Population-Based Study on the Prevalence and Risk Factors of Orthostatic Hypotension in Subjects With Pre-Diabetes and Diabetes

Jin-Shang Wu, MD, MS[1,2]
Yi-Ching Yang, MD, MPH[1,2]
Feng-Hwa Lu, MD, MS[1,2]
Chih-Hsing Wu, MD[2]
Ru-Hsueh Wang, MD[2]
Chih-Jen Chang, MD[1,2]

OBJECTIVE — The aim of this study was to investigate the relationship between pre-diabetes and orthostatic hypotension and to examine the prevalence and correlates of orthostatic hypotension in community dwellers with normal glucose tolerance (NGT), pre-diabetes, and diabetes.

RESEARCH DESIGN AND METHODS — All participants were classified as having NGT (n = 1,069), pre-diabetes (n = 412), or diabetes (n = 157). Orthostatic hypotension was defined as a decline in systolic/diastolic blood pressure of ≥20/10 mmHg when an individual changed from a supine to a standing position. The cardiovagal response to standing was the ratio between the longest RR interval around beat 30 and the shortest RR interval around beat 15 after standing (30 max–to–15 min ratio).

RESULTS — The prevalences of orthostatic hypotension were 13.8, 17.7, and 25.5% in subjects with NGT, pre-diabetes, and diabetes, respectively. For all subjects, age, diabetes, hypertension, and a decreased 30 max–to–15 min ratio, but not pre-diabetes, were independently associated with orthostatic hypotension. Age, hypertension, and 30 max–to–15 min ratio were the correlates of orthostatic hypotension in NGT subjects. Age and hypertension were related to orthostatic hypotension in pre-diabetic subjects. A1C and hypertension were the determinants of orthostatic hypotension in diabetic subjects. Supine blood pressure was related to orthostatic hypotension in all subjects and subgroups.

CONCLUSIONS — Pre-diabetic subjects do not have a higher risk of orthostatic hypotension than subjects with NGT, although the risk of orthostatic hypotension is higher in diabetic subjects. Hypertension and supine blood pressure were risk factors for orthostatic hypotension in both pre-diabetic and diabetic subjects. Age and A1C were the correlates of orthostatic hypotension in pre-diabetic and diabetic subjects, respectively. The cardiovagal response to standing is an important determinant of orthostatic hypotension in subjects with NGT but not in pre-diabetic and diabetic subjects.

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Diabetic autonomic neuropathy with abnormal cardiovascular reflex has been associated with increased mortality from unexpected sudden death and renal failure (1). Orthostatic hypotension is one clinical manifestation of diabetic autonomic neuropathy (1) and is also a significant risk factor for fall, syncope, cardiovascular disease, and all-cause morality (1–4). Recently, pre-diabetes has been suggested to produce a significant increase in all-cause mortality and combined diabetes and cardiovascular disease mortality risks (5). However, the relationship between pre-diabetes and orthostatic hypotension is not clear, although there have been reports about orthostatic hypotension in subjects with diabetes (3,6–11).

When a normal individual stands up from a lying position, the baroregulatory reflex produces vagal inhibition and sympathetic stimulation, resulting in an increase in heart rate and vasoconstriction to maintain the systemic blood pressure. Any impairment in the reflex arc, such as an efferent lesion with an inability to increase heart rate and vasoconstriction, may result in orthostatic hypotension (2,12). The initial heart rate response to standing consists of a maximal tachycardia around beat 15, followed by a relative bradycardia around beat 30 (12). It is generally recommended that the 30 max–to–15 min ratio (calculated by dividing the longest RR interval around beat 30 and the shortest RR interval around beat 15 after standing) be used as a cardiovagal response to standing (12). Although diabetic subjects exhibited impaired cardiac autonomic function (1,13), the cardiovagal response to active standing in subjects with diabetes and even pre-diabetes is not clear.

