9.511	29	.000	-9.06410	.95299	-11.0132	-7.1150
	Equal variances not assumed			-9.679	27.506	.000	-9.06410	.93643	-10.9838	-7.1443

Demographic Questions

Several key demographic questions were asked of the participants in order to gain insight into their perceptions specific to comfort in using a calculator, degree of participating in exercises or physical activities, duration of participating in exercise or physical activities.

Table 4 shows participants' perspective regarding how easy they did the participants find of using calculator. Overall, most participants' responses were positive towards using a calculator. Specifically, 9 participants of the young-old adults group and 5 participants of the old adults group mentioned that using the calculator was very easy, 7 participants of the young-old adults group and 5 participants of the old adults group was easy, 2 participants of the young-old adults group and 3 participants of the old adults group was natural, and 1 participant of the old adults group found it difficult.

Table 4

Participants Perceptions Towards Using Calculator

		age		Total
		Young-old	old	
Using Calculator	very easy	9	5	14
	easy	7	4	11
	neutral	2	3	5
	difficult	0	1	1
Total		18	13	31

Table 5 shows if the participants engaged in physical activities or exercises during the past month. Surprisingly, all the young-old adults' group participants, 12 old adults group participants answered by yes, while only there was one participant of the old adult group noted no.

Table 5

Participants Perceptions Regarding Engaging in Exercises or Physical Activity During the Past Month

		age		
		Young-old	old	Total
Participating exercise or activity	yes	18	12	30
	no	0	1	1
Total		18	13	31

Table 6 displays that participants' perceptions regarding their duration of participating in exercises or physical activities per week. There were 7 participants of the young-old group and 4 participants of the old adult group noting that they engaged in exercise or physical activities for less than 75 minutes, 3 participants of the young-old adults group and 2 participants of the old adults group noted 75 minutes, 3 participants of the young-old adults group and 3 participants of the old adults group noted 150 minutes, and 5 participants of the young-old adults group and 3 participants of the old adults group noted more than 150 minutes. Only one participant of the old adults group did not answer this question because the participant did not participate in exercises or physical activities at all.

Table 6

The Duration of Participating in Exercise or Physical Activity per Week

		age		
		Young-old	old	Total
Duration of participating exercise activity per week	less than 75 minutes	7	4	11
	75 minutes	3	2	5
	150 minutes	3	3	6
	more than 150 minutes	5	3	8
Total		18	12	30

Baseline/Eligibility Test

Mini Mental State Examination (MMSE). The descriptive statistics of MMSE for the young-old adults group was, *M*=28.73, *SD* = 1.13, and the descriptive statistics of MMSE for the old adults group was, *M*=28.08, *SD* = 1.38 (Table 7). An independent samples t-test comparing the mean scores of young-old adults group and old adults group found a nonsignificant difference between the means of the two groups (t (29) = 1.43, p =.16) (Table 8).

Table 7

Descriptive Statistics for MMSE

age	Mean	Std. Deviation	N
Young-old	28.7222	1.12749	18
old	28.0769	1.38212	13
Total	28.4516	1.26065	31

Table 8

Independent Sample Test for MMSE

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MMSE	Equal variances assumed	.028	.868	1.431	29	.163	.64530	.45105	-.27719	1.56779
	Equal variances not assumed			1.383	22.619	.180	.64530	.46644	-.32051	1.61111

Dynamic Gait Index (DGI). The descriptive statistics of DGI for the young-old adults group was, *M*=22.39, *SD* = 1.19, and the descriptive statistics of DGI for the old adults group was, *M*=22.38, *SD* = 1.32 (Table 9). An independent samples t-test comparing the mean scores of young-old adults group and old adults group found a nonsignificant difference between the means of the two groups (t (29) = .009, p =.99) (Table 10).

Table 9

Descriptive Statistics for DGI

age	Mean	Std. Deviation	N
young-old	22.3889	1.19503	18
old	22.3846	1.32530	13
Total	22.3871	1.22956	31

Table 10

Independent Sample Test for DGI

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
DGI	Equal variances assumed	.101	.753	.009	29	.993	.00427	.45518	-.92668	.93523
	Equal variances not assumed			.009	24.313	.993	.00427	.46308	-.95084	.95938

The Timed Up and Go Test (TUG). The descriptive statistics of TUG for the young-old adults group was, *M*= 8.33, *SD*= 1.57, and the descriptive statistics of TUG for the old adults group was, *M*=9.77, *SD* = 1.59 (Table 11). An independent samples t-test comparing the mean scores of young-old adults group and old adults group found a significant difference between the means of the two groups (t (29) = -2.05, p =.018) (Table 12).

Table 11

Descriptive Statistics for TUG

age	Mean	Std. Deviation	N
young-old	8.3333	1.57181	18
old	9.7692	1.58923	13
Total	8.9355	1.71144	31

Table 12

Independent Sample Test for TUG

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TUG	Equal variances assumed	.163	.689	-2.498	29	.018	-1.43590	.57473	-2.61136	-.26044
	Equal variances not assumed			-2.494	25.841	.019	-1.43590	.57579	-2.61981	-.25199

Velocity (cm/sec)

The table of descriptive statistics (Table 13) shows the mean and standard deviation at the two different independent levels. For velocity in young-old adults group, the descriptive statistics of walking task was *M*= 97.24, *SD*= 17.08, the descriptive statistics of walking while calculating was, *M*= 77.54, *SD*= 15.21, the descriptive statistics of walking while stepping over obstacle was, *M*= 93.43, *SD*= 14.65, and the descriptive statistics of walking while talking was, *M*= 88.34, *SD*= 17.01. For velocity in old adults group, the descriptive statistics of walking task was *M*= 95.28, *SD*= 19.91, the descriptive statistics of walking while calculating was, *M*= 64.91, *SD*= 15.91, the descriptive statistics of walking while stepping over obstacle was, *M*= 86.78, *SD*= 19.66, and the descriptive statistics of walking while talking was, *M*= 80.91, *SD*= 17.3. The highest velocity mean was for the young-old adults group in walking task whereas the lowest velocity mean was for old adults group in walking while calculating.

Table 13

Descriptive Statistics

age		Velocity of Walking	Velocity of Walking & Calculating	Velocity of Walking & Stepping Over Obstacle	Velocity of Walking & Talking
young-old	Mean	97.2387	77.5357	93.4317	88.3419
	Std. Deviation	17.08030	15.20653	14.65499	17.01274
	N	18	18	18	18
old	Mean	95.2810	64.9078	86.7787	80.9151
	Std. Deviation	19.90675	15.91454	19.65791	17.29823
	N	13	13	13	13
Total	Mean	96.4177	72.2401	90.6417	85.2275
	Std. Deviation	18.02202	16.50658	16.95324	17.25057
	N	31	31	31	31

Assumptions. The assumptions were assessed to make sure that the statistical design is an appropriate method to analyze the data. The dependent variable (velocity) is normally distributed for each combination of the groups of the two factors except for walking while talking (Table 14). Furthermore, the velocity is a ratio scale. The populations are homogeneity of variance (Table 15). The homogeneity of variance of differences = Mauchly's test of sphericity (Table 16) for single task and dual tasking and (Table 17) for dual tasking only. The samples were randomly from the population. Additionally, the samples are independent from each other for the old people groups. In conclusion, the samples are related to each other in task conditions.

Table 14

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Velocity of Walking	.084	31	.200*	.980	31	.809
Velocity of Walking & Calculating	.139	31	.129	.952	31	.176
Velocity of Walking & Stepping Over Obstacle	.131	31	.189	.949	31	.146
Velocity of Walking & Talking	.173	31	.019	.917	31	.019

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 14 shows that Shapiro-Wilk test was not significant deviation from normality for velocity at walking task, D *(*31) = .98, p =.809, at walking while calculation task, D *(*31) = .95, p =.176, and at walking while stepping over obstacle task, D *(*31) = .95, p =.146. In contrast, there was a significant deviation from the normality at walking while talking task, D (31) = .92, p=.019. However, given that while the number of participants were greater than 30, so we assumed the normality and proceeded with caution as supported by the central limit theorem.

The central limit theorem provides that while the sample size is large, no matter what the shape of the population is (Field, 2013).

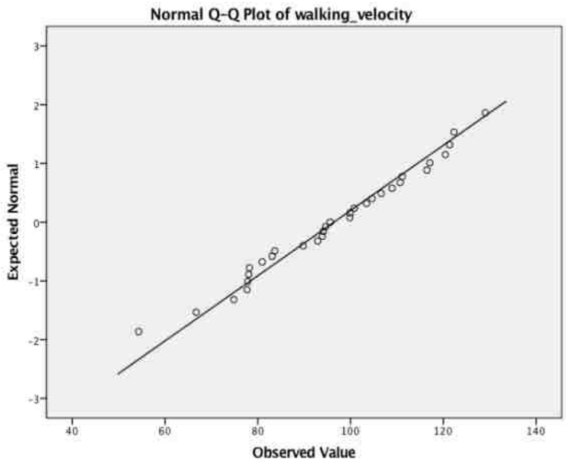

Figure 1. Normal Q-Q plot of velocity in walking task.

Figure 1 shows the Q-Q plots supported the above findings: for velocity in walking task the dots were close to the diagonal line that would be expected from a normal distribution dots.

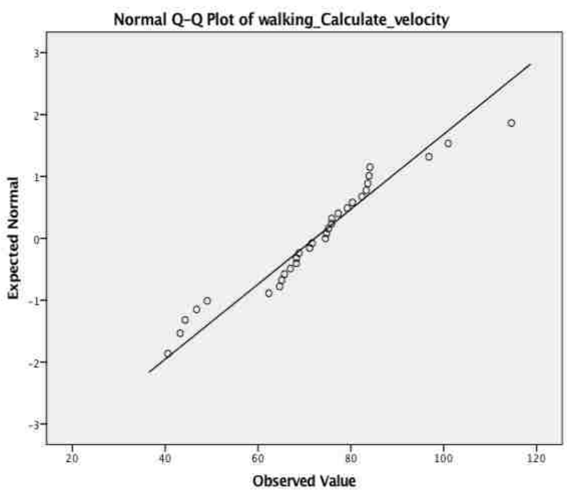

Figure 2. Normal Q-Q plot of velocity in walking while calculating task.

Figure 2 showed the Q-Q plots supported the above findings: for velocity in walking while calculating task the dots were close to the diagonal line, which would be expected from a normal distribution dots.

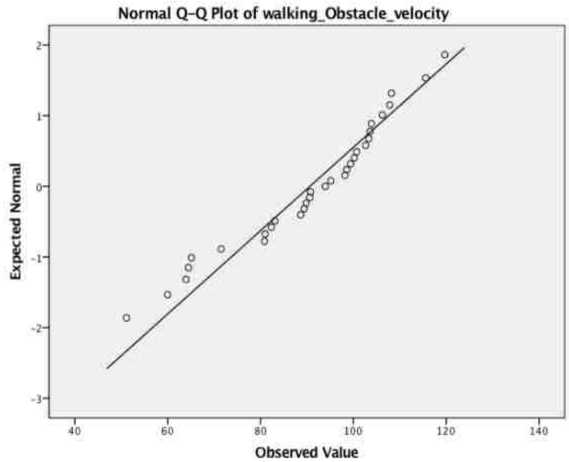

Figure 3. Normal Q-Q plot of velocity in walking while stepping over obstacle task.

Figure 3 shows the Q-Q plots supported the above findings: for velocity in walking while stepping over obstacle task the dots were close to the diagonal line that would be expected from a normal distribution dots.

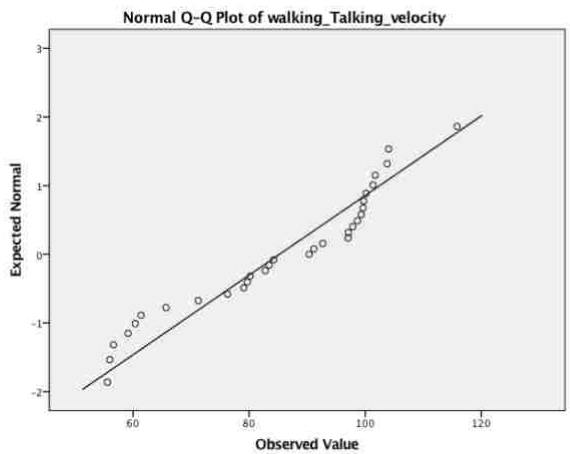

Figure4. Normal Q-Q plot of velocity in walking while talking task.

Figure 4 shows the Q-Q plots supported the above findings: for velocity in walking while talking task the dots were not close to the diagonal line, which would not be expected a normal distribution dots.

Table 15

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Velocity of Walking	.212	1	29	.649
Velocity of Walking & Calculating	.496	1	29	.487
Velocity of Walking & Stepping Over Obstacle	1.159	1	29	.291
Velocity of Walking & Talking	.003	1	29	.957

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + age
Within Subjects Design: velocity

Table 15 shows the assumption of Levene's test of variances. For the velocity of walking task, *F (*1, 29) = .212, *p* =.649, for the velocity of walking while calculation task, *F (*1, 29) = .5, *p* =.487, for the velocity of walking while stepping over obstacle task, *F* (1, 29) = 1.16, *p* =.291, for the velocity of walking while talking task, *F (*1, 29) = .003, *p* =.957. All the conditions of tasks are not significant, which indicates that this assumption has been met.

Table 16

Mauchly's Test of Sphericity[a] For Single Task and Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Velocity	.746	8.133	5	.149	.872	.999	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + age
Within Subjects Design: velocity

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 16 shows Mauchly's test of Sphericity for single task and dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 16, Sphericity is assumed given that the assumption has been met because there was a nonsignificant difference in variances of differences among four tasks, $\chi 2$ (5) = 8.13, p =.149, (ε = .75).

Table 17

Mauchly's Test of Sphericity[a] For Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Velocity	.986	.390	2	.823	.986	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: velocity
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 17 shows Mauchly's test of Sphericity for dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 17, Sphericity is assumed given that the assumption has been met because there was a nonsignificant difference in variances of differences among three tasks, $\chi 2$ (2) = 8.39, p =.823, (ε = .99).

Hypothesis 1. Table 18 shows between subject main effect. The main effect for the age classification groups was not significant, F (1, 29) = 1.71, p =.201, partial $\eta 2$ = .06. The partial eta squared is medium, which means that 6% of variances in velocity is explained by age classification groups. So, we accept null hypothesis 1. The statistical power (G* power) for the age classification (between factors) levels was .99 (Figure 5).

Table 18

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	884001.667	1	884001.667	974.730	.000	.971
age	1550.624	1	1550.624	1.710	.201	.056
Error	26300.671	29	906.920			

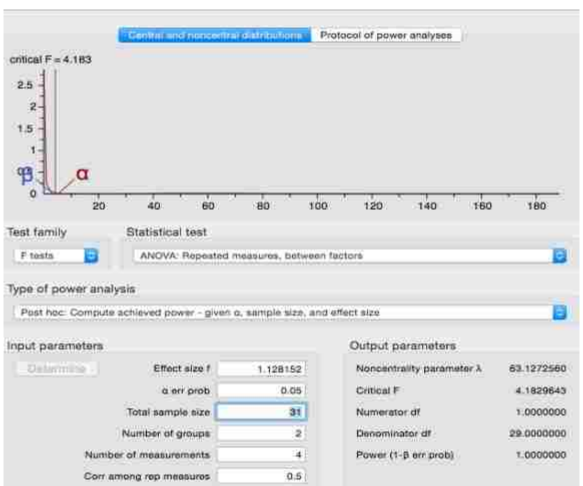

Figure 5. Post hoc power to determine the statistical power for levels of age classification factor.

Hypothesis 2. Table 19 shows within subject main effect for single task and dual tasks. The main effect of velocity was significant, F (3, 87) = 41.64, p =.001, partial $\eta 2$ = .6. The partial eta squared is large, which means that 60 % of the variances in velocity is explained by the single task and dual tasks, therefore supporting why we do see significance in the time effect. So, we reject null hypothesis 2. The statistical power (G* power) for single task and dual tasking (within factors) levels was .99 (Figure 6).

Table 19

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Velocity	Sphericity Assumed	10314.060	3	3438.020	41.636	.000	.589
	Greenhouse-Geisser	10314.060	2.616	3943.082	41.636	.000	.589
	Huynh-Feldt	10314.060	2.998	3440.845	41.636	.000	.589
	Lower-bound	10314.060	1.000	10314.060	41.636	.000	.589
Velocity * age	Sphericity Assumed	432.450	3	144.150	1.746	.164	.057
	Greenhouse-Geisser	432.450	2.616	165.326	1.746	.171	.057
	Huynh-Feldt	432.450	2.998	144.268	1.746	.164	.057
	Lower-bound	432.450	1.000	432.450	1.746	.197	.057
Error (Velocity)	Sphericity Assumed	7183.904	87	82.574			
	Greenhouse-Geisser	7183.904	75.856	94.704			
	Huynh-Feldt	7183.904	86.929	82.641			
	Lower-bound	7183.904	29.000	247.721			

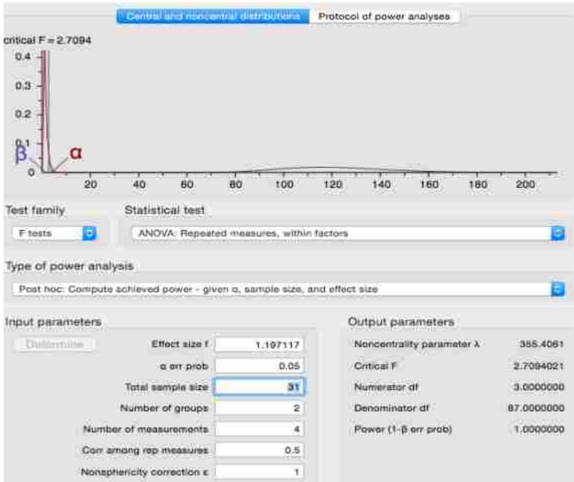

Figure 6. Post hoc power to determine the statistical power for levels of task 1 and task 2 factor.

For pairwise comparison (Table 20), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 4 (numbers of pairwise comparisons), so .05/4 = .0125 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Table 20 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.

Table 20

Pairwise Comparisons

(I) Velocity	(J) Velocity	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	25.038*	2.599	.000	17.678	32.398
	3	6.155*	2.169	.049	.014	12.296
	4	11.631*	1.745	.000	6.689	16.574

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Hypothesis 3. Table 21 shows within subject main effect for dual tasks. The main effect of velocity was significant, *F* (2, 58) = 30.93, *p* =.001, partial *η2* = .52. The partial eta squared is large, which means that 52 % of the variances in velocity is explained by the tasks. So, we reject null hypothesis 3. The statistical power (G* power) for dual tasking (within factor) levels was .99 (Figure 7).

