Changes in Body Mass Index and its Relationships to Other Cardiovascular Risk Factors among Japanese Population: Results from the 1980 and 1990 National Cardiovascular Surveys in Japan

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Few studies have attempted to investigate the changes in body mass index (BMI) and its relationship to other cardiovascular factors in Asian populations, including Japanese. Data from two national cross-sectional surveys on circulatory disorders in 1980 and 1990 in Japan were used in this study. The sample consisted of 10,556 participants in the 1980 survey and 8,385 in the 1990 survey, aged ≥ 30 years. The results show that after adjusting for age, smoking, alcohol consumption (ALC) and daily life physical activity (PA), mean BMI increased 0.49 kg/m² (95% confidence interval: 0.34-0.65) in men aged 30-59 and 0.61 kg/m² (0.37-0.86) in those aged ≥ 60 from 1980 to 1990. In women, however, mean BMI decreased 0.24 kg/m² (-0.39 0.09) in those aged 30-59 and increased 0.38 kg/m² (0.12-0.64) in those aged ≥ 60 . BMI was significantly associated with hypertension, diabetes and hypercholesterolaemia. In both genders, cu-smokers had lower mean BMI than never smokers, while among the cu-smokers, mean BMI was positively associated with the number of cigarettes smoked per day. In men, BMI was positively associated with ALC and negatively associated with PA, while in women, BMI was negatively associated with ALC and positively associated with PA. The results suggest that BMI has significantly increased in men and in elderly women. BMI, even in the Japanese population who are characterized by relative low BMI, is significantly associated with several cardiovascular risk factors. *J Epidemiol*, 1999 ; 9 : 163-174

changes, body mass index, cardiovascular risk factors, Japanese

In Japan, malignant neoplasm and cardiovascular disease are major causes of death. Among the major causes of death, age-adjusted mortality rates from both cerebrovascular disease and heart disease, including coronary heart disease (CHD), have been declining since 1970. These changes have been thought to result primarily from the control of high blood pressure, including both primary and secondary preventive measures ¹⁾. However, since the intake of fat has increased with lifestyle westernization, there is some concern that both mortality and morbidity from CHD may soon show an increasing trend ²⁾. If potentially epidemic CHD is to be prevented, it is important to understand the trends in cardiovascular risk factors. Some previous studies have reported an increase in serum cholesterol concentrations and an increase in the prevalence of diabetes mellitus in Japan ³⁻⁵⁾. However, little attention has been paid to

changes in the body mass index (weight (kg)/height(m²)). Furthermore, possibly because Asian populations, including Japanese, have a much lower body mass index (BMI) than Caucasians, the associations between BMI and other cardiovascular factors are not well understood in Asian populations. In the present study, we used data of the 1980 and 1990 National Cardiovascular Surveys in Japan to investigate the changes in BMI, and the associations between BMI and the prevalence of hypertension, diabetes mellitus, hypercholesterolaemia, cigarette smoking, alcohol consumption and daily life physical activity.

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METHODS

Design of the surveys

The Ministry of Health and Welfare of Japan organized the 1980 and 1990 National Cardiovascular Surveys. The two surveys had a similar study design, but were independently carried out. For the 1980 survey, 300 districts were randomly selected from the "Survey of Sample Districts of Population for Statistics of Health and Welfare" ⁶. The subjects were all residents aged 30 or older by the 1st of November 1980. The total number of eligible residents was 13,771. However, 10,897 persons were actually examined in the survey. Consequently, the overall participation rate was 79.1% (73.8% for men and 84.3% for women). In the 1990 survey, 300 districts were drawn at random from the 1990 National Livelihood Survey of households and household members in all parts of Japan ⁷. The total number of eligible residents using the same age criterion as in the 1980 survey was 10,956. However, only 8,926 individuals were actually examined, for a participation rate of 81.5%: 76.1% for men and 86% for women. In the present study, subjects who had completed physical examinations, blood tests and questionnaire surveys were included in the data analyses. Overall, the sample size was 10,556 in 1980 and 8,385 in 1990.

