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Association of Prediabetes and Diabetes Mellitus with Cardiovascular Disease Risk Factors among Japanese Urban Workers and their Families: A Cross-Sectional Study

Tsukasa Namekata[1-2*], Kohji Shirai[3], Mitsuko Nakata[1], Kenji Suzuki[4], Chikao Arai[4] and Norio Ishizuka[4]

[1]*Pacific Rim Disease Prevention Center, P.O. Box 25444, Seattle, WA 98165-2344, USA*

[2]*Department of Health Services, School of Public Health, University of Washington, Box 357660, Seattle, WA 98195-7660, USA*

[3]*Department of Internal Medicine, Sakura Hospital Medical Center, Toho University, 546-1 Shizu, Sakura-shi, Chiba, 285-8741, Japan*

[4]*Japan Health Promotion Foundation, 1-24-4 Ebisu, Shibuya-ku, Tokyo, 150-0013, Japan*

[*]**Corresponding author:** Tsukasa Namekata, Pacific Rim Disease Prevention Center, P.O. Box 25444, Seattle, WA 98165-2344, USA, Tel: (206) 695-2367; Fax: (206) 695-2367; E-mail: namekata@comcast.net

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Abstract

Purpose: The purposes of the study were to examine prevalence of prediabetes and diabetes mellitus (here after called diabetes) and to examine the association of prediabetes and diabetes with cardiovascular disease (CVD) risk factors among Japanese urban workers and their families.

Methods: Subjects were 9881 men and 12033 women of company employees and their families between 17 and 87 years of age who participated in cardiovascular disease screening in major cities, Japan. Persons having diabetes were defined as those taking medication of diabetes and/or having medical history of diabetes and/or whose fasting plasma glucose was equal to or higher than 126 mg/dl and/or whose hemoglobinA1c was equal to or higher than 6.5%. Persons with prediabetes were defined as those whose fasting plasma glucose was from 100 mg/dl to 125 mg/dl and/or whose hemoglobinA1c was from 5.7% to 6.4% excluding persons defined as having diabetes. In addition to descriptive analysis, logistic regression method was applied to examine the association of prediabetes and diabetes with CVD risk factors.

Results: There were 2001 (20.3%) men and 2756 (22.9%) women with prediabetes, whereas 678 (6.9%) men and 330 (2.7%) women were identified as having diabetes. Significant odds ratios (ORs) of prediabetes and diabetes were observed in association with age, hypertension, triglycerides ≥200 mg/dl and BMI ≥25 in both genders. Significant ORs of prediabetes and diabetes appeared in low HDL-C (<40 mg/dl), ex-smokers and smokers among men but not among women, except significant OR of diabetes in ex-smokers. Among women negatively significant ORs of prediabetes and diabetes were found in drinkers≤4 times/week but not among men except 0.73 of OR for those with diabetes drinking ≥5 times/week.

Conclusions: Our results confirmed that prevalence of prediabetes and diabetes increased with advancing age and that prediabetes and diabetes share almost the same CVD risk factors.

Keywords: Diabetes mellitus; Prediabetes; Body mass index; Smoking; Alcohol consumption; Japanese population; Cardiovascular disease risk factors

Abbreviations:

DM: Diabetes Mellitus; ORs: Odds Ratios; CVD: Cardiovascular Disease; ADA: American Diabetes Association; IFG: Impaired Fasting Glucose; FPG: Fasting Plasma Glucose; HbA1c: Glycol-hemoglobin A1c; NGSP: National Glycol-Hemoglobin Standardization Program; TG: Triglycerides; HDL-C: High Density Lipoprotein Cholesterol; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HP: Hypertension; PWV: Aortic Pulse Wave Velocity; CAVI: Cardio- Ankle Vascular Index

Introduction

Diabetes mellitus (hereafter called diabetes) is a chronic illness which requires continuous medical care, and its prevalence continues to rise among developed countries. Shaw et al. estimated that the prevalence of diabetes among adults (aged 20-79 years) was 6.4% of the world population affecting 285 million adults in 2010, and will increase to 7.7%, 439 million adults by 2030 [1]. This diabetes epidemic places financial burden on most industrial nations. The direct medical cost of diabetes in the United States was estimated to be $116 billion in 2007 [2]. Thus, it is crucial to prevent onset of diabetes before it requires substantial medical resources because of its complications.

