INTRODUCTION

To maintain stability during locomotion, it relies on body-based and visual senses [1], such as perception of self-motion. People with more than 15 years of diabetes mellitus (DM) are at a high risk of suffering from diabetic neuropathy with abnormal sensation and sensory loss of their feet [2], which increases the incidence of fall injuries. Thus, the reliance on visual senses is crucial in DM population. The visual perception of self-motion has been previously shown to alter spatiotemporal gait characteristics in people with diabetes mellitus (DM) [3]. However, it is not clear if the visual perception exhibits the similar effect on gait alteration in people with and without DM.

Therefore, the aim of preliminary study was to investigate the differences of gait alteration between people with DM and their age-matched healthy control when self-motion was perceived during locomotion. We hypothesized that the perception of self-motion would alter gait patterns more prominently in DM group when compared those in age-matched group.

METHODS

Three chronic type 2 DM (mean year of diabetic diagnosis = 17 years; one female; mean age= 58.7 ± 6 years old) who have been diagnosed and pre-screened by both neurologist (P.T.) and endocrinologist (V.S.); two healthy age-matched adults (males; mean age= 58 years old) were recruited and walked on a treadmill (Bertec Corp. Columbus, OH).

Each subject walked five minutes at their self-selected pace for familiarization followed by three two-minute treadmill walking trials with and without virtual environment (VE). The VE was presented by three projectors in front of subjects that generated the visual flow of corridor matched with walking speed (Fig. 1). All subjects were given a seven-scale Presence Questionnaire to test their self-immersion to the VE at the end of the study.

Figure 1: A subject walked on a treadmill with a safety harness while a virtual, speed-matched moving corridor was presenting ahead.

Three-dimensional spatiotemporal data were collected using NDI motion capture system at 100 Hz (Northern Digital Inc, Waterloo, Canada) and processed using custom-written MATLAB program (MathWorks, Inc., Natick, MA). Gait parameters (step length, step width, step time) were calculated. Step length was defined as the distance between two consecutive heel strikes of different legs; step width was the mediolateral distance between two heels at the moment of both feet contacted the treadmill belt; step time was the duration of two consecutive heel strikes of different legs. The average and variability (coefficient of variance, CV) of step length, step width and step time were calculated and reported.
Two-way ANOVA (VE vs. non-VE as within-subject factor and two subject groups as between-subject factor) with repeated measure was applied to compare all spatiotemporal gait parameters. Pairwise comparison tests with Bonferroni adjustment were performed when significant effect was found. The significance level was set at 0.05.

RESULTS AND DISCUSSION

Age and body mass index did not show the significant difference between the two groups ($p = 0.89$ and $p = 0.44$ respectively). All participants had a strong self-immersion in the VE with Presence Questionnaire score $6.6 \pm 0.55$ (out of seven). A significant group effect was found in step length ($p = 0.03$; Fig. 2a), which DM group had shorter step length than control group. A significant interaction between group and VE exhibited in step width ($p = 0.04$). Individuals with DM decreased their step width more than those in control group when VE was presented ($p < 0.05$; Fig. 2b). No significant main effect was found on CV of gait parameters.

The finding of decreased step length in DM group is consistent with previous studies without VE that DM population adopt a new walking strategy in sagittal plane due to the fear of falling [4,5]. In addition, the DM group in this study altered their gait in frontal plane (decreased step width) when visual perception of self-motion was given by VE. It implies that, without normal sensory input, subjects with DM could rely on visual perception from VE to alter their gait patterns. More subjects are warranted to examine if the gait alternations found in the DM group is beneficial to their gait stability and fall reduction.

CONCLUSIONS

Overall, compared subjects with type 2 DM with their age-matched healthy control, this preliminary study provides further evidence that visual perception of self-motion plays a prominent role on gait adjustment/alteration in DM during treadmill walking. Virtual environment could be useful for DM to establish a walking strategy that is safe to prevent from future incidence of falls.

REFERENCES


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![Figure 2](image2.png)

Figure 2: (a) The effect of DM condition on step length during treadmill walking; (b) The interaction of visual perception of self-motion and DM condition on step width during treadmill walking (VE: virtual environment; asterisk: $p < 0.05$).