

Postural Hypotension and Postural Dizziness in Patients With Non-Insulin-Dependent Diabetes

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Background: Postural hypotension with a decline of 20 mm Hg or more in systolic blood pressure on standing is considered a potentially dangerous hypotensive response. Postural dizziness is often strongly associated with postural hypotension. However, there is conflicting evidence, and previous studies have been confined to the elderly, not specifically to patients with diabetes. Thus, we evaluated the association between postural hypotension and postural dizziness, and determined the factors most likely related to postural hypotension in patients with diabetes.

Methods: The subjects were 204 consecutive non-insulin-dependent patients with diabetes and 408 age- and sex-matched control subjects. Postural hypotension was defined as a decline of 20 mm Hg or more in systolic blood pressure 1 minute after standing. Postural dizziness was any feelings of dizziness, lightheadedness, or faintness that occurred while standing during the examination.

Results: The prevalence of postural hypotension and postural dizziness in patients with diabetes was higher than in control subjects. Those patients with both diabetes and

postural hypotension were older and had higher supine systolic blood pressures and higher plasma glycosylated hemoglobin and fasting glucose levels. They had higher prevalence of postural dizziness, hypertension, and cerebrovascular disease, and lower standing systolic blood pressures than those without postural hypotension. They also were more often being treated with antihypertensive agents. Only 32.8% of patients with diabetes with postural hypotension suffered from postural dizziness. Postural dizziness, hypertension, cerebrovascular disease, and plasma glycosylated hemoglobin levels were independently associated with postural hypotension in patients with diabetes.

Conclusions: Postural dizziness, glycemic control, hypertension, and cerebrovascular disease were important determinants of postural hypotension in patients with diabetes. Postural hypotension was associated with postural dizziness, but it cannot be determined clinically just from the presence of postural dizziness because the sensitivity for diagnosis of postural hypotension is low.

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POSTURAL hypotension is considered the most dramatic clinical manifestation and hallmark of diabetic autonomic neuropathy.^{1,2} In patients with diabetes, autonomic neuropathy with abnormal cardiovascular reflex tests has been associated with increased mortality from unexpected sudden death and renal failure.^{3,4} However, there is no uniform criterion for postural hypotension that may be symptomatic or asymptomatic.⁵ Although postural hypotension is most commonly defined as a drop of 20 mm Hg or more in systolic blood pressure from the lying posture to the upright posture,⁶⁻¹¹ the lack of symptoms associated with postural hypotension raises a question about the clinical value of this definition. It is reasonable to define postural hypotension as a particular decline in blood pressure that can predict a poor outcome.¹⁰ A study of the Hypertension Detection and Follow-up Program⁶ revealed that a decline of 20 mm Hg or more in sys-

tolic blood pressure after standing was associated with a high 5-year mortality rate, which indicated a poor prognosis for patients with diabetes complicated with hypertension. Epidemiological evidence also suggested that postural change with a decrease of 20 mm Hg or more in systolic blood pressure was a significant risk factor for fall and syncope.^{7,8} Furthermore, a drop of more than 20 mm Hg in postural systolic blood pressure was a risk factor for symptomatic occlusive cerebrovascular disease.⁹ Therefore, Lipsitz¹⁰ thought that postural hypotension with a decline of 20 mm Hg or more in systolic blood pressure on standing should be used to define a potentially dangerous hypotensive response.

Postural dizziness was believed to be due to reduced cerebral perfusion.^{8,12,13} However, Ohashi et al¹⁴ used single photon emission computed tomography to examine cerebral blood flow and showed that regional cerebral autoregulation was not associated with postural dizziness. Thus, the mecha-

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SUBJECTS AND METHODS

The subjects were 204 consecutive non-insulin-dependent patients with diabetes and 408 age- and sex-matched nondiabetic control subjects who underwent physical examinations for preventive reasons at the National Cheng Kung University Hospital between October 1992 and September 1994. Subjects were excluded from the study for sympathectomy, anemia, thyroid disorder, pregnancy, chronic alcohol use, and/or use of anti-Parkinson drugs, narcotics, sedatives, antipsychotic agents, or antidepressants within 2 weeks of the study. The subjects with diabetes included 114 men and 90 women with a mean age \pm SD of 57.9 \pm 10.5 years. The nondiabetic control subjects were 228 men and 180 women with a mean age \pm SD of 57.1 \pm 9.5 years.