Recently, a group of individuals whose glucose levels, although not meeting the criteria of diabetes, are too high to be considered as normal are defined as having prediabetes [3]. Zhang et al. found that prediabetes is a strong predictor to progress to diabetes in the future

[4]. Using the Stern and Framingham risk estimates, Ackermann et al. estimated that the probabilities for incident of type 2 diabetes (over 7.5 years) and cardiovascular disease (CVD, over 10 years) were 33.5% and 10.7% respectively among adults meeting the 2003 American Diabetes Association (ADA) definition for prediabetes [5]. Perreault et al. pointed out that reversion to normal glucose regulation from prediabetes is significantly associated with a reduced risk of future diabetes [6]. Also, Pour et al. confirmed that lifestyle intervention (e.g., diet and exercise) for prediabetes can significantly reduce the incidence of type 2 diabetes [7].

To target persons with prediabetes and make an effective plan for prevention of diabetes, we need to answer the following questions: (1) Does prevalence of prediabetes and diabetes increase as age advances? (2) Are prediabetes and diabetes associated significantly with CVD risk factors? (3) If yes, is the risk of diabetes in association with CVD risk factors higher than the risk of prediabetes?"

To provide answers to the above questions we analyzed a large data set based on CVD screening conducted for urban workers and their families in Japan.

Materials and Methods

Subjects

Subjects for the study were recruited from January 2006 to May 2009 through the screening program at Japan Health Promotion Foundation which has been conducting cardiovascular disease and cancer screening throughout major cities in Japan. Subjects were employees and their family members in companies of major cities in Japan: 9,881 men and 12,033 women between 17 and 87 years of age (Table 1). The study was approved by the Institutional Review Board and all subjects gave their consent to participate in the study.

Males	**Age**	**≤29**	**30-39**	**40-49**	**50-59**	**60-69**	**≥70**	**Total**
Normal	Number	1042	2338	1731	1235	704	152	7202
	Percent	97.7%	87.9%	72.2%	55.2%	56.5%	54.9%	72.9%
Prediabetes	Number	22	270	555	738	350	66	2001
	Percent	2.1%	10.2%	23.2%	33.0%	28.1%	23.8%	20.3%
Diabetes	Number	2	51	110	263	193	59	678
	Percent	0.2%	1.9%	4.6%	11.8%	15.5%	21.3%	6.9%
Total	Number	1066	2659	2396	2236	1247	277	9881
	Percent	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Females	**Age**	**≤29**	**30-39**	**40-49**	**50-59**	**60-69**	**≥70**	**Total**
Normal	Number	892	2657	2340	2235	711	112	8947
	Percent	98.6%	86.0%	74.8%	62.5%	61.9%	60.2%	74.4%
Prediabetes	Number	11	413	728	1184	361	59	2756
	Percent	1.2%	13.4%	23.3%	33.1%	31.4%	31.7%	22.9%
Diabetes	Number	2	19	59	159	76	15	330
	Percent	0.2%	0.6%	1.9%	0.5%	6.6%	8.1%	2.7%
Total	Number	905	3089	3127	3578	1148	186	12033
	Percent	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Diabetes: FPG>=126 mg/dl or HbA1c>=6.5% or diabetes medication use or medical history of diabetes mellitus, and prediabetes: FPG 100-125 mg/dl or HbA1c 5.7-6.4%

Table 1: Study participants according to status of normal, prediabetes and diabetes mellitus by age and gender

Definition of prediabetes and diabetes

In 2003, ADA has proposed the criterion for prediabetes as those having Impaired Fasting Glucose (IFG), between 100 mg/dl and 125 mg/dl in Fasting Plasma Glucose (FPG). Also, ADA classified persons whose Glycol-hemoglobin A1c (HbA1c) is between 5.7 to 6.4% as having high risk for future diabetes [3]. Japan Diabetes Society defines people whose FPG is between 100 mg/dl and 110 mg/dl as high- normal FPG, and states that this group has higher prevalence of impaired glucose tolerance than those whose FPG is normal [8]. In our present study persons having diabetes were defined as those taking medication for diabetes and/or having history of diabetes and /or those whose fasting plasma glucose was equal to or higher than 126 mg/dl and/or whose HbA1c was equal to or higher than 6.5% in value of the National Glycol-hemoglobin Standardization Program (NGSP). Persons with prediabetes were defined as those whose fasting plasma glucose was from 100 mg/dl to 125 mg/dl and/or whose HbA1c was from 5.7% to 6.4% in NGSP value except those defined as having diabetes.