The methods used for the examinations were described in detail in the reports on the two surveys ^{6,7}. Briefly, height (cm) and weight (kg) were measured in bare feet and in light clothing. Blood pressure was measured in mmHg in each participant's right arm, with a standard mercury sphygmomanometer. Urinary glucose was tested by paper colorimetry, and the results were classified as negative or positive. Total cholesterol was measured by an enzymatic method with a Hitachi 736-60. For both the 1980 and 1990 surveys, cooperation was obtained from the Department of Epidemiology and Mass Examination for Cardiovascular Diseases, Osaka Medical Center for Cancer and Cardiovascular Diseases, which has 16 years of experience with the U.S. CDC-NHLBI Lipid Standardization Program of the Centers for Disease Control ^{6,7}.

Statistical methods

BMI was calculated as $\text{weight(kg)/height(m}^2\text{)}$ and was used as a continuous variable in the data analysis. It was also categorized into four levels according to quartiles of the BMI distributions of subjects in the 1980 and 1990 surveys. Overweight was classified as $\text{BMI} \geq 25 \text{ kg/m}^2$.

Hypertensive subjects were those who had systolic blood pressure $\geq 160 \text{ mmHg}$ or diastolic blood pressure $\geq 95 \text{ mmHg}$, or who were under treatment with antihypertensive agents. In both 1980 and 1990 surveys, although blood glucose levels were determined, however, methods of their measurements were different, and glycohemoglobin A1c was tested only in the 1990 survey. Therefore, in the present study, subjects were

classified as diabetes mellitus (DM) for any of the following conditions: self-reported history of DM or positive urinary glucose test because only these were available and comparable as crude indices of DM in the 1980 and 1990 surveys ⁶⁻⁸. Hypercholesterolaemia was defined as total cholesterol $\geq 220 \text{ mg/dl}$.

Cigarette smoking status was classified as never smoking, ex-smoking or cu-smoking (current smoking). Cu-smokers were further divided into those who smoked 1-20, 21-40 and ≥ 41 cigarettes per day. According to the available data on drinking habits in the 1980 and 1990 surveys, alcohol consumption was divided into three categories: never, ex- and cu-drinking. Daily life physical activity were classified into three categories that are usually used in Japan. This classification is based on both occupational and leisure time physical activity. The category I is the least active group, and the category III is the most. The category I (light) usually includes sedentary workers and housewives without infants and toddlers. The category II (moderate) includes industry workers and self-employed women. The category III (heavy) includes farmers, fishermen and professorial sportsmen.

To test differences in mean BMI and the prevalence of overweight between the 1980 and 1990 surveys, t-tests and Chi-square tests were used by gender and by five 10-year age-groups (30-39, 40-49, 50-59, 60-69 and 70 years or over). The changes in BMI, by gender and age (30-59 and 60 or over), were further examined by adjusting for age and three lifestyle factors (smoking, alcohol consumption and daily life physical activity) using analyses of covariance method. To examine the associations between BMI and hypertension, DM and hypercholesterolaemia, logistic regression models were used to calculate multi-adjusted odds ratios (OR) and the 95% confidence interval (95%CI) of OR. In these models, hypertension, diabetes or hypercholesterolaemia was the dependent variable (binary, 0=no, 1=yes), and BMI was the independent variable (by quartiles). The multi-adjusted factors were age, smoking, alcohol consumption and daily life physical activity. To explore the relationships between BMI and three lifestyle factors (smoking, alcohol consumption and daily life physical activity), age-adjusted mean BMI was compared between three categories of each factor by gender and survey year. Finally, the 1980 and 1990 surveys were combined and further analyzed using two multiple linear regression models. In these linear regression models, BMI was the dependent variable (continuous) and lifestyle factors were the independent variables by adjusting for survey year and age. Model 1 included all of the subjects in the total combined sample, while model 2 included subjects who were cu-smokers. In model 1, survey year was coded as 0 for the 1980 survey and 10 for the 1990 survey, age was used as a continuous variable (years), ex-smoking and cu-smoking were coded as two dummy variables (0=no, 1=yes), drinking habits were coded as: 0= never drinking, 1=ex-drink-

Table 1. Characteristics of the study participants in 1980 and 1990 for men and women.

