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Impaired balance is related to the progression of diabetic complications in both young and older adults

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ABSTRACT

Aims: To investigate the balance ability in younger and older adults with diabetes and evaluate the associations between balance ability and microvascular complications.
Methods: This cross-sectional observational study compared 162 participants and 177 controls with and without type 2 diabetes, respectively. Balance ability was assessed using two static (one-legged stance and postural sway area) and two dynamic (Timed Up and Go [TUG] and Functional Reach) tests. Diabetic microangiopathy was also evaluated.
Results: Participants with diabetes, including both younger (<50 years) and older (≥50 years) participants, showed significantly worse balance ability in all four tests and were more likely to have a history of falls than the controls (all $P < 0.01$). In all age groups, severe impairment of balance ability was associated with progression of diabetic microvascular complications. In all and older diabetic adults, a longer duration of diabetes ($P = 0.022$) and higher TUG test score ($P = 0.004$), and female sex ($P = 0.01$) and higher TUG score ($P = 0.001$), respectively, were related to a history of falls. On the other hand, among younger diabetic adults, only a non-significant association with longer duration of diabetes ($P = 0.066$) was observed.
Conclusions: Impaired balance ability correlates with microvascular diabetic complications. Accurate assessment of balance ability in adults with diabetes could predict the risk of falls, particularly benefitting people with diabetic complications.

1. Introduction

Among the elderly population, falls commonly lead to morbidity, disability, and loss of independence. The factors often reported to be associated with falls in older people include age, sex, muscle strength, impaired balance, sensory impairment, chronic diseases, psychotropic medication use, hypotension, and sarcopenia.[1,2] Further, recurrent falls and a fear of falling may have strong impacts on the quality of life,[3] and are independent risk factors for admission to nursing facilities.[4] In particular, older persons with diabetes are at a higher risk for falls and fractures than those without diabetes,[5,6] and diabetic complications such as peripheral neuropathy and impaired vision are known to affect gait and increase the risk for falls.[7–9] However, the association between impaired balance and microvascular diabetic complications has not yet been examined thoroughly, particularly in relatively young people with diabetes.

A fall is preceded by loss of balance, and balance ability is frequently evaluated by using the Berg Balance Scale and the Timed Up and Go (TUG) test. The latter has been recommended as a routine screening test for fall risk according to the guidelines published by the American Geriatric Society and the British Geriatric Society.[10,11] Impairment of balance is also evaluated clinically by using the one-legged stance test with the eyes open (OLS test),[12] the Functional Reach (FR) test,[13] and the body sway test.[14] In the present study, we hypothesized that even relatively young people with diabetes may have impaired balance. While these balance tests are useful tools for predicting falls among older adults, there have been only a few reports about whether they can effectively evaluate impairment of balance among younger adults with diabetes.

Furthermore, the associations between impaired balance and microvascular complications of diabetes have not been well

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characterized. If impaired balance plays a role in the etiology of falls in people with diabetic complications, one can expect that severe diabetic complications would be associated with an increased risk of future falls. Accordingly, this study was performed to investigate which clinical characteristics (including the severity of microvascular diabetic complications) and balance test results were related to a history of falls in both younger and older participants with diabetes.

2. Subjects and methods

2.1. Participants

Japanese participants with type 2 diabetes ($n = 162$), diagnosed according to the World Health Organization criteria,[15] and a control group of 177 Japanese participants without diabetes (fasting plasma glucose <7 mmol/L and hemoglobin A1c [HbA1c] < 48 mmol/mol [6.5%]) were enrolled in this cross-sectional observational study. The participants were registered for the study at the Department of Metabolic Medicine of Kumamoto University Hospital and at Seigatoh Hospital from January 2011 to March 2016. While we did not collect data on the participants' level of physical activity, all included participants could care for themselves and lived independently. The exclusion criteria included blindness, previous fracture, wheelchair-bound/bedridden state, advanced-stage dementia, hypopituitarism, stroke, spinal disease, knee osteoarthritis, and hypo/hyperthyroidism.

This study was performed in accordance with the principles stated in the Declaration of Helsinki.[16] All participants provided written informed consent. The protocol was approved by the ethics committees of Kumamoto University (approval number: 1219) and Seigatoh Hospital (approval number: 2,014,001). This study was also registered with the University Hospital Medical Information Network (registration number: UMIN000008698).

2.2. Methods

All participants answered a self-administered questionnaire about falls within the past 12 months. A fall was defined as an unintentional change in body position that resulted in falling to the ground or to a lower level and did not result from a stroke, vertigo, syncope, or an accident.