Table 21

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Velocity	Sphericity Assumed	5699.733	2	2849.867	30.928	.000	.516
	Greenhouse-Geisser	5699.733	1.973	2889.283	30.928	.000	.516
	Huynh-Feldt	5699.733	2.000	2849.867	30.928	.000	.516
	Lower-bound	5699.733	1.000	5699.733	30.928	.000	.516
Velocity * age	Sphericity Assumed	159.396	2	79.698	.865	.426	.029
	Greenhouse-Geisser	159.396	1.973	80.800	.865	.425	.029
	Huynh-Feldt	159.396	2.000	79.698	.865	.426	.029
	Lower-bound	159.396	1.000	159.396	.865	.360	.029
Error (Velocity)	Sphericity Assumed	5344.376	58	92.144			
	Greenhouse-Geisser	5344.376	57.209	93.419			
	Huynh-Feldt	5344.376	58.000	92.144			
	Lower-bound	5344.376	29.000	184.289			

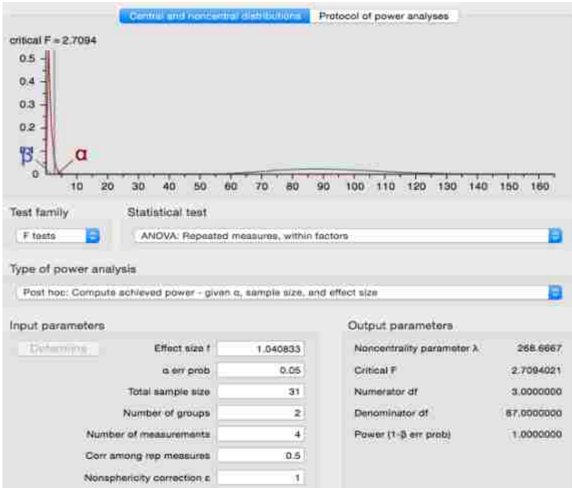

Figure 7. Post hoc power to determine the statistical power for levels of task 2 factor.

For pairwise comparison (Table 22), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 3 (numbers of pairwise comparisons), so .05/3 = .016 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Therefore, there was a significant difference in velocity between walking while calculating and walking while stepping over obstacle, *p* =.001, and between walking while calculating and walking while talking, *p* =.001.

Table 22

Pairwise Comparisons

(I) velocity		Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-18.883*	2.583	0.000	-25.447	-12.320
	3	-13.407*	2.332	0.000	-19.333	-7.480
2	1	18.883*	2.583	0.000	12.320	25.447
	3	5.477	2.490	0.108	-0.849	11.803
3	1	13.407*	2.332	0.000	7.480	19.333
	2	-5.477	2.490	0.108	-11.803	0.849

Hypothesis 4. Table 19 shows the main effect of task conditions x age groups interaction. The main effect of task conditions x age groups interaction was not significant, *F* (3, 87) = 1.75, *p* =.164, partial $\eta 2$ = .06. The partial eta squared is medium, which means that 6% of the variances in velocity is explained by the interaction of the two independent variables. So, we accept the null hypothesis 4. The statistical power (G* power) for task conditions x age groups interaction was .9 (Figure 8).

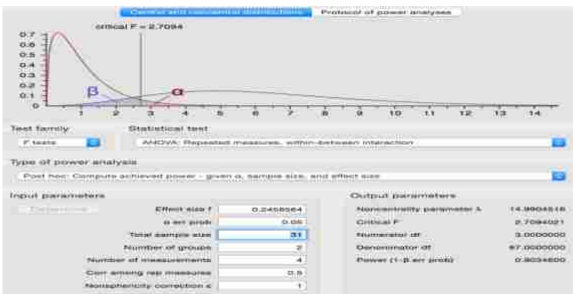

Figure 8. Post hoc power to determine the statistical power for the interaction between levels of task conditions and age groups.

The interaction between independent variables on velocity shows that young-old adults group had higher velocity for single task and for dual tasking than old adults group. Both groups had the highest velocity when they performed single task that was walking. Additionally, both groups had the lowest velocity when they performed dual tasks, specifically walking while calculating (Figure 9).

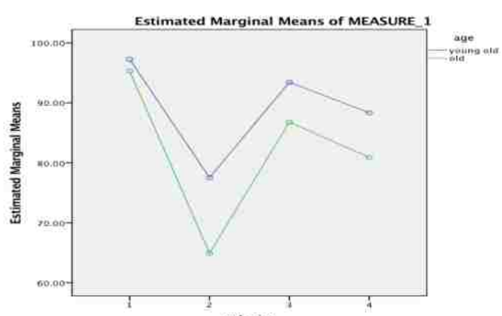

Figure 9. The interaction between both independent variables on velocity.

Cadence (Steps/Min)

The table of descriptive statistics (Table 23) shows the mean and standard deviation at the two different independent levels. For cadence in young-old adults group, the descriptive statistics of walking task was *M*= 98.15, *SD*= 12.47, the descriptive statistics of walking while calculating was, *M*= 89.72, *SD*= 11.25, the descriptive statistics of walking while stepping over obstacle was, *M*= 94.32, *SD*= 12.64, and the descriptive statistics of walking while talking was, *M*= 96.01, *SD*= 10.1. For cadence in old adults group, the descriptive statistics of walking task was *M*= 104.72, *SD*= 17.94, the descriptive statistics of walking while calculating was, *M*= 84.21, *SD*= 15.25, the descriptive statistics of walking while stepping over obstacle was, *M*= 92.31, *SD*= 11.86, and the descriptive statistics of walking while talking was, *M*= 92.99, *SD*= 16.46. The highest cadence mean was for the old adults group in walking task whereas the lowest cadence mean was for old adults group in walking while calculating.

Table 23

Descriptive Statistics

age		Cadence of Walking	Cadence of Calculating	Cadence of Stepping Over Obstacle	Cadence of Walking & Talking
young-old	Mean	98.1541	89.7220	94.3188	96.0121
	Std. Deviation	12.47480	11.25579	12.63716	10.09323
	N	18	18	18	18
old	Mean	104.7215	84.2097	92.3104	92.9906
	Std. Deviation	17.93625	15.24625	11.86142	16.45641
	N	13	13	13	13
Total	Mean	100.9082	87.4104	93.4766	94.7450
	Std. Deviation	15.09043	13.13077	12.15680	12.97500
	N	31	31	31	31

Assumption. The assumption was assessed to make sure that the statistical design is an appropriate method to analyze the data. The dependent variable (cadence) is normally distributed for each combination of the groups of the two factors except for walking while talking (Table 24). Furthermore, the cadence is a ratio scale. The populations are homogeneity of variance (Table 25). The homogeneity of variance of differences = Mauchly's test of sphericity (Table 26) for single task and dual tasking and (Table 27) for dual tasks. The samples were randomly from the population. Additionally, the samples are independent from each other for the old people groups. In conclusion, the samples are related to each other in task conditions.

Table 24

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Cadence of Walking	.139	31	.131	.944	31	.105
Cadence of Walking & Calculating	.122	31	.200*	.976	31	.699
Cadence of Walking & Stepping Over Obstacle	.118	31	.200*	.941	31	.090
Cadence of Walking & Talking	.110	31	.200*	.975	31	.675

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 24 shows that Shapiro-Wilk test was not significant deviation from normality for cadence at walking task, *D* (31) = .94, *p* =.105, at walking while calculation task, *D* (31) = .98, *p* =.699, at walking while stepping over obstacle task, *D* (31) = .94, *p* =.090, and at walking while talking task, *D* (31) = .97, *p* =.675. so, the assumption has been met.

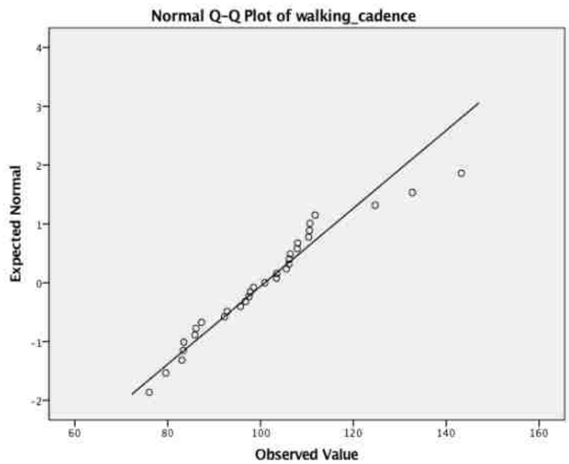

Figure 10. Normal Q-Q plot of cadence in walking task.

Figure 10 shows the Q-Q plots supported the above findings: for cadence in walking task the dots were close to the diagonal line that would be expected from a normal distribution dots.

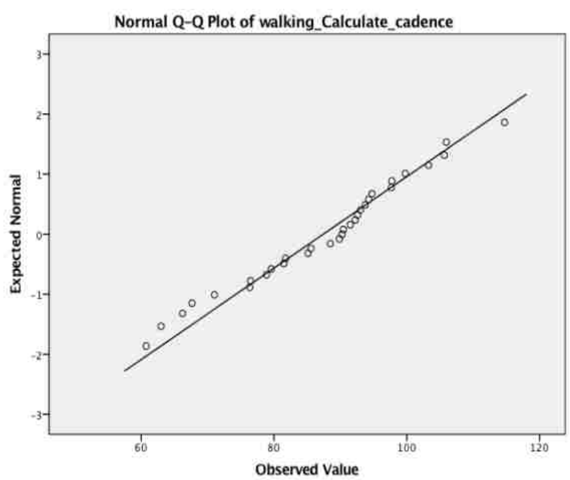

Figure 11. Normal Q-Q plot of cadence in walking while calculating task.

Figure 11 shows the Q-Q plots supported the above findings: for cadence in walking while calculating task the dots were close to the diagonal line, which would be expected from a normal distribution dots.

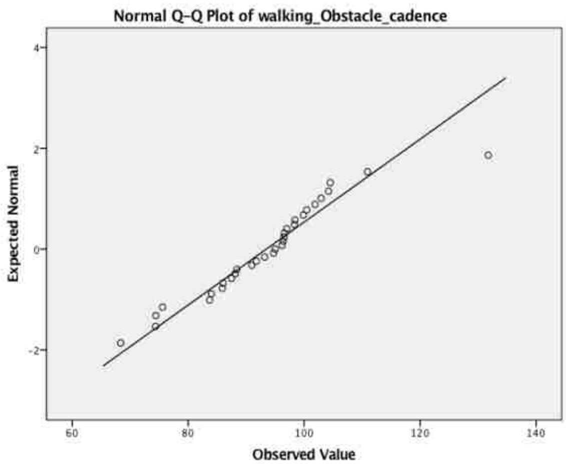

Figure 12. Normal Q-Q plot of cadence in walking while stepping over obstacle task.

Figure 12 shows the Q-Q plots supported the above findings: for cadence in walking while stepping over obstacle task the dots were close to the diagonal line that would be expected from a normal distribution dots.

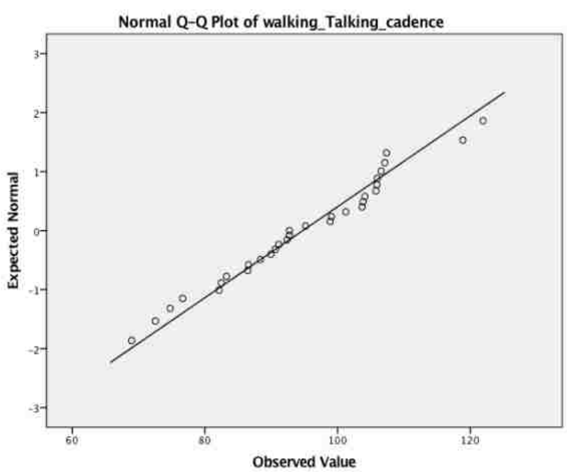

Figure 13. Normal Q-Q plot of cadence in walking while talking task.

Figure 13 shows the Q-Q plots supported the above findings: for cadence in walking while talking task the dots were close to the diagonal line, which would be expected a normal distribution dots.

Table 25

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Cadence of Walking	.481	1	29	.493
Cadence of Walking & Calculating	2.440	1	29	.129
Cadence of Walking & Stepping Over Obstacle	.142	1	29	.709
Cadence of Walking & Talking	3.228	1	29	.083

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + age
Within Subjects Design: cadence

Table 25 shows the assumption of Levene's test of variances. For cadence of walking task, *F* (1, 29) = .48, *p* =.493, for cadence of walking while calculation task, *F* (1, 29) = 2.44, *p* =.129, for cadence of walking while stepping over obstacle task, *F* (1, 29) = .124, *p* =.709, for cadence of walking while talking task, *F* (1, 29) = 3.23, *p* =.083. All the conditions of tasks are not significant, which indicates that this assumption has been met.

Table 26

Mauchly's Test of Sphericity[a] For Single Task and Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Cadence	.683	10.583	5	.060	.810	.920	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: cadence
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 26 shows Mauchly's test of Sphericity for single task and dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 26, Sphericity is assumed given that the assumption has been met because there was a nonsignificant difference in variances of differences among four tasks, $\chi^2 (5) = 10.58$, $p = .06$, ($\varepsilon = .68$).

Table 27

Mauchly's Test of Sphericity[a] For Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Cadence	.794	6.443	2	.040	.829	.904	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: cadence
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 27 shows Mauchly's test of Sphericity for dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 27, Sphericity is assumed given that the assumption has not been met because there was a significant difference in variances of differences among three tasks, $\chi 2$ (2) = 6.44, p =.04< .05, (ε = .90).

Hypothesis 1. Table 28 shows between subject main effect. The main effect for the age classification groups was not significant, F (1, 29) = .061, p =.806, partial $\eta 2$ = .002. The partial eta squared is small, which means that .2% of variances in cadence is explained by age classification groups. So, we accept null hypothesis 1. The statistical power (G* power) for the age classification (between factors) levels was .06 (Figure 14), which requires to increase the sample size up to 2450 to reach the statistical power of .8 (Figure 15).

Table 28

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1068407.771	1	1068407.771	2200.013	.000	.987
age	29.814	1	29.814	.061	.806	.002
Error	14083.476	29	485.637			

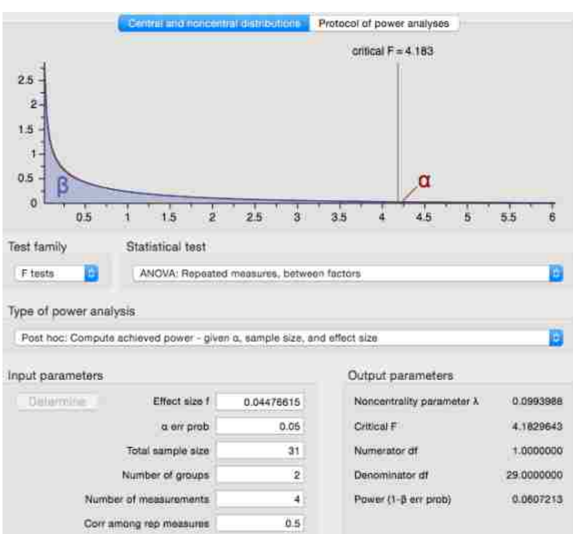

Figure 14. Post hoc power to determine the statistical power for levels of age classification factor.

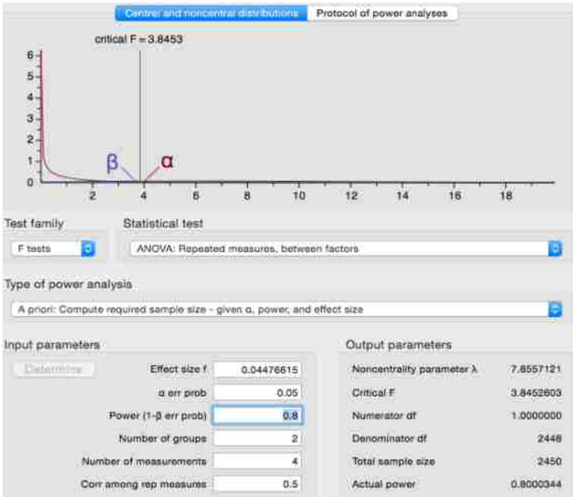

Figure 15. A priori to determine sample size to reach statistical power of .8 for levels of age groups factor.

Hypothesis 2. Table 29 shows within subject main effect for single task and dual tasks. The main effect of cadence was significant, *F* (3, 87) = 13.69, *p* =.001, partial $\eta 2$ = .32. The partial eta squared is large, which means that 32 % of the variances in cadence is explained by the single task and dual tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 2. The statistical power (G* power) for single task and dual tasking (within factors) levels was .99 (Figure 16).

Table 29

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Cadence	Sphericity Assumed	3185.723	3	1061.908	13.686	.000	.321
	Greenhouse-Geisser	3185.723	2.431	1310.705	13.686	.000	.321
	Huynh-Feldt	3185.723	2.761	1154.010	13.686	.000	.321
	Lower-bound	3185.723	1.000	3185.723	13.686	.001	.321
Cadence * age	Sphericity Assumed	624.474	3	208.158	2.683	.052	.085
	Greenhouse-Geisser	624.474	2.431	256.928	2.683	.065	.085
	Huynh-Feldt	624.474	2.761	226.212	2.683	.057	.085
	Lower-bound	624.474	1.000	624.474	2.683	.112	.085
Error (Cadence)	Sphericity Assumed	6750.530	87	77.592			
	Greenhouse-Geisser	6750.530	70.486	95.772			
	Huynh-Feldt	6750.530	80.056	84.322			
	Lower-bound	6750.530	29.000	232.777			

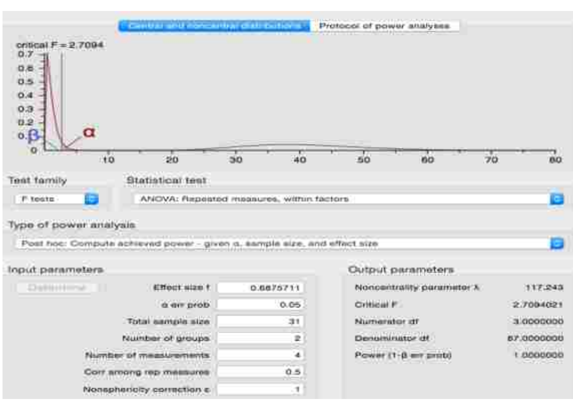

Figure 16. Post hoc power to determine the statistical power for levels of task 1 and task 2 factor.

