CHAPTER 5

DISCUSSION

The aim of the present study was to investigate the effects of specific cognitive domains, mainly attention and executive function on gait performance in individuals with aMCI. Findings revealed that overall; gait performance of aMCI was different than their healthy aged-, gender-matched controls. Specifically participants with aMCI showed significant slower gait velocity, shorter stride length, and higher stride length variability than healthy controls. As for the effect of cognitive load, both groups had slower gait velocity, shorter stride length and larger swing time variability in dual-task compared to single-task conditions. Each cognitive domain had similar effects on gait performance of participants with aMCI and controls except for attention which was tested by using the digit span task where participants with aMCI demonstrated markedly increased gait unsteadiness as indicated by an increase of swing time variability compared to controls.

5.1 Mean spatiotemporal parameters

Consistent with previous studies (21, 27), the present study found that gait performance declines were demonstrated in individuals with aMCI. Overall, participants with aMCI walked slower and with shorter stride length than their age- and gender-matched controls (significant group effect). In line with these findings, Verghese et al. (21) found that participants with aMCI had significant shorter stride length as compared to healthy older adults. In addition, Maquet et al. (27) found that individuals with aMCI had slower gait velocity compared to cognitively intact elders. Together, these findings on gait performance declines in individuals with aMCI confirm the notion that cognitive function is essential for walking. Our findings also support previous suggestion by Maquet et al. that gait analysis protocol may contribute to distinguish motor performance of persons with cognitive intact from persons with cognitive impairment such as individuals with MCI (27).

An absence of Group X Condition interaction suggested that the 3 dual-tasks used in the present study had similar effects on mean gait parameters of individuals with aMCI and controls. The results did not support our hypothesis that the effects of adding cognitive effort during walking will deteriorate mean gait performance of individuals with aMCI more than that of healthy controls. On one hand, this finding may be interpreted that cognitive load had similar effects on gait in individuals with aMCI and controls. On the other hand, one may debate that, perhaps, mean gait parameters may not be sensitive enough to capture early gait changes in aMCI persons since they are relatively healthy and independent in functional mobility (7). Hausdroff suggested that measures of stride to stride fluctuation during walking (i.e. gait variability) may be more sensitive than the measures of mean gait parameters in providing a clinical index of gait instability and fall risk (13). Thus, findings on gait variability may further advance our understanding on the interplay between cognition and gait performance. In fact, it was the case in the present study. The effects of specific cognitive dual-task were revealed for gait variability but not mean gait parameters.

5.2 Gait variability

There was an approach significant Group X condition interaction for swing time variability. Specifically, swing time variability for the aMCI group appeared to be larger than controls under the digit span condition. This finding compared the changes of swing time variability across groups, irrespective with their baseline performance. Thus, the results could be influenced by baseline performance (i.e. single task condition). To account for this effect, we also calculated the relative dual-task cost (DTC) by comparing the changes of gait performance under dual-tasking with respect to gait performance under single-tasking (37). The results showed that under the digit span task, aMCI group had significant greater DTC of swing time variability than the control group (significant Group X condition interaction).

The greater DTC indicated the poorer performance on gait under dual-task condition. The mechanisms underlying an increased DTC have been proposed (38). For example, increased DTC occurs due to structural interference (common resources are needed for both tasks) or due to limited capacity to attend to both tasks. In the present study, increased DTC observed in the aMCI group is likely to be due to the limited capacity to divide attention between walking and performing the digit span task. The results support the hypothesis that specific cognitive domains affect gait performance in individuals with aMCI. In this study, the effects of adding attentional demand during walking (digit span test condition) resulted in an increased swing time variability of individuals with aMCI. It has been reported that individuals with aMCI often demonstrate attention deficit before other cognitive domains (4). Thus, they may be unable to divide attention between walking and performing the digit span task.

In the present study, fluctuations of stride length and swing time were measured (i.e. stride length variability and swing time variability). However, significant finding was only observed for the swing time variability. Increased swing time variability may reflect diminished balance control ability in individuals with aMCI during performing secondary task. The swing phase challenges the human balance control system ability since one limb is in forward progression on a minimized base of support (single limb support) (41).