Demographic characteristics, medical history, and use of medications were assessed using a standard structured questionnaire. All the subjects received a complete physical examination, measurement of seated blood pressure, body weight, height, and ophthalmic consultation. The laboratory tests included blood chemistry analysis, a 75-g oral glucose tolerance test after a 10-hour overnight fast, and standard 12-lead electrocardiography.

Blood pressure and heart rate were measured based on the American Heart Association recommendations²⁶ with a vital sign monitor (DINAMAP TM, model 1846SX; Critikon Inc, Irvine, Calif). The participants were instructed to not consume alcohol, coffee, or tea, or to smoke cigarettes on the day of the examination. Measurements were obtained at least 3 hours after a meal in a quiet room. The appropriate-sized cuff was wrapped around the right upper arm and blood pressure and heart rate were recorded after the subject had rested in a supine position for at least 5 minutes. The subject was then asked to stand, with the entire forearm relaxed and supported at the heart level (fourth intercostal space) on an adjustable table; measurements of blood pressure and heart rate were repeated after 1, 2, and 3 minutes of standing.^{5,26} The subjects were asked about any feelings of dizziness, light-headedness, or faintness during the standing procedure and a positive or negative response was recorded.

Clinical diagnoses and definitions were determined as follows: (1) Diabetes mellitus was diagnosed with a fasting plasma glucose measurement of 7.8 mmol/L (140 mg/dL) or greater or 11.1 mmol/L (200 mg/dL) or greater 2 hours after a glucose load (75 g), when a history of diabetes was reported, or if the subject currently used insulin or an oral hypoglycemic agent.²⁷ (2) Postural hypotension was defined as a drop in systolic blood pressure from the lying position to the upright position of 20 mm Hg or more after 1 minute of standing.^{11,16,25} (3) Postural dizziness was defined as any feelings of dizziness, light-headedness, or faintness while standing during the examination.^{11,16,25} (4) Body mass index (BMI or Quetelet index) was calculated as weight in kilograms divided by the square of the height in meters: weight (kg)/[height (m)]². (5) Hypertension was defined as the average of 3 seated readings of systolic/diastolic blood pressure equal to or higher than 140/90 mm Hg or a positive response to a history of hypertension or current use of antihypertensive agents.²⁸ (6) Cerebrovascular disease was defined as a previously documented stroke or transient ischemic attack, or presence of hemiparesis, asymmetric hyperreflexia, motor rigidity, or a positive Babinski reflex on physical examination.⁷ (7) Diabetic retinopathy included background and preproliferative and proliferative diabetic retinopathy.²⁹ (8) Electrocardiography of left bundle-branch block or ischemic patterns were interpreted according to the Minnesota code.³⁰ They included Q-QS abnormalities, various degrees of ST segment depression, T-wave changes, and left bundle-branch block (Minnesota code 1.1-3; 4.1-3; 5.1-3 and 7.1).³⁰

Comparisons of categorical variables were analyzed using the χ^2 test. Comparisons of continuous variables between the 2 groups were carried out using the Student *t* test or the Mann-Whitney *U* test, where appropriate. Analysis of variance was used for comparisons of blood pressure and levels of fasting plasma glucose, glycosylated hemoglobin, cholesterol, and triglycerides with covariance of age and BMI between the 2 groups. Stepwise multiple logistic regression analysis was used to assess the association of clinical variables with postural hypotension. *P* values of .05 or lower indicated statistical significance.

nism of postural dizziness may be heterogeneous.¹⁵ Clinically, postural dizziness is often strongly associated with postural hypotension, but the evidence is conflicted.^{11,16-18} Some people with minor drops in systemic blood pressure develop clinical signs of cerebral ischemia and complain of dizziness or faintness on standing, whereas others with greater drops in blood pressure remain asymptomatic.¹² Thus, some reports indicate that postural hypotension is related to postural dizziness,^{16,18} while others show that there is no association between postural hypotension and postural dizziness.^{11,17}

Certain medications, normal aging, and some pathological changes such as diabetes mellitus, hypertension, and cerebrovascular disease are believed to be associated with postural hypotension.^{10,19,20} Similarly, postural dizziness is also associated with age, medication use, and comorbid diseases such as diabetes and stroke.^{16,21,22} Some of these associated factors are interrelated and interdependent, which may confound the relationship between postural hypotension and postural dizziness.