For pairwise comparison (Table 30), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 4 (numbers of pairwise comparisons), so .05/4 = .0125 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Table 30 showed that there was a significant difference in cadence between walking and walking while calculating, p =.00, between walking and walking while stepping over obstacle, *p* =.003, and between walking and walking while talking, *p* =.014. Additionally, there was a significant difference in cadence between walking while calculating and walking while talking, *p* =.002.

Table 30

Pairwise Comparisons

(I) Cadence	(J) Cadence	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	14.472*	2.262	.000	8.068	20.876
	3	8.123*	2.098	.003	2.183	14.064
	4	6.936*	2.078	.014	1.051	12.822

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Hypothesis 3. Table 31 shows within subject main effect for dual tasks. The main effect of cadence was significant, *F* (1.81, 52.43) = 5.8, *p* =.007, partial $\eta 2$ = .17. The partial eta squared is large, which means that 17 % of the variances in cadence is explained by the tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 3. The statistical power (G* power) for dual tasking (within factors) levels was .99 (Figure 17).

Table 31

Tests of Within-Subjects Effects

	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Cadence	Sphericity Assumed	991.351	2	495.675	5.794	.005	.167
	Greenhouse-Geisser	991.351	1.659	597.566	5.794	.008	.167
	Huynh-Feldt	991.351	1.808	548.359	5.794	.007	.167
	Lower-bound	991.351	1.000	991.351	5.794	.023	.167
Cadence * age	Sphericity Assumed	49.082	2	24.541	.287	.752	.010
	Greenhouse-Geisser	49.082	1.659	29.586	.287	.711	.010
	Huynh-Feldt	49.082	1.808	27.149	.287	.730	.010
	Lower-bound	49.082	1.000	49.082	.287	.596	.010
Error (Cadence)	Sphericity Assumed	4962.259	58	85.556			
	Greenhouse-Geisser	4962.259	48.110	103.143			
	Huynh-Feldt	4962.259	52.428	94.650			
	Lower-bound	4962.259	29.000	171.112			

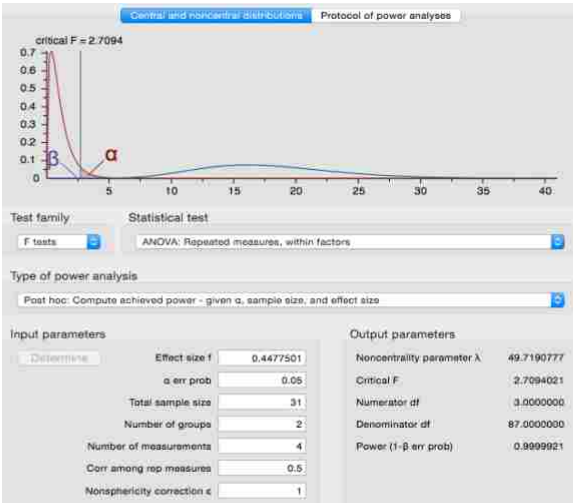

Figure 17. Post hoc power to determine the statistical power for levels of task 2 factor.

For pairwise comparison (Table 32), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 3 (numbers of pairwise comparisons), so .05/3 = .016 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Therefore, there was a significant difference in cadence between walking while calculating and walking while talking, *p* =.002.

Table 32

Pairwise Comparisons

					95% Confidence Interval for Difference[b]	
(I) cadence		Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
1	2	-6.349*	2.433	0.043	-12.531	-0.166
	3	-7.536*	1.824	0.001	-12.170	-2.902
2	1	6.349*	2.433	0.043	0.166	12.531
	3	-1.187	2.785	1.000	-8.263	5.889
3	1	7.536*	1.824	0.001	2.902	12.170
	2	1.187	2.785	1.000	-5.889	8.263

Hypothesis 4. Table 29 shows the main effect of tasks condition x age groups interaction on cadence. The main effect of tasks conditions x age groups interaction was not significant, *F* (3, 87) = 2.68, *p* =.052, partial $\eta 2$ = .09. The partial eta squared is medium, which means that 9% of the variances in cadence is explained by the interaction of the two independent variables. So, we accept the null hypothesis 4. The statistical power (G* power) for task conditions x age groups interaction was .98 (Figure 18).

Figure 18. Post hoc power to determine the statistical power for the interaction between levels of task conditions and age groups.

The interaction between independent variables on cadence shows that young-old adults group had lower cadence for single task than old adults group and higher cadence for dual tasking than old adults group. Both groups had the highest cadence when they performed single task, which was walking. Additionally, both groups had the lowest cadence when they performed dual tasking specifically walking while calculating (Figure 19).

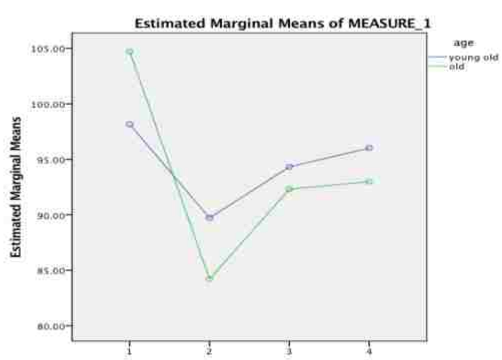

Figure 19. The interaction between both independent variables on cadence.

Double Supports: Left Leg (GC%)*

The table of descriptive statistics (Table 33) shows the mean and standard deviation at the two different independent levels. For double support for left leg in young-old adults group, the descriptive statistics of walking task was *M*= .29, *SD* = .06, the descriptive statistics of walking while calculating was, *M*= .35, *SD* = .07, the descriptive statistics of walking while stepping over obstacle was, *M*= .27, *SD* = .05, and the descriptive statistics of walking while talking was, *M*= .35, *SD* = .13. For double support for left leg in old adults group, the descriptive statistics of walking task was *M*= .29, *SD* = .08, the descriptive statistics of walking while calculating was, *M*= .39, *SD* = .09, the descriptive statistics of walking while stepping over obstacle was, *M*= .28, *SD* = .07, and the descriptive statistics of walking while talking was, *M*= .33, *SD* = .09. The highest double support for left leg mean was for the old adults group in walking while calculating task whereas the lowest double support for left leg mean was for young-old adults group in walking while stepping over obstacle.

Table 33

Descriptive Statistics

	Double support of left leg of Walking	Double support of left leg of Walking & Calculating	Double support of left leg of Walking & Stepping Over Obstacle	Double support of left leg of Walking & Talking
Mean	.2900	.3650	.2784	.3414
Std. Deviation	.06749	.08199	.05817	.11519
N	31	31	31	31

*GC%: Gait Cycle%

Assumption. The assumption was assessed to make sure that the statistical design is an appropriate method to analyze the data. The dependent variable (double support for left leg) is normally distributed only for walking of the groups of the two factors (Table 34). Furthermore, the double support for left leg is a ratio scale. The populations are homogeneity of variance (Table 35). The homogeneity of variance of differences = Mauchly's test of sphericity (Table 36) for single task and dual tasking and (Table 37) for dual tasking only. The samples were randomly from the population. Additionally, the samples are independent from each other for the old people groups. In conclusion, the samples are related to each other in task conditions.

Table 34

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Double support of left leg of Walking	.073	31	.200*	.981	31	.847
Double support of left leg of Walking & Calculating	.176	31	.015	.907	31	.011
Double support of left leg of Walking & Stepping Over Obstacle	.163	31	.036	.897	31	.006
Double support of left leg of Walking & Talking	.173	31	.019	.870	31	.001

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 34 showed that Shapiro-Wilk test was not significant deviation from normality for double support for left leg at walking task, *D* (31) = .98, *p* =.847. In contrast, there was a significant deviation from the normality at walking while calculating task, *D* (31) = .91, *p* =.011, at walking while stepping over obstacle, *D* (31) = .9, *p* =.006, and at walking while talking, *D* (31) = .87, *p* =.001; however, while the number of participants were more than 30, so we assume the normality and will proceed with caution as supported by the central limit theorem. The central limit theorem provides that while the sample size is large, no matter what the shape of the population is (Field, 2013).

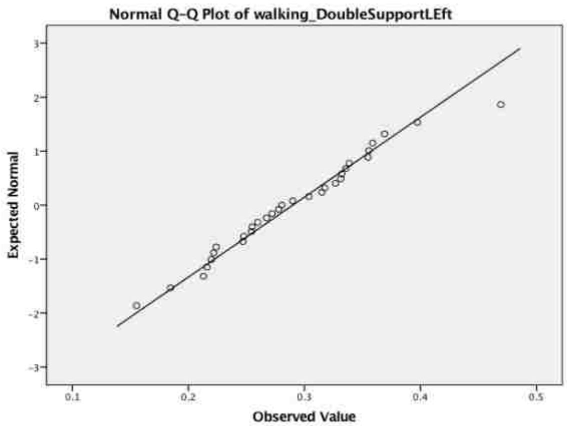

Figure 20. Normal Q-Q plot of double support for left leg in walking task.

Figure 20 shows the Q-Q plots supported the above findings: for double support for left leg in walking task the dots were close to the diagonal line that would be expected from a normal distribution dots.

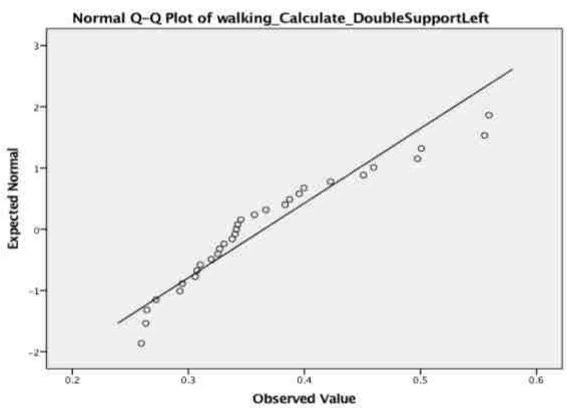

Figure 21. Normal Q-Q plot of double support for left leg in walking while calculating task.

Figure 21 shows the Q-Q plots supported the above findings: for double support for left leg in walking while calculating task the dots were not close to the diagonal line, which would not be expected a normal distribution dots.

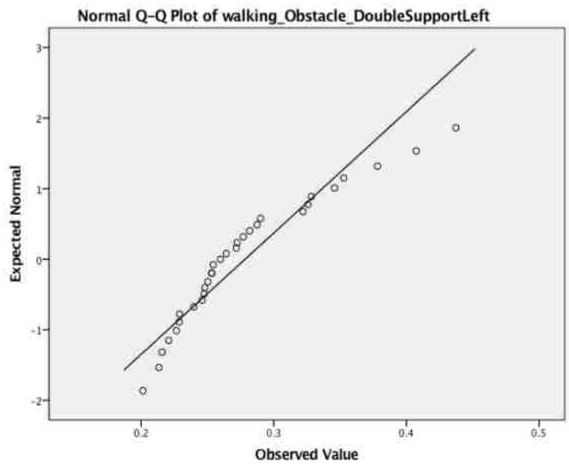

Figure 22. Normal Q-Q plot of double support for left leg in walking while stepping over obstacle task.

Figure 22 shows the Q-Q plots supported the above findings: for double support for left leg in walking while talking task the dots were not close to the diagonal line, which would not be expected a normal distribution dots.

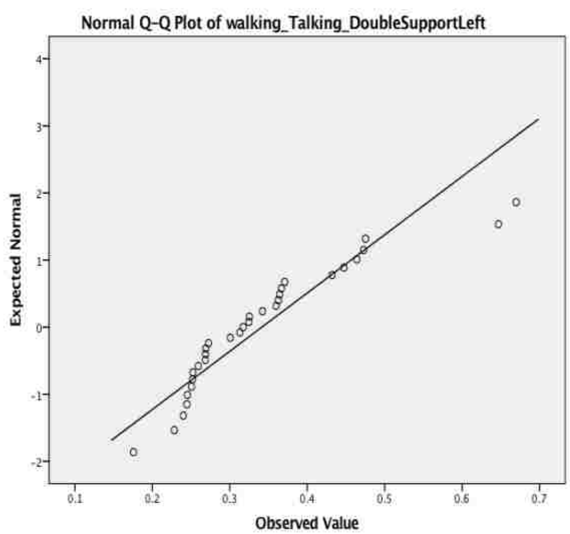

Figure 23. Normal Q-Q plot of double support left leg in walking while talking task.

Figure 23 shows the Q-Q plots supported the above findings: for double support for left leg in walking while talking task the dots were not close to the diagonal line, which would not be expected a normal distribution dots.

Table 35

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Double support of left leg of Walking	.728	1	29	.400
Double support of left leg of Walking & Calculating	.815	1	29	.374
Double support of left leg of Walking & Stepping Over Obstacle	1.376	1	29	.250
Double support of left leg of Walking & Talking	.520	1	29	.476

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + age
Within Subjects Design: doublesupportleft

Table 35 shows the assumption of Levene's test of variances. For double support for left leg of walking task, *F* (1, 29) = .73, *p* =.4, for double support for left leg of walking while calculation task, *F* (1, 29) = 81, *p* =.374, for double support for left leg of walking while stepping over obstacle task, *F* (1, 29) = 1.38, *p* =.25, for double support for left leg of walking while talking task, *F* (1, 29) = .52, *p* =.476. All the conditions of tasks are not significant, which indicates that this assumption has been met.

Table 36

Mauchly's Test of Sphericity[a] For Single Task and Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Double Support of Left Leg	.289	34.382	5	.000	.623	.687	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
Table 34 Design: Intercept + age
Within Subjects Design: doublesupportleft
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 36 shows Mauchly's test of Sphericity for single task and dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 36, Sphericity is assumed given that the assumption has not been met because there was a significant difference in variances of differences among four tasks, $\chi 2$ (5) = 34.38, p =.001, (ε = .62).

Table 37

Mauchly's Test of Sphericity[a] For Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Double Support of Left Leg	.616	13.565	2	.001	.723	.777	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: doublesupportleft
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 37 shows Mauchly's test of Sphericity for dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 37, Sphericity is assumed given that the assumption has not been met because there was a significant difference in variances of differences among three tasks, $\chi 2$ (2) = 13.56, p =.001, (ε = .72).

Hypothesis 1. Table 38 shows between subject main effect. The main effect for the age classification groups was not significant, F (1, 29) = .13, p =.724, partial $\eta 2$ = .004. The partial eta squared is medium, which means that .4% of variances in double support for left leg is explained by age classification groups. So, we accept null hypothesis 1. The statistical power (G* power) for the age classification (between factors) levels was .07 (Figure 24), which requires to increase the sample size up to 1224 to reach the statistical power of .8 (Figure 25).

Table 38

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	12.322	1	12.322	641.323	.000	.957
age	.002	1	.002	.127	.724	.004
Error	.557	29	.019			

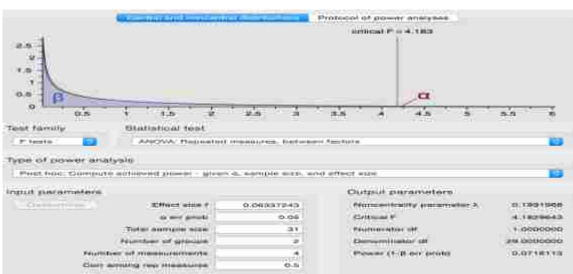

Figure 24. Post hoc power to determine the statistical power for levels of age classification factor.

Figure 25. A priori to determine sample size to reach statistical power of .8 for levels of age groups factor.

Hypothesis 2. Table 39 shows within subject main effect for single task and dual tasks. The main effect of double support for left leg was significant, *F* (1.87,54.22) = 17.55, *p* =.001, partial *η2* = .38. The partial eta squared is large, which means that 38 % of the variances in double support for left leg is explained by the single task and dual tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 2. The statistical power (G* power) for single task and dual tasking (within factors) levels was .99 (Figure 26).

Table 39

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Double Support of Left Leg	Sphericity Assumed	.160	3	.053	17.552	.000	.377
	Greenhouse-Geisser	.160	1.870	.086	17.552	.000	.377
	Huynh-Feldt	.160	2.062	.078	17.552	.000	.377
	Lower-bound	.160	1.000	.160	17.552	.000	.377
Double Support of Left Leg * age	Sphericity Assumed	.013	3	.004	1.437	.237	.047
	Greenhouse-Geisser	.013	1.870	.007	1.437	.246	.047
	Huynh-Feldt	.013	2.062	.006	1.437	.246	.047
	Lower-bound	.013	1.000	.013	1.437	.240	.047
Error (Double Support of Left Leg)	Sphericity Assumed	.265	87	.003			
	Greenhouse-Geisser	.265	54.216	.005			
	Huynh-Feldt	.265	59.811	.004			
	Lower-bound	.265	29.000	.009			

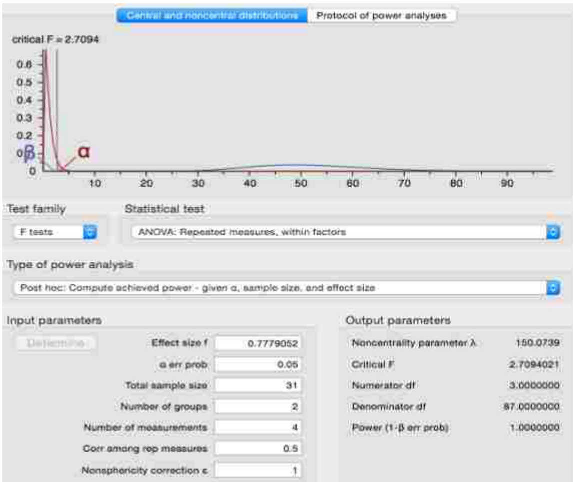

Figure 26. Post hoc power to determine the statistical power for levels of task 1 and task 2 factor.

For pairwise comparison (Table 40), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 4 (numbers of pairwise comparisons), so .05/4 = .0125 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Table 40 showed that there was a significant difference in double support for left leg between walking and walking while calculating, p =.001, and between walking and walking while talking, p =.016.

Table 40

Pairwise Comparisons

(I) Double Support of Left Leg	(J) Double Support of Left Leg	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	-.078*	.013	.000	-.114	-.042
	3	.011	.008	.927	-.011	.033
	4	-.050*	.015	.016	-.093	-.007

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Hypothesis 3. Table 41 shows within subject main effect for dual tasks. The main effect of double support for left leg was significant, *F* (1.44, 44.91) = 16.5, *p* =.001, partial *η2* = .36. The partial eta squared is large, which means that 36 % of the variances in double support for left leg is explained by the tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 3. The statistical power (G* power) for dual tasking (within factors) levels was .99 (Figure 27).