Clinical measurements

Blood was drawn from subjects after a 12 hour fast. The following measurements were made: total cholesterol and triglycerides (TG) by enzymatic assay; high density lipoprotein cholesterol (HDL-C) by modified enzymatic method; glucose by hexokinase glucose-6- phosphate dehydrogenate assay; and HbA1c by latex agglutination.

Persons having hypertension were defined as those taking hypertension drugs and/or having medical history of hypertension and/or as those whose systolic blood pressure (SBP) was equal to or higher than 140 mmHg and/or diastolic blood pressure (DBP) was equal to or higher than 90 mmHg. Persons with the state of borderline hypertension were defined as those whose SBP was from 120 mmHg to 139 mmHg and/or DBP was from 80 mmHg to 89 mmHg except those defined as having hypertension, following the guideline by American Heart Association in 2007 [9].

Questionnaire

During the screening, a short self-administered questionnaire was filled out by each subject. It contains questions on medical history and lifestyle factors such as smoking habit and alcohol consumption.

Statistical methods

In addition to the use of descriptive statistics, logistic regression method was used to examine the association of prediabetes and diabetes with cardiovascular disease risk factors. Statistical Packages for Social Sciences version 17 was used for data analysis.

Results

Distribution of study participants is shown according to age, gender, and status of prediabetes or diabetes in Table 1. There were 2001 (20.3%) men and 2756 (22.9%) women with prediabetes, whereas 678 (6.9%) men and 330 (2.7%) women were identified as having diabetes. Prevalence of prediabetes and diabetes increased with advancing age. Prevalence of prediabetes sharply increased until reaching 50-59 years of age in both genders: from 2.1% for ≤29 years of age to 33.0% for 50-59 years of age among men and from 1.2% for ≤29 years of age to 33.1% for 50-59 years of age among women. Regarding prevalence of diabetes, on the other hand, the rate of increase in men was more than double the rate of increase in women: 0.2% for ≤29 years of age to 21.3% for ≥70 years of age among men and 0.2% for ≤29 years of age to 8.1% for ≥70 years of age among women.

mean ± SD	Age	≤29	30-39	40-49	50-59	60-69	≥70
Systolic blood pressure	Males	119 ± 11	122 ± 13	126 ± 14	132 ± 16	133 ± 17	136 ± 16
	Females	109 ± 10	113 ± 12	119 ± 14	127 ± 16	130 ± 16	135 ± 16
Diastolic blood pressure	Males	69 ± 9	74 ± 10	79 ± 11	83 ± 11	81 ± 10	78 ± 11
	Females	63 ± 8	66 ± 9	71 ± 10	75 ± 11	76 ± 10	77 ± 10
Total cholesterol (mg/dl)	Males	186 ± 33	204 ± 34	214 ± 36	213 ± 34	211 ± 32	209 ± 34
	Females	180 ± 28	194 ± 32	209 ± 34	233 ± 36	236 ± 35	233 ± 42
HDL-C (mg/dl)	Males	62 ± 15	59 ± 16	60 ± 17	61 ± 18	63 ± 18	62 ± 18
	Females	76 ± 15	76 ± 17	77 ± 18	76 ± 19	75 ± 19	73 ± 17
Triglycerides (mg/dl)	Males	95 ± 77	135 ± 103	158 ± 169	147 ± 113	126 ± 72	122 ± 81
	Females	59 ± 31	70 ± 57	79 ± 49	96 ± 55	105 ± 55	108 ± 54
Body Mass Index (kg/m^2)	Males	22.3 ± 3.5	23.9 ± 3.7	24.2 ± 3.2	24.1 ± 2.9	23.7 ± 2.8	23.5 ± 3.0
	Females	20.4 ± 3.0	20.9 ± 3.1	21.7 ± 3.2	22.2 ± 3.2	22.3 ± 3.0	22.9 ± 3.6
Prevalence (%)	**Age**	**≤29**	**30-39**	**40-49**	**50-59**	**60-69**	**≥70**
Drinkers	Males	61.8	73.4	77.9	79.3	77.4	66.8
	Females	50.4	45.5	43.4	36.2	33.4	27.0
Ex-smokers	Males	11.2	18.7	25.4	31.6	35.9	37.2
	Females	10.4	13.3	9.1	5.8	6.1	4.8
Smokers	Males	55.4	51.9	48.4	41.2	28.5	18.1
	Females	22.8	15.6	11.7	8.5	5.7	3.8