The prevalence of orthostatic hypotension in diabetic subjects varied extremely from 8.2 to 43%, depending on the diagnostic criterion and study subject selection (3,6–10). Aging and some pathological changes, such as hypertension and cardiovascular disease, have been shown to be risk factors for orthostatic hypotension (2,6,9,11). However, some of the risk factors are interrelated, which may confound the effect of diabetes and even pre-diabetes on orthostatic hypotension. Most of the studies on orthostatic hypotension in diabetic subjects were hospital based, not population based (3,6–8,10), and adopted only the postural change in systolic blood pressure as the criteria (3,6–8). There is a lack of epidemiological study on orthostatic hypotension in subjects across the different blood glucose levels, including normal glucose tolerance (NGT), pre-diabetes, and diabetes. Research on whether the cardiovagal response to standing is differ-

From the [1]Department of Family Medicine, College of Medicine, National Cheng Kung University, Taiwan, Republic of China; and the [2]Department of Family Medicine, National Cheng Kung University Hospital, Taiwan, Republic of China.
Corresponding author: Chih-Jen Chang, em75210@email.ncku.edu.tw.
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ent among these three groups is also lacking. Thus, the aim of this study was to investigate the relationship between pre-diabetes and orthostatic hypotension and also to examine the prevalence and risk factors for orthostatic hypotension in subjects with NGT, pre-diabetes, and diabetes from population-based data in Tainan, Taiwan.

RESEARCH DESIGN AND METHODS

— Subjects were participants in a community-based study for chronic diseases conducted in Tainan, a city in southern Taiwan with a population of about 700,000. A three-stage sampling scheme was used to generate a stratified systemic cluster sample of households throughout the city. Initially, the city was classified into seven strata according to its administrative districts. In each of the districts, one area was selected from each stratum by adopting probability proportion to the size of the areas within that specific stratum, and every fifth household within each of the seven selected areas was then systematically identified. Finally, the members of each household aged ≥20 years were invited to participate in the study, and 2,416 eligible subjects were selected. A total of 1,638 subjects, representing a response rate of 67.8%, completed the study protocol. Details of the sampling method have been described elsewhere (14). Written consent was obtained from all participants, and the research committee of National Cheng Kung University Hospital, Taiwan, approved this study.

Clinical examination and blood pressure measurement

Demographic characteristics, dietary habits, cigarette smoking, alcohol use, physical activity, medical history, and medication use were assessed by a standard structured questionnaire. All of the subjects received a physical examination, with measurement of body weight and height. The laboratory tests included blood biochemistry, urinalysis, and standard 12-lead electrocardiography after a 10-h overnight fast. Subjects without a history of diabetes received a 75-g oral glucose tolerance test after measurement of blood pressure in the seated, supine, and standing positions. A blood sample was obtained 2 h after the subject drank a glucose solution.

Blood pressure and heart rate changes after standing were measured with a DINAMAP vital sign monitor (model 1846SX; Critikon, Irvine, CA) and electrocardiograph (α-8000; Cardiosuny, Tokyo, Japan). The participants were instructed not to consume alcohol, coffee, tea, or cigarettes on the day of the examination. All measurements were taken between 8:00 and 10:00 A.M. in a quiet room. Two seated blood pressure measurements and heart rate were measured separately with at least 5-min intervals after the subject had rested for at least 15 min. The subject then rested in a supine position for at least 15 min. After supine blood pressure and heart rate were measured twice, the subject was asked to stand from the supine position with the entire forearm relaxed and supported at the heart level (fourth intercostal space) on an adjustable table. Blood pressure and heart rate were measured twice again after 1 and 3 min of standing. The 30 max–to–15 min ratio, an index of the cardiovagal response to standing from supine position (12), was calculated.

Definition of clinical variables

NGT was defined as fasting plasma glucose <5.6 mmol/l and 2-h postload glucose <7.8 mmol/l without a history of diabetes. Pre-diabetes included impaired fasting glucose and impaired glucose tolerance. Impaired fasting glucose was fasting plasma glucose of 5.6–6.9 mmol/l and 2-h postload glucose <11.1 mmol/l without a history of diabetes. Impaired glucose tolerance was defined as 2-h postload glucose of 7.8–11.1 mmol/l and fasting plasma glucose <7.0 mmol/l without a history of diabetes. Diabetes was diagnosed with a fasting plasma glucose ≥7.0 mmol/l, 2-h postload glucose ≥11.1 mmol/l, or a positive response to history of diabetes or current use of insulin or an oral hypoglycemic agent (15). Orthostatic hypotension was defined as a decline in systolic blood pressure of at least 20 mmHg and/or a decline in diastolic blood pressure of at least 10 mmHg after either 1 or 3 min of standing after an individual changed from a supine to a standing position (16). Hypertension was defined as the average of two readings of seated systolic/diastolic blood pressure ≥140/90 mmHg or a positive response to a history of hypertension (17). BMI was derived by dividing weight in kilograms by the square of height in meters. Total physical activity, including work, walking, and leisure time, was assessed in METs per week over all activities for the past year (18). Cerebrovascular disease was defined as a previously documented history or the presence of hemiparesis, asymmetric hyperreflexia, motor rigidity, or a positive Babinski reflex on physical examination. Electrocardiograms showing left bundle branch block or ischemic patterns were interpreted according to the Minnesota code. They included Q-QS abnormalities, various degrees of ST segment depression, T-wave changes, and left bundle branch block (19).