Findings on the DTC of stride length variability also showed similar trend as the DTC of swing time variability. There was a trend that the DTC of stride length variability is greater for the aMCI group than the control group in the digit span condition. However, the interaction between groups and testing conditions was not significant. One potential explanation is that there was a large variation of DTC of stride length variability in the aMCI group. Another potential explanation that may account for the significant finding of swing time variability but not stride length variability was that swing time variability was not affected by gait speed (speed-independent) while stride length variability was associated with gait speed (12, 42). Thus, finding on stride length variability in the aMCI group under the dual-task conditions may be confound by the reduction of gait speed.

Executive function covers several cognitive skills including initiation, planning, organizing, selecting response, problem solving, adaptability, abstract reasoning and arithmetic skill (28). Arithmetic skill (i.e. subtraction task) is often used to represent a task that requires executive function during walking among healthy elders and cognitive impairment persons (30, 43). Although several studies reported deficits in financial ability such as balancing checkbook, managing bank statement in individuals with MCI (44, 45), we did not find specific effects of the subtraction task interference on gait performance in individuals with aMCI. It is possible that the subtraction task used in the present study (i.e. subtract by 3) was not complex enough to capture mild executive function deficits in individuals with aMCI.

Finally, verbal fluency test was included to serve as the control condition. We wanted to ascertain that the alteration in gait performance during dual-task is due to the impairment of executive or attention domains not by an influence of the articulo-motor component (i.e. speaking). Previous studies reported both verbal fluency and semantic memory are preserved in aMCI persons (7, 15). Consistent with our hypothesis, the result showed no significant difference among aMCI and healthy controls in the verbal fluency dual-task condition.

5.3 Clinical implications and limitations

Findings from the present study expand our understanding on the early interaction between gait and cognition in individuals with aMCI. Information derived from this study may be beneficial for detection of elders who are at risk of mobility and cognitive declines. Consequently, intervention to slow down mobility and cognitive declines can be implemented at an early stage.

The knowledge derived from this study provides information about gait changes among persons with aMCI. Swing time variability may be used as an indicator for early detection of gait impairment in individuals with aMCI. Consequently, early intervention can be implemented at an early stage.

The strength of this study included the well-defined MCI criteria which followed Petersen's criteria (7, 15). To date, Petersen's criteria have been widely used both in clinical and research settings. In addition, we selected to assess the gait parameters using electronic walkway which proposed to be a highly reliable in examining spatio-temporal gait characteristics both under single-and dual-task conditions (9). However, this study has certain limitations. It is impossible to determine only one aspect of cognitive domain at a time. Cognitive function is far more complicated than what we proposed in the present study. It requires interplay between multiple cognitive aspects. For example, the digit span test which was used to represent the attentional aspect of cognitive function also involves working memory, one component of executive function. It is too simple to claim that digit span task represents attention domain of the cognition and subtraction task represents the executive function domain of cognition. Thus, one needs to keep this in mind when interpreted the results of the study.

Future study should investigate gait characteristics of individuals with aMCI while performing episodic memory task. Episodic memory is proposed to be one of the core cognitive impairment in individuals with aMCI. In addition, adding the kinematic variables may provide insight into the modifications of trunk, pelvis, and lower limb joint angle in response to gait compensation under dual-task condition. The postural adaptation during encounter with complex situation (i.e. dual-task condition) may reveal via postural adjustments but not temporo-spatial parameters.

5.4 Conclusion

Overall, the 3 cognitive tasks had similar effects on gait performance in both aMCI and control groups except for attention. Adding attention effort deteriorates gait performance (reflected via increased swing time variability) in individuals with aMCI more than that of age-, gender-matched, cognitively intact controls. This finding suggests that elders with cognitive impairment require more attention for controlling gait than cognitively intact elders. Therefore, assessment of gait performance while performing the attentional demand secondary task may complement current standard criteria used to differentiate individuals with aMCI from cognitively intact persons. Swing time variability may be used as an indicator for early detection of gait impairment in individuals with aMCI.