	1980			1990		
	N	Mean/rate	SD	N	Mean/rate	SD
Men						
Age	4643	50	13.40	3500	53	13.72
Body mass index (kg/m ²)	4641	22.50	2.87	3496	22.96	3.00
Systolic BP (mmHg)	4640	138	21.06	3500	138	20.02
Diastolic BP (mmHg)	4640	84	12.37	3500	84	11.65
Total cholesterol (mg/dl)	4637	186.37	32.89	3260	198.63	36.84
Cigarette smoking (%)						
Never smoker	843	18.2		739	21.1	
Ex-smoker	872	18.8		828	23.7	
Cu-smoker	2920	63.0		1933	55.2	
Alcohol consumption (%)						
Never drinker	924	19.9		1230	35.1	
Ex-drinker	268	5.8		249	7.1	
Cu-drinker	3444	74.3		2021	57.7	
Daily life physical activity (%) ^{a)}						
Light	1324	28.6		1722	49.2	
Moderate	2706	58.4		1331	38.0	
Heavy	603	13.0		447	12.8	
Hypertension (%) ^{b)}	1287	27.7		978	27.9	
Diabetes mellitus (%) ^{c)}	319	6.9		335	10.0	
Hypercholesterolaemia (%) ^{d)}	700	15.1		878	26.9	
Women						
Age	5913	50	13.47	4885	53	14.11
Body mass index (kg/m ²)	5913	22.83	3.38	4879	22.84	3.32
Systolic BP (mmHg)	5909	134	21.74	4884	134	20.80
Diastolic BP (mmHg)	5909	80	12.00	4884	80	11.73
Total cholesterol (mg/dl)	5905	191.21	33.89	4565	207.04	38.74
Cigarette smoking (%)						
Never smoker	5186	87.8		4286	87.8	
Ex-smoker	142	2.4		133	2.7	
Cu-smoker	578	9.8		465	9.5	
Alcohol consumption (%)						
Never drinker	4603	78.0		4513	92.4	
Ex-drinker	99	1.7		54	1.1	
Cu-drinker	1200	20.3		317	6.5	
Daily life physical activity (%) ^{a)}						
Light	2757	47.1		2709	55.5	
Moderate	2801	47.8		1855	38.0	
Heavy	299	5.1		321	6.6	
Hypertension (%) ^{b)}	1320	22.3		1203	24.6	
Diabetes mellitus (%) ^{c)}	186	3.1		236	5.0	
Hypercholesterolaemia (%) ^{d)}	1133	19.2		1578	34.6	

a) Daily life physical activity was classified based on subject's occupational and leisure time physical activity.

b) Subjects were classified as having hypertension for those who had SBP $\geq$ 160 or DBP $\geq$ 95 mmHg, or who were under treatment with antihypertensive agents.

c) Subjects were classified as diabetes mellitus (DM) for any of the following conditions: self-reported history of DM or positive urinary glucose.

d) Hypercholesterolaemia was defined as total cholesterol $\geq$ 220 mg/dl.

ing and 2=cu-drinking, and daily life physical activity was coded as: 0=light, 1=moderate and 2=heavy. In model 2, the same coding values for adjusted and independent variables were used as in model 1, except that smoking status was coded according to the number of cigarettes smoked daily (1, 2 and 3 for subjects who smoked 1-20, 21-40 and ≥ 41 cigarettes per day). SPSS ver. 7.5 software was used for all data analyses[®].

RESULTS

General characteristics of the two surveys

Table 1 shows the general characteristics of the 1980 and 1990 surveys. Both men and women were older in the 1990 survey than in 1980 (mean age 53 vs. 50 years for both genders). Mean BMI in men was higher in 1990 than in 1980 (22.96 vs. 22.5 kg/m²), but appeared to be similar in women between the two surveys (22.84 vs. 22.83 kg/m²). The mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were similar in the 1980 and 1990 surveys in both genders. Mean total cholesterol was higher in 1990 than in 1980 in

both genders. The prevalence of cu-smoking and cu-drinking were lower in 1990 than in 1980 in men and women. The percentage of subjects who engaged in light physical activity was higher in 1990 than in 1980 in men and women. The prevalence of hypertension was similar between 1980 and 1990 in men, but was higher in 1990 in women. The prevalence of DM and hypercholesterolaemia were higher in 1990 than in 1980 in men and women.

Changes in body mass index and prevalence of overweight by gender and age

Table 2 shows that, among men, mean BMI and the prevalence of overweight significantly increased from 1980 to 1990 in the five 10-year age groups. Mean BMI increased between 0.37 and 0.67 kg/m², and the prevalence of overweight increased from 4.4 to 6.1 percentage points. In women aged <50 years, mean BMI significantly decreased from 0.32 to 0.39 kg/m², while mean BMI in those aged 60-69 significantly increased 0.49 kg/m² from 1980 to 1990. Increased BMI was also observed in women aged 50-59 and in those aged ≥ 70

Table 2. Age specific mean body mass index (kg/m²) and prevalence of overweight (BMI ≥ 25 kg/m²), and their changes from 1980 to 1990 for men and women.