Table 41

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Double Support of Left Leg	Sphericity Assumed	.126	2	.063	16.498	.000	.363
	Greenhouse-Geisser	.126	1.445	.087	16.498	.000	.363
	Huynh-Feldt	.126	1.553	.081	16.498	.000	.363
	Lower-bound	.126	1.000	.126	16.498	.000	.363
Double Support of Left Leg * age	Sphericity Assumed	.013	2	.006	1.665	.198	.054
	Greenhouse-Geisser	.013	1.445	.009	1.665	.206	.054
	Huynh-Feldt	.013	1.553	.008	1.665	.204	.054
	Lower-bound	.013	1.000	.013	1.665	.207	.054
Error (Double Support of Left Leg)	Sphericity Assumed	.222	58	.004			
	Greenhouse-Geisser	.222	41.909	.005			
	Huynh-Feldt	.222	45.044	.005			
	Lower-bound	.222	29.000	.008			

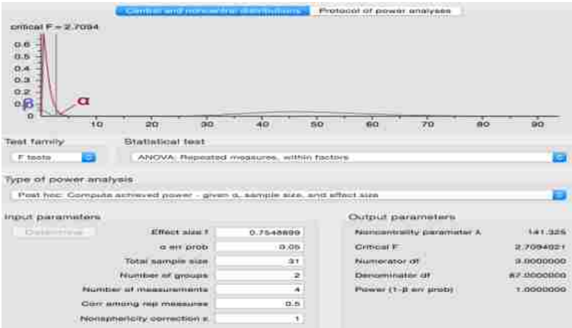

Figure 27. Post hoc power to determine the statistical power for levels of task 2 factor.

For pairwise comparison (Table 42), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 3 (numbers of pairwise comparisons), so .05/3 = .016 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Therefore, there was a significant difference in double support for left leg between walking while calculating and walking while stepping over obstacle, *p* =.001. Additionally, there was a significant difference in double support for left leg between walking while stepping over obstacle and walking while talking, *p* =.006.

Table 42

Pairwise Comparisons

(I) Double support left leg	(J) Double support left leg	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	.089*	.010	.000	.064	.114
	3	.028	.018	.406	-.018	.075
2	1	-.089*	.010	.000	-.114	-.064
	3	-.061*	.018	.006	-.107	-.015
3	1	-.028	.018	.406	-.075	.018
	2	.061*	.018	.006	.015	.107

Hypothesis 4. Table 39 shows the main effect of tasks conditions x age groups interaction. The main effect of tasks conditions x age groups interaction was not significant, *F* (1.87, 54.22) = 1.44, *p* =.246, partial $\eta 2$ = .05. The partial eta squared is medium, which means that 5% of the variances in double support for left leg is explained by the interaction of the two independent variables. So, we accept the null hypothesis 4. The statistical power (G* power) for task X age groups interaction was .83 (Figure 28).

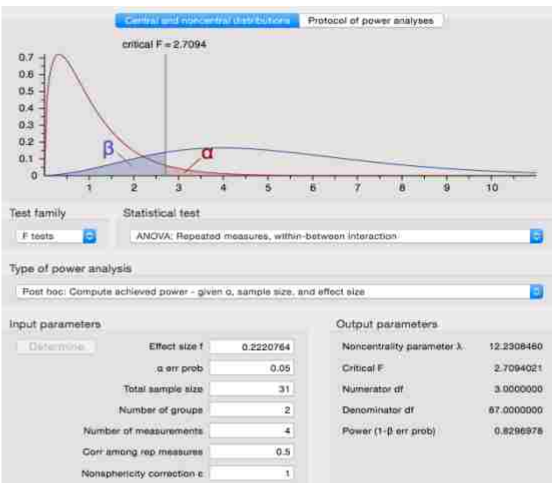

Figure 28. Post hoc power to determine the statistical power to the interaction between levels of task conditions and age groups.

The interaction between independent variables on double support left for leg shows that young-old adults group and old adults group had quite similar double support for left leg for walking and for walking while stepping over obstacle. For walking while calculating, the old adults group had higher double support left leg than young-old adults group. The young-old adults group had higher double support for left leg than old adults group in walking while talking (Figure 29).

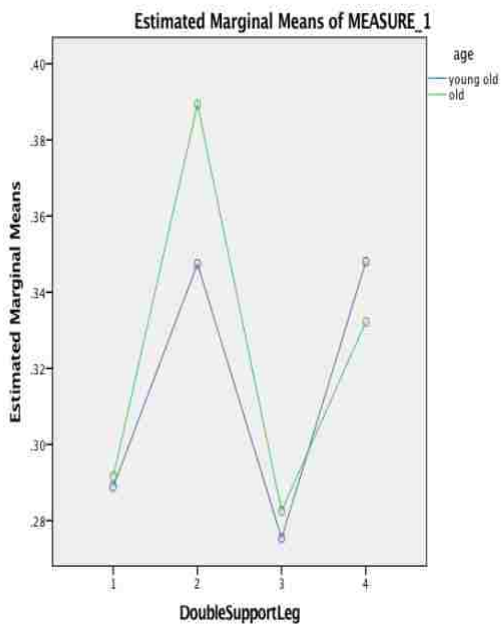

Figure 29. The interaction between both independent do on double support for left leg.

Double Supports: Right Leg (GC%)

The table of descriptive statistics (Table 43) shows the mean and standard deviation at the two different independent levels. For double support for right for leg in young-old adults group, the descriptive statistics of walking task was *M*= .3, *SD*= .07, the descriptive statistics of walking while calculating was, *M*= .35, *SD*= .08, the descriptive statistics of walking while stepping over obstacle was, *M*= .28, *SD*= .06, and the descriptive statistics of walking while talking was, *M*= .33, *SD*= .1. For double supports for right leg in old adults group, the descriptive statistics of walking task was *M*= .29, *SD*= .08, the descriptive statistics of walking while calculating was, *M*= .37, *SD*= .1, the descriptive statistics of walking while stepping over obstacle was, *M*= .28, *SD*= .07, and the descriptive statistics of walking while talking was, *M*= .36, *SD*= .15. The highest double support for right leg mean was for the old adults group in walking while calculating task whereas the lowest double support for right leg mean was for old adults group in walking while stepping over obstacle.

Table 43

Descriptive Statistics

	Double support of right leg of Walking	Double support of right leg of Walking & Calculating	Double support of right leg of Walking & Stepping Over Obstacle	Double support of right leg of Walking & Talking
Mean	.2900	.3650	.2784	.3414
Std. Deviation	.06749	.08199	.05817	.11519
N	31	31	31	31

Assumption. The assumption was assessed to make sure that the statistical design is an appropriate method to analyze the data. The dependent variable (double support for right leg) is normally distributed for each combination of the groups of the two factors except for walking while talking (Table 44). Furthermore, the double support for right leg is a ratio scale. The populations are homogeneity of variance (Table 45). The homogeneity of variance of differences = Mauchly's test of sphericity (Table 46) for single task and dual tasking and (Table 47) for dual tasking only. The samples were randomly from the population. Additionally, the samples are independent from each other for the old people groups. In conclusion, the samples are related to each other in task conditions.

Table 44

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Double support of right leg of Walking	.116	31	.200*	.983	31	.893
Double support of right leg of Walking & Calculating	.147	31	.085	.939	31	.077
Double support of right leg of Walking & Stepping Over Obstacle	.155	31	.057	.920	31	.024
Double support of right leg of Walking & Talking	.151	31	.068	.870	31	.001

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 44 shows that Shapiro-Wilk test was not significant deviation from normality for double support for right leg at walking task, D (31) = .98, p =.893, and at walking while calculating task, D (31) = .94, p =.077. In contrast, there was a significant deviation from the normality, at walking while stepping over obstacle, *D* (31) = .92, *p* =.024, and at walking while talking, *D* (31) = .87, *p* =.001; however, while the number of participants were more than 30, so we assume the normality and will proceed with caution as supported by the central limit theorem. The central limit theorem provides that while the sample size is large, no matter what the shape of the population is (Field, 2013).

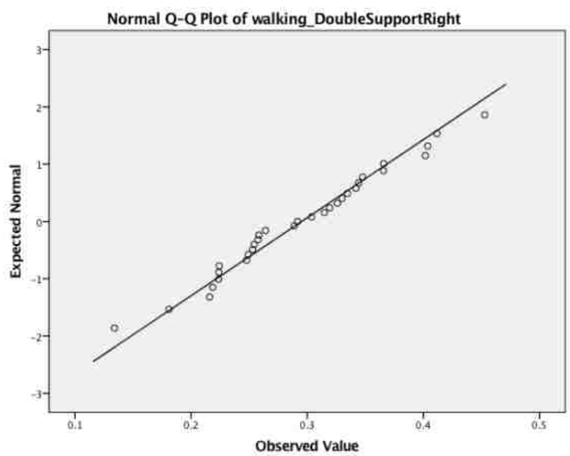

Figure 30. Normal Q-Q plot of double support for right leg in walking task.

Figure 30 shows the Q-Q plots supported the above findings: for double support for right leg in walking task the dots were close to the diagonal line that would be expected from a normal distribution dots.

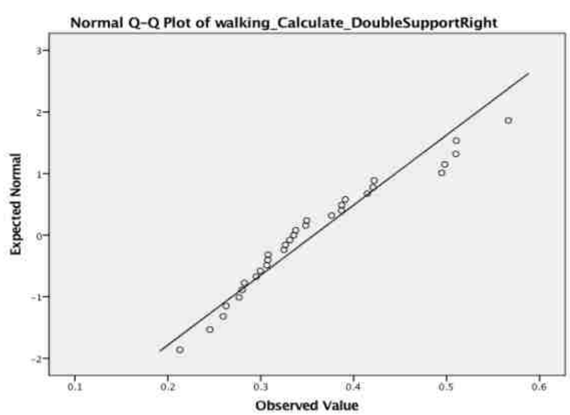

Figure 31. Normal Q-Q plot of double support for right leg in walking while calculating task.

Figure 31 shows the Q-Q plots supported the above findings: for double support for right leg in walking while calculating task the dots were close to the diagonal line, which would be expected a normal distribution dots.

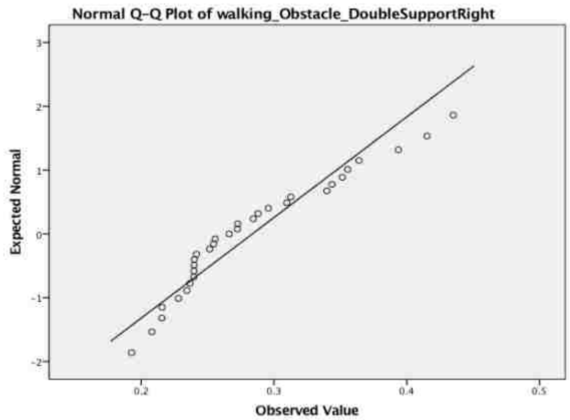

Figure 32. Normal Q-Q plot of double support right for leg in walking while stepping over obstacle task.

Figure 32 shows the Q-Q plots supported the above findings: for double support for right leg in walking while talking task the dots were not close to the diagonal line, which would not be expected a normal distribution dots.

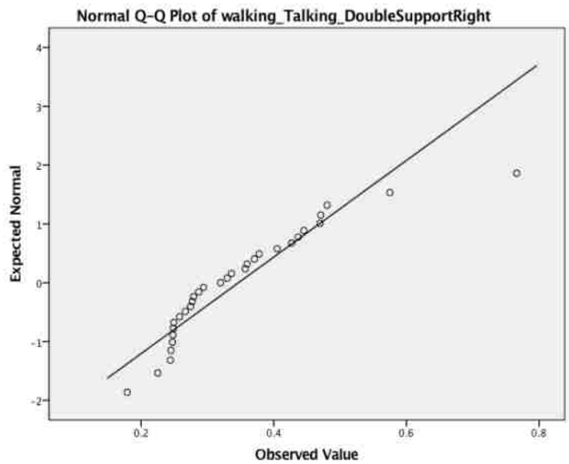

Figure 33. Normal Q-Q plot of double support right leg in walking while talking task.

Figure 33 shows the Q-Q plots supported the above findings: for double support for right leg in walking while talking task the dots were not close to the diagonal line, which would not be expected a normal distribution dots.

Table 45

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Double support of right leg of Walking	.420	1	29	.522
Double support of right leg of Walking & Calculating	.726	1	29	.401
Double support of right leg of Walking & Stepping Over Obstacle	.663	1	29	.422
Double support of right leg of Walking & Talking	1.154	1	29	.292

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + age
Within Subjects Design: doublesupportright

Table 45 shows the assumption of Levene's test of variances. For double support for right leg of walking task, F (1, 29) = .42, p =.522, for double support for right leg of walking while calculation task, F (1, 29) = .73, p =.401, for double support for right leg of walking while stepping over obstacle task, F (1, 29) = .66, p =.422, for double support for right leg of walking while talking task, F (1, 29) = 1.15, p =.292. All the conditions of tasks are not significant, which indicates that this assumption has been met.

Table 46

Mauchly's Test of Sphericity[a] For Single Task and Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Double Support for Right Leg	.313	32.173	5	.000	.625	.690	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: doublesupportright
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 46 shows Mauchly's test of Sphericity for single task and dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 46, Sphericity is assumed given that the assumption has not been met because there was a significant difference in variances of differences among four tasks, $\chi 2$ (5) = 32.17, p =.001, (ε = .62).

Table 47

Mauchly's Test of Sphericity[a] For Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Double Support for Right Leg	.733	8.696	2	.013	.789	.856	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: doublesupportright
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 47 shows Mauchly's test of Sphericity for dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 47, Sphericity is assumed given that the assumption has not been met because there was a significant difference in variances of differences among three tasks, $\chi 2$ (2) = 8.7, p =.013, (ε = .86).

Hypothesis 1. Table 48 shows between subject main effect. The main effect for the age classification groups was not significant, F (1, 29) = .27, p =.607, partial $\eta 2$ = .009. The partial eta squared is medium, which means that .9% of variances in double support for right leg is explained by age classification groups. So, we accept null hypothesis 1. The statistical power (G* power) for the age classification (between factors) levels was .01 (Figure 34), which requires to increase the sample size up to 544 to reach the statistical power of .8 (Figure 35).

Table 48

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	12.505	1	12.505	581.867	.000	.953
age	.006	1	.006	.270	.607	.009
Error	.623	29	.021			

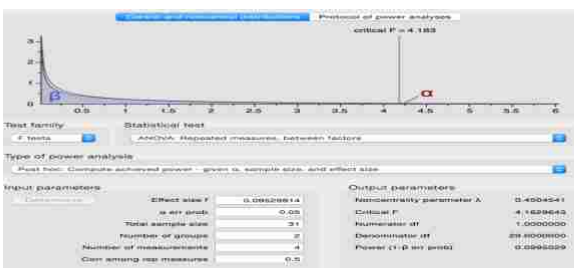

Figure 34. Post hoc to determine the statistical power for level of age classifications factor.

Figure 35. A priori to determine sample size to reach the statistical power of .8 for levels of age groups.

Hypothesis 2. Table 49 shows within subject main effect for single task and dual tasks. The main effect of double support for right leg was significant, *F* (1.876,54.39) = 11.94, *p* =.001, partial $\eta 2$ = .3. The partial eta squared is large, which means that 30 % of the variances in double support for right leg is explained by the single task and dual tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 2. The statistical power (G* power) for single task and dual tasking (within factors) levels was .99 (Figure 36).

Table 49

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Double Support for Right Leg	Sphericity Assumed	.132	3	.044	11.937	.000	.292
	Greenhouse-Geisser	.132	1.876	.071	11.937	.000	.292
	Huynh-Feldt	.132	2.070	.064	11.937	.000	.292
	Lower-bound	.132	1.000	.132	11.937	.002	.292
Double Support for Right Leg * age	Sphericity Assumed	.009	3	.003	.823	.485	.028
	Greenhouse-Geisser	.009	1.876	.005	.823	.438	.028
	Huynh-Feldt	.009	2.070	.004	.823	.448	.028
	Lower-bound	.009	1.000	.009	.823	.372	.028
Error (Double Support for Right Leg)	Sphericity Assumed	.321	87	.004			
	Greenhouse-Geisser	.321	54.390	.006			
	Huynh-Feldt	.321	60.023	.005			
	Lower-bound	.321	29.000	.011			

Figure 36. Post hoc to determine the statistical power for levels of task 1 and task 2 factor.

For pairwise comparison (Table 50), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 4 (numbers of pairwise comparisons), so .05/4 = .0125 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Table 50 showed that there was a significant difference in double support for right leg between walking and walking while calculating, p =.001, and between walking and walking while talking, p =.0014.

Table 50

Pairwise Comparisons

(I) Double Support of Right Leg	(J) Double Support of Right Leg	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-.064*	.013	.000	-.100	-.029
	3	.012	.008	.920	-.011	.034
	4	-.054*	.016	.014	-.101	-.008

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Hypothesis 3. Table 51 shows within subject main effect for dual tasks. The main effect of double support for right leg was significant, *F* (1.712, 49.637) = 10.47, *p* =.001, partial *η2* = .26. The partial eta squared is large, which means that 26 % of the variances in double support for right leg is explained by the tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 3. The statistical power (G* power) for task 2 (dual tasks) (within factors) levels was .99 (Figure 37).

Table 51

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Double Support for Right Leg	Sphericity Assumed	.103	2	.052	10.469	.000	.265
	Greenhouse-Geisser	.103	1.579	.065	10.469	.000	.265
	Huynh-Feldt	.103	1.712	.060	10.469	.000	.265
	Lower-bound	.103	1.000	.103	10.469	.003	.265
Double Support for Right Leg * age	Sphericity Assumed	.006	2	.003	.653	.524	.022
	Greenhouse-Geisser	.006	1.579	.004	.653	.491	.022
	Huynh-Feldt	.006	1.712	.004	.653	.502	.022
	Lower-bound	.006	1.000	.006	.653	.426	.022
Error (Double Support for Right Leg)	Sphericity Assumed	.286	58	.005			
	Greenhouse-Geisser	.286	45.778	.006			
	Huynh-Feldt	.286	49.637	.006			
	Lower-bound	.286	29.000	.010			

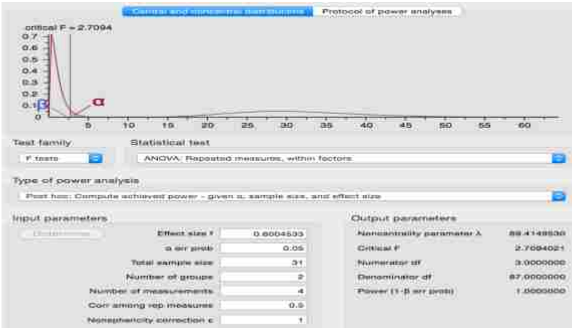

Figure 37. Post hoc to determine the statistical power for levels of task 2 factor.