Statistical analysis

Data analyses were performed using SSPS (version 10.0 for Windows; SSPS, Chicago, IL). Comparisons of categorical variables were analyzed using a χ^2 test or Fisher's exact test, when the expected number of cells was less than five. ANOVA was used to compare continuous variables among the subjects with NGT, pre-diabetes, and diabetes. Bonferroni post hoc tests were also used to compare the max30-to-15min ratio among groups. The Kruskal-Wallis test was used for comparison of plasma triglyceride and physical activity levels among groups.

Multiple logistic regression was used to assess the contribution to orthostatic hypotension by different clinical factors in total subjects. The outcome variable was orthostatic hypotension and the predictor variables included age, sex, BMI, physical activity, pre-diabetes, diabetes, hypertension, cerebrovascular disease, ischemic electrocardiographic (ECG) pattern, 30 max–to–15 min ratio, and antihypertensive agent use. We also examined the effect of supine systolic/diastolic blood pressure as a continuous variable on orthostatic hypotension in another model. In addition, the risk factors for orthostatic hypotension were assessed in subgroups with NTG, pre-diabetes, and diabetes based on multiple logistic regression analysis. The predictor variables included age, sex, BMI, physical activity, A1C, hypertension (or supine blood pressure), cerebrovascular disease, ischemic ECG pattern, 30 max–to–15 min ratio, and antihypertensive agent use. $P \leq 0.05$ was considered significant.

RESULTS

— A total of 1,638 participants were classified into NGT (n = 1,069), pre-diabetes (n = 412), and diabetes (n = 157) groups. Table 1 shows the comparison of clinical characteristics among subjects with NGT, pre-diabetes, and diabetes. There were significant differences in age, BMI, supine and standing systolic/diastolic blood pressures, heart

Table 1—*Comparison of clinical variables among subjects with NGT, pre-diabetes, and diabetes*

	NGT	Pre-diabetes	Diabetes	*P* value
n	1,069	412	157	
Age (years)	39.4 ± 14.0	49.5 ± 14.2	57.7 ± 12.8	<0.001
Male sex (%)	46.9	47.1	57.1	0.227
BMI (kg/m^2)	23.0 ± 3.3	24.7 ± 3.8	25.8 ± 3.5	<0.001
Supine SBP (mmHg)	114.4 ± 17.5	124.5 ± 21.0	135.8 ± 24.9	<0.001
Supine DBP (mmHg)	69.7 ± 9.6	74.7 ± 10.9	78.7 ± 11.1	<0.001
Supine HR (beats/min)	66.1 ± 10.3	69.0 ± 11.2	72.6 ± 12.1	<0.001
Standing SBP (mmHg)	107.0 ± 18.3	117.1 ± 22.7	126.5 ± 27.4	<0.001
Standing DBP (mmHg)	68.4 ± 10.7	72.6 ± 12.8	73.3 ± 11.9	<0.001
Standing HR (beats/min)	75.7 ± 11.5	76.7 ± 12.2	78.1 ± 13.2	<0.001
Physical activity, MET-h/week*	61.7 ± 88.5	58.3 ± 75.3	32.8 ± 36.7	<0.001
Fasting glucose (mmol/l)	4.9 ± 0.4	5.6 ± 0.5	8.7 ± 3.4	<0.001
A1C (%)	4.9 ± 0.5	5.1 ± 0.6	7.5 ± 2.3	<0.001
Cholesterol (mmol/l)	4.9 ± 1.1	5.2 ± 1.0	5.3 ± 1.4	<0.001
Triglyceride (mmol/l)*	1.3 ± 1.0	1.5 ± 0.9	2.3 ± 3.6	<0.001
HDL cholesterol (mmol/l)	1.4 ± 0.4	1.3 ± 0.3	1.2 ± 0.4	<0.001
Hypertension (%)	10.9	26.0	49.0	<0.001
Ischemic ECG pattern (%)	10.9	15.3	20.4	0.002
Cerebrovascular disease (%)	1.4	2.4	8.3	<0.001
Antihypertensive use (%)	4.1	12.1	23.6	<0.001
Current alcohol use (%)	12.4	13.8	14.0	0.711
Current smoking (%)	21.8	18.0	22.9	0.209