	1980			1990			Mean/rate	
	N	Mean/rate	SD	N	Mean/rate	SD	diff.	P
Mean body mass index (kg/m ²)								
Men								
Age, 30-39	1233	22.60	2.77	659	22.97	3.00	+0.37	**
40-49	1211	23.05	2.85	837	23.45	2.91	+0.40	**
50-59	1033	22.62	2.82	797	23.28	2.79	+0.66	***
60-69	687	21.96	2.85	713	22.63	3.09	+0.67	***
≥70	477	21.37	2.92	490	22.03	3.11	+0.67	**
Women								
Age, 30-39	1603	22.12	3.10	1034	21.80	2.99	-0.32	**
40-49	1489	23.21	3.41	1175	22.82	3.22	-0.39	**
50-59	1330	23.29	3.34	1045	23.39	3.18	+0.10	NS
60-69	919	22.99	3.53	921	23.48	3.55	+0.49	**
≥70	572	22.53	3.53	704	22.77	3.45	+0.25	NS
prevalence of overweight (%)								
Men								
Age, 30-39	238	19.3		156	23.7		+4.4	*
40-49	280	23.1		239	28.6		+5.4	**
50-59	207	20.0		208	26.1		+6.1	**
60-69	96	14.0		135	18.9		+5.0	*
≥70	54	11.3		85	17.3		+6.0	**
Women								
Age, 30-39	236	14.7		138	13.3		-1.4	NS
40-49	362	24.3		248	21.1		-3.2	0.051
50-59	387	29.1		301	28.8		-0.3	NS
60-69	222	24.2		290	31.5		+7.3	***
≥70	127	22.2		183	26.0		+3.8	NS

NS=not significant ($P>0.05$), * $P<0.05$, ** $P<0.01$, *** $P<0.001$.

years, but these differences between the 1980 and 1990 surveys were not significant. The prevalence of overweight decreased in women under 60 years, but increased in those aged ≥ 60 years from 1980 to 1990. Taking into consideration of birth-cohort effects on BMI, for example, the comparisons of BMI between subjects aged 30-39 years in 1980 and those aged 40-49 years in 1990 (a 10-years aging effect), Table 2 also shows that, even in women, aging is found to be associated with increasing BMI among the population under 70 years old.

Table 3 shows that after adjusting for age, smoking, alcohol consumption and daily life physical activity, mean BMI (95% CI) significantly increased 0.49 kg/m² (0.34 - 0.65 kg/m²) in

men aged 30-59, and 0.61 kg/m² (0.37 - 0.86 kg/m²) in those aged ≥ 60 from 1980 to 1990. In women, however, mean BMI significantly decreased 0.24 kg/m² (-0.39 - 0.09 kg/m²) in subjects aged 30-59 and increased 0.38 kg/m² (0.12 - 0.64 kg/m²) in those aged ≥ 60 from 1980 to 1990.

Table 4 shows that among men and women, age-adjusted prevalence of hypertension decreased, while the prevalence of diabetes and hypercholesterolaemia increased among both younger (30-59 years) and older (≥ 60 years) subjects from 1980 to 1990.

Table 3. Adjusted mean body mass index and its changes from 1980 to 1990 for men and women.