For pairwise comparison (Table 52), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 3 (numbers of pairwise comparisons), so .05/3 = .016 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Therefore, there was a significant difference in double support for right leg between walking while calculating and walking while stepping over obstacle, p =.001, and there was a significant difference between walking while stepping over obstacle and walking while talking, p =.007.

Table 52

Pairwise Comparisons

(I) Double support right		Mean Difference (I-J)	Std. Error	Sig.^{b}	95% Confidence Interval for Difference^b Lower Bound	Upper Bound
1	2	.076*	0.013	0.000	0.044	0.108
	3	0.010	0.021	1.000	-0.043	0.063
2	1	-.076*	0.013	0.000	-0.108	-0.044
	3	-.066*	0.020	0.007	-0.116	-0.016
3	1	-0.010	0.021	1.000	-0.063	0.043
	2	.066*	0.020	0.007	0.016	0.116

Hypothesis 4. Table 49 shows the main effect of tasks conditions x age groups interaction. The main effect of tasks conditions x age groups interaction was not significant, *F* (1.876, 54.39) = .823, *p* =.438, partial $\eta 2$ = .03. The partial eta squared is small, which means that 3% of the variances in double support for right leg is explained by the interaction of the two independent variables. So, we accept the null hypothesis 4. The statistical power (G* power) for single task and dual tasking (within factors) levels was .6 (Figure 38), which requires to increase the sample size up to 50 to reach the statistical power of .8 (Figure 39).

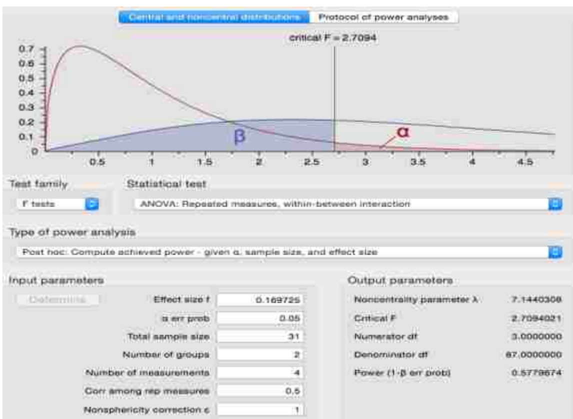

Figure 38. Post hoc to determine the statistical power to the interaction between levels of task conditions and age groups.

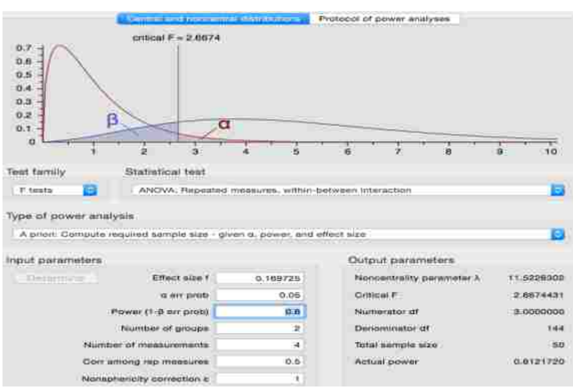

Figure 39. A priori to determine sample size to reach the statistical power of .8 for the interaction between levels of task conditions and age groups.

The interaction between independent variables on double support for right leg shows that young-old adults group and old adults group had quite similar double support for right leg for walking and walking while stepping over obstacle. For walking while calculating and walking while talking, the old adults group had higher double support right leg than young-old adults group (Figure 40).

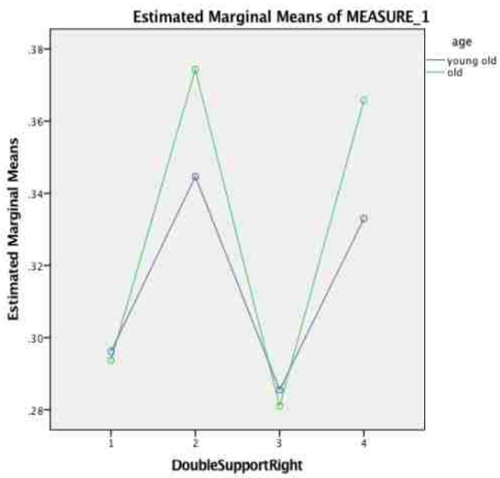

Figure 40. The interaction between both independent variables on double support for right leg.

Stride Length: Left Leg (cm)

The table of descriptive statistics (Table 53) shows the mean and standard deviation at the two different independent levels. For stride length for left leg in young-old adults group, the descriptive statistics of walking task was *M*= 119.7, *SD* = 11.52, the descriptive statistics of walking while calculating was, *M*= 100.2, *SD* = 14.1, the descriptive statistics of walking while stepping over obstacle was, *M*= 123.73, *SD* = 13.66, and the descriptive statistics of walking while talking was, *M*= 107.15, *SD* = 17.77. For stride length for left leg in old adults group, the descriptive statistics of walking task was *M*=109.53, *SD* = 16.57, the descriptive statistics of walking while calculating was, *M*= 89.39, *SD* = 13.78, the descriptive statistics of walking while stepping over obstacle was, *M*= 109.60, *SD* = 19.95, and the descriptive statistics of walking while talking was, *M*= 101.80, *SD* = 14.6. The highest stride length for left leg mean was for the young adults group in walking while stepping over obstacle whereas the lowest stride length for left leg mean was for old adults group in walking calculating.

Table 53

Descriptive Statistics

	Stride length of left leg of Walking	Stride length of left leg of Walking & Calculating	Stride length of left leg of Walking & Stepping Over Obstacle	Stride length of left leg of Walking & Talking
Mean	115.4340	95.6626	117.8070	104.9104
Std. Deviation	14.52799	14.76627	17.75182	16.47201
N	31	31	31	31

Assumption. The assumption was assessed to make sure that the statistical design is an appropriate method to analyze the data. The dependent variable (stride length for left leg) is normally distributed for each combination of the groups of the two factors except for walking while talking (Table 54). Furthermore, the stride length for left leg is a ratio scale. The populations are homogeneity of variance (Table 55). The homogeneity of variance of differences = Mauchly's test of sphericity (Table 56) for single task and dual tasking and (Table 57) for dual tasking only. The samples were randomly from the population. Additionally, the samples are independent from each other for the old people groups. In conclusion, the samples are related to each other in task conditions.

Table 54

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Stride length of left leg of Walking	.118	31	.200*	.980	31	.816
Stride length of left leg of Walking & Calculating	.089	31	.200*	.968	31	.471
Stride length of left leg of Walking & Stepping Over Obstacle	.113	31	.200*	.978	31	.751
Stride length of left leg of Walking & Talking	.076	31	.200*	.974	31	.625

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 54 shows that Shapiro-Wilk test was not significant deviation from normality for stride length for left leg at walking task, D (31) = .98, p =.816, at walking while calculating task, D (31) = .97, p =.471, at walking while stepping over obstacle, D (31) = .98, p =.751, and at walking while talking, D (31) = .97, p =.625. So, the assumption has been met.

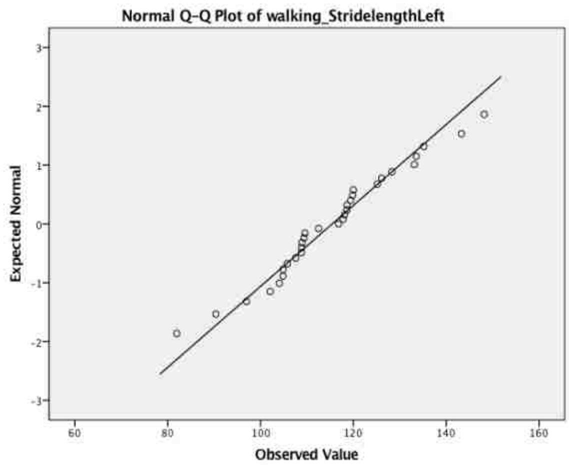

Figure 41. Normal Q-Q plot of stride length for left leg in walking task.

Figure 41 shows the Q-Q plots supported the above findings: for stride length for left leg in walking task the dots were close to the diagonal line that would be expected from a normal distribution dots.

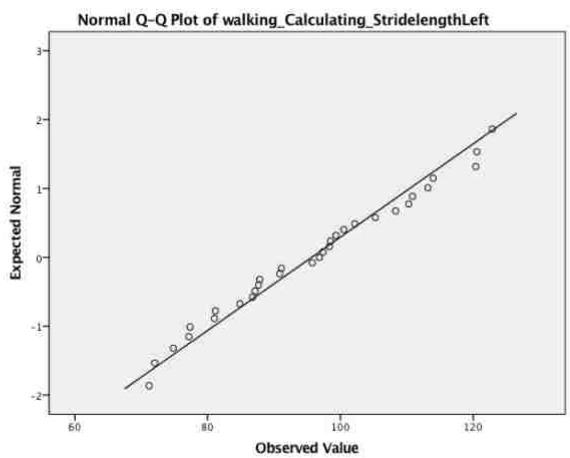

Figure 42. Normal Q-Q plot of stride length for left leg in walking while calculating task.

Figure 42 shows the Q-Q plots supported the above findings: for stride length for left leg in walking while calculating task the dots were close to the diagonal line, which would be expected a normal distribution dots.

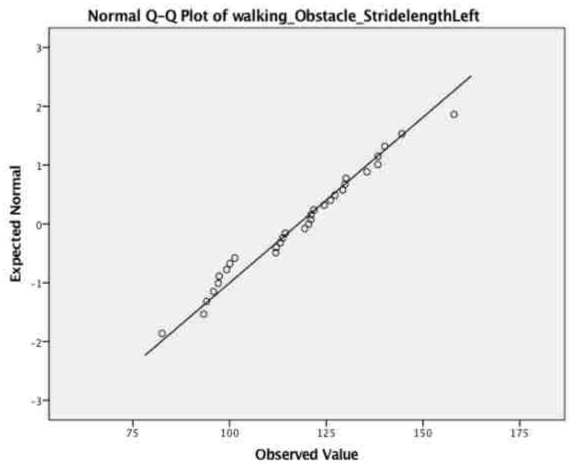

Figure 43. Normal Q-Q plot of stride length for left leg in walking while stepping over obstacle task.

Figure 43 shows the Q-Q plots supported the above findings: for stride length for left leg in walking while talking task the dots were close to the diagonal line, which would be expected a normal distribution dots.

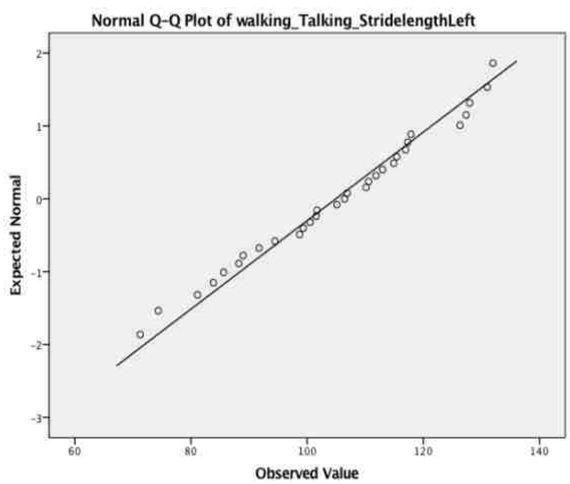

Figure 44. Normal Q-Q plot of stride length for left leg in walking while talking task.

Figure 44 shows the Q-Q plots supported the above findings: for stride length for left leg in walking while talking task the dots were close to the diagonal line, which would be expected a normal distribution dots.

Table 55

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Stride length of left leg of Walking	.460	1	29	.503
Stride length of left leg of Walking & Calculating	.004	1	29	.951
Stride length of left leg of Walking & Stepping Over Obstacle	1.845	1	29	.185
Stride length of left leg of Walking & Talking	1.136	1	29	.295

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + age
Within Subjects Design: stridelengthleft

Table 55 shows the assumption of Levene's test of variances. For the stride length for left leg of walking task, *F* (1, 29) = .46, *p* =.503, for stride length for left leg of walking while calculation task, *F* (1, 29) = .004, *p* =.951, for stride length for left leg of walking while stepping over obstacle task, *F* (1, 29) = 1.84, *p* =185, for stride length for left leg of walking while talking task, *F* (1, 29) = 1.14, *p* =.295. All the conditions of tasks are not significant, which indicates that this assumption has been met.

Table 56

Mauchly's Test of Sphericity[a] For Single Task and Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Stride length of left leg	.841	4.786	5	.443	.907	1.000	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: stridelengthleft
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 56 shows Mauchly's test of Sphericity for single task and dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 56, Sphericity is assumed given that the assumption has been met because there was a nonsignificant difference in variances of differences among four tasks, χ *2* (5) = 4.77, *p* =.443, (ε = .84),

Table 57

Mauchly's Test of Sphericity[a] for Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Stride length of left leg	.983	.487	2	.784	.983	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: stridelengthleft
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 57 shows Mauchly's test of Sphericity for dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 57, Sphericity is assumed given that the assumption has been met because there was nonsignificant difference in variances of differences among three tasks, $\chi 2$ (2) = 49, p =.784, (ε = .98).

Hypothesis 1. Table 58 shows between subject main effect. The main effect for the age classification groups was significant, *F* (1, 29) = 4.37, *p* =.045, partial $\eta 2$ = .131. The partial eta squared is large, which means that 13.1% of variances in stride length for left leg is explained by age classification groups. So, we accept null hypothesis 1. The statistical power (G* power) for the age classifications (between factors) levels was .75 (Figure 45), which requires to increase the sample size up to 36 to reach the statistical power of .8 (Figure 46).

Table 58

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1399273.872	1	1399273.872	1980.043	.000	.986
age	3089.922	1	3089.922	4.372	.045	.131
Error	20493.968	29	706.689			

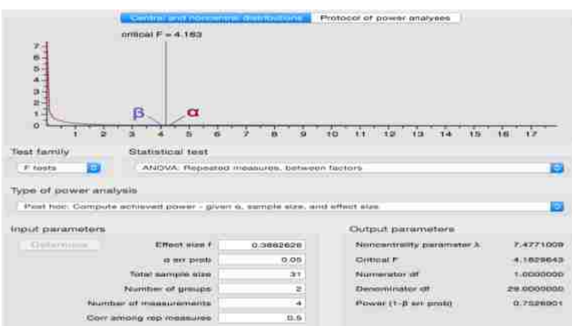

Figure 45. Post hoc to determine the statistical power for level of age classifications factor.

Figure 46. A priori to determine sample size to reach the statistical power of .8 for levels of age groups.

Hypothesis 2. Table 59 shows within subject main effect for single task and dual tasks. The main effect of stride length for left leg was significant, *F* (3,87) = 40.58, *p* =.001, partial $\eta 2$ = .58. The partial eta squared is large, which means that 58 % of the variances in stride length left leg is explained by the task 1 (single task) and task 2 (dual tasks), therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 2. The statistical power (G* power) for single task and dual tasking (within factors) levels was .99 (Figure 47).

Table 59

Tests of Within-Subjects Effects for Single Task and Dual tasks

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Stride length of left leg	Sphericity Assumed	9216.606	3	3072.202	40.582	.000	.583
	Greenhouse-Geisser	9216.606	2.721	3386.977	40.582	.000	.583
	Huynh-Feldt	9216.606	3.000	3072.202	40.582	.000	.583
	Lower-bound	9216.606	1.000	9216.606	40.582	.000	.583
Stride length of left leg * age	Sphericity Assumed	296.647	3	98.882	1.306	.278	.043
	Greenhouse-Geisser	296.647	2.721	109.014	1.306	.279	.043
	Huynh-Feldt	296.647	3.000	98.882	1.306	.278	.043
	Lower-bound	296.647	1.000	296.647	1.306	.262	.043
Error (Stride length of left leg)	Sphericity Assumed	6586.252	87	75.704			
	Greenhouse-Geisser	6586.252	78.914	83.461			
	Huynh-Feldt	6586.252	87.000	75.704			
	Lower-bound	6586.252	29.000	227.112			

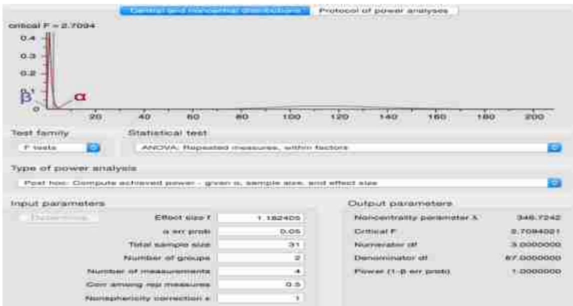

Figure 47. Post hoc to determine the statistical power for levels of task 1 and task 2 factor.

For pairwise comparison (Table 60), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 4 (numbers of pairwise comparisons), so .05/4 = .0125 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Table 60 showed that there was a significant difference in stride length for left leg between walking and walking while calculating, *p* =.001, and between walking and walking while talking, *p* =.001.

Table 60

Pairwise Comparisons

(I) Stride length of left leg	(J) Stride length of left leg	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	19.824*	2.389	.000	13.059	26.589
	3	-2.053	1.967	1.000	-7.623	3.517
	4	10.135*	1.830	.000	4.954	15.317

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Bonferroni.

Hypothesis 3. Table 61 shows within subject main effect for dual tasks. The main effect of stride length for left leg was significant, F (2, 58) = 42.02, p =.001, partial $\eta 2$ = .59. The partial eta squared is large, which means that 59 % of the variances in stride length for left leg is explained by the tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 3. The statistical power (G* power) for dual tasking (within factors) levels was .99 (Figure 48).

Table 61

Tests of Within-Subjects Effects for Dual tasks

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Stride length of left leg	Sphericity Assumed	7257.137	2	3628.568	42.017	.000	.592
	Greenhouse-Geisser	7257.137	1.966	3691.176	42.017	.000	.592
	Huynh-Feldt	7257.137	2.000	3628.568	42.017	.000	.592
	Lower-bound	7257.137	1.000	7257.137	42.017	.000	.592
Stride length of left leg * age	Sphericity Assumed	296.623	2	148.312	1.717	.189	.056
	Greenhouse-Geisser	296.623	1.966	150.871	1.717	.189	.056
	Huynh-Feldt	296.623	2.000	148.312	1.717	.189	.056
	Lower-bound	296.623	1.000	296.623	1.717	.200	.056
Error (Stride length of left leg)	Sphericity Assumed	5008.841	58	86.359			
	Greenhouse-Geisser	5008.841	57.016	87.849			
	Huynh-Feldt	5008.841	58.000	86.359			
	Lower-bound	5008.841	29.000	172.719			

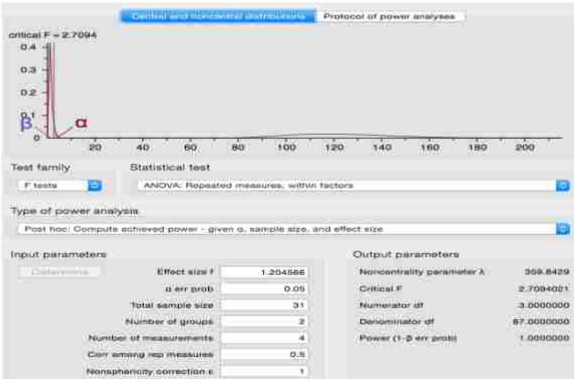

Figure 48. Post hoc to determine the statistical power for levels of task 2 factor.