Table 2: Characteristics of study participants

Characteristics of study participants are shown in Table 2. It was observed that the averages for both systolic and diastolic blood pressure linearly increased with advancing age in both genders with an exception of men's diastolic blood pressure after 60 years of age of which average slightly decreased. Almost all averages of clinical indicators increased until 60 years of age except HDL-C of which averages were constantly at the same level in both genders. Striking differences in averages of clinical indicators between genders were observed and were unfavorable for men in terms of cardiovascular disease risk. BMI averages ranged from 22.3 to 24.2 among men and from 20.4 to 22.9 among women. Greater prevalence of drinkers and smokers was observed among men than among women. Also, greater prevalence of drinkers and smokers was observed among younger women than among older women.

Tables 3 and 4 show odds ratios (ORs) of prediabetes and diabetes associated with CVD risk factors among men and women, respectively. Crude ORs are shown to be compared with adjusted ORs which were taken as final results. Significant ORs of prediabetes and diabetes were observed in association with age, hypertension, triglycerides ≥200 mg/dl and BMI ≥25 in both genders. Significant ORs of prediabetes and diabetes appeared in low HDL-C (<40 mg/dl), ex-smokers and smokers among men but not among women, except significant OR of diabetes for ex-smokers. Among women negatively significant ORs of prediabetes and diabetes were found in drinkers ≤4 and ≥5 times/week but not among men except 0.73 of OR for those with diabetes drinking ≥5 times/week. In addition, we examined the association of prediabetes and diabetes with quantity of alcohol consumption (not shown in tables): comparing with non-drinkers, significant negative ORs of prediabetes in women drinking 1-3 drinks (1 drink=23 g ethanol) per occasion ≤4 times/week (OR=0.62, 95% CI: 0.49-0.80) and ≥5 times/week (OR=0.73, CI: 0.57-0.93), significant negative ORs of diabetes in men drinking 1-3 drinks per occasion ≤4 times/week (OR=0.73, CI: 0.54-0.99) and ≥5 times/week (OR=0.68, CI: 0.54-0.87), and significant negative ORs of diabetes in women drinking <1 drink (OR=0.59, CI: 0.43-0.82) and 1-3 drinks (OR=0.43, CI: 0.20-0.94) per occasion ≤4 times/week and <1 drink per occasion ≥5 times/week (OR=0.30, CI: 0.16-0.58).

Covariates		Prediabetes			Diabetes		
		Crude Odds Ratio	Adjusted Odds Ratio	95%CI	Crude Odds Ratio	Adjusted Odds Ratio	95%CI
Age (Ref: <40)	40-49	3.71	3.34	2.85 - 3.92***	4.05	3.75	2.66 - 5.27***
	50-59	6.92	6.11	5.20 - 7.18***	13.58	13.20	9.55 - 18.25***
	60-69	5.76	5.28	4.37 - 6.38***	17.48	18.37	13.04 - 25.89***
	≥70	5.03	4.56	3.29 - 6.33***	24.75	24.25	15.66 - 37.56***
Hypertension (HP) (Ref: normal)	Borderline HP	1.58	1.18	1.03 - 1.36*	1.80	1.15	0.89 - 1.50
	HP	3.24	1.45	1.24 - 1.70***	6.24	1.92	1.46 - 2.51***
HDL-C (Ref: ≥ 40 mg/dl)	<40 mg/dl	1.50	1.24	1.00 - 1.54*	2.02	1.39	1.02 - 1.90*
Triglycerides (Ref: <150 mg/dl)	150-199	1.43	1.08	0.92 - 1.25	1.13	1.01	0.78 - 1.30
	≥200	1.70	1.25	1.07 - 1.45**	2.37	1.75	1.40 - 2.19***
BMI (Ref: 20-22.9)	<18.5	0.44	0.58	0.36 - 0.91*	0.92	1.20	0.67 - 2.14
	18.5-19.9	0.69	0.88	0.68 - 1.13	0.56	0.83	0.52 - 1.32
	23-24.9	1.46	1.21	1.05 - 1.39**	1.25	0.96	0.75 - 1.23
	25-27.9	1.98	1.58	1.37 - 1.83***	2.02	1.40	1.11 - 1.78**
	≥28	2.07	2.13	1.75 - 2.59***	3.43	3.60	2.70 - 4.78***
Drinking (Ref: Non-drinkers)	≤4 times/week	0.70	1.01	0.87 - 1.16	0.74	0.83	0.65 - 1.04
	≥5 times/week	0.70	1.04	0.90 - 1.19	1.09	0.73	0.59 - 0.91**
Smoking (Ref: Non-smokers)	Ex-smokers	1.42	1.17	1.01 - 1.34*	1.56	1.26	1.01 - 1.58*
	Current smokers	1.05	1.20	1.05 - 1.37**	1.03	1.40	1.13 - 1.74**