	1980		1990		Mean	Mean diff. 95%CI	
	Mean	SE	Mean	SE	diff.	lower	upper
<i>Aged 30-59 years</i>							
Men							
Adjusted factor.							
Age only	22.77	0.05	23.25	0.06	+0.48	+0.33	+0.63 ***
Age and:							
Smoking	22.78	0.05	23.23	0.06	+0.45	+0.30	+0.60 ***
Alcohol consumption	22.75	0.05	23.27	0.06	+0.51	+0.36	+0.67 ***
Daily life physical activity	22.77	0.05	23.24	0.06	+0.48	+0.33	+0.63 ***
All of the above factors	22.76	0.05	23.25	0.06	+0.49	+0.34	+0.65 ***
Women							
Adjusted factor.							
Age only	22.86	0.05	22.65	0.06	-0.21	-0.36	-0.07 **
Age and:							
Smoking	22.86	0.05	22.65	0.06	-0.21	-0.36	-0.07 **
Alcohol consumption	22.87	0.05	22.63	0.06	-0.24	-0.39	-0.09 **
Daily life physical activity	22.86	0.05	22.64	0.06	-0.21	-0.36	-0.07 **
All of the above factors	22.87	0.05	22.63	0.06	-0.24	-0.39	-0.09 **
<i>Aged ≥ 60 years</i>							
Men							
Adjusted factor.							
Age only	21.71	0.09	22.39	0.09	+0.68	+0.44	+0.92 ***
Age and:							
Smoking	21.74	0.09	22.38	0.09	+0.64	+0.41	+0.88 ***
Alcohol consumption	21.69	0.09	22.41	0.09	+0.71	+0.47	+0.96 ***
Daily life physical activity	21.76	0.09	22.36	0.09	+0.61	+0.36	+0.85 ***
All of the above factors	21.76	0.09	22.37	0.09	+0.61	+0.37	+0.86 ***
Women							
Adjusted factor.							
Age only	22.80	0.09	23.19	0.09	+0.40	+0.15	+0.64 **
Age and:							
Smoking	22.81	0.09	23.18	0.09	+0.37	+0.12	+0.62 **
Alcohol consumption	22.81	0.09	23.18	0.09	+0.37	+0.12	+0.62 **
Daily life physical activity	22.78	0.09	23.20	0.09	+0.42	+0.16	+0.67 **
All of the above factors	22.81	0.09	23.19	0.09	+0.38	+0.12	+0.64 **

P<0.01, *P<0.001

Table 4. Age-adjusted prevalence of hypertension, diabetes and hypercholesterolaemia and their changes from 1980 to 1990 for men and women ^{a, b)}.

	1980	1990	Diff. between 1990 to 1980
<i>Aged 30-59 years</i>			
Men			
Hypertension	24.1	21.0	-3.1
Diabetes mellitus	5.4	6.5	+1.1
Hypercholesterolaemia	16.0	27.6	+11.6
Women			
Hypertension	16.4	14.7	-1.7
Diabetes mellitus	2.1	3.1	+1.0
Hypercholesterolaemia	15.8	26.8	+11.0
<i>Aged ≥ 60 years</i>			
Men			
Hypertension	61.4	53.5	-7.9
Diabetes mellitus	10.9	15.2	+4.3
Hypercholesterolaemia	12.1	24.5	+12.4
Women			
Hypertension	59.9	58.4	-1.5
Diabetes mellitus	6.0	8.4	+2.4
Hypercholesterolaemia	27.9	47.7	+19.8

a) Definition for hypertension, diabetes mellitus and hypercholesterolaemia, see Table 1 notes.

b) Age-adjustment by using the 1985 Standard Population of Japan.

Body mass index and risk of hypertension, diabetes and hypercholesterolaemia

The associations between BMI (by quartiles) and risk of hypertension, diabetes and hypercholesterolaemia are presented in Table 5 according to two age groups (30-59 and ≥ 60 years). In general, increased BMI was consistently and significantly associated with an increasing risk of hypertension, diabetes and hypercholesterolaemia in both genders in the 1980 and 1990 surveys, with the exception of the multi-adjusted odds ratios for the risk of diabetes in men and women aged 30-59 in 1990, which appeared to be inversely associated with BMI. However, these latter odds ratios were not significant.

Body mass index and lifestyle factors

Table 6 shows that among men, cu-smokers had lower BMI compared with never smokers and ex-smokers. Among cu-smokers, however, an increase in the number of cigarettes smoked daily was associated with increased mean BMI, and these associations were significant in those aged 30-59 years in the 1980 and 1990 surveys. Ex-smokers appeared to have slightly lower BMI than never smokers in the 1980 survey, and a slightly higher BMI in the 1990 survey. Drinkers (ex- and cu-drinking) appeared to have higher mean BMI than never drinkers in 1980 and 1990 surveys, but these differences were not significant. Subjects with light physical activity had the highest age-adjusted mean BMI in the 1980 and 1990 surveys,

except that those aged 30-59 years old in the 1980 survey had a slightly lower mean BMI than those with heavy physical activity.