For pairwise comparison (Table 62), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 3 (numbers of pairwise comparisons), so .05/3 = .016 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Therefore, there was a significant difference in stride length for left leg between walking while calculating and walking while stepping over obstacle, *p* =.001, and between walking while calculating and walking while talking, *p* =.001. Furthermore, there was a significant difference in stride length for left leg between walking while stepping over obstacle and walking while talking, *p* =.001.

Table 62

Pairwise Comparisons

(I) Stride length left		Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-21.877*	2.544	0.000	-28.341	-15.414
	3	-9.689*	2.319	0.001	-15.581	-3.797
2	1	21.877*	2.544	0.000	15.414	28.341
	3	12.189*	2.305	0.000	6.332	18.046
3	1	9.689*	2.319	0.001	3.797	15.581
	2	-12.189*	2.305	0.000	-18.046	-6.332

Hypothesis 4. Table 59 shows the main effect of tasks conditions x age groups interaction. The main effect of tasks conditions x age groups interaction was not significant, *F* (3,87) = 1.31, *p* =.278, partial $\eta 2$ = .04. The partial eta squared is quite medium, which means that 4% of the variances in stride length left leg is explained by the interaction of the two independent variables. So, we accept the null hypothesis 4. The statistical power (G* power) for task X age groups interaction was .8 (Figure 49).

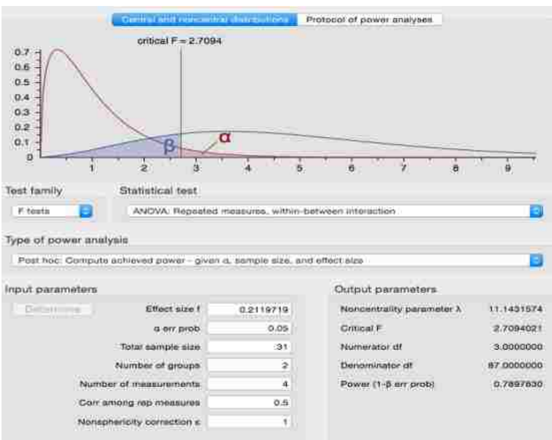

Figure 49. Post hoc to determine the statistical power to the interaction between levels of task conditions and age groups.

The interaction between independent variables on stride length for left leg shows that young-old adults group had higher stride length for left for all tasks (task1 and task 2). For young adults group, walking while stepping over obstacle had higher stride length for left leg, whereas walking while calculating had the lowest stride length. For old adults group, walking and walking while stepping over obstacle had higher stride length for left leg, whereas walking while calculating had the lowest stride length for leg left (Figure 50).

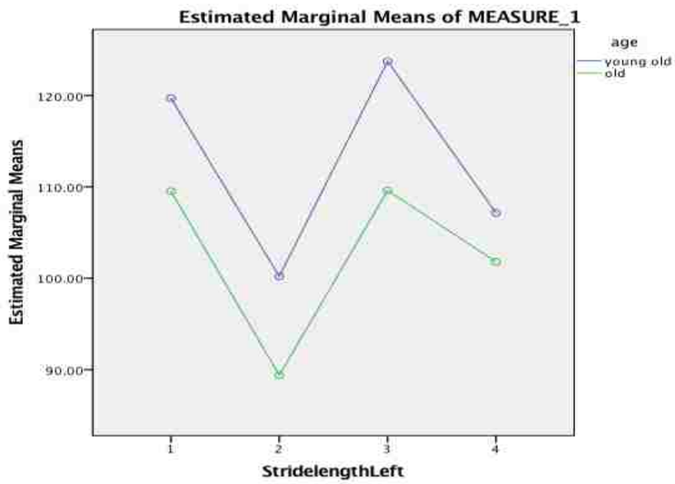

Figure 50. The interaction between both independent variables on stride length for left leg.

Stride Length: Right Leg (cm)

The table of descriptive statistics (Table 63) shows the mean and standard deviation at the two different independent levels. For stride length for right leg in young-old adults group, the descriptive statistics of walking task was *M*= 116.56, *SD*= 17.37, the descriptive statistics of walking while calculating was, *M*= 99.03, *SD* = 15.12, the descriptive statistics of walking while stepping over obstacle was, *M*= 119.75, *SD* = 19.69, and the descriptive statistics of walking while talking was, *M*= 107.7, *SD* = 16.42. For stride length for right leg in old adults group, the descriptive statistics of walking task was *M*= 110.47, *SD* = 16.48, the descriptive statistics of walking while calculating was, *M*= 89.93, *SD* = 16.2, the descriptive statistics of walking while stepping over obstacle was, *M*= 109.69, *SD* = 20.28, and the descriptive statistics of walking while talking was, *M*= 101.32, *SD* = 13.01. The highest stride length for right leg mean was for the young-old adults group in walking while stepping over obstacle task whereas the lowest stride length for right leg mean was for old adults group in walking while calculating.

Table 63

Descriptive Statistics

	Stride length of right leg of Walking	Stride length of right leg of Walking & Calculating	Stride length of right leg of Walking & Stepping Over Obstacle	Stride length of right leg of Walking & Talking
Mean	114.0032	95.2143	115.5314	105.0255
Std. Deviation	17.00062	15.97914	20.24305	15.18792
N	31	31	31	31

Assumption. The assumption was assessed to make sure that the statistical design is an appropriate method to analyze the data. The dependent variable (stride length for right leg) is normally distributed for each combination of the groups of the two factors except for walking while talking (Table 64). Furthermore, the stride length for right leg is a ratio scale. The populations are homogeneity of variance (Table 65). The homogeneity of variance of differences = Mauchly's test of sphericity (Table 66) for single task and dual tasking and (Table 67) for dual tasking only. The samples were randomly from the population. Additionally, the samples are independent from each other for the old people groups. In conclusion, the samples are related to each other in task conditions.

Table 64

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Stride length of right leg of Walking	.141	31	.122	.941	31	.088
Stride length of right leg of Walking	.112	31	.200*	.954	31	.198
Stride length of right leg of Walking	.147	31	.084	.950	31	.153
Stride length of right leg of Walking	.094	31	.200*	.978	31	.762

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 64 shows that Shapiro-Wilk test was not significant deviation from normality for stride length for right leg at walking task, D (31) = .94, p =.088, at walking while calculating task, D (31) = .95, p =.198, at walking while stepping over obstacle, D (31) = .95, p =.153, and at walking while talking, D (31) = .98, p =.762.

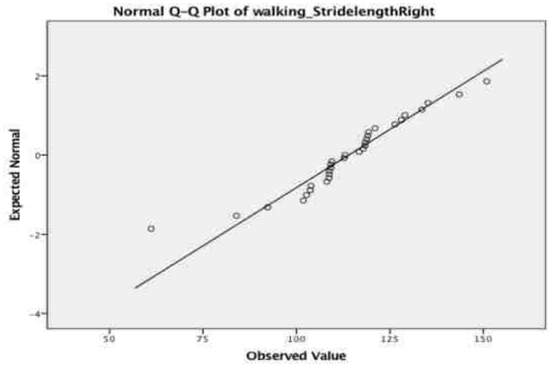

Figure 51. Normal Q-Q plot of stride length for right leg in walking task.

Figure 51 shows the Q-Q plots supported the above findings: for stride length for right leg in walking task the dots were close to the diagonal line that would be expected from a normal distribution dots.

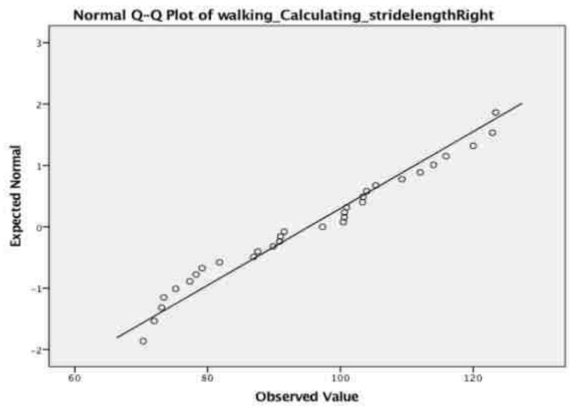

Figure 52. Normal Q-Q plot of stride length for right leg in walking while calculating task.

Figure 52 shows the Q-Q plots supported the above findings: for stride length for right leg in walking while calculating task the dots were close to the diagonal line, which would be expected a normal distribution dots.

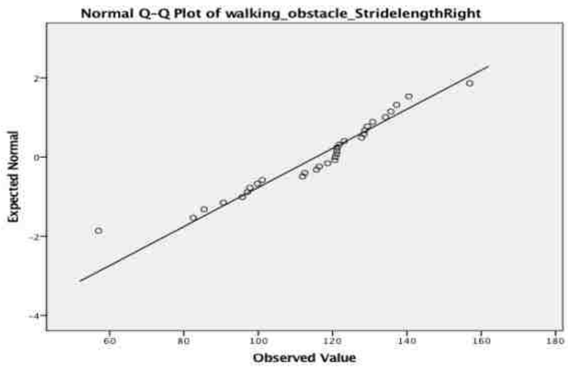

Figure 53. Normal Q-Q plot of stride length for right leg in walking while stepping over obstacle task.

Figure 53 shows the Q-Q plots supported the above findings: for stride length for right leg in walking while talking task the dots were close to the diagonal line, which would be expected a normal distribution dots.

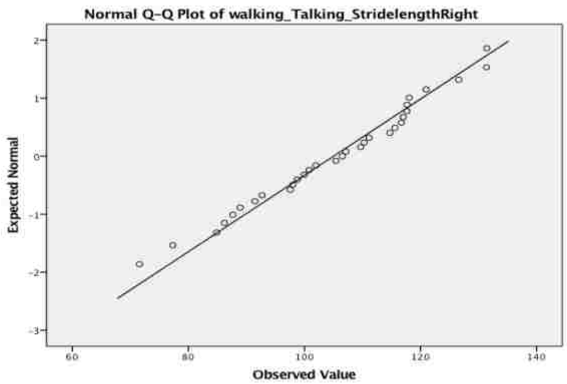

Figure 54. Normal Q-Q plot of stride length for right leg in walking while talking task.

Figure 54 shows the Q-Q plots supported the above findings: for stride length for right leg in walking while talking task the dots were close to the diagonal line, which would be expected a normal distribution dots.

Table 65

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Stride length of right leg of Walking	.003	1	29	.956
Stride length of right leg of Walking	.414	1	29	.525
Stride length of right leg of Walking	.655	1	29	.425
Stride length of right leg of Walking	1.170	1	29	.288

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + age
Within Subjects Design: stridelengthright

Table 65 shows the assumption of Levene's test of variances. For stride length for right leg of walking task, F (1, 29) = .003, p =.956, for stride length for right leg of walking while calculation task, F (1, 29) = .41, p =.525, for stride length for right leg of walking while stepping over obstacle task, F (1, 29) = .65, p =.425, for stride length for right leg of walking while talking task, F (1, 29) = 1.17, p =.288. All the conditions of tasks are not significant, which indicates that this assumption has been met.

Table 66

Mauchly's Test of Sphericity[a] For Single Task and Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Stride length of right leg	.700	9.880	5	.079	.828	.943	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: stridelengthright
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 66 shows Mauchly's test of Sphericity for task 1 (single task) and task 2 (dual tasks), which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 66, Sphericity is assumed given that the assumption has been met because there was nonsignificant difference in variances of differences among four tasks, $\chi 2$ (5) = 9.88, p =.079, (ε = .7).

Table 67

Mauchly's Test of Sphericity[a] for Dual tasks

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Stride length of right leg	.952	1.368	2	.505	.955	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept + age
Within Subjects Design: stridelengthright
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Table 67 shows Mauchly's test of Sphericity for dual tasks, which is used to check the equality of variances of differences between the conditions of tasks. As noted in Table 67, Sphericity is assumed given that the assumption has been met because there was nonsignificant difference in variances of differences among three tasks, $\chi 2$ (2) = 1.37, p =.505, (ε = .95).

Hypothesis 1. Table 68 shows between subject main effect. The main effect for the age classification groups was not significant, F (1, 29) = 2, p =.168, partial $\eta 2$ = .06. The partial eta squared is medium, which means that 6% of variances in stride length for right leg is explained by age classification groups. So, we accept null hypothesis 1. The statistical power (G* power) for the age classification (between factors) levels was .43 (Figure 55), which requires to increase the sample size up to 74 to reach the statistical power of .8 (Figure 56).

Table 68

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1377732.491	1	1377732.491	1461.177	.000	.981
age	1887.733	1	1887.733	2.002	.168	.065
Error	27343.879	29	942.892			

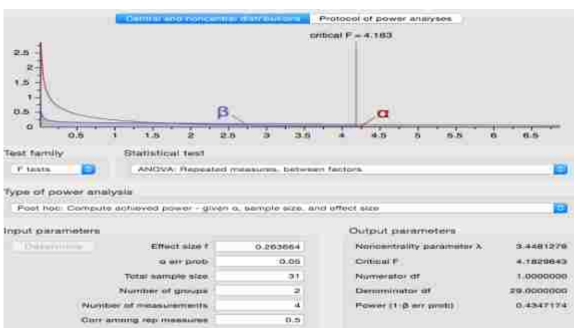

Figure 55. Post hoc to determine the statistical power for level of age classifications factor.

Figure 56. A priori to determine sample size to reach the statistical power of .8 for levels of age groups.

Hypothesis 2. Table 69 shows within subject main effect for single task and dual tasks. The main effect of stride length for right leg was significant, *F* (3,87) = 37.25, *p* =.001, partial $\eta 2$ = .56. The partial eta squared is large, which means that 56 % of the variances in stride length for right leg is explained by the single task and dual tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 2. The statistical power (G* power) for single task and dual tasking (within factors) levels was .99 (Figure 57).

Table 69

Tests of Within-Subjects Effects for Single Task and Dual tasks

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Stride length of right leg	Sphericity Assumed	7995.059	3	2665.020	37.252	.000	.562
	Greenhouse-Geisser	7995.059	2.483	3219.560	37.252	.000	.562
	Huynh-Feldt	7995.059	2.828	2827.398	37.252	.000	.562
	Lower-bound	7995.059	1.000	7995.059	37.252	.000	.562
Stride length of right leg * age	Sphericity Assumed	88.696	3	29.565	.413	.744	.014
	Greenhouse-Geisser	88.696	2.483	35.717	.413	.707	.014
	Huynh-Feldt	88.696	2.828	31.367	.413	.732	.014
	Lower-bound	88.696	1.000	88.696	.413	.525	.014
Error (Stride length of right leg)	Sphericity Assumed	6223.936	87	71.539			
	Greenhouse-Geisser	6223.936	72.015	86.426			
	Huynh-Feldt	6223.936	82.004	75.898			
	Lower-bound	6223.936	29.000	214.618			

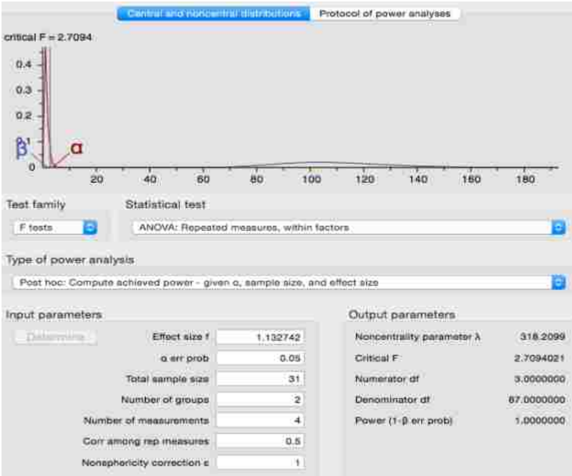

Figure 57. Post hoc to determine the statistical power for levels of task 1 and task 2 factor.

For pairwise comparison (Table 70), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 4 (numbers of pairwise comparisons), so .05/4 = .0125 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Table 70 showed that there was a significant difference in stride length for right leg between walking and walking while calculating, p =.001, and between walking and walking while talking, p =.001

Table 70

Pairwise Comparisons

(I) Stride length for right leg	(J) Stride length for right leg	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
1	2	18.789*	2.224	.000	14.247	23.331
	3	-1.528	1.682	.371	-4.964	1.907
	4	8.978*	1.724	.000	5.458	12.498

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Hypothesis 3. Table 71 shows within subject main effect for dual tasks. The main effect of stride length for right leg was significant, *F* (2,58) = 35.66, *p* =.001, partial $\eta 2$ = .55. The partial eta squared is large, which means that 55 % of the variances in stride length for right leg is explained by the tasks, therefore we can understand why we do see significance in the time effect. So, we reject null hypothesis 3. The statistical power (G* power) for dual tasking (within factors) levels was .99 (Figure 58).

Table 71

Tests of Within-Subjects Effects for Dual tasks

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Stride length of right leg	Sphericity Assumed	6184.440	2	3092.220	35.656	.000	.551
	Greenhouse-Geisser	6184.440	1.909	3239.618	35.656	.000	.551
	Huynh-Feldt	6184.440	2.000	3092.220	35.656	.000	.551
	Lower-bound	6184.440	1.000	6184.440	35.656	.000	.551
Stride length of right leg * age	Sphericity Assumed	55.381	2	27.691	.319	.728	.011
	Greenhouse-Geisser	55.381	1.909	29.011	.319	.718	.011
	Huynh-Feldt	55.381	2.000	27.691	.319	.728	.011
	Lower-bound	55.381	1.000	55.381	.319	.576	.011
Error (Stride length of right leg)	Sphericity Assumed	5029.961	58	86.723			
	Greenhouse-Geisser	5029.961	55.361	90.857			
	Huynh-Feldt	5029.961	58.000	86.723			
	Lower-bound	5029.961	29.000	173.447			

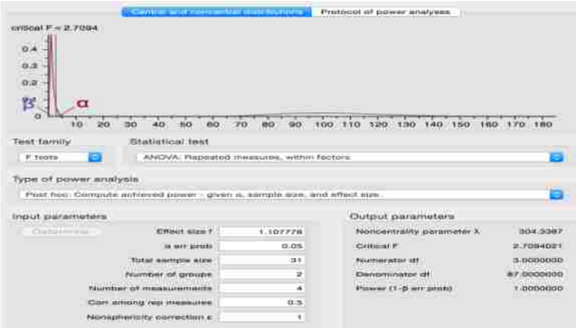

Figure 58. Post hoc to determine the statistical power for levels of task 2 factor.

