CHAPTER 5

DISCUSSION

The aim of the present study was to investigate the effects of ability to allocate attention during walking as a function of age, balance ability, and secondary task characteristics. Healthy young adults, healthy older adults, and older adults with balance impairment were asked to walk under 4 different conditions, 1 of which was performed under the single-task condition and the remaining 3 were performed under the dual-task conditions. The single-task condition was a narrow walking task; the dual-task conditions were: (1) narrow walking while counting backward by 1 task, (2) narrow walking while counting backward by 3s task, and (3) narrow walking while performing the tray carrying task. For each dual-task condition, the participants were asked to walk under three prioritization conditions: (1) focus on both tasks equally, (2) focus primarily on the narrow walking task, and (3) focus primarily on the secondary task. The hypothesis of this study was that only healthy young adults and healthy older adults will show the ability to allocate attention between a walking task and an counting backward by 1 task, whereas all participants will not be able to allocate attention between a walking task and a counting backward by 3s task. In addition, all participants will be able to allocate attention between a walking task and a tray carrying task. Our findings partially supported this hypothesis. The results demonstrated that only healthy young adults were able to allocate their attention between narrow walking and counting backward by 1 tasks. Moreover, when the secondary cognitive task became more difficult, healthy young adults were still able to allocate their attention. The evidence showing the ability to allocate attention between the narrow walking and tray carrying tasks was not found in any groups.

The results of this study demonstrated that only healthy young adults were able to focus on either gait task or secondary cognitive task, as instructed. Healthy young adults spent more time during swing and walked slower when instructed to focus on the narrow walking task, compared to focus on the counting backward by 1 and by 3s task, respectively. Moreover, healthy young adults counted faster when they were instructed to primarily focus on the counting backward by 1 task. Thus, our findings suggested that the ability to allocate attention between a walking task and a cognitive task declined with advancing age. Specifically, only healthy young adults, not healthy older adults, were able to allocate their attention during walking while counting backward by 1 and by 3s tasks. These findings are in line with Yogev-Seligmann et al.'s study (27) which found that only healthy young adults were able to shift their attention between the level walking and verbal fluency tasks. In contrast to Siu et al.'s studies (24, 25), both healthy young adults and older adults showed the evidence of shifting attention between obstacle avoidance and auditory Stroop tasks. Despite the fact that the characteristics of older adults in these studies were comparable, these inconsistent findings may be due to the different cognitive tasks used. While the cognitive stimuli in Siu et. al's study (i.e. indicate the pitch of the voice presented during either heel strike or swing phase) were presented discretely at a fixed location, those used in Yogev-Seligmann et al.'s study (i.e. recall as many words as possible) and this study (i.e. counting backward) were a self-paced and more continuous in nature. Whether the effect of stimuli on the ability to allocate attention differs across age groups should be further examined.

In addition, our findings revealed that older adults with balance impairment were not able to allocate their attention between walking and cognitive tasks. This is in line with Siu et al.'s study (25), which found that older adults with balance impairment showed deficits in flexibly allocating their attention between the two tasks. As we expected, the ability to allocate attention deteriorated along with a decline in balance ability. Older adults, especially older adults with balance impairment, may have experienced deterioration of the systems involving in gait control; hence, the central nervous system might need more attention to maintain appropriate control of posture to compensate for these deficits. Consequently, there is a reduction in the available resources to properly allocate attention between tasks.

The results from this study also demonstrated that when healthy young adults were asked to prioritize the narrow walking task over the counting backward by 3s task, they walked slower. This finding is consistent with Siu et al.'s studies (24, 25), which found that healthy young adults walked slower when they were asked to focus on the obstacle avoidance task, as compared to focus on the auditory Stroop task. However, these findings are inconsistent with the finding from Yogev-Seligmann et al.'s study (27), which found that healthy young adults walked faster when they were instructed to focus on the level walking task as opposed to the no focus condition. These discrepancies may due to the gait tasks used in the studies. The participants in Siu et al.'s study (24, 25) were asked to walk over an obstacle, located in the center of the walkway and the goal of the task was trying not to hit the obstacle. Similarly, the gait task used in our study was the narrow walking task and the goal of the task was trying not to step onto or outside each strip of tape. Thus, when participants in our study and in Siu's study were asked to prioritize the gait over the cognitive tasks, they slowed down so that they did not hit an obstacle and reduced the number of steps onto or outside the line. However, the gait task used in Yogev-Seligmann et al.'s study (27) was the level walking task and there was no specific goals in terms of walking. Thus, this may suggest that the nature of the gait task also influences the ability to shift attention between the gait and cognitive tasks.