Studies on the factors most likely related to postural hypotension in subjects with diabetes have been few,^{23,24} and they did not examine postural hypotension as an outcome variable in multivariate analysis with adjustment for other confounding factors. One of the studies did not adjust for the use of medications, which was one of the important associated factors of postural hypotension.²⁴ As for the association between postural hypotension and postural dizziness, some studies have examined their relationship,^{11,16-18,25} but the subjects were limited to the elderly, not specifically to patients with diabetes. Therefore, we have conducted a case-controlled study to evaluate the association between postural hypotension and postural dizziness in patients with diabetes.

RESULTS

Table 1 shows the clinical characteristics of subjects with diabetes and nondiabetic control subjects. Subjects with diabetes had significantly higher BMI, seated blood pres-

Table 1. Comparison of Clinical Variables in Subjects With Diabetes and Nondiabetic Control Subjects*

Variables	Subjects With Diabetes (n = 204)	Control Subjects (n = 408)	P
Age, y	57.9 ± 10.5	57.1 ± 9.5	.31
Men, %	56	56	>.99
Body mass index, kg/m ²	25.5 ± 4.8	24.0 ± 3.4	<.001
Average of 3 seated readings			
Systolic blood pressure, mm Hg†	134.1 ± 20.3	127.4 ± 16.1	<.001
Diastolic blood pressure, mm Hg†	77.9 ± 7.1	76.6 ± 7.8	<.001
Heart rate, beats/min	70.2 ± 11.9	65.2 ± 9.7	<.001
Fasting plasma glucose, mmol/L (mg/dL)†	10.2 ± 4.3 (184 ± 77)	5.8 ± 2.1 (104 ± 38)	<.001
Glycosylated hemoglobin, %	8.0 ± 2.1	5.3 ± 1.2	<.001
Cholesterol, mmol/L (mg/dL)†	5.6 ± 1.3 (217 ± 50)	5.1 ± 1.1 (197 ± 43)	<.001
Triglycerides, mmol/L (mg/dL)†	1.8 ± 1.4 (159 ± 124)	1.4 ± 1.0 (124 ± 89)	<.001
Creatinine, μmol/L (mg/dL)	90.4 ± 36.7 (1.0 ± 0.4)	84.7 ± 29.1 (0.96 ± 0.3)	.03
Left bundle-branch block or ischemic pattern on electrocardiogram, %	11.8	8.6	.21
Cerebrovascular disease, %	4.9	3.2	.29
Hypertension, %	50.0	28.7	<.001
Antihypertensive agent use, %	27.5	12.5	<.001

* Values are given as mean ± SD unless otherwise indicated; P values are for the difference between the subject groups.

† Adjusted for age and body mass index.

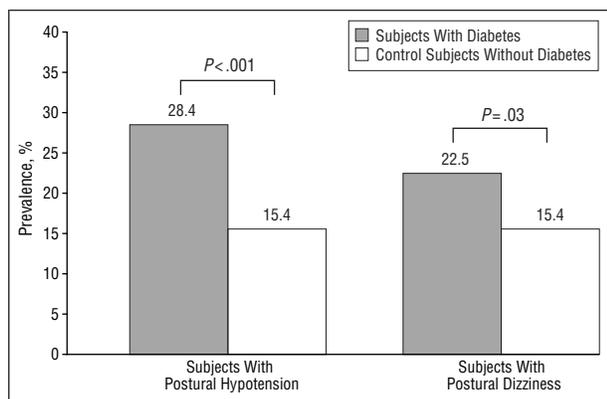


Figure 1. Prevalence of postural hypotension and postural dizziness in subjects with diabetes and nondiabetic control subjects. P values are for the difference between the groups beneath the respective P value brackets.