For pairwise comparison (Table 72), it was conducted to determine where the difference lied. Bonferroni was used, so we divided alpha (.05) by 3 (numbers of pairwise comparisons), so .05/3 = .016 (to control Type I error) and so on (known as Holmes correction [Field, 2013]).

Therefore, there was a significant difference in stride length for right leg between walking while calculating and walking while stepping over obstacle, *p* =.001, and between walking while calculating and walking while talking, *p* =.001. Furthermore, there was a significant difference in stride length for right leg between walking while stepping over obstacle and walking while talking, *p* =.001.

Table 72

Pairwise Comparisons

(I) Stride length right		Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-20.240*	2.636	0.000	-26.937	-13.542
	3	-10.031*	2.199	0.000	-15.619	-4.444
2	1	20.240*	2.636	0.000	13.542	26.937
	3	10.208*	2.335	0.000	4.276	16.141
3	1	10.031*	2.199	0.000	4.444	15.619
	2	-10.208*	2.335	0.000	-16.141	-4.276

Hypothesis 4. Table 69 shows the main effect of tasks conditions x age groups interaction. The main effect of tasks conditions x age groups interaction was not significant, *F* (3, 87) = .41, *p* =.744, partial *η2* = .01. The partial eta squared is small, which means that 1% of the variances in stride length for right leg is explained by the interaction of the two independent variables. So, we accept the null hypothesis 4. The statistical power (G* power) for task X age groups interaction was .3 (Figure 59), which requires to increase the sample size up to 98 to reach the statistical power of .8 (Figure 60).

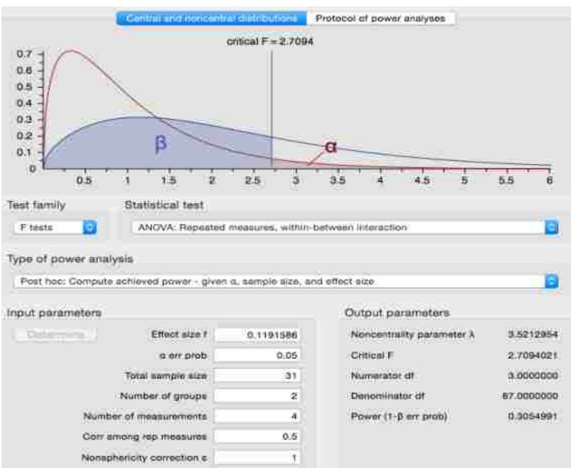

Figure 59. Post hoc to determine the statistical power to the interaction between levels of task conditions and age groups.

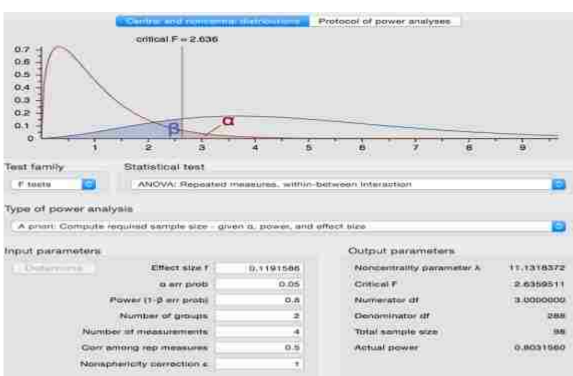

Figure 60. A priori to determine sample size to reach the statistical power of .8 for the interaction between levels of task conditions and age groups.

The interaction between independent variables on stride length for right leg shows that young-old adults group and old adults group had quite similar stride length for right leg for walking and walking while stepping over obstacle. For walking while calculating and walking while talking, the old adults group had higher stride length for right leg than young-old adults group (Figure 62).

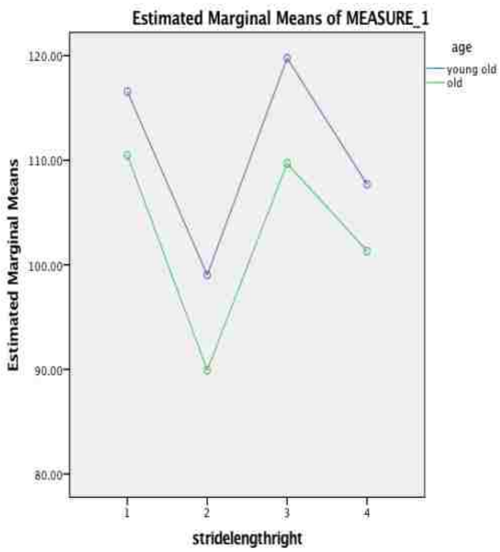

Figure 62. The interaction between both independent variables on stride length for right leg.

Dual tasking costs

Dual task cost assesses the effect of performing dual tasking compared to a single task (Bock, 2008; McIaas et al., 2015). Dual tasking cost can be calculated for each subject and task based on this formula: Dual Tasking Cost (%) = $\frac{Single\ task - Dual\ task}{Single\ task} \times 100$. Bock (2008) mentioned that the high cost of the dual tasking reflects the deficits of performing dual tasking compared to a single task due to the complexity of the task. The dual tasking cost increased as the complexity of the task increased for both groups (Figure 63 & Figure 64). 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).

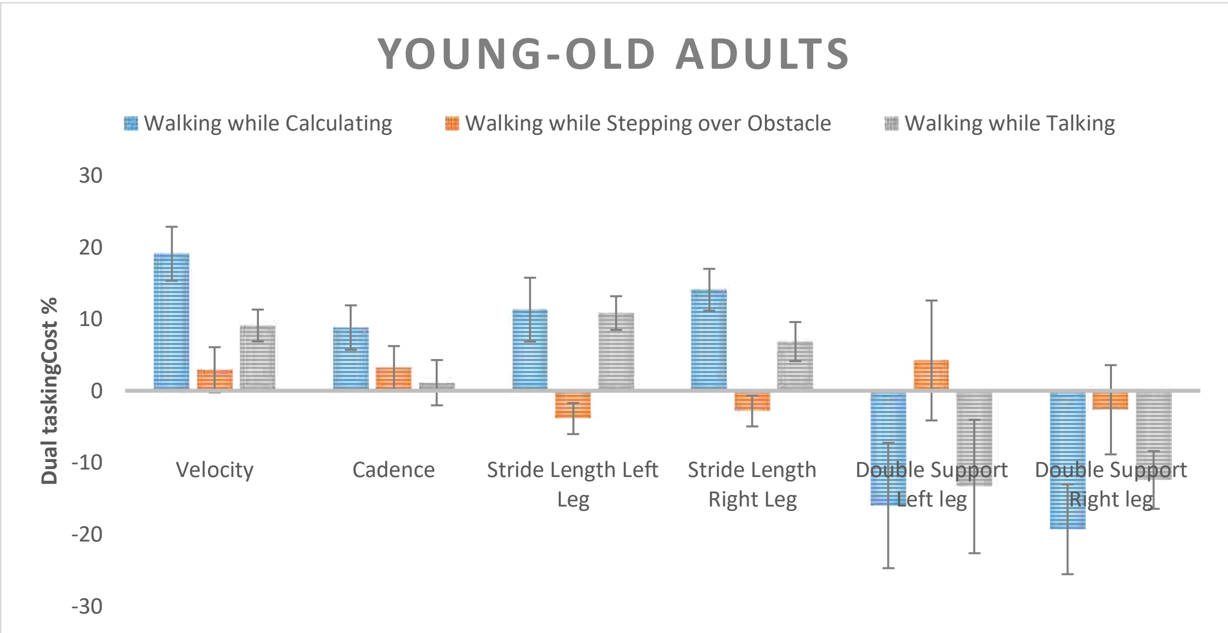

Figure 63. Dual tasking cost on young-old adults.

Figure 64. Dual tasking cost on old adults.

Three Additional Questions

When participants were asked, “What do you usually do when you walk? ”, 5 participants of the young-old adults group and 1 participants of the old adults group mentioned that they talk on the phone, 4 participants of the young-old adults group and 8 participants of the old adults group noted that they talk with friends, 2 participants of the young-old adults group and 1 participants of the old adults group noted that they carry bags, 3 participants of the young-old adults group and 2 participants of the old adults group noted that they listen to music, 1 participants of the young-old adults group noted that they pray the rosary, 2 participants of the young-old adults group noted that they just walking, 1 participants of the old adults group noted doing Croshea, and 1 participants of the young-old adults group mentioned that they think (Table 73).

Table 73

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

When participants were asked, “How often do you walk and do something else at the same time?”, 8 participants of the young-old adults group and 8 participants of the old adults group mentioned that they were always performing dual tasks, 5 participants of the young-old adults group and 3 participants of the old adults group noted performing dual tasking sometimes, 1 participants of the young-old adults group and 1 participants of the old adults group noted performing dual tasking rarely, 1 participants of the young-old adults group noted performing dual tasking once a month, 1 participants of the young-old adults group and 1 participants of the old adults group noted never performing dual tasks, and 2 participants of the young-old adults group noted performing dual tasking once a week (Table 74).

Table 74

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

When the participants were asked, “Which part of experiment was the most challenging for you during performing the study?”, 16 participants of the young-old adults group and 10 participants of the old adults group mentioned that walking while calculating was more challenge for them, 1 participants of the old adults group noted that walking while stepping over obstacle was more challenge, 1 participants of the old adults group mentioned that walking while talking was more challenge, and 2 participants of the young-old adults group and 1 participants of the old adults group) said that none of the dual tasking was challenging for them (Table 75).

Table 75

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

The Responses for the Secondary Task While Performing Dual Task

After the participants' responses to calculator's question and to polar question (sitting and walking), the primary investigator analyzed the errors. For the responses of walking while calculating, there was no significant difference between the means of the two groups (t (20.36) = .41, p = .682) (Table 76). Furthermore, for the responses of walking while talking, there was no significant difference between the means of the two groups (t (29) = -3.07, p = .761) (Table 77).

Table 76

Independent Samples Test for Reponses of Walking While Calculating

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Calculating responses	Equal variances assumed	4.568	.041	-.439	29	.664	-.34615	.7887	-1.95937	1.26706
	Equal variances not assumed			-.415	20.364	.682	-.34615	.8339	-2.08377	1.39146

Table 77

Independent Samples Test for Reponses of Walking While Talking

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Talking responses	Equal variances assumed	.834	.369	.307	29	.761	.35897	1.16827	-2.030	2.7483
	Equal variances not assumed			.292	20.781	.773	.35897	1.23003	-2.200	2.9186

CHAPTER 5

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, Horslen, Carpenter, Adkin, 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.

Conclusion

This study intended to assess the effects of dual tasking—which requires different levels of cognitive and motor demands—on gait parameters in the community-living healthy elderly population. It appeared that the spatiotemporal parameters of gait significantly changed between walking versus walking while engaging in a secondary task, and between walking while engaging in different types of dual tasks: fine motor-motor tasks, cognitive task, and gross motor-motor tasks. However, this study showed that the age classifications— young-old adults versus old adults—did not impact the spatiotemporal parameters of gait. Additionally, the interaction between the age classifications and the types of dual tasking on the spatiotemporal parameters of gait was not significant.

Our observations support the findings of other studies specific to the notions that the more complex the secondary task, the greater the impact there is on the spatiotemporal parameters of gait in the elderly. Furthermore, we believe that exploring participant's individual characteristics can help to positively address their ability to walk and perform the secondary task.

As we reflect upon our findings we believe that our work by virtue of the task we explored, specifically the walking while calculating, that vision plays a significant role in dual tasking. Vision in our task played a critical role as the task requirements created contextual interference for the elderly, which inherently divided their visual attention thereby requiring competition for limited vision resources. Therefore, when combining two tasks that require visual processing, the elderly may coordinate two resources of visual information by; (a) one is used to navigate the environment and (b) the another one is used for the secondary task, which exceeds the attentional demands of the secondary task.

The impairment ability to allocate attention while walking occurs when the secondary task is required to be performed due to four possible explanations. First, the participants direct their attention to the secondary task and do not respond to physical hazards in the environment. Second, the participants had the inability to shift attention between two tasks. Third, the participants decreased the attentional capacity. Fourth, the participants increased the demands for the secondary task. Therefore, performing dual task plays a critical role to predict falls for the elderly.

Based upon our observations, physical therapists and employees at senior housing facilities must seek to prevent secondary impairments that might result from the elderly not effectively dual tasking. As health care professionals, we must ensure safety while promoting functional independence in the elderly population. We believe, the first step is realizing that all tasks are not created equally and that by providing opportunities for the elderly to learn to develop successful strategies to meet the demands of differing types of dual tasks: cognitive task, fine motor-motor tasks, and gross motor-motor tasks, we are promoting their independence.

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Appendix A

Informed consent

SETON HALL UNIVERSITY
1 8 5 6

Informed Consent

Researchers Affiliation

My name is Mohammed Alsaeed, and I am the primary investigator (PI) for this study. I am a doctoral student in Department of Interprofessional Health Science and Health Administration, School of Health Science and Medical Science at Seton Hall University. This study project will have two assistant researchers, Mazen Homoud and Faisal Turkestani, who are doctoral students in Department of Interprofessional Health Science and Health Administration, School of Health Science and Medical Science at Seton Hall University.

Research Purpose

The purpose of the study is to find out how doing two tasks at once (dual tasking) affects gait in the elderly. The results of this study will help us learn what types of dual task affect the gait patterns in the elderly and help us reduce the rate of falls.

Procedure

When participants arrive at the testing site, the PI will greet them and ask them to read and sign the informed consent form. After the participants sign the consent form, the PI will answer any question(s).

After that, the PI will assess the participants' cognitive abilities using the Mini Mental State Examination (MMSE), which is a simple tool consisting of ability to tell time, place, immediate recall, short term memory, and language ability. To assess walking, the participants will be required to complete the Dynamic Gait index (DGI), which includes walking while turning your head and walking up and down 4 stairs. To assess balance, the participants will be asked to complete the time up and go test (TUG), which includes standing up from a chair, walking 3 meters, turning around, walking back, and sitting back again. None of these tools will be placed on the participants' bodies. All tools are standard tools used by physical therapists and are valid and reliable

If the participant is eligible to continue, the PI will measure the participant's both right and left leg lengths. Specifically, the PI [who is a male] will take a cloth tape measure and measure from the top of the greater trochanter (hip joint) to the floor. In order to take this measurement, the PI's hands will come in contact with the participants'clothing, which covers their hip joints. The participant then will be asked to pick from two folders that have the same set of study tests but in different orders. The PI will place a gait belt around the participants' waists for safety reasons. A gait belt looks like a standard belt used to hold up pants and allows physical therapists a safe place to grab if needed during walking.

For all tasks, the participant will stand at the start marker tape and wait. Then the PI will say, "Ready, go." After that, the participants will start to walk over the GAITRite system (vinyl mat with embedded sensors, which sends data to a laptop) at a normal speed until the participants reach the stop marker tape.

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JUN 1 2 2018

School of Health and Medical Sciences
Department of Interprofessional Health Sciences and Health Administration
Tel: 973.275.2076 • Fax: 973.275.2171
400 South Orange Avenue • South Orange, New Jersey 07079 • gradmeded.shu.edu

The participants will be required to walk several times over the mat. In a random order, the participants will 1) walk on the mat at their own pace, 2) walk at a normal speed and step over an obstacle, 3) walk on the mat at normal speed, hear yes or no questions that will provide by the external speaker, and answer them loudly until they reach the end line, (the participants can say "SKIP" if they cannot hear the question or do not understand it), and 4) hold a calculator using two hands, walk, listen to the calculation questions from the external speaker, solve it, and say the result loudly until they reach the end line. At the end of the study, the participants will sit on a chair. After 2 minutes, the PI will ask the participants to respond to spoken yes or no questions again, and the participants will answer them loudly. The participants can say "SKIP" if they cannot hear the question or do not understand it. the PI will sit in front of the participants and write down their answers. Next, the PI will read out to the participants three questions around doing two things at once dual tasking questions and ask the participants to respond to each one verbally. The PI will write down their responses.

The participants will perform 3 trials under each of the task conditions in random order. The total length of the mat is 4 meters (14 feet). The mat measures the number of steps, the walking speed, and the amount of time spend on both legs while walking. While the participants are performing this test, the PI will be close by for safety reasons. The total time of the session will be around 90 minutes. The participants can ask for more rest time, if needed.

Refusal or Withdrawal of Participation

As a participant, you will receive ($25) as a gift card at the end of the study. you can withdraw consent or refuse to participate at any time without any penalty or risk of any kind.

Anonymity

To ensure anonymity, the participants will be assigned a code. Only the PI will have access to the code. If the PI wants to report this information from this study in a journal or in a professional meeting, the PI will only use the code only.

Confidentiality

All information on participants and data that is gathered during this study will be kept on a USB drive. The USB will be locked in a file cabinet in the PI's home office, whose address is 76 Continental Rd, Morris Plains, NJ 07950. If the PI wants to use these data in future research or publication, the PI will only use the code, not the participants' names. The PI will transfer the Data from GAITRite software system onto a USB memory key and Windows Media Video files, saved on DVD, and securely stored in a separate locked cabinet in the PI's home office.

Access to Research Records

Only the PI will have access to this cabinet via lock and key.

Anticipated Risks/Discomfort

Performing two tasks concurrently is a normal activity needed for day-to-day living. However, there is potential that a participant may feel dizzy or trip during the study. To prepare for any potential issue such as trip or unsteady feeling of the participants, the PI will place a gait belt around participants' waist and walk along the side of the mat during the trials. A gait belt is a standard piece of equipment used to assist in keeping a person safe when walking.

The Department of Health and Human Services requires that you be advised as to the availability of medical treatment if a physical injury should result from research procedures. No special medical arrangements have been made regarding your participation in this project. If you are a registered student at SHU, you are eligible to received medical treatment at the University Health Service. If you are not a registered student at the University, immediate medical treatment is available at usual and customary fees at the local community hospital.

Benefits
This study will increase our knowledge of how to safely doing two things at once in the community. There will be no direct benefits to you as a participant.

