Comparison of Balance Ability Between Patients With Type 2 Diabetes and With and Without Peripheral Neuropathy

Kil-Byung Lim, MD, PhD, Dong Jun Kim, MD, PhD, Jeong-hyun Noh, MD, Jeehyun Yoo, MD, Jung-Wha Moon, PhD

Objectives: (1) To examine the effects of peripheral neuropathy on balance stability in patients with type 2 diabetes, and (2) to assess static and dynamic balance and functional limitations.

Design: A cross-sectional study.

Setting: Outpatient clinic.

Patients: Subjects with type 2 diabetes and healthy subjects (n = 60) were divided into 3 groups: subjects with diabetes and with established peripheral neuropathy (diabetic peripheral neuropathy [DPN] group) (n = 17), subjects with diabetes and without peripheral neuropathy (diabetic control group) (n = 25), and subjects without diabetes (nondiabetic control [NDC] group) (n = 18).

Methods: Sensory impairment assessment, motor impairment assessment, and functional limitation assessment were assessed by using the Balance Master system.

Results: In motor impairment assessment, left-to-right directional control in the rhythmic weight shift was significantly poorer in the diabetic control group than in the NDC group during slow movement ($P = .027$). During fast movement, it was poorer in the DPN group than in the NDC group ($P = .022$). In the unilateral stance test of functional limitation assessment with both eyes open, the mean center of gravity sway velocity was significantly higher in the DPN group than in the NDC group ($P = .011$ for the left leg standing, $P = .008$ for the right leg standing) and higher in the DPN group than in the diabetic control group ($P = .027$ for the right leg standing). In the tandem walk test, walking speed was significantly lower in the DPN group than in the NDC group ($P = .033$), and end sway was significantly greater in the DPN group than in the NDC group ($P = .020$).

Conclusions: Analysis of the results of this study suggest that functional limitations may occur more in the patients with diabetes and with peripheral neuropathy, and dynamic balance stability may decrease more with the patients with diabetes than with the subjects without diabetes. Further studies on balance rehabilitation that concern dynamic balance stabilities and exercise abilities are needed in patients with diabetes.

PM R 2014;6:209-214

INTRODUCTION

The incidence of diabetes has been increasing worldwide, especially in Asian countries where industrial advances have progressed rapidly. According to the World Health Organization report, 110.4 million persons had diabetes in the 1990s, 210 million persons had diabetes in the 2000s, and this number is predicted to increase to 299 million persons by 2025 [1]. Diabetes can cause retinopathy, renal failure, cardiovascular disease, and peripheral neuropathy. Aggressive control of blood glucose levels and concurrent diseases is mandatory to minimize such complications. Exercise has proved to be effective in the control of blood glucose levels and the prevention of complications, and is thus recommended as an important treatment method along with dietary therapy and pharmacotherapy [2]. Diabetic peripheral neuropathy (DPN) is the most common complication

K.-B.L. Department of Rehabilitation Medicine, Ilsanpaik Hospital, Inje University, Gyeonggi-do, South Korea
Disclosure: nothing to disclose

D.J.K. Department of Endocrinology, Ilsanpaik Hospital, Inje University, Gyeonggi-do, South Korea
Disclosure: nothing to disclose

J.-h.N. Department of Endocrinology, Ilsanpaik Hospital, Inje University, Gyeonggi-do, South Korea
Disclosure: nothing to disclose

J.Y. Department of Rehabilitation Medicine, Inje University College of Medicine, Ilsanpaik Hospital, 170 Joohwaro, Ilsanseo-gu, Goyang-si, Gyeonggi-do, South Korea. Address correspondence to: J.Y.; e-mail: jhyoo@paik.ac.kr
Disclosure: nothing to disclose

J.-W.M. MS Sports Medicine Center, Ilsanpaik Hospital, Inje University, Gyeonggi-do, South Korea
Disclosure: nothing to disclose

This work was supported by a 2009 Inje University research grant.

Peer reviewers and all others who control content have no relevant financial relationships to disclose.

Submitted for publication January 14, 2013; accepted November 14, 2013.

among microvascular diseases and can reduce quality of life, and may be the main cause of nontraumatic amputation [3].