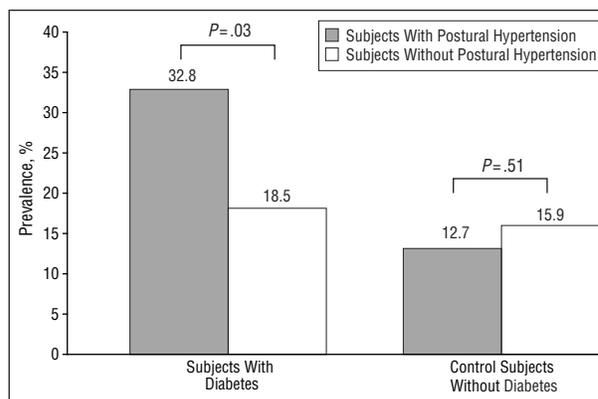


Figure 2. Prevalence of postural dizziness in subjects with diabetes and nondiabetic control subjects with and without postural hypotension. P values are for the difference between the groups beneath the respective P value brackets.

sure, and heart rate; they had significantly higher plasma creatinine, cholesterol, triglyceride, fasting glucose, and glycosylated hemoglobin levels, and a significantly higher prevalence of hypertension and use of antihypertensive agents than nondiabetic control subjects. However, there were no significant differences between subjects with diabetes and nondiabetic control subjects in age, sex, prevalence of cerebrovascular disease, or left bundle-branch block or ischemic patterns on electrocardiography.

Figure 1 reveals the prevalence of postural hypotension and postural dizziness in subjects with diabetes and nondiabetic control subjects. Subjects with diabetes had a significantly higher prevalence of postural hypotension and postural dizziness than nondiabetic control subjects (subjects with diabetes vs those without: postural hypotension, 28.4% vs 15.4%, $P < .001$; postural dizziness, 22.5% vs 15.4%, $P = .03$). If we used the criterion of decrease in systolic blood pressure of 20 mm Hg or greater within 3 minutes of standing as the diagnosis of postural hypotension, subjects with diabetes also had significantly higher prevalence of postural hypoten-

sion and postural dizziness than nondiabetic control subjects (subjects with diabetes vs those without: postural hypotension, 36.3% vs 22.8%, $P < .001$; postural dizziness, 26.5% vs 19.1%, $P = .04$) (data not shown).

Figure 2 illustrates the prevalence of postural dizziness in subjects with diabetes and nondiabetic control subjects with and without postural hypotension. Among subjects with diabetes, those with postural hypotension had a higher prevalence of postural dizziness than those without. However, only 19 (32.8%) of 58 subjects with both diabetes and postural hypotension suffered from postural dizziness. Among nondiabetic control subjects, there was no significant difference in the prevalence of postural dizziness between those with and those without postural hypotension.

The prevalence of postural hypotension in subjects receiving different types of antihypertensive medications was as follows: calcium channel blockers, 18.8% (9/48); α -blockers, 26.3% (5/19); β -blockers, 13.6% (3/22); labetalol, 27.3% (3/11); angiotensin-converting enzyme inhibitors, 10.8% (4/37); diuretics, 30.0% (3/10); nitrates, 16.7% (2/12); and

Table 2. Comparison of Clinical Variables in Subject Groups Both With and Without Diabetes Mellitus and Postural Hypotension (PH)*