Note: Ref = reference category; *p<0.05, **p<0.01, ***p<0.001; CI = Confidence Interval of adjusted odds ratio

Table 3: Odds ratios to estimate risks of prediabetes and diabetes mellitus in association with CVD risk factors: Males

Covariates		Prediabetes			Diabetes		
		Crude Odds Ratio	Adjusted Odds Ratio	95%CI	Crude Odds Ratio	Adjusted Odds Ratio	95%CI
Age (Ref: <40)	40-49	2.60	2.26	1.98 - 2.59***	4.26	3.23	1.94 - 5.38***
	50-59	4.43	3.47	3.04 - 3.96***	12.02	7.27	4.49 - 11.77***
	60-69	4.25	3.16	2.65 - 3.76***	18.07	9.70	5.75 - 16.37***
	≥70	4.41	2.97	2.11 - 4.20***	22.63	10.59	5.07 - 22.15***
Hypertension (HP) (Ref: normal)	Borderline HP	2.21	1.55	1.40 - 1.72***	3.17	1.57	1.15 - 2.14**
	HP	2.92	1.44	1.25 - 1.69***	8.29	2.12	1.50 - 2.99***
HDL-C (ref: ≥50 mg/dl)	<50 mg/dl	1.46	0.98	0.80 - 1.20	2.47	1.11	0.73 - 1.68
Triglycerides (Ref:<150 mg/dl)	150-199	1.91	1.20	0.99 - 1.45	3.20	1.33	0.90 - 1.98
	≥200	2.28	1.43	1.12 - 1.81**	5.84	2.40	1.58 - 3.64***
BMI (Ref: 20-22.9)	<18.5	0.62	0.83	0.71 - 0.98*	0.50	0.81	0.47 - 1.39
	18.5-19.9	0.71	0.86	0.76 - 0.98*	0.59	0.81	0.53 - 1.24
	23-24.9	1.26	1.06	0.93 - 1.21	2.17	1.59	1.14 - 2.23**
	25-27.9	1.82	1.46	1.25 - 1.70***	4.78	3.15	2.26 - 4.39***
	≥28	2.62	2.20	1.80 - 2.70***	7.30	5.15	3.47 - 7.65***
Drinking (Ref: Non-drinkers)	≤4 times/week	1.26	0.89	0.80 - 0.99*	0.41	0.56	0.41 - 0.77***
	≥5 times/week	0.96	0.83	0.72 - 0.96*	0.37	0.42	0.27 - 0.66***
Smoking (Ref: Non-smokers)	Ex-smokers	0.76	1.01	0.86 - 1.20	0.90	1.59	1.05 - 2.42*
	Current smokers	0.69	0.92	0.79 - 1.08	0.50	0.97	0.62 - 1.53

Note: Ref = reference category; *p<0.05, **p<0.01, ***p<0.001; CI = Confidence Interval of adjusted odds ratio

Table 4: Odds ratios to estimate risks of prediabetes and diabetes mellitus in association with CVD risk factors: Females

Discussion

Regarding the association between prediabetes or diabetes and increase in age, we observed an increasing trend in prevalence of prediabetes and diabetes in both genders as age advanced (Table 1): from 2.1% of prediabetes and 0.2% of diabetes for 29 years of age and younger to 23.8% of prediabetes and 21.3% of diabetes for 70 years of age and older, respectively, among men; and from 1.2% of prediabetes and 0.2% of diabetes for 29 years of age and younger to 31.7% of prediabetes and 8.1% of diabetes for 70 years of age and older, respectively, among women. That is, about 45% of men and 40% of women from our study population fell in either prediabetes or diabetes after reaching 70 years of age, as compared with 41% of men and 35% of women, respectively, in the 2007 National Health and Nutrition Survey in Japan [10].

In this paper, we conducted the logistic regression analysis to assess the association of CVD risk factors with either prediabetes or diabetes to confirm the hypothesis that prediabetes and diabetes share the same risk factors. First, age is a substantial risk factor for diabetes and prediabetes, as ORs increased significantly with ages (Tables 3 and 4). Persons 70 years of age and over had more than 24 times greater estimated risk among men and 11 times greater estimated risk among women for having diabetes than those younger than 40 years of age, whereas the same trend was observed in ORs of prediabetes with a less dramatic increase: 5 times greater estimated risk among men and 3 times greater estimated risk among women.