Patients with DPN frequently present with numbness and pain in the extremities due to decreases in peripheral nerve function and with balance instability due to decreases in proprioceptive functions. Because walking velocity and step width decrease more in patients with diabetes and with DPN than in those without DPN, patients with diabetes and with DPN are at high risk of falling [4,5]. In addition, decreases in movement perception of the hip and ankle joints can induce static and dynamic balance instabilities and thus increase the risk of falling [6-8]. Falling can increase morbidity and mortality by causing femur and ankle fractures, cerebral concussions, and cerebral hemorrhages. In addition, fear about falling decreases willingness to walk; inhibits exercise and/or physical activities, which are effective methods for blood glucose control; lowers quality of life through muscle weakness, postural instability, and gait abnormalities; and increases the incidence of secondary injuries associated with falling.

An early detection of DPN, along with adequate management and training for balance impairment, can help decrease instances of falling. Many studies have been published about balance ability in patients with diabetes, and they have mostly focused on the relationship between DPN and balance ability [5,8-11]. Few studies have compared balance ability in patients with diabetes and with and without peripheral neuropathy [6,12,13]. There have been no comparative studies that used the Balance Master system (NeuroCom Inc, Clackamas, OR) to evaluate sensory impairment, motor impairment, and functional limitation to compare patients with DPN with patients with diabetes and without peripheral neuropathy. Therefore, this study was conducted to quantitatively measure balance stability and to compare the results among patients with diabetes and with DPN, patients without DPN, and healthy subjects.

METHODS

Study Subjects

This study included 42 subjects with type 2 diabetes mellitus who were older than 40 years of age and were recruited from the Departments of Rehabilitation Medicine and Endocrinology at our hospital. All provided signed informed consent. Exclusion criteria were the following: a history of cardiovascular disease, orthopedic disease, renal dysfunction (serum creatinine level, $\geq$2.0 mg/dL), hepatic dysfunction (aspartate transaminase or alanine transaminase level, $\geq$40 IU/L), or other life-threatening diseases; having been medicated with gabapentin, pregabalin, or thioctic acid for pain control; and having been medicated with antipsychotic agents. Eighteen adults without diabetes, ages 40 years old or older, who met the same exclusion criteria as the subjects with diabetes were brought in as the control group (nondiabetic control [NDC] group).

DPN Evaluation

After informed consent, all the subjects underwent nerve conduction studies of the bilateral lower extremities by using Neuroscreen Plus (Jaeger-Toennies, Freiburg, Germany). The sural and superficial peroneal nerve for sensory nerve and the posterior tibial and peroneal nerve for motor nerve were tested. Mean values of onset latencies and amplitudes of each nerve were calculated, and mean nerve conduction velocities also were calculated in case of motor nerves. Normal reference values of each nerve were based on the manual by Lee and DeLisa [14]. All the subjects also were evaluated by the Michigan Neuropathy Screening Instrument (MNSI), which consists of 2 assessments: part 1 is a 15-item self-administered questionnaire scored by summing abnormal responses, and part 2 is a physical examination of the lower extremities that includes inspection and assessment of fine touch, vibration sensation, and ankle reflexes. MNSI is scored by assigning points for abnormal findings.

DPN was defined as present based on the following: (1) if subjects showed any abnormality in sensory and/or nerve conduction studies, and (2) if subjects had 7 or more positive responses on the MNSI questionnaire or a score of >2.0 on the MNSI examination [15]. The subjects were divided into 2 groups based on the results of their nerve conduction studies and MNSI. The subjects who were diagnosed as DPN were placed in the DPN group (n = 17), and the other subjects were placed in the diabetic control (DC) group (n = 25). There were no significant differences in gender, age, height, or body weight between the 2 groups. However, disease duration from diagnosis to the commencement of this study and the types of medication administered at the time of the study were significantly different between the DPN and DC groups ($P = .001$, $P = .021$, respectively) (Table 1).

Balance Stability Evaluation

Balance stability was separately assessed by using the Balance Master system after complete description of test procedures to each participant. All the participants then underwent sensory impairment assessment (SIA), tests of static balance stability and motor impairment assessment (MIA), tests of dynamic balance stability, and functional limitation assessment (FLA), as they stood in front of the monitor of the Balance Master system. Because different features of their own shoes, for example, thickness of their soles, would have influenced test results, the participants were asked to wear special shoes fitted for their feet, which were provided by the balance test laboratory (Figure 1).

SIA

SIA was performed by using modified clinical test sensory interaction on balance (mCTSIB). All the subjects were asked to stand on the foam-covered force plate of the test machine,