Payment/Remuneration
All participants will receive ($25) as a gift card at the end of the study.

Alternative Procedure
This study does not require for intervention or treatment. For that, no recommendations for alternative procedures will be made.

Contact information:
If you have any question or concerns about this study, or if you interested in the results, please do not hesitate to contact:

The primary investigator:
Mohammed Alsaeed,
201-486-7639
alsaeemo@shu.edu

The investigator's advisor:
Genevieve Pinto-Zipp, PT, EdD
973-275-2457
Genevieve.Zipp@shu.edu

Right of research subjects:
If you have any questions about your rights as a research participants, you may contact Seton Hall University Institutional Review Board (IRB) (Mary F. Ruzicka, Ph.D.) by e-mail irb@shu.edu, by or by phone at (972) 313-6314.

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- **I have read and understand the above information. I have had my questions answered to my satisfaction. I consent to participate in the study.**

- **A copy of the consent will be given to you for your records. Your signature will consider as a willingness to participate in the study.**

____

______________________ ______________________

Printed Name of Subject Signature of Subject Date

____

Signature of the PI Date

Subject Code: ______________

Appendix B

Screening protocol

Subject Code: ______________________________

Please read the following questions carefully and respond by using the check mark (√) under yes or no column.

The statement	YES	NO
1. Is your age between 65 to 85 years old?		
2. Are you able to walk at home and outside for 10 feet?		
3. Do you walk using assistive device?		
4. Have you fallen down within the last 6 months?		
5. Do you have any medical problems such as stroke, multiple sclerosis, Parkinsonism etc.		
6. Do you suffer from any medical condition that influences your balance or movement?		
7. Do you suffer from any medical condition or have any problem that limits your ability to hold objects by using both hands?		
8. Do you have uncorrected vision problems that limit your ability to read?		
9. Do you have uncorrected hearing problems that limit your ability to listen?		
10. Are you able to read, write, and speak in English language as the 6^{th} grade level?		

*Note: answering yes to any of the questions (**Except questions # 1,2, &10**) will be excluded from the study.*

- Based upon your responses to the previous questions, you can continue to this study.
- Based upon your responses to the previous questions, you cannot continue to this study. I thank you for your willingness.

Appendix C

Demographic Questions

Please read the following questions carefully and answer them.

Subject Code: ______________________________

1. How old are you? ______________________________ years old.

2. What is your gender? • Male • Female

3. How easy do you find it to use a calculator?

• Very easy • Easy • Neutral • Difficult • Very difficult

4. During the past month, other than your regular job, did you participate in any physical activities or exercises?

• Yes • No If yes, please answer questions 5 and 6.

5. How long do you participate in physical activity or exercise per week?

• Less than 75 minutes • 75 minutes • 150 minutes • More than 150 minutes

6. Please list three types of activities that you usually perform:

1. 2. 3.

Appendix D

Data sheet - Talking while walking

Subject Code: ______________________________

The participant will hear the following questions via headphone and answer them loudly while walking with normal speed:

	Trial 1		Trial 2		Trial 3		# Wrong		
	Yes	No	Yes	No	Yes	No	T1	T2	T3
1. Do you have blue eyes?									
2. Were you born after 1980?									
3. Do you have a dog?									
4. Do you love read fiction books?									
5. Do you exercise every day for 4 hours?									
6. Are you Giant's fan?									

Appendix D1

Data sheet - Talking while sitting

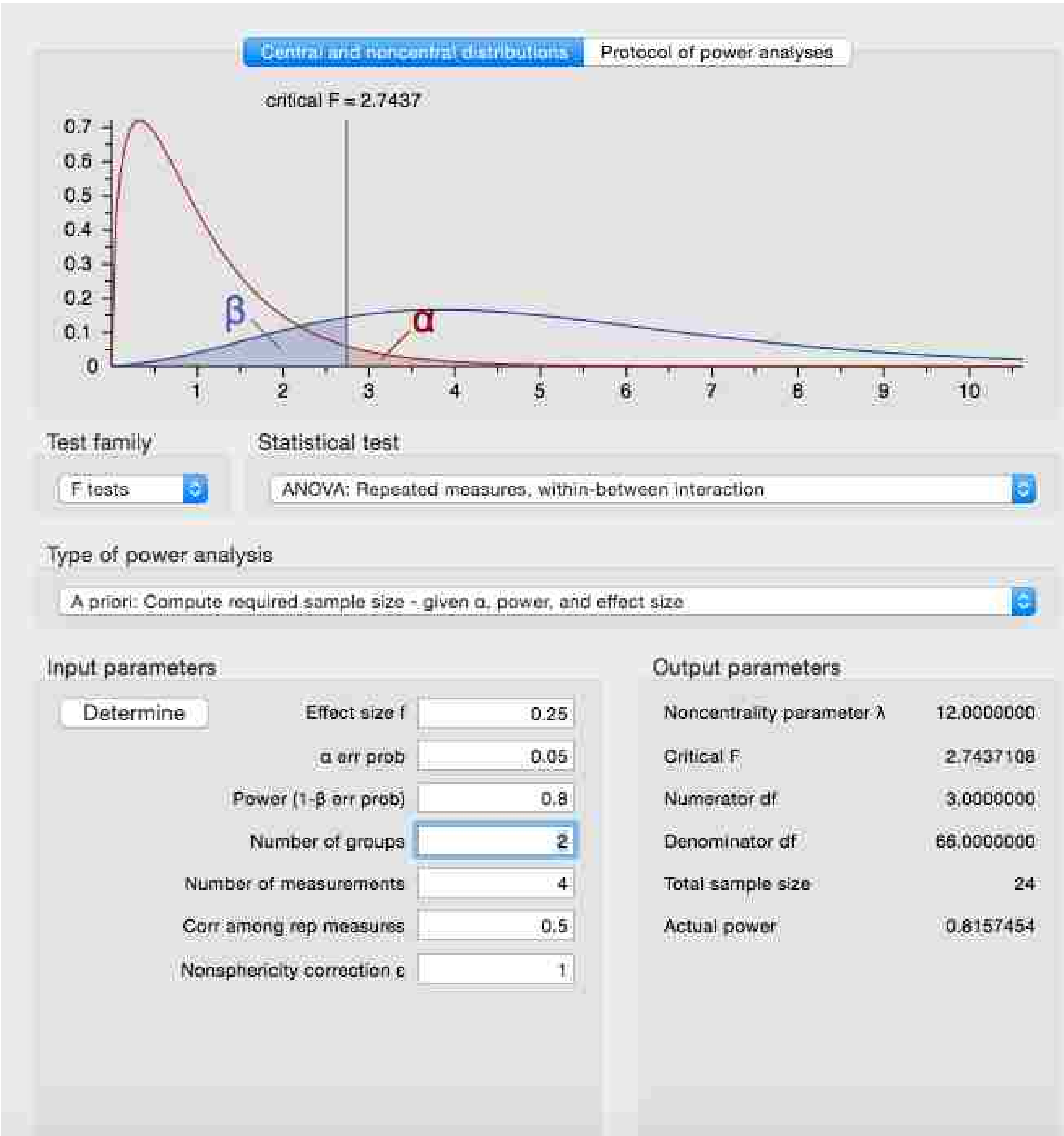
Subject Code: ______________________________

The participant will hear the following questions via speaker and answer them while sitting:

The questions	Answers	
	Yes	No
1. Do you have blue eyes?		
2. Were you born after 1980?		
3. Do you have a dog?		
4. Do you love read fiction books?		
5. Do you exercise every day for 4 hours?		
6. Are you Giant's fan?		

Appendix E

Calculating the number of subjects by using G*Power



Appendix F

Permission letters

CATHOLIC CHARITIES *in the* DIOCESE OF PATERSON
"...providing help, creating hope..."

Catholic Family & Community Services

Divisions
Father English Community Center
Hispanic Information Center of Passaic
Hope House

Mr. Mohammed Alsaeed,

I on behalf of Senior Activities Program, CFCS **agree to have you post your IRB approved study recruitment fliers for "Assessing the effects of dual asking on spatiotemporal parameters of gait in older adults: Exploring age and task demands" at our center.**

I on behalf of Senior Activities Program, CFCS **agree to allow you to physically conduct your IRB approved study for ""Assessing the effects of dual asking on spatiotemporal parameters of gait in older adults: Exploring age and task demands" on site.**

Signature [signature] 5/2/17 **Date**

24 DeGrasse Street - Paterson, NJ 07505-2001 PHONE 973-279-7100 FAX: 973-523-1150 Email: cfcs@catholicharities.org
"Our Mission - to serve people in need, advocate for justice and call people of good will to do the same."

Older Adult Services

900 Clifton Avenue, C-5 Barn Clifton,New Jersey 07013

Phone # 973-470-2234 Fax # (973) 594-1979 Gail Hoogmoed – Supervisor

Mr. Mohammed Alsaeed,

I on behalf of City of Clifton Sr Center **agree to have you post your IRB approved study recruitment fliers for "Assessing the effects of dual asking on spatiotemporal parameters of gait in older adults: Exploring age and task demands" at our center.**

I on behalf of City of Clifton Sr Center **agree to allow you to physically conduct your IRB approved study for ""Assessing the effects of dual asking on spatiotemporal parameters of gait in older adults: Exploring age and task demands" on site.**

Gail Hoogmoed 5/1/17

Signature **Date**

Appendix G1

Recruitment flyer at Senior Living Center in

Paterson, NJ

How do you walk?

Looking for senior adults aged **65 to 85 years old** to join a study that tests **walking** while **adding numbers, talking, and stepping over an obstacle**. From this study's findings, we seek to learn how a senior person completes a task that needs different mental skills, balance abilities, and overall movement control. We hope the study findings will help health care workers decrease the number of falls in senior people when they are doing things and walking at the same time.

- **Where will the study be done?**
  - In the community rooms at Governor Paterson Towers
- **How long will the study take?**
  - Around 90 minutes.
- **Who can participate?**
  - Anyone who is
    - Between 65–85 years old
    - Able to walk without any help for 10 feet
    - Able to read, write, and speak in English at the 6th grade level
    - You must also be able to successfully complete a motor and cognitive tests used by Physical therapists to assess balance
- **Who cannot participate?**
  - People who have,
    - Uncorrected vision or hearing problems
    - Have had pain or stiffness in the lower or upper parts of your body or broken bones in the past 6 months
    - Use an assistive device, such as a walker, cane, or leg brace while walking
    - Any medical condition such as a stroke or nerve problems that affect balance, walking, or movement.
    - If you use a hearing aid

Please Note

- As a subject, you will be asked to complete three standard valid and reliable measurements that are used by physical therapist. 1) Mini Mental State Examination, which will assess your cognitive abilities. 2) Dynamic Gait Index, which will assess your walking abilities. 3) The Time Up and Go, which will assess your balance.
- All subjects will be given a code number to maintain their anonymity.
- Your name will not be used in this research.
- Each person who participates and finishes all the study requirements will receive a **($25) gift card**.

The primary investigator:
Mohammed Alsaeed, Doctoral Student
School of Health and Medical Science
Dep. of Inter-Professional Health Science and Health Administration.
Seton Hall University
201-486-7639 alsaeemo@shu.edu

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Approval Date

Expiration Date
JUN 1 2 2018

Appendix G2

Recruitment flyer at Older Adult Services in

Clifton, NJ

How do you walk?

Looking for senior adults aged **65 to 85 years old** to join a study that tests **walking** while **adding numbers, talking, and stepping over an obstacle**. From this study's findings, we seek to learn how a senior person completes a task that needs different mental skills, balance abilities, and overall movement control. We hope the study findings will help health care workers decrease the number of falls in senior people when they are doing things and walking at the same time.

- **Where will the study be done?**
  - In the main room
- **How long will the study take?**
  - Around 90 minutes.
- **Who can participate?**
  - Anyone who is
    - Between 65–85 years old.
    - Able to walk without any help for 10 feet.
    - Able to read, write, and speak in English at the 6th grade level.
    - You must also be able to successfully complete a motor and cognitive tests used by Physical therapists to assess balance.
- **Who cannot participate?**
  - People who have,
    - Uncorrected vision or hearing problems
    - Have had pain or stiffness in the lower or upper parts of your body or broken bones in the past 6 months
    - Use an assistive device, such as a walker, cane, or leg brace while walking
    - Any medical condition such as a stroke or nerve problems that affect balance, walking, or movement
    - If you use a hearing aid

Please Note

- As a subject, you will be asked to complete three standard valid and reliable measurements that are used by physical therapist. 1) Mini Mental State Examination, which will assess your cognitive abilities. 2) Dynamic Gait Index, which will assess your walking abilities. 3) The Time Up and Go, which will assess your balance.
- All subjects will be given a code number to maintain their anonymity.
- Your name will not be used in this research
- Each person who participates and finishes all the study requirements will receive a **($25) gift card**.

The primary investigator:
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201-486-7639 **alsaeemo@shu.edu**

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Appendix G3

Recruitment flyer at Seton Hall University

How do you walk?

Looking for senior adults aged **65 to 85 years old** to join a study that tests **walking** while **adding numbers, talking, and stepping over an obstacle**. From this study's findings, we seek to learn how a senior person completes a task that needs different mental skills, balance abilities, and overall movement control. We hope the study findings will help health care workers decrease the number of falls in senior people when they are doing things and walking at the same time.

- **Where will the study be done?**
  - In the main room
- **How long will the study take?**
  - Around 90 minutes.
- **Who can participate?**
  - Anyone who is
    - Between 65–85 years old.
    - Able to walk without any help for 10 feet.
    - Able to read, write, and speak in English at the 6th grade level.
    - You must also be able to successfully complete a motor and cognitive tests used by Physical therapists to assess balance.
- **Who cannot participate?**
  - People who have,
    - Uncorrected vision or hearing problems
    - Have had pain or stiffness in the lower or upper parts of your body or broken bones in the past 6 months
    - Use an assistive device, such as a walker, cane, or leg brace while walking
    - Any medical condition such as a stroke or nerve problems that affect balance, walking, or movement
    - If you use a hearing aid

Please Note

- As a subject, you will be asked to complete three standard valid and reliable measurements that are used by physical therapist. 1) Mini Mental State Examination, which will assess your cognitive abilities. 2) Dynamic Gait Index, which will assess your walking abilities. 3) The Time Up and Go, which will assess your balance.
- All subjects will be given a code number to maintain their anonymity.
- Your name will not be used in this research
- Each person who participates and finishes all the study requirements will receive a **($25) gift card**.

The primary investigator:
Mohammed Alsaeed,
School of Health and Medical Science
Dep. of Inter-Professional Health Science
and Health Administration.
Seton Hall University
201-486-7639 **alsaeemo@shu.edu**

Seton Hall University
Institutional Review Board
JUN 12 2017
Approval Date

Expiration Date
JUN 12 2018

Appendix H

Data sheet - Calculating while walking

Subject Code: ____________________________

The subject will hear the following calculation via speaker. The subject will add them by using the calculator. Then the subject will answer them loudly while walking with normal speed

Calculation	Trial 1	Trial 2	Trial 3	# of wrong
15+37+64				
14+36				
8+3+75				
91+ 37+ 80				

Appendix I

Obstacle dropping

Subject Code: ______________________________

The primary investigator will ask the participant to walk and negotiate an obstacle hurdle. The PI will note if the participant hit with any part of their shoe (H), cleared (C) or knocked over (K) the obstacle.

	Number of dropping			**Total**
	Trial 1	**Trial 2**	**Trial 3**	

Appendix J

Three additional questions

Subject Code: ______________________________

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?**

Appendix K

Seton Hall University's IRB approval

REQUEST FOR APPROVAL OF RESEARCH, DEMONSTRATION OR RELATED ACTIVITIES INVOLVING HUMAN SUBJECTS

All material must be typed.

PROJECT TITLE:

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

CERTIFICATION STATEMENT:

In making **this application,** I(we) certify that I(we) have read and understand the University's policies and procedures governing research, development, and related activities involving human subjects. I (we) shall comply with the letter and spirit of those policies. I(we) further acknowledge my(our) obligation to (1) obtain written approval of significant deviations from the originally-approved protocol BEFORE making those deviations, and (2) report immediately all adverse effects of the study on the subjects to the Director of the Institutional Review Board, Seton Hall University, South Orange, NJ 07079.

Mohammed Alsaeed (Principle Investigator) 5-1-2017

RESEARCHER(S) DATE

Please print or type out names of **all researchers below signature. Use separate sheet of paper, if necessary.**

My signature indicates that I have reviewed the attached materials of my student advisee and consider them to meet IRB standards.

Dr. Genevieve Pinto-Zipp
Dr. Ning Zhang
Dr. Fortunato Battaglia

5-1-2017

RESEARCHER'S FACULTY ADVISOR [for student researchers only] DATE

Genevieve Zipp

Please print or type out name below signature

The request for approval submitted by the above researcher(s) was considered by the IRB for Research Involving Human Subjects Research at the May 2017 meeting.

The application was approved ✓ not approved ___ by the Committee. Special conditions were _____ were not ✓ set by the IRB. (Any special conditions are described on the reverse side.)

Mary F. Ruzicka, Ph.D. 6/12/17

DIRECTOR, SETON HALL UNIVERSITY INSTITUTIONAL REVIEW BOARD FOR HUMAN SUBJECTS RESEARCH DATE

Seton Hall University
3/2005

SETON HALL UNIVERSITY
1856

June 12, 2017

Mohammed Alsaeed
76 Continental Road
Morris Plains, NJ 07950

Dear Mr. Alsaeed,

The Seton Hall University Institutional Review Board has reviewed the information you have submitted addressing the concerns for your proposal entitled "Assessing the Effects of Dual Tasking on Spatiotemporal Parameters of Gait in Older Adults: Exploring Age and Task Demands". Your research protocol is hereby approved as revised under full review.

Enclosed for your records are the signed Request for Approval form, the stamped original Consent Form, and the stamped Recruitment Flyers. Make copies only of these stamped forms.

The Institutional Review Board approval of your research is valid for a one-year period from the date of this letter. During this time, any changes to the research protocol must be reviewed and approved by the IRB prior to their implementation.

According to federal regulations, continuing review of already approved research is mandated to take place at least 12 months after this initial approval. You will receive communication from the IRB Office for this several months before the anniversary date of your initial approval.

Thank you for your cooperation.

In harmony with federal regulations, none of the investigators or research staff involved in the study took part in the final discussion and the vote.

Sincerely,

Mary F. Ruzicka, Ph.D.

Mary F. Ruzicka, Ph.D.
Professor
Director, Institutional Review Board

cc: Dr. Genevieve Pinto Zipp