Data are means ± SD or %. SBP and DBP represent the average of two supine (standing) systolic/diastolic blood pressures; HR represents the average of two supine (standing) heart rates. *Kruskal-Wallis test.

rate, physical activity, A1C, fasting plasma glucose, cholesterol, triglycerides, and HDL cholesterol and the prevalence of hypertension, ischemic ECG pattern, cerebrovascular diseases, and antihypertensive use among subjects with NGT, pre-diabetes, and diabetes.

The prevalences of orthostatic hypotension were 13.8, 17.7, and 25.5% in subjects with NGT, pre-diabetes, and diabetes, respectively (Fig. 1). The difference in the prevalence of orthostatic hypotension was significant among groups ($P < 0.001$, test for trend). The 30 max–to–15 min ratio also differed significantly among subjects with NGT, pre-diabetes, and diabetes ($P < 0.001$) (Fig. 1). A post hoc test showed that subjects with pre-diabetes and diabetes had a lower 30 max–to–15 min ratio than subjects with NGT ($P < 0.001$). Diabetic subjects also had a lower 30 max–to–15 min ratio than pre-diabetic subjects ($P = 0.001$).

Table 2 shows the effect of clinical variables on the risk of orthostatic hypotension in all subjects on the basis of multiple logistic regression analysis. Model 1 showed that age ($P = 0.042$), diabetes ($P = 0.038$), hypertension ($P = 0.007$), and decreased 30 max–to–15 min ratio ($P = 0.023$), but not pre-diabetes ($P = 0.830$), were independently associated with orthostatic hypotension. For the effect of supine blood pressure on orthostatic hypotension, supine systolic ($P < 0.001$) and diastolic blood pressures ($P < 0.001$) were independently related to orthostatic hypotension in model 2 and model 3, respectively.

Table 3 shows the effects of clinical variables on the risk of orthostatic hypotension in subjects with NGT, pre-diabetes, and diabetes on the basis of multiple logistic regression analysis. For subjects with NGT, age ($P = 0.030$), hypertension ($P = 0.024$), and 30max-to-15min ratio ($P = 0.036$) were independently related to orthostatic hypotension. Age ($P = 0.031$) and hypertension ($P = 0.020$) were the independently associated factors for orthostatic hypotension in pre-diabetic subjects. A1C ($P = 0.028$) and hypertension ($P = 0.018$) were significantly associated with orthostatic hypotension in diabetic subjects. The 30 max–to–15 min ratio was not associated with orthostatic hypotension in either pre-diabetic ($P = 0.171$) or diabetic ($P = 0.241$) subjects. For the effect of supine blood pressure on orthostatic hypotension (data not shown), both supine systolic and diastolic blood pressures were independently related to orthostatic hypotension in subjects with NGT, pre-diabetes, and diabetes (systolic blood pressure: NGT $P < 0.001$, pre-diabetes $P = 0.001$, diabetes $P = 0.02$; diastolic blood pressure: NGT $P < 0.001$, pre-diabetes $P = 0.008$, diabetes $P = 0.03$).

