CHAPTER 5

DISCUSSION

The purpose of the present study was to investigate the factors that contribute to the dual-task decrements (DTD) during walking in elders. The first hypothesis of this study was that the cognitive function (executive function and ability to allocate attention), balance and mobility performance (balance and gait speed), affect and emotional well-being (balance confidence and depression) were related to the dual-task gait changes among older adults. This hypothesis was partially supported. The results demonstrated that after controlling for possible confounders (i.e. age and number of drugs taken per day), the ability to allocate attention (i.e. priority cost), mobility performance (i.e. gait speed), and history of imbalance (i.e. whether older adults lose balance under the single-task or dual-task conditions) were associated with the dual-task related gait changes. The second hypothesis of this study was that the ability to allocate attention and the balance and mobility performance would have the greatest effect on the dual-task decrements in elders. This second hypothesis was supported. The ability to allocate attention and gait speed were found to have the greatest effect on the dual-task decrement during gait.

The results of this study demonstrated that the DTD in gait speed were mildly correlated with history of imbalance (r = -0.33) and cognitive-priority cost on average swing time (r = 0.30), and moderately correlated with gait speed deriving from Timed 10-Meter Walk test (r = 0.44). Furthermore, in the regression models, after controlling for age and number of drugs taken per day, these three variables accounted for 39% of the variation in the DTD in gait speed. Specifically, gait speed was identified as a greatest influence which accounted for 22% of the variance. This result is consistent with Hausdorff et al.'s study (18) which found that usual gait speed was associated with the DTD in gait speed. Not surprisingly, since dual-task decrement in gait speed was assessed by comparing the gait speed when walked with a cognitive task relative to walked without a cognitive task, gait speed under single-task condition made a significant contribution to the dual-task related gait changes.

The results from this study also demonstrated that the DTD in average swing time were mildly correlated with history of imbalance ($r = 0.28$), cognitive-priority cost on average gait speed ($r = 0.33$), and gait-priority cost on the rate of verbal responses ($r = -0.12$). These three variables accounted for 30% of the variation in the DTD in average swing time after controlling for age and number of drugs taken per day. The greatest influence on the DTD in average swing time was the ability to allocate attention to the cognitive task (i.e. cognitive-priority cost on average gait speed), which accounted for 13% of the variance. In contrast to previous finding, Hausdorff and colleagues (18) found no association between DTD in average swing time and any variables. As we expected that the ability to allocate attention was one of the factors that may contribute to the dual-task decrement, it was not included in the study by Hausdorff et al. This finding is in line with Silsupadol et al.'s studies (49, 50), however, which found that the dual-task performance could be improved by training the ability to shift attention between tasks. Thus, these results support the notion that the ability to flexibly allocate attention is one of the crucial components to successfully walk while performing secondary tasks and that the ability to allocate attention is probably the additional mechanism beyond the sharing resources between two tasks (i.e. capacity-sharing model) (19, 51).

To confirm that the older adults in our study were able to allocate their attention as instructed, each elder was asked to walk while simultaneously performing a cognitive task under three different instructional sets: 1) focus on the gait task; 2) focus on the cognitive task; and 3) focus on both tasks equally. The results showed that when asked to prioritize the gait task, elders walked slower (compared to cognitive-priority condition), spent more time in swing (compared to no-priority condition), and reduced the number of missteps (compared to no-priority and cognitive-priority conditions). Furthermore, when asked to prioritize the cognitive task, elders counted backward more quickly (compared to sitting) and more accurately (compared to gait-priority condition). This finding is consistent with Siu et al. (19) who found that only healthy older adults, not older adults with balance impairment, were able to flexibly shift their attention between the obstacle crossing task and the Stroop task. However, it is important to note that healthy older adults in Siu et al.' study (19) reported no falls in the previous year and scored high on the Berg Balance Score (average BBS = 55.6, out of a total of 56), whereas participants in our study were relatively healthy older adults who scored lower on the balance test (average BBS = 51.7) with many reporting a fall or loss of balance in the previous year. In addition, the effect of task prioritizations varied among gait variables in this study, which the greatest effect was shown on the rate of missteps and rate of verbal and correct responses. This may be due to the fact that the rate of missteps and verbal responses were used as a feedback to the participants whether they actually allocated attention as required.

In addition to DTD in gait speed and average swing time, we also examined the contributing factors to DTD in swing time variability. The results revealed that only gait speed was correlated (r = -0.13) and associated with the DTD in swing time variability (accounted for 9% of the variance). In line with Hausdorff et al.'s study (18) which found only weak associations between DTD in swing time variability and executive function, mobility, and depression. There are several possible explanations for the non-significant associations between the DTD in swing time variability and such variables. Firstly, the factors may affect only certain aspects of gait (i.e. gait speed, and average swing time). Secondly, using GaitRite with limited number of steps might not be the ideal way to obtain the gait variability, which is proposed to be a sensitive measure for balance. Thirdly, they might be the ceiling effect inherent in the balance, balance confidence, and depression tests, therefore no significant correlations were found between these variables and DTD. Finally and more intuitively, several factors including the executive function, balance performance and confidence, and depressive symptoms may only affect walking performance under single-task condition, suggesting that these factors do not contribute to the dual-task processing during walking. These effects were also observed for other gait parameters (i.e. gait speed and swing time).

The findings from this study provide further evidence to support the idea that the concurrent attentionally-demanding cognitive task has a deleterious effect on gait in older adults. Consistent with previous studies (1, 5, 15, 23), when walking while simultaneously performing a cognitive task, elders walked slower, spent more time in swing, and demonstrated greater gait variability. The same effects were observed even when the walking task became more difficult (i.e. narrow walking).

It should be noted, however, that the concurrent cognitive task has a deleterious effect only on some aspects of gait (i.e. gait speed, swing time and swing time variability), not on the rate of missteps. When walking while performing a cognitive task, the rate of missteps decreased compared to walking without any secondary task. In addition, the rate of verbal responses increased under dual-task walking compared to sitting condition. These results support the u-shaped relationship (52) between postural and cognitive tasks which suggested that postural control can be improved by giving low cognitive demand. In addition, the level of arousal associated with an attentionally-demanding cognitive task may also play a role in improving both gait and cognitive performance while dual-tasking. Alternatively, an improvement in gait and cognitive performance under dual-task condition may result from speed-accuracy trade-offs. For example, when asked to focus on the narrow walking task, older adults demonstrated an increase in step accuracy with a reduction in gait speed.

This study provides a better understanding of the factors that contribute to the dual-task decrement in the elderly. However, there are a few limitations. First, a self-report of fall and imbalance in the previous year might be unreliable due to recall error. In addition, even though a more heterogeneous cohort was expected, the participants in this study were relatively healthy, which may result in less effects of variables on the dual-task decrement during gait among older adults. Given the importance of dual-tasking in daily activities, additional research is warranted to better elucidate all other contributing factors (including motivation, feedback, training, and personal preferences) that may affect dual-task related gait changes among older adults and patient population.

5.1 Conclusion

This study provides additional evidence that dual tasking among older adults is a highly dynamic process. The influences of gait speed, the ability to allocate, and history of imbalance were observed, however the contributions of these factors to the DTD were relatively small and varied among each aspect of gait. The present findings, nevertheless, suggested that the ability to effectively shift attention, and history of imbalance should be considered and included in the study examining the contributing factors to dual-task related gait changes.