Variables	Subjects With Diabetes			Control Subjects Without Diabetes			P	P†	P‡
	PH (+) (n = 58)	PH (-) (n = 146)	P	PH (+) (n = 63)	PH (-) (n = 345)	P			
Age, y	60.7 ± 10.0	56.8 ± 10.5	<.05	60.5 ± 7.6	56.4 ± 9.7	<.05	...	...
Men, %	62.1	53.4	...	57.1	55.7	...	...	...
Body mass index, kg/m ²	25.2 ± 6.4	25.6 ± 4.1	...	24.0 ± 3.4	24.0 ± 3.4	...	...	<.01
Supine systolic blood pressure, mm Hg§	144.6 ± 20.3	131.1 ± 25.6	<.01	138.2 ± 22.2	123.0 ± 22.1	<.001	...	<.001	
Systolic blood pressure after 1 min of standing, mm Hg§	118.0 ± 20.4	126.2 ± 27.8	<.01	111.1 ± 22.3	117.1 ± 24.2	<.01	...	<.001	
Supine resting heart rate, beats/min	68.1 ± 13.3	69.1 ± 11.2	...	64.2 ± 8.7	65.4 ± 9.8	...	...	<.01
Heart rate after 1 min of standing, beats/min	75.5 ± 13.7	77.5 ± 11.2	...	73.0 ± 10.5	75.3 ± 11.3	...	...	...
Heart rate change after 1 min of standing, beats/min	7.4 ± 7.7	8.3 ± 5.9	...	8.9 ± 6.9	9.8 ± 6.6	...	...	...
Albumin, g/L	43.4 ± 3.5	43.5 ± 3.7	...	42.7 ± 2.9	42.8 ± 3.4	...	...	...
Cholesterol, mmol/L (mg/dL)§	5.8 ± 1.4 (224 ± 54)	5.6 ± 1.3 (217 ± 50)	...	5.1 ± 0.9 (197 ± 35)	5.1 ± 1.1 (197 ± 43)	...	<.01	<.001	
Triglyceride, mmol/L (mg/dL)§	2.1 ± 1.8 (186 ± 159)	1.7 ± 1.3 (151 ± 115)	...	1.2 ± 0.7 (106 ± 62)	1.4 ± 1.1 (124 ± 97)	...	<.001	<.001	
Creatinine, μmol/L (mg/dL)	98.3 ± 47.5 (1.1 ± 0.5)	87.3 ± 31.1 (1.0 ± 0.35)	...	84.9 ± 20.4 (1.0 ± 0.23)	84.6 ± 30.4 (1.0 ± 0.34)	...	...	...
Fasting plasma glucose, mmol/L (mg/dL)§	11.7 ± 5.0 (211 ± 90)	9.6 ± 3.4 (173 ± 61)	<.01	5.5 ± 1.7 (99 ± 31)	5.9 ± 2.2 (106 ± 40)	...	<.001	<.001	
Glycosylated hemoglobin, %§	8.7 ± 1.9	7.7 ± 2.1	<.01	5.1 ± 0.9	5.4 ± 1.3	...	<.001	<.001	
Duration of diabetes, y	6.6 ± 6.4	4.9 ± 5.4	...	...	...	...	...	...
Cerebrovascular disease, %	10.3	2.7	<.05	3.2	3.2	...	<.05	...	
Hypertension, %	70.7	41.8	<.001	41.3	26.4	<.05	<.01	<.001	
Left bundle-branch block or ischemic pattern on electrocardiogram, %	15.5	10.3	...	9.5	8.4	...	...	...
Diabetic retinopathy, %	25.2	16.1	...	...	...	...	...	...
Insulin use, %	5.2	2.7	...	...	...	...	...	...
Hypoglycemic agent use, %	63.1	63.0	...	...	...	...	...	...
Antihypertensive agent use, %	44.8	20.5	<.001	9.5	13.0	...	<.001	<.05	

* Values are given as mean ± SD unless otherwise indicated; P values are for the difference between the subject groups; PH (+), subjects with PH; PH (-), subjects without PH; and ellipses, not applicable.

† These P values are for the difference between subjects with PH, with and without diabetes.

‡ These P values are for the difference between subjects without PH, with and without diabetes.

§ Adjusted for age and body mass index.

hydralazine, 33.3% (1/3). In univariate analysis, there was no association between postural hypotension and any of the above antihypertensive medications. Thus, we merged those subjects using the above antihypertensive medications into 1 group for analysis.

Table 2 presents the comparisons of clinical variables in the subjects with diabetes and nondiabetic control subjects with and without postural hypotension. Subjects with both diabetes and postural hypotension were older and had higher supine systolic blood pressures, higher plasma glycosylated hemoglobin and fasting glucose levels, and higher prevalences of hypertension and cerebrovascular disease, and use of antihypertensive agents; they had lower standing systolic blood pressure than subjects with diabetes without postural hypotension. There

were no statistical differences between subjects with diabetes who had postural hypotension and those who did not in sex, BMI, supine resting heart rate, heart rate change (heart rate after 1 minute of standing vs supine resting heart rate), or duration of diabetes. There were no statistical differences in plasma albumin, cholesterol, triglyceride, or creatinine levels or in the prevalence of left bundle-branch block or ischemic patterns on electrocardiographic studies; and there were no statistical differences in diabetic retinopathy or the use of insulin and oral hypoglycemic agents. In nondiabetic control subjects, those with postural hypotension were older and had higher supine systolic blood pressure and prevalence of hypertension, and lower standing systolic blood pressure than those without postural hypotension.