In women aged ≥ 60 years in the 1980 survey, cu-smokers had significantly lower age-adjusted mean BMI than ex-smokers and never smokers. Among cu-smokers, an increase in the number of cigarettes smoked daily was significantly associated with increasing mean BMI in those aged 30-59 years, while the association was not clear in those aged ≥ 60 in the 1980 and 1990 surveys. There was no clear association between drinking and BMI in women, although cu-drinkers had a lower BMI than never drinkers. Women whose physical activity was categorized as "light" appeared to have lower age-adjusted mean BMI than those with moderate and heavy physical activities in both the 1980 and 1990 surveys, with the exception of those aged ≥ 60 in the 1990 survey.

Table 7 shows the results of the associations between BMI and lifestyle factors by combining the 1980 and 1990 surveys. Prior to this analysis, these associations were initially analyzed for the 1980 and 1990 surveys separately (by adjusting for age and lifestyle factors), and then for the combined sample of the two surveys (by adjusting for survey year, age and lifestyle factors). The separate results for the 1980 and 1990 surveys were not shown because they were similar to the results of the combined sample. Model 1 indicated that among all of the subjects, BMI was negatively and significantly associated with cu-

Table 5. Multi-adjusted odds ratios (95% CI) for body mass index (by quartiles) associated with the prevalence of hypertension, diabetes mellitus and hypercholesterolaemia by two age groups in 1980 to 1990 for men and women ^{a,b,c}.

	Hypertension						Diabetes mellitus						Hypercholesterolaemia					
	Aged 30-59 years			Aged ≥60 years			Aged 30-59 years			Aged ≥60 years			Aged 30-59 years			Aged ≥60 years		
	95%CI			95%CI			95%CI			95%CI			95%CI			95%CI		
	OR	lower	upper	OR	lower	upper	OR	lower	upper	OR	lower	upper	OR	lower	upper	OR	lower	upper
<i>1980 survey</i>																		
Men																		
BMI-Q1	1			1			1			1			1			1		
BMI-Q2	1.52	1.14	2.03	2.07	1.46	2.93	1.12	0.72	1.74	1.23	0.75	2.01	1.60	1.14	2.25	1.44	0.88	2.35
BMI-Q3	2.24	1.69	2.97	2.35	1.60	3.44	1.11	0.71	1.75	1.05	0.62	1.78	3.17	2.30	4.36	1.60	0.97	2.62
BMI-Q4	4.05	3.06	5.35	2.41	1.56	3.73	1.63	1.06	2.51	1.90	1.10	3.28	4.64	3.38	6.36	2.21	1.30	3.76
Women																		
BMI-Q1	1			1			1			1			1			1		
BMI-Q2	1.08	0.78	1.49	1.93	1.36	2.74	1.11	0.57	2.14	1.28	0.63	2.58	1.29	0.99	1.67	1.61	1.13	2.31
BMI-Q3	2.16	1.61	2.90	2.89	2.04	4.08	0.98	0.49	1.93	1.57	0.81	3.02	1.43	1.10	1.85	2.03	1.44	2.86
BMI-Q4	3.88	2.93	5.13	4.04	2.86	5.71	2.23	1.25	3.97	1.92	1.02	3.59	2.21	1.73	2.82	2.14	1.53	2.98
<i>1990 survey</i>																		
Men																		
BMI-Q1	1			1			1			1			1			1		
BMI-Q2	1.57	1.05	2.36	1.31	0.92	1.88	0.70	0.42	1.16	1.90	1.14	3.14	2.20	1.50	3.23	1.37	0.90	2.11
BMI-Q3	1.96	1.33	2.91	1.90	1.33	2.70	0.69	0.43	1.12	1.88	1.15	3.07	3.27	2.27	4.71	2.30	1.55	3.42
BMI-Q4	3.69	2.53	5.38	2.48	1.72	3.57	0.72	0.45	1.16	2.84	1.76	4.57	5.63	3.93	8.06	2.70	1.81	4.02
Women																		
BMI-Q1	1			1			1			1			1			1		
BMI-Q2	2.00	1.33	3.01	1.76	1.25	2.47	0.64	0.35	1.17	1.52	0.87	2.63	1.16	0.90	1.49	1.44	1.06	1.97
BMI-Q3	3.03	2.05	4.49	2.46	1.75	3.46	0.78	0.44	1.39	1.48	0.86	2.56	1.75	1.37	2.24	1.49	1.09	2.02
BMI-Q4	6.67	4.59	9.70	3.36	2.43	4.64	1.07	0.63	1.81	1.24	0.73	2.10	2.19	1.72	2.79	1.57	1.18	2.09

a) Subjects were classified as having hypertension for those who had SBP ≥ 160 or DBP ≥ 95 mmHg, or who were under treatment with antihypertensive agents. Subjects were classified as diabetes mellitus (DM) for any of the following conditions: self-reported history of DM or positive urinary glucose test. Hypercholesterolaemia was defined as total cholesterol ≥ 220 mg/dl.