CONCLUSIONS — Most of the studies on diabetic orthostatic hypotension have adopted the postural change in systolic blood pressure as the criterion (3,6–9), except for one study that used mean blood pressure to define orthostatic hypotension (10). When the criterion was a reduction in systolic blood pressure of at least 20 mmHg, the prevalence of diabetic orthostatic hypotension varied from 8.2 to 43% (3,6–9). Cryer et al. (10) reported that 18% of 100 diabetic patients had orthostatic hypotension with a decline in mean blood pressure of 20 mmHg or more. We adopted a consensus criterion of orthostatic hypotension that was a fall in blood pressure of at least 20 mmHg systolic or 10 mmHg diastolic from lying to upright position, and the prevalence of orthostatic hypotension was 25.5% in our diabetic subjects. A report on the prevalence of orthostatic hypotension in pre-diabetic subjects is not available. Our

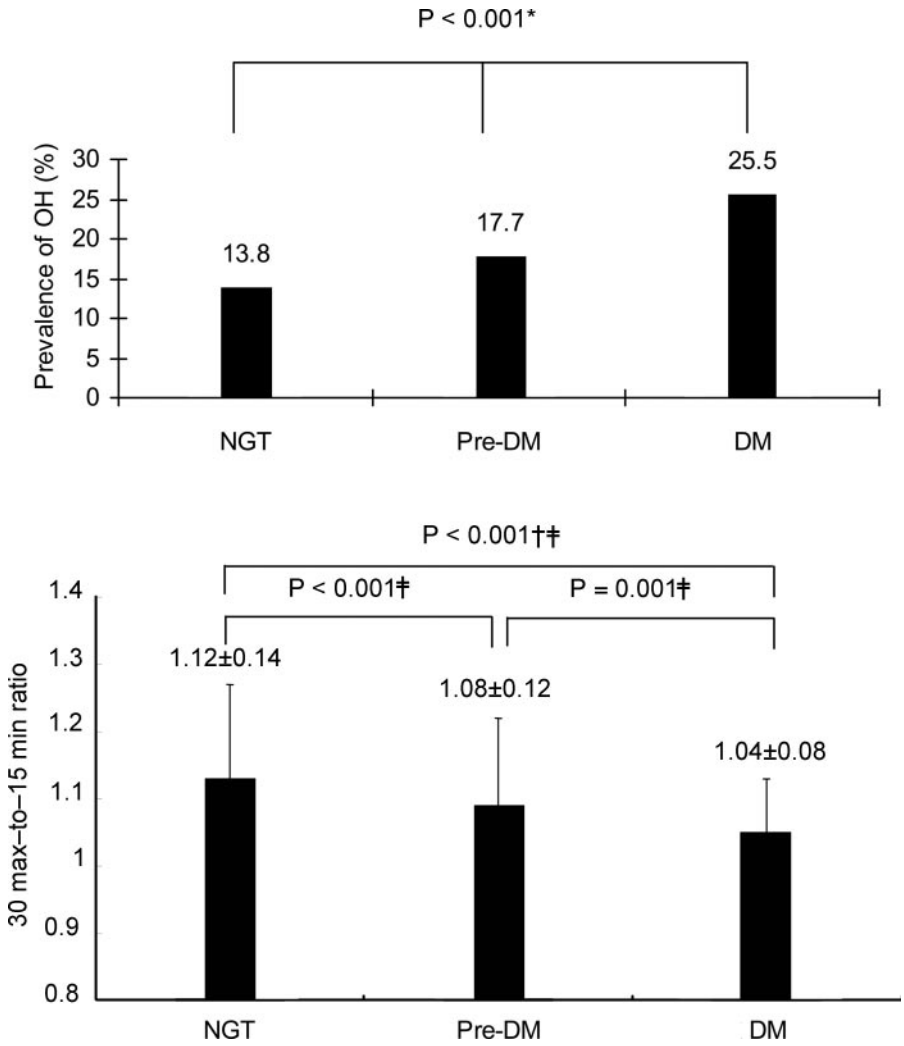

Figure 1—*Comparisons of prevalence of orthostatic hypotension (OH) (*A*) and 30 max–to–15 min ratio, an index of cardiovagal response to standing from supine position (*B*), in subjects with NGT, pre-diabetes (pre-DM), and diabetes (DM). *P < 0.001 test for trend; †ANOVA among groups; ‡Bonferroni post hoc test.*

study showed that the prevalence of orthostatic hypotension in subjects with pre-diabetes was 17.7%.