Table 3. Multiple Logistic Regression Analysis in the Relationship Between Clinical Variables and Postural Hypotension*

Variables	Total No. of Subjects (N = 612)		Control Subjects (n = 408)		Subjects With Diabetes (n = 204)	
	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)
Postural dizziness	.51	...	.45	...	.02	2.52 (1.16-5.48)
Age, y	.005	1.03 (1.01-1.06)	.01	1.04 (1.01-1.07)	.21	...
Body mass index, kg/m ²	.51	...	.90	...	.30	...
Cholesterol, mmol/L	.90	...	.87	...	.61	...
Triglyceride, mmol/L	.87	...	.33	...	.43	...
Creatinine, μmol/L	.64	...	.97	...	.16	...
Diabetes mellitus	.005	1.83 (1.20-2.80)	...	...	...	...
Glycosylated hemoglobin, %	...	...	.29	...	.002	1.34 (1.11-1.61)
Duration of diabetes, y	...	...	...	...	.24	...
Diabetic retinopathy	...	...	...	...	.38	...
Hypertension	.001	2.06 (1.33-3.18)	.01	2.31 (1.21-4.39)	.002	2.30 (1.48-6.06)
Cerebrovascular disease	.26	...	.77	...	.04	4.55 (1.06-19.58)
Insulin use	.14	...	...	...	.18	...
Oral hypoglycemic agent use	.80	...	...	...	.08	...
Antihypertensive agent use	.73	...	.07	...	.34	...

*OR indicates odds ratio; CI, confidence interval; and ellipses, not applicable.

As compared with nondiabetic control subjects with postural hypotension, subjects with both diabetes and postural hypotension had higher plasma cholesterol, triglyceride, fasting glucose, and glycosylated hemoglobin levels, and higher prevalences of hypertension, cerebrovascular disease, and use of antihypertensive agents. Subjects with diabetes but without postural hypotension had higher BMI, higher supine and standing systolic blood pressure, higher plasma cholesterol, triglyceride, fasting glucose, and glycosylated hemoglobin levels, and higher prevalence of hypertension and use of antihypertensive agents than nondiabetic control subjects without postural hypotension.

To examine the relationship between postural hypotension and postural dizziness, the outcome variable was postural hypotension and the predictor variables included postural dizziness and other clinical variables in multiple logistic regression analysis (**Table 3**). For total study populations, the predictor variables included postural dizziness, age, BMI; plasma cholesterol, triglyceride, and creatinine levels; and diabetes mellitus, hypertension, cerebrovascular disease, and use of insulin or oral hypoglycemic and antihypertensive agents. The results show that an independently positive correlation existed between postural hypotension and the following variables: age ($P = .005$), diabetes mellitus ($P = .005$), and hypertension ($P = .001$). An increase in the number of these independently associated factors increased the likelihood of postural hypotension. In subjects with diabetes, the predictor variables of multiple logistic regression included postural dizziness, age, BMI; plasma cholesterol, triglyceride, creatinine, and glycosylated hemoglobin levels; and duration of diabetes, diabetic retinopathy, hypertension, cerebrovascular disease, and use of insulin or oral hypoglycemic and antihypertensive agents. The results demonstrated that postural dizziness ($P = .02$), glycosylated hemoglobin levels ($P = .002$), hypertension ($P = .002$), and cerebrovascular disease ($P = .04$) were independently associated with postural hypotension. In non-

diabetic control subjects, the predictor variables included postural dizziness, age, and BMI; plasma cholesterol, triglyceride, creatinine, and glycosylated hemoglobin levels; and hypertension, cerebrovascular disease, and use of antihypertensive agents. The results indicated that age ($P = .01$) and hypertension ($P = .01$) were independently related to postural hypotension.

