CHAPTER 2

LITERATURE REVIEW

2.1 The prevalence of falls in older adults

Fall is one of the most common and serious health problems among older adults. It is often defined as an unexpectedly, unintentionally coming to rest on the ground, floor, other lower levels (e.g. chair, wall), or contact with a supporting surface (1, 4, 14, 20). Approximately 30% of people over the age of 65 report falls at least once a year. It has been suggested that fall rate increases to 40% among those over the age of 75 (2, 3) and is twice as high in women as in men until the age of 75 years. Among persons aged 65-69 years, 62% report falling outdoors while 38% report falling indoors. However, it has been suggested that the proportion of indoor and outdoor fallers alters with increasing age, that is, 30% of elders aged 85 years and over report falling outdoors and 70% report falling indoors (21).

2.2 Dual-task related gait changes

Falls in older adults commonly occurs during walking (22). Recently, it has been shown that older adults tend to lose their balance and fall during walking while simultaneously performing a secondary task such as walking while talking (1, 9, 14). The dual-task method, which participants are required to perform a gait task and a cognitive task simultaneously, has then been used to investigate the interactions between cognition and the control of gait. For example, Priest et al. (23) examined the effect of age on gait changes during level walking. Nineteen young adults and 23 older adults were asked to walk under four conditions: walking without any secondary tasks; walking while counting backward from 100 by 3s; 4s; and 6s. The results showed decreased stride velocity and increased variability of stride velocity under dual-task conditions compared to single-task condition in both age groups. However, older adults had higher dual-task decrements in stride velocity (Figure 1) and variability of stride velocity compared to younger adults (Figure 2).

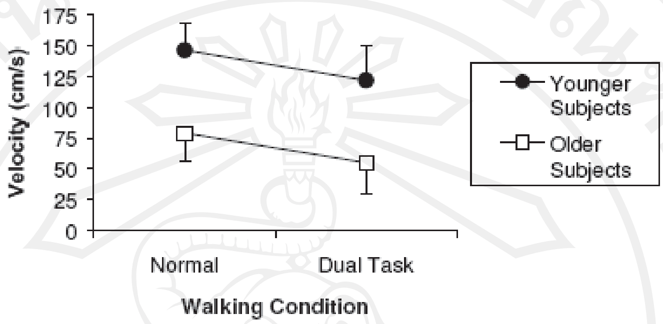

Figure 1 The effect of age and dual task on stride velocity (23)

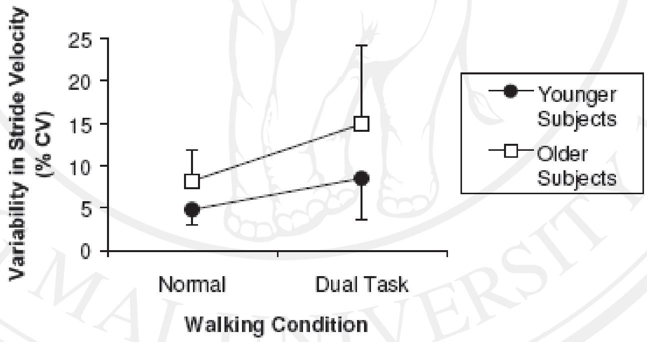

Figure 2 The effect of age and dual task on variability of stride velocity (23)

Similarly, Hollman et al. (5) found decreased gait velocity and increased variability of gait velocity under dual-task conditions compared to single-task condition in young, middle and older adults. These changes were larger in older adults compared to young and middle adults (Figure 3).