Diabetes was found to be independently associated with orthostatic hypotension in our study, which is consistent with results in the literature (1,2). Diabetic orthostatic hypotension usually has a neurogenic cause associated with efferent involvement of the baroregulatory reflex arc with damaged sympathetic vasoconstrictor fibers in the splanchnic bed, muscle, and skin (1). An earlier laboratory study also suggested that the pathophysiological defect of diabetic orthostatic hypotension is the lack of ability to increase vascular resistance resulting from impaired sympathetic function of nerves innervating resistance vessels (20). In contrast, a diminished cardiovagal response and heart rate change after standing play an insignificant role in diabetic orthostatic hypotension (20). In the natural course of diabetic autonomic neuropathy, parasympathetic impairment with a decreased cardiovagal tone usually appears first and then reduced sympathetic activity with an impaired vasoconstriction and a fixed heart rate develops later (21). Cardiovagal dysfunction has been found very early in the course of diabetes, exists in 51% of the diabetic population (22), and may have resulted in the disassociation between standing cardiovagal function and orthostatic hypotension in our diabetic subjects.

Our results show that the risk of orthostatic hypotension was higher in diabetic subjects than in subjects with NGT but not in pre-diabetic subjects. The difference in the risk of orthostatic hypotension between pre-diabetic and diabetic subjects may be related to the different stages in the course of diabetic autonomic dysfunction. In diabetic subjects, the sympathetic activity decreased with impaired vasoconstriction in the later stage of diabetes (21). In contrast, pre-diabetic subjects may have an intact sympathetic

Table 2—*Adjusted odds ratios and 95% CIs for the effect of clinical variables on the risk of orthostatic hypotension in total subjects based on multiple logistic regression analysis*

	Model 1		Model 2		Model 3	
Variables	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value
Age (years)	1.018 (1.004–1.032)	0.042	1.012 (1.002–1.025)	0.040	1.012 (1.001–1.023)	0.042
Sex, male vs. female	1.010 (0.718–1.421)	0.953	1.175 (0.878–1.572)	0.279	1.315 (0.976–1.773)	0.072
Diabetes vs. NGT	1.682 (1.022–2.789)	0.038	1.528 (1.014–2.394)	0.036	1.395 (1.008–2.163)	0.040
Pre-diabetes vs. NGT	1.020 (0.695–1.696)	0.830	0.982 (0.696–1.385)	0.926	0.951 (0.674–1.341)	0.773
Hypertension, yes vs. no	1.956 (1.205–3.175)	0.007	—	—	—	—
Supine systolic blood pressure (mmHg)	—	—	1.021 (1.014–1.033)	<0.001	—	—
Supine diastolic blood pressure (mmHg)	—	—	—	—	1.036 (1.021–1.052)	<0.001
30 max–to–15 min ratio	0.160 (0.033–0.779)	0.023	0.203 (0.050–0.828)	0.026	0.224 (0.054–0.926)	0.039
Antihypertensive medication use, yes vs. no	0.810 (0.444–1.505)	0.518	0.791 (0.432–1.327)	0.375	0.986 (0.607–1.602)	0.955

Dependent variable: orthostatic hypotension; independent variables: age, sex, BMI, physical activity, diabetes vs. NGT; pre-diabetes vs. NGT, hypertension (or supine systolic/diastolic blood pressure), cerebrovascular disease, ischemic ECG pattern, 30 max–to–15 min ratio, and antihypertensive medication use.

Table 3—*Adjusted odds ratios and 95% CIs for the effect of clinical variables on the risk of orthostatic hypotension in subjects with NGT, pre-diabetes, and diabetes based on multiple logistic regression analysis*

	NGT		Pre-diabetes		Diabetes	
	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value	Odds ratio (95% CI)	*P* value
n	1,069		412		157	
Age (years)	1.023 (1.008–1.130)	0.030	1.058 (1.005–1.114)	0.031	1.012 (0.996–1.028)	0.130
Sex, male vs. female	1.295 (0.858–1.956)	0.219	1.081 (0.612–1.912)	0.788	1.431 (0.568–3.605)	0.448
A1C (%)	1.105 (0.810–1.479)	0.491	1.166 (0.735–1.850)	0.514	1.269 (1.010–1.598)	0.028
Hypertension, yes vs. no	2.079 (1.106–4.194)	0.024	2.330 (1.130–4.455)	0.020	3.190 (1.187–6.953)	0.018
Antihypertensive use, yes vs, no	0.682 (0.259–1.792)	0.437	0.960 (0.372–2.479)	0.933	0.782 (0.235–2.601)	0.689
30 max–to–15 min ratio	0.123 (0.141–0.910)	0.036	0.119 (0.006–2.503)	0.171	0.358 (0.064–1.995)	0.241