Interestingly, healthy young adults walked with an equivalent gait speed in the "no priority" condition compared to the "gait priority" condition when walk while simultaneously counting backward by 3s. Even without the instruction to prioritize one task over the others, healthy young adults seem to prioritize postural stability over success on the secondary cognitive task. These findings support the posture-first concept that giving the gait task a top priority, especially in high-risk situations, should be done to avoid instability and injuries in all age groups (36).

In addition to a function of age and balance ability, we also examined the effect of ability to allocate attention as a function of secondary task characteristics. All participants were asked to shift attention during walking while simultaneously counting backward at two levels of difficulty (i.e. by 1 and by 3s). It was shown that when the difficulty of secondary cognitive task increased, healthy young adults were still able to allocate their attention. This finding is somewhat in line with the U-shape theory (53), which suggested that postural control would be enhanced or diminished depending on the difficulty of the tasks and that individual differences could modulate the relationship between the difficulty and the performance of the tasks. Huxhold and colleagues also found that healthy young adults performed as well on the easy and difficult version of the standing tasks.

Even though, there was the evidence showing that healthy young adults were able to allocate their attention during walking while counting backward both by 1 and 3s, these effects were seen on different outcome measures. While the ability to allocate attention during walking while counting backward by 1 was seen on the swing time and rate of verbal response, the ability to allocate attention during walking while counting backward by 3s was seen on the gait speed. One possibility is that healthy young adults can easily walk and count backward by 1 at the same time, thus, success on the cognitive task would then take priority. However, when the demand of the task (walk and count backward by 3s) increases, the gait task would then be the first priority.

Surprisingly, the ability to allocate attention between the walking task and the tray carrying task was not found across all groups. This may be due to the fact that both the narrow walking task and the tray carrying task use very similar input modalities. In other words, there was a high visual interference between the tasks. Not only do participants need to prevent stepping onto or outside the tapes for the narrow walking task, but they also need to avoid spilling the water. Thus, this finding supports the notion that vision plays an important role in control of locomotion (54) and that information from visual input is used to interpret the spatial information and prepare an appropriate step to maintain the postural stability. Since the tray carrying task employ most information from the visual system (producing structural interference with the gait task), it may not be the ideal task to investigate the central interference between the gait task and the secondary task.

Results from this study provide further evidence to support the idea that the concurrent attentionally-demanding cognitive task has a detrimental effect on gait (7, 16, 18). When either the manual or cognitive secondary task was added, people walked slower. However, there were few exceptions: 1) the gait speed was similar in the single-task waking and walking with counting backward by 1 for healthy young adults, and 2) the gait speed was comparable in the single-task walking and walking with tray carrying task for older adults with balance impairment. These findings may confirm that 1) counting backward by 1 was not challenging for healthy young adults and 2) while healthy older adults know their limit and adjust the strategies according to the task demand, older adults with balance impairment did not do so. Older adults with balance impairment walked with the same gait speed, but stepped onto/outside the lines more often in the "walking while performing the tray carrying task", compared to single-task walking. In addition, they stepped onto or outside the lines more often than healthy older adults (46.69 and 35.27 steps/min, respectively). Similarly, older adults with balance impairment walked faster with higher missteps in the "walking while performing tray carrying task", compared to "walking while counting backward by 3s" task, thus supporting the speed-accuracy trade-off theory.

Even though, this study provides a better understanding of the ability to allocate attention between the gait task and the secondary task as a function of age, balance ability, and task characteristics. There are a few limitations. First, as a previous noted, the tray carrying task we used as a secondary task may not be the best manual task to study the central interference between the gait and non-gait motor tasks. Second, the number of falls and imbalance in the previous 12 months might be unreliable due to recall error. Given its apparent complexity, additional research is warranted to better elucidate all other factors (including gait task characteristics and personal preference) that may affect the ability to allocate attention among older adults and patient population.

5.1 Conclusion

This study provides evidence that the ability to allocate attention during gait is strongly influenced by the secondary task characteristics. However, this effect was less obvious in the older adults both with and without balance deficits. In addition, our study confirmed that the ability to shift attention between the gait task and the secondary task was impaired in older adults. Thus, resource allocation should be included as a complementary intervention in fall prevention programs for the elderly. Finally, the current findings suggested that age, balance ability, and task characteristics should be taken into account when investigating the ability to allocate attentional resources during performance of a gait task and an additional task.