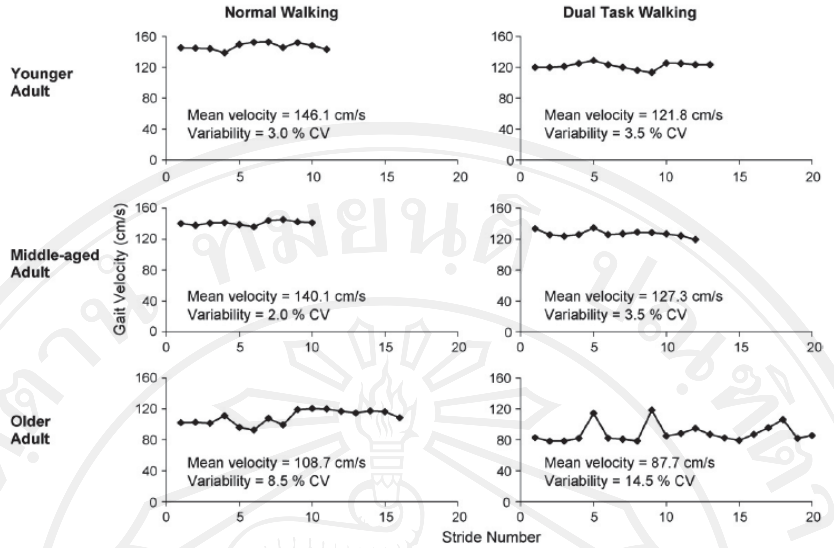

Figure 3 Representative examples of gait velocity and stride-to-stride variability in gait velocity under single-task condition and dual-task condition from one young, one middle-aged, and one older adults (5)

In addition, Springer et al. (15) investigated the effects of age on gait variability in 19 young adults, 24 healthy older adults, and 17 older adults with a history of fall. Four different conditions were tested in the study: 1) walking without any secondary task; 2) walking while performing the simple phoneme monitoring task (i.e. walking while listening to a text via headphone, and then answered 10 multiple-choice questions); 3) walking while performing the complex phoneme monitoring task (i.e. walking while listening to a text via headphone, and count the number of times that the prespecified word appeared); and 4) walking while performing the serial 7 subtraction (i.e. walking while counting backward by seven from 500). The results showed that all groups decreased their gait speed under dual-task conditions (Figure 4). However, increased swing time variability under dual-task conditions compared to single-task condition were found in the elderly fallers, but not in the healthy young and older adult groups (Figure 5).

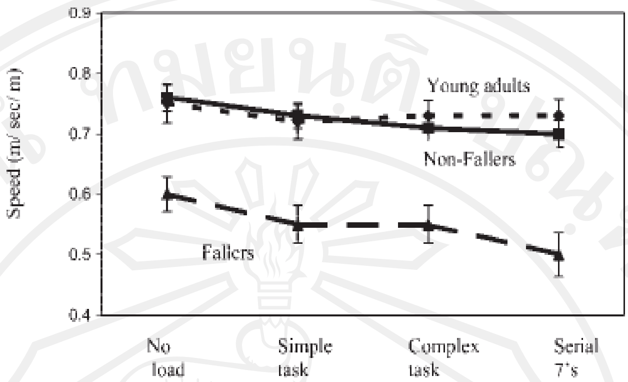

Figure 4 The effects of dual task on gait speed among young adults, healthy older adults, and older fallers (15)

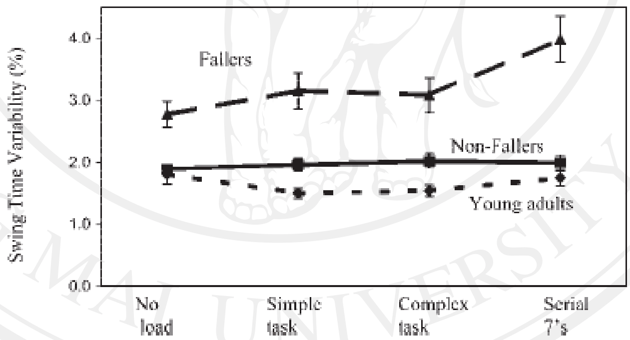

Figure 5 The effects of dual task on swing time variability among young adults, healthy older adults, and older fallers (15).