Dependent variable: orthostatic hypotension; independent variables: age, sex, BMI, physical activity, A1C, hypertension, cerebrovascular disease, ischemic ECG pattern, 30 max–to–15 min ratio, and antihypertensive use.

drive with sufficiently compensated vasoconstriction to prevent orthostatic hypotension. Thus, the risk of orthostatic hypotension was higher in diabetic subjects but not in pre-diabetic subjects. However, the 30 max–to–15 min ratio was not independently associated with orthostatic hypotension in our pre-diabetic subjects. This finding may be related to the fact that a decreased cardiovagal tone already existed in pre-diabetic subjects (13), resulting in an underestimated association between orthostatic hypotension and cardiovagal response to standing.

In our diabetic subjects, the plasma A1C level was a factor positively associated with orthostatic hypotension, and other studies have also revealed that diabetic subjects with increased A1C levels are vulnerable to development of orthostatic hypotension (3,6,9) and that glycemic control is critical in the prevention of orthostatic hypotension in such subjects (3,6,9). In contrast, the A1C level was not related to orthostatic hypotension in pre-diabetic subjects and those with NGT after adjustment for other confounding factors. Thus, a threshold effect of hyperglycemia may exist for the development of orthostatic hypotension, and the higher the A1C level, the higher the risk of orthostatic hypotension in diabetic patients.

Our results showed that a lower 30 max–to–15 min ratio was independently related to orthostatic hypotension in subjects with NGT, providing epidemiological evidence that a decreased cardiovagal response to standing was one of the determinants for the development of orthostatic hypotension. A previous laboratory study showed that orthostatic hypotension occurred at the onset of an orthostatic challenge as a result of vagal dysfunction induced by parasympathetic blockade and suggested that vagal withdrawal was the dominant factor in the maintenance of hemodynamic homeostasis at the onset of standing in healthy subjects (23), consistent with our results (23). Therefore, the cardiovagal response to standing is still an important factor for the maintenance of blood pressure homeostasis during orthostatic change from a lying to a standing position.

The literature has shown that age, hypertension, and supine systolic and diastolic blood pressures are risk factors for orthostatic hypotension (2,6,9,11,24). Age was positively related to orthostatic hypotension in our subjects with NGT and pre-diabetes but not in those with diabetes. This relationship may be due to higher mortality in diabetic subjects with orthostatic hypotension (1). Our study showed that both hypertension and diabetes were risk factors for orthostatic hypotension, and thus the risk of orthostatic hypotension is greater in diabetic subjects with hypertension than in nondiabetic subjects with hypertension. Our results also showed that supine blood pressure was associated with orthostatic hypotension. This result is consistent with an earlier finding that supine systolic/diastolic blood pressure is related to the fall of blood pressure after standing from a supine position (11). Conversely, antihypertensive agent use was not associated with orthostatic hypotension in our study. There may be an adjustment of the treatment regimen because of a side effect or related symptom, resulting in an underestimation of the relationship between antihypertensive agent use and orthostatic hypotension (25). Furthermore, the incidence of orthostatic hypotension decreased, followed by decreasing blood pressure after use of antihypertensive agents (25).

In summary, the prevalence of orthostatic hypotension was 25.5% and 17.7% in subjects with diabetes and pre-diabetes, respectively. Pre-diabetic subjects do not have a higher risk of orthostatic hypotension than subjects with NGT, although the risk of orthostatic hypotension is higher in diabetic subjects. Hypertension and supine blood pressure were significantly related to orthostatic hypotension in all subjects and subgroups with NGT, pre-diabetes, and diabetes. In addition, age and glycemic control were the correlates of orthostatic hypotension in pre-diabetic and diabetic subjects, respectively. The cardiovagal response to standing is an important determinant for the maintenance of blood pressure homeostasis during orthostatic change from a lying position to standing position in subjects with NGT but not in pre-diabetic and diabetic subjects.

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