If we used the criterion of decrease in systolic blood pressure of 20 mm Hg or greater within 3 minutes of standing as the diagnosis of postural hypotension, the relationships between postural hypotension and postural dizziness were not changed in the diabetic, nondiabetic, and total groups. For total study populations, age ($P = .002$), diabetes mellitus ($P = .03$), hypertension ($P = .002$), and cerebrovascular disease ($P = .04$) were independently associated factors of postural hypotension. In subjects with diabetes, postural dizziness ($P = .03$), glycosylated hemoglobin levels ($P = .008$), hypertension ($P = .005$), and cerebrovascular disease ($P = .01$) were independently associated with postural hypotension. In nondiabetic control subjects, age ($P = .004$) and hypertension ($P = .04$) were independently related to postural hypotension (data not shown).

COMMENT

There are varying criteria for the diagnosis of postural hypotension^{19,20,31}; the most recent consensus is a drop in blood pressure of at least 20 mm Hg systolic or 10 mm Hg diastolic within 3 minutes of either standing or head-up tilt of at least 60°. However, several important studies have examined the relationship between postural dizziness and postural hypotension with the test of 1 minute of standing.^{11,16,25} For comparison with the above studies, we used the criterion of 1 minute of standing in this study. The impact of changing the criterion from 1 minute to 3 minutes of quiet standing was only that the prevalence of postural hypotension and postural dizziness increased in subjects both with and without diabetes. However, there

was no change in the relationship between postural hypotension and postural dizziness in the 2 groups.

Diabetes mellitus was an independently associated factor of postural hypotension in our study, which is consistent with the literature.^{1,3,19,32} Regarding the mechanism of postural hypotension in diabetes, there is more commonly a neurogenic cause usually associated with efferent involvement of the baroregulatory reflex arc with damaged sympathetic vasoconstrictor fibers in the splanchnic bed, muscle, and skin.⁵ In contrast, diminished cardiac acceleration may play a lesser role in the development of postural hypotension.^{33,34}

Our patients with diabetes had a higher resting heart rate than nondiabetic control subjects, which is consistent with other reports.^{35,36} A higher resting heart rate is often observed in patients with diabetes, and this is due to cardiac vagal neuropathy.^{35,36} With progression of diabetic autonomic neuropathy, some patients experienced initial tachycardia that may be followed by a decreased heart rate and, ultimately, a fixed heart rate due to the progression of cardiac sympathetic nerve dysfunction.³⁷⁻³⁹ The increase in heart rate on standing results from the dual effects of inhibition in cardiac vagal tone and increase in sympathetic tone.⁴⁰ The heart rate change after standing in those subjects with postural hypotension was lower than in those without because sympathetic abnormalities in patients with diabetes are detectable almost exclusively after cardiac vagal neuropathy is impaired.⁴¹⁻⁴³ Although all of our subjects with postural hypotension, both with and without diabetes, had lower heart rate changes than those without postural hypotension, the difference was not significant. This may be due to the high fatality rate in subjects with postural hypotension^{3,4} and the minor role of diminished cardiac acceleration in the development of postural hypotension,^{33,34} thus causing an underestimate in the relationship between postural hypotension and heart rate change after standing.

Reported studies have revealed that poor glycemic control of diabetes mellitus, which is shown by increasing plasma glycosylated hemoglobin levels, was vulnerable to postural hypotension.^{23,24} In our patients with diabetes, plasma glycosylated hemoglobin was an independently positive factor correlated with postural hypotension. Therefore, good glycemic control is important in the prevention of postural hypotension in subjects with diabetes, which is also suggested in other reports.^{1,23,24}

Duration of diabetes has often been perceived as an associated factor of postural hypotension, but the evidence was sparse. The prevalence of postural hypotension (the criteria of postural hypotension with a systolic blood pressure change of 30 mm Hg or more) increased with duration of diabetes in a young group (aged 18-34 years).²⁴ However, our study and another report²³ showed that duration was not independently associated with postural hypotension. Because postural hypotension was associated with increased mortality,^{3,4} the prevalence of postural hypotension in survivors would be diminished.²⁴ This may be the partial explanation for the discrepancy between the prevalence of postural hypotension and duration of diabetes.