We found that hypertension was significantly associated with prediabetes and diabetes in both genders as observed in other studies [11,12], whereas borderline hypertension was significantly associated both with prediabetes and diabetes among women and with prediabetes among men.

De Fronzo et al. find that among individuals with prediabetes and type 2 diabetes, the incidence of small, dense LDL particles (phenotype B) markedly increases and represents a major risk factor for accelerated atherogenesis [13]. Our results support their implication, since lower HDL-C (<40 mg/dl) among men and higher triglycerides (≥200 mg/dl) in both genders were significantly associated with prediabetes and diabetes.

We found a linear association between BMI and prediabetes and diabetes in both genders, implying that prevalence of prediabetes and

diabetes increases as BMI becomes higher in our study population. In comparison with 20-22.9 of BMI, ORs of prediabetes for BMI<18.5 (that is considered to be very slim) were 0.58 among men and 0.83 among women, implying that prevalence of prediabetes is much further decreased as BMI becomes smaller. Then, do we recommend that people maintain their BMI less than 18.5? Our answer is "no" because extremely slim persons are susceptible to certain diseases. Chen et al. examined the association between BMI and cardiovascular disease mortality in the data from the Asia Cohort Consortium and their results show a U shaped association between BMI and overall CVD mortality in East Asians including Japanese: elevated risk of death was observed for overall CVD at BMI value 25 and above and at BMI value 17.4 and below, compared with reference range of 22.5-24.9 [14].

Cullmann et al. show that high alcohol consumption and binge drinking increases the risk of prediabetes and type 2 diabetes in men, while low alcohol consumption lowers the risk of type 2 diabetes in women in Swedish population [15]. Our women's results are consistent with Cullmann's findings: estimated risk of both prediabetes and diabetes were significantly lowered in less frequent drinkers as well as frequent drinkers, compared with non-drinkers, while estimated risk of diabetes became significantly low in frequent male drinkers. Our results are consistent with the trend in lowering risk for the development of diabetes with an increase in frequency of alcohol intake among Japanese men followed up for about 10 years by Heianza et al. [16]. Our findings and theirs imply that alcohol possibly works protectively toward both prediabetes and diabetes, as in the same way that alcohol lowers the risk of coronary heart disease [17].

We found that the estimated risk of prediabetes and diabetes was significantly elevated in both male current smokers and ex-smokers, while the estimated risk of diabetes was raised in female ex-smokers, compared with non-smokers. Our results are consistent with Shi et al.'s findings showing that smoking was positively associated with type 2 diabetes mellitus among middle-age and elderly Chinese men [18].

Overall, both prediabetes and diabetes were associated with all of the CVD risk factors included in our analysis except HDL-C among women and implying persons with both conditions are more advanced in atherosclerosis or arteriosclerosis. Namekata et al. show significant odds ratios of the abnormally high aortic pulse wave velocity (PWV, an indicator of arteriosclerosis reflecting stiffness of artery and atherosclerosis) in an association with diabetes mellitus among Japanese Americans and among native Japanese (3.66 and 2.43, respectively) [19]. Recently, Namekata et al. have developed criteria of cardio-ankle vascular index (CAVI), a new indicator of arteriosclerosis reflecting both stiffness of artery and atherosclerosis in the arteries from heart to ankle which is converted from PWV, and observe that ORs of having abnormally high CAVI scores after making adjustment for ages among persons with diabetes mellitus are 10.02 for men and 8.42 for women, compared with those without diabetes [20,21]. Their results estimate much faster advancement of arteriosclerosis among persons with diabetes than in the group without diabetes.

A limitation of this study is that it is an observational and cross-sectional study. The strength of this study is having the large sample size and including several clinical and behavioral factors as covariates with enough statistical power.

In conclusion, (1) prevalence of prediabetes and diabetes increased as age became higher; (2) prediabetes and diabetes were significantly associated with the established CVD risk factors; and (3) the estimated risk of diabetes in association with CVD risk factors was higher than that of prediabetes. As the American Diabetes Association's guideline recommends [3], it is important to introduce an early intervention of lifestyle and diet modification to persons with prediabetes to prevent them from onset of diabetes.

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