b) BMI-Q1, BMI-2, BMI-3 and BMI-4 are for quartiles of body mass index 1 (less than 20.52 kg/m²), 2 (20.52-22.51 kg/m²), 3 (22.52-24.68 kg/m²) and 4 (24.69 kg/m² or more). Odds ratios were calculated in comparison to quartile 1.

c) Multi-adjusted factors: age (year), smoking (0=never smoking, 1=ex-smoking and 2=cu-smoking), drinking (0=never drinking, 1=ex-drinking, 2=cu-drinking) and daily life physical activity (0=light, 1=moderate and 2=heavy).

smoking in men aged 30-59 and ≥ 60 years, and in women aged ≥ 60 years. There were no significant associations between BMI and ex-smoking in either gender. BMI was positively and significantly associated with alcohol consumption in men. This association, however, was negative and non-significant in women. In men, BMI was negatively and significantly associated with daily life physical activity in those aged ≥ 60 years, while this association was significant and positive in women aged 30-59 years.

Among cu-smokers, the associations between BMI and lifestyle factors were examined by model 2. A significant positive association between BMI and the number of cigarettes smoked daily was observed in both genders aged 30-59 years. Among male cu-smokers, alcohol consumption was positively, and physical activity was negatively, associated with BMI, but

these associations were not significant. In female cu-smokers, BMI was negatively and significantly associated with alcohol consumption in those aged 30-59 years, while there was no significant association between BMI and physical activity.

DISCUSSION

Our study has three important features: (1) the results are based on the most recent representative nationwide surveys in Japan, (2) it is the first detailed study to focus on the changes in BMI and the relationships between BMI and other cardiovascular factors in Japanese, and (3) the results may be informative for other Asian countries, since with their economic development and possible lifestyle westernization, they may experience the same changes in cardiovascular factors as Japan.

Table 6. Age-adjusted mean body mass index (kg/m²) and lifestyle factors by two age groups in 1980 and 1990 for men and women.

	1980				1990			
	Aged 30-59		Aged ≥ 60		Aged 30-59		Aged ≥ 60	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Men								
Smoking status								
Never smoker	23.32	0.11	22.51	0.19	23.47	0.13	22.32	0.20
Ex-smoker	22.94	0.12	22.12	0.16	23.50	0.14	22.95	0.15
Cu-smoker	22.56	0.06	21.27	0.11	23.09	0.08	22.03	0.13
ANCOVA test	***		***		***		**	
Cu-smokers								
1-20 cig/day	22.30	0.08	21.30	0.12	22.75	0.10	22.04	0.14
21-40 cig/day	22.86	0.10	21.44	0.26	23.51	0.13	22.47	0.33
≥41 cig/day	23.06	0.22	21.93	0.76	24.15	0.38	22.24	1.54
ANCOVA test	***		NS		**		NS	
Alcohol consumption								
Never drinking	22.57	0.11	21.57	0.16	23.16	0.10	22.18	0.14
Ex-drinking	23.10	0.25	21.82	0.25	23.36	0.30	22.38	0.25
Cu-drinking	22.79	0.05	21.76	0.11	23.30	0.08	22.55	0.13
ANCOVA test	NS		NS		NS		NS	
Daily life physical activity								
Light	22.77	0.09	21.97	0.14	23.37	0.09	22.47	0.12
Moderate	22.71	0.06	21.60	0.12	23.20	0.09	22.32	0.16
Heavy	22.99	0.13	21.56	0.23	23.06	0.16	22.03	0.30
ANCOVA test	NS		NS		NS		NS	
Women								
Smoking status								
Never smoker	22.86	0.05	22.91	0.10	22.65	0.06	23.25	0.09
Ex-smoker	22.83	0.35	23.39	0.49	23.31	0.37	22.70	
Cu-smoker	22.61	0.16	21.94	0.27	22.81	0.17	22.58	0.44
ANCOVA test	NS		**		NS		NS	0.31
Cu-smokers								
1-20 cig/day	22.47	0.17	21.93	0.32	22.57	0.20	22.44	0.30
21-40 cig/day	22.99	0.52	22.96	1.18	23.78	0.67	24.49	0.98
≥41 cig/day	26.79	1.64	17.84	3.92	31.38	2.50	-	-
ANCOVA test	*		NS		**		NS	
Alcohol consumption								
Never drinking	22.88	0.06	22.83	0.10	22.69	0.06	23.20	0.09
Ex-drinking	22.75	0.40	23.61	0.62	23.13	0.51	21.32	0.85
Cu-drinking	22.69	0.11	22.63	0.24	22.47	0.19	23.18	0.48
ANCOVA test	NS		NS		NS		NS	
Daily life physical activity								
Light	22.71	0.07	22.67	0.13	22.60	0.08	23.29	0.10
Moderate	22.91	0.07	22.88	0.14	22.70	0.08	22.81	0.18
Heavy	23.30	0.24	23.28	0.32	23.02	0.19	23.28	0.45
ANCOVA test	NS		NS		NS		NS	