The relationship between dual-task decrement during walking and recurrent falls has also been investigated. Faulkner et al. (1) investigated association between poorer performance and a history of recurrent falls in 377 community-dwelling older adults. The subjects were asked to perform cognitive tasks (i.e. a simple reaction time and the visual spatial decision task) while performing the "straight walk" task (i.e.

walk 20 meters) and the "turn walk" task (i.e. walk 20 meters with a turn at 10 meters). It was shown that slower walking speed under dual-task conditions (compared to single-task conditions) was associated with the recurrent fall history. Older adults who walked more slowly were at a greater chance of having multiple falls.

Overall, compared with usual walking, gait speed decreased and gait variability increased significantly while walking with the cognitive tasks in older adults, particular in faller older adults. Although dual-task related gait changes have been extensively established in older adults, the factors that contribute to these deficits have not been clearly elucidated.

2.3 The contributing factors to dual-task gait performance

The risk of falling is often categorized into intrinsic (personal) and extrinsic (environmental) factors. Some examples of intrinsic factors include balance impairment, mobility impairment, cognitive impairment, lower extremity weakness, visual deficits, and polypharmacy (i.e. four or more drugs taken per day). Examples of extrinsic factors include poor lighting, slippery surface, inappropriate footwear, and inappropriate furniture (24-28). However, this section will specifically discuss the potential intrinsic contributors which have been suggested to affect dual-task gait performance in the elderly population.

2.3.1 Cognitive function

2.3.1.1 Executive function

Recent research has suggested that maintaining balance during walking requires not only sensorimotor integration but also cognitive function (29). Coppin et al. (30) examined the association between executive function and walking performance under single-task and dual- task conditions in 737 community-dwelling older adults. Executive function was assessed using the Trail Making Test (TMT). In the single-task condition, older adults were asked to walk 7 meters with their usual gait speed and their fast gait speed, and walk 60 meters with their fast gait speed. In the dual-task condition, the older adults were asked to walk with different motor and cognitive tasks e.g. talking, picking up an object from the ground, carrying a light large package, walking over obstacles, and wearing a weighted vest. The results showed that older adults who performed poorly on the TMT (poor executive function) walked significant slower than those who performed better on the TMT (good executive function). The amount of gait changes (percent decline) depended on the nature of the task (e.g. larger gait decrement in "talking while walking task" than in "carrying a large object task").

Springer et al. (15) also investigated the correlation between the executive function and gait performance under single- and dual-task conditions. The results revealed that there was a negative significant correlation between the performance on the executive function tests using the Stroop test and swing time variability, suggesting that poor executive function performers showed high magnitude of inconsistency during gait. In addition, this effect was more pronounced under dual-task condition than single-task condition.

2.3.1.2 Ability to allocate attention

Previous studies suggested that the impairment of executive function was associated with the gait performance under dual-task conditions (15, 30). However, recent research suggested that another factor that may contribute to dual-task gait is the ability to allocate attention. Siu et al. (19) examined the ability to allocate attention between two tasks in healthy older adults and older adults with balance impairment. Twelve healthy older adults and 12 older adults with balance impairment were asked to walk across the obstacle while performing the auditory Stroop task under three instructions: 1) focus on the crossing obstacle task; 2) focus on the auditory Stroop task; and 3) focus on both tasks equally. It was shown that the older adults with balance impairment decreased their ability to allocate attention when performing two tasks at once, compared with healthy older adults.

In summary, cognitive function, in particular executive function and the ability to allocate attention, has been demonstrated to be associated with dual-task gait performance. Thus, older adults with cognitive impairment are at increased risk of falls.

2.3.2 Balance performance

There is no research investigating the effect of balance performance on dual-task gait changes. However, recent research has suggested that the dual-task decrement is often larger in older adults with balance impairment compared to healthy older adults (31, 32). For example, patients with Parkinson's disease showed greater dual-task decrement than healthy older adults. Bond and Morris (31) found that older adults with Parkinson's disease had slower walking speed and decrease in stride length under dual-task condition compared to single-task condition, while there was no difference between conditions in healthy older adults. Likewise, Yogev et al. (32) found that older adults with Parkinson's disease had larger swing time variability under dual-task conditions compared to single-task condition, which this did not show in healthy older adults (Figure 6). Thus, it suggests that not only cognitive function, but also balance performance may be a factor contributing to the dual-task decrement in older adults.