The prevalence of postural hypotension was 28.4% in our subjects with diabetes. Hilsted and Low¹ re-

ported 2 studies on diabetes mellitus complicated with postural hypotension in 19 (26%) of 73 patients and 7 (43%) of 16 patients. Tsutsu et al²³ reported on 157 (18%) of 886 cases of patients with diabetes. The variation was considered to be due to the referral bias.¹

The literature has revealed that cerebrovascular disease is a risk factor associated with postural hypotension,^{10,11,19} because it may interrupt the central nervous system pathways that control autonomic reflexes.³² Cerebrovascular disease was an independently associated factor of postural hypotension in our patients with diabetes. However, the Cardiovascular Health Study Collaborative Research Group did not find a positive association between postural hypotension and stroke,¹⁷ suggesting that a high fatality rate in strokes associated with postural hypotension (ie, the result of a survival effect) may explain the negative results in the association between stroke and postural hypotension.¹⁷

Our results suggest that hypertension is associated with postural hypotension in subjects with diabetes and in nondiabetic control and total subjects as well, which is consistent with the findings of other studies.^{11,16,18,25,44} Hypertension has been shown to be associated with impaired baroreflex sensitivity, which may be due to a decrease in vascular compliance and consequent diminution of baroreceptor stretch and relaxation during blood pressure changes.^{44,45} Moreover, an increase in blood pressure and the duration of hypertension may exacerbate the decline in baroreflex sensitivity, in part, causing postural hypotension.^{20,45}

Although the literature has shown that antihypertensive medication was related to postural hypotension,^{10,19} our study and another report⁴⁶ revealed that there was no significant association between postural hypotension and antihypertensive medication. Masuo et al⁴⁷ showed that the incidence of postural hypotension decreased significantly followed by decreasing blood pressure and normalizing blood pressure with the use of antihypertensive drugs (especially calcium channel blockers, β -blockers, and angiotensin-converting enzyme inhibitors) in elderly patients with hypertension. This may be a partial explanation for the dissociation between postural hypotension and antihypertensive medication. Another factor could be due to an underestimation in a cross-sectional study if a past occurrence of a treatment adverse effect or related symptom led to an adjustment of the treatment regimen.⁴⁶

The mechanism of postural dizziness remains obscure and may be heterogeneous.¹² Some reports have suggested postural hypotension or cerebral ischemia may be involved in postural dizziness,^{12,13} and others have suggested vestibular dysfunction, vision impairment, and disorders in the proprioceptive system may be also involved.^{15,48} Thus, postural hypotension is just 1 of the causes of postural dizziness, and it is not surprising that only 19 (32.8%) of 58 subjects with diabetes and postural hypotension suffer from postural dizziness. This is consistent with other reports suggesting that postural hypotension may be a cause of postural dizziness, but most subjects with postural hypotension in the studies of the elderly^{16,18} did not suffer from postural dizziness. Thus, the sensitivity was low for the diagnosis of postural hypotension based solely on the presence of postural diz-

ziness relative to the diagnosis based on the postural blood pressure changes. Therefore, postural hypotension cannot be clinically determined just from the presence of postural dizziness.

In conclusion, the prevalence of postural hypotension and postural dizziness in patients with diabetes was higher than in nondiabetic control subjects. Only 32.8% of subjects with both diabetes and postural hypotension suffered from postural dizziness. Age, diabetes mellitus, and hypertension were independently associated with postural hypotension. Plasma glycosylated hemoglobin levels, postural dizziness, hypertension, and cerebrovascular disease are independent determinants of postural hypotension in subjects with diabetes. Clinically, older adults and patients with diabetes mellitus or hypertension should receive regular monitoring of supine and upright blood pressure changes. Good glycemic control is important in preventing postural hypotension in patients with diabetes. Postural hypotension was associated with postural dizziness in subjects with diabetes, but it cannot be diagnosed clinically just from the postural dizziness because of the low sensitivity in the diagnosis of postural hypotension based only on postural dizziness relative to the diagnosis based on postural systolic blood pressure changes.

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