Blood and urine samples were obtained for laboratory tests. The age, body mass index (BMI), blood pressure, and total cholesterol, high-density lipoprotein cholesterol, triglyceride, and HbA1c levels were evaluated in all participants. The HbA1c values are expressed in accordance with the National Glycohemoglobin Standardization Program, as defined by the Japan Diabetes Society.[17] Hypertension was diagnosed if the blood pressure was ≥140/90 mmHg or if the participant was receiving antihypertensive treatment. Dyslipidemia was diagnosed in cases of total cholesterol ≥5.69 mmol/L, triglycerides ≥1.69 mmol/L, and/or high-density lipoprotein cholesterol <1.03 mmol/L, or if the person was receiving lipid-lowering therapy.

2.3. Diagnosis and staging of diabetic microvascular complications

Retinopathy was assessed via direct ophthalmoscopy and fundus photography, with the diagnosis being made by an experienced ophthalmologist or diabetologist. The participants were graded as demonstrating no diabetic retinopathy (NDR), simple diabetic retinopathy (SDR), or (pre)proliferative/proliferative diabetic retinopathy ([P]PDR) using the Davis classification.[18] To assess nephropathy, the urine albumin-to-creatinine ratio (UACR) was calculated, and the participants were classified as having normoalbuminuria (UACR <30 mg/g), microalbuminuria (UACR = 30–300 mg/g), or macroalbuminuria (UACR ≥300 mg/g). Diabetic polyneuropathy was diagnosed according to the criteria of the Diabetic Neuropathy Study Group in Japan, which defines neuropathy on the basis of abnormal results in at least two of three neurological tests (positive neuropathic symptoms, impaired vibratory sensation, and impaired Achilles tendon reflex).[17]

2.4. Assessment of balance

Balance was assessed by using two static balance tests (the OLS test and measurement of the standing postural sway area [SPSA test]) and two dynamic balance tests (the TUG and FR tests). The OLS test measures the time (in seconds) that an individual can stand unassisted on either leg with the eyes open and arms by the side, with a longer time indicating better balance.[19] The OLS test score was defined as the longest time achieved in three trials. For the SPSA test, postural stability was examined by using a stabilometer (GP-7; Anima Co., Tokyo, Japan) to measure the sway of the center of gravity. The participant stood on the stabilometer platform in an upright position for 30 s with both feet together and the eyes open. We analyzed the data obtained by using the manufacturer's static stabilography analysis software (version 1.07, Anima Co.), and the area inside the circumference of the stabilogram was measured as an index of sway of the center of gravity. In the TUG test, the time required for the participant to rise from a chair and walk 3 m, turn and walk back, and sit down again as quickly as possible was measured. The TUG test score was defined as the fastest time over three trials. In the FR test, the ability to reach forward with either arm from a bilateral stance position is assessed.[13,20] The participant stands behind a line perpendicular and adjacent to a wall with the feet a comfortable distance apart, after which the arm closer to the wall is raised to shoulder height and the position of the tip of the middle finger is marked.[21] Then, the participant is asked to reach forward as far as possible without losing their balance or taking a step; the new position of the fingertip is marked and the distance between the two marks is recorded. The FR test score was defined according to the maximum distance achieved during the forward reach in three attempts.

2.5. Statistical analysis

Statistical analyses were performed using SPSS version 21 (IBM, Armonk, NY, USA). Clinical characteristics and balance data were compared between the participants with and without diabetes by using the Student's t-test or the Mann–Whitney U test. The same analyses were repeated for participants aged <50 years and ≥50 years from both groups. The chi-square test was employed to assess differences in the frequencies of the measured variables between participants with diabetes who had a history of falls and those without a history. To explore the association between the different balance test scores and the severity of diabetic complications, multiple comparisons were performed with the Kruskal–Wallis test, followed by the Bonferroni test where appropriate. Correlations between participants who had diabetes with or without a history of falls were evaluated using the Spearman rank correlation analysis method. To examine independent determinants of a history of falls in the participants with diabetes, multiple logistic regression analysis with forward selection (likelihood ratio) was performed using fall history as the dependent variable, both for all adults with diabetes, and for young and older adults separately. Variables showing significant differences in the baseline comparisons were included in the analyses (age, sex, hypertension, duration of diabetes, retinopathy, and scores achieved on the OLS, TUG, and FR tests). For all analyses, the level of significance was set at $P < 0.05$.

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