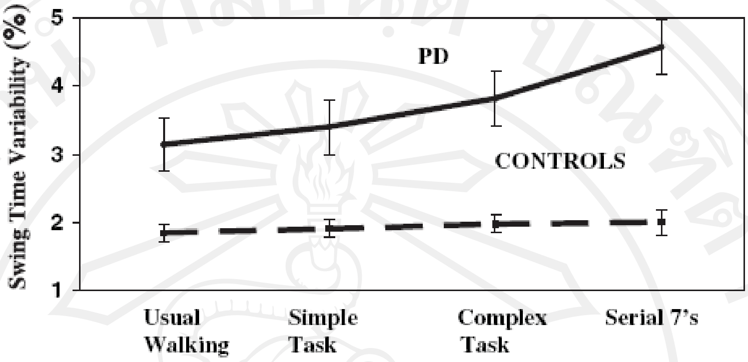

Figure 6 The effects of dual task on gait variability among older adults with Parkinson's disease and healthy older adults (32)

2.3.3 Gait speed

Recent study has suggested that gait performance under dual-task condition can be affected by gait speed. Dubost et al. (33) examined the effect of gait speed on dual-task related changes in stride time variability in healthy older adults. They found that decreased walking speed was associated with increased stride time variability under dual-task condition compared to single-task condition. Thus, gait speed was taken into account in this study.

2.3.4 Balance confidence

To our knowledge, there has been no research investigating the effect of fear of falling on dual-task gait changes. However, it has been suggested that fear of falling has impact on gait and balance under single-task condition among older adults. Herman et al. (34) examined the factors that might be associated with changes in gait among older adults with a higher-level gait disorder (HLGD). Gait variability was found to be significantly associated with the geriatric depression and fear of falling scores in HLGD participants. Menz et al. (35) also found the relationships between fear of falling and gait pattern (i.e. step length) in community-dwelling older adults.

2.3.5 Depression

Depression, a psychological distress, is another factor that can affect gait under dual-task condition. There is no research investigating the effect of depression on dual-task gait changes. However, Lemke et al. (36) demonstrated that depressed participants had significantly slower gait velocity, reduced stride length, double limb support, and cycle duration during walking without any secondary tasks, compared to healthy controls. Likewise, Hausdorff et al. (37) found that depressed participants had slower walking speed, decreased swing time, and increased stride time compared to healthy controls. Swing time variability was also found to be significantly larger in the depressed group than healthy controls.

Although several factors that contribute to the dual-task decrement during walking have been documented, the amount of such factors which affect the dual-task decrement while walking in older adults is still unknown. Hausdorff et al. (18) investigated the factors that might contribute to the dual-task decrements among healthy older adults, including cognitive function, mobility performance, emotional well-being, and usual walking performance. Two hundred and twenty eight older adults were asked to walk under 4 conditions: 1) walking without any secondary tasks; 2) walking while performing the Serial 3 subtraction task (i.e. walking while counting backward by 3s from any three digits); 3) walking while performing the Serial 7 subtraction task (i.e. walking while counting backward by 7s from any three digits); and 4) walking while performing the complex phoneme monitoring task (i.e. walking while listening to a text via headphone, and count the number of times that the two prespecified words appeared). They found that there was a significant correlation between the dual-task deficiency and usual walking performance, as well as the cognitive function. However, the effect between these factors and dual-task decrements were very small. This may due to the ceiling effect in healthy older adults. Furthermore, other factors that may contribute to the dual-task decrements in healthy older adults (e.g. the ability to allocate attention) were not included in the study. Thus, this study was designed to evaluate the effect of factors that could possibly contribute to dual-task deficits during walking in older adults.