Gait Abnormality and Strategies Adopted in Patients with Well-Controlled Diabetes Mellitus During Obstacle-Crossing

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ABSTRACT

Diabetes mellitus is one of the major death-causing diseases. Individuals with DM are 2.5-fold more likely to have accidental fall and fall-related injuries than normal individuals [1]. Since tripping over obstacles during locomotion has been reported as one of the most frequent causes of falls, research on the kinematics and kinetics of the lower extremities during this functional activity has received much attention [2]. Healthy elder people were suggested to adopt more conservative strategy for obstacle crossing compared to the young, due to safe considerations [3]. Since DM complications, including neuropathy and vascular disease, may affect the performance of locomotion and obstacle negotiation, whether or not people with DM can maintain their gait and pelvic motion while crossing obstacles requires investigation. The purpose of the present study was to compare the endpoint trajectory and the joint mechanics of the lower extremities between healthy subjects and individuals with DM during obstacle-crossing with the leading limb.

INTRODUCTION:

Diabetes mellitus is one of the major death-causing diseases. Individuals with DM are 2.5-fold more likely to have accidental fall and fall-related injuries than normal individuals [1]. Since tripping over obstacles during locomotion has been reported as one of the most frequent causes of falls, research on the kinematics and kinetics of the lower extremities during this functional activity has received much attention [2]. Healthy elder people were suggested to adopt more conservative strategy for obstacle crossing compared to the young, due to safe considerations [3]. Since DM complications, including neuropathy and vascular disease, may affect the performance of locomotion and obstacle negotiation, whether or not people with DM can maintain their gait and pelvic motion while crossing obstacles requires investigation. The purpose of the present study was to compare the endpoint trajectory and the joint mechanics of the lower extremities between healthy subjects and individuals with DM during obstacle-crossing with the leading limb.

MATERIALS AND METHODS:

12 well-controlled DM patients (age: 55±8 years, height: 165±7.4 cm, weight: 67±12.7 kg) and 12 age-matched healthy adults (age: 53±7 years, height: 160±5.7 cm, weight: 58±8.1 kg) participated in the present study. In a gait lab, subjects wearing infrared retroreflective markers walked at self-selected pace and crossed obstacles of three different heights (10, 20 and 30% of leg length). Kinematic and kinetic data were measured with a motion analysis system (Vicon512, Oxford Metrics, U.K.) and two force plates (AMTI, Advanced Mechanical Technology, U.S.A.) placed on each side of the obstacle, Fig. 1. A model of the locomotor system was used to calculate the angles and moments at the hips, knees and ankles as well as pelvic motion. Crossing joint angles and moments were obtained when the swing toe was above the obstacle. Toe clearances, horizontal distances, step lengths and step widths were also calculated using the heel and toe markers. For all calculated of variance (RM ANOVA) with one between-subject factor (groups) and one within-subject variables, a mixed repeated measures analysis factor (obstacle height) was performed.
If height effect was found, a polynomial test was performed to determine the trend (linear or quadratic). The significance level was set at $\alpha=0.05$.

RESULTS:
No significant differences were found for horizontal distances between the DM and normal groups but the DM group had significantly smaller toe clearances, Fig. 2.

![Leading Toe Clearance](image1)

Figure 2. Leading toe clearance for the DM (black bars) and normal (grey bars) groups when crossing obstacles of three different heights (10, 20 and 30% leg length). (*$p<0.05$; $\rightarrow$linearly increasing; $\leftarrow$linearly decreasing)

The DM group was found to have reduced swing ankle dorsiflexion ($p<0.05$). They also had greater pelvic anterior tilt, stance hip flexion but smaller stance ankle dorsiflexion, Fig. 3. The trailing crossing ankle plantarflexor moments and hip internal rotator moments were significantly greater than normal ($p<0.05$).

DISCUSSION:
The reduced swing toe clearance in the DM group seemed to be resulted from the reduced swing ankle dorsiflexion, most likely associated with the impairment of proprioception at the ankle joint. The impaired proprioception at the ankle joint also led to the smaller dorsiflexion at the stance ankle. Smaller dorsiflexion of the stance ankle tended to keep the body center of mass more posteriorly. To maintain the body stability, greater pelvic anterior tilt and stance hip flexion were needed to bring the trunk forward. This would then require greater crossing ankle plantarflexor moments for the equilibrium at the stance ankle. This also contributed to the smaller leading toe clearance.

CONCLUSION
The DM group adopted different joint kinematic strategy during obstacle crossing with decreased swing toe clearance, which would increase the risk of tripping. If the demands on the control and strength of the stance ankle plantarflexors can not be met, risk of tripping over obstacles may further increase in DM patients.

![Pelvic Anterior Tilt(+)](image2)

Figure 3. Crossing angles of the pelvis for the DM (black bars) and normal (grey bars) groups for three different obstacle heights (10, 20 and 30% leg length). (*$p<0.05$; $\rightarrow$linearly increasing; $\leftarrow$linearly decreasing)

REFERENCES