NS=not significant (P>0.05), *P<0.05, **P<0.01, ***P<0.001.

ANCOVA test=analysis of covariance.

Table 7. Multiple linear regression models ^{a)} for the associations between body mass index and lifestyle factors among all of the subjects (Model 1), and among cu-smoker only (Model 2) for men and women.

	Subjects aged 30-59		Subjects aged ≥ 60	
	B	SE	B	SE
Model 1 among all subjects				
Men				
Sample size (n)		5759		2354
Cu-smoking	-0.625	0.098 ***	-0.818	0.165 ***
Ex-smoking	-0.224	0.124 NS	0.080	0.179 NS
Drinking	0.120	0.045 **	0.180	0.068 **
Physical activity	-0.025	0.058 NS	-0.202	0.092 *
Women				
Sample size (n)		7674		3079
Cu-smoking	-0.001	0.128 NS	-0.769	0.218 ***
Ex-smoking	0.263	0.260 NS	-0.045	0.337 NS
Drinking	-0.091	0.052 NS	-0.081	0.115 NS
Physical activity	0.194	0.062 **	0.050	0.109 NS
Model 2 among cu-smokers				
Men				
Sample size (n)		3635		1207
No. of smoked daily	0.547	0.077 ***	0.284	0.196 NS
Drinking	0.066	0.059 NS	0.153	0.095 NS
Physical activity	-0.046	0.073 NS	-0.104	0.127 NS
Women				
Sample size (n)		745		292
No. of smoked daily	1.504	0.377 ***	0.914	0.742 NS
Drinking	-0.351	0.135 **	-0.301	0.282 NS
Physical activity	0.053	0.210 NS	-0.001	0.392 NS

a) Adjustment for survey year, age and other factors in these models.

NS=not significant ($P>0.05$), * $P<0.05$, ** $P<0.01$, *** $P<0.001$.

Changes in body mass index

Our findings indicate that BMI significantly increased in Japanese men aged ≥ 30 and in women aged ≥ 60 years. In contrast, BMI significantly decreased in women aged 30-59. These associations were independent of age, smoking, alcohol consumption and daily physical activity. Similar to the results in BMI, the prevalence of overweight increased in men in each 10-year age-group. In women, however, the prevalence of overweight decreased in those under 60 years, and increased in those over 60 years old.

Among men, increases in BMI and the prevalence of overweight have been reported in several Western countries ¹⁰⁻¹³. Among middle-aged women, increases in BMI and the prevalence of overweight have also been recently seen in the United Kingdom, the United States, Sweden and Australia, but not in Italy, Finland or The Netherlands ¹²⁻¹⁸. There are comparatively few studies in Asian countries. In China, Ge et al., using China Nutrition Surveys, reported that mean BMI increased from 1980 to 1989 in Chinese men and women, and the proportion of obesity (BMI > 25 kg/m²) increased 4.8% for urban resi-

dents and 2% for rural residents aged 20-45 years ¹⁹. In Japan, the trend in BMI from 1956 to 1980 was reported by Ueshima et al. ²⁰. In a recent report by Sakata et al., the changes of BMI from 1970 to 1990 were described, while other potential confounding factors were not considered in their data analyses, such as smoking, alcohol consumption and daily life physical activity ²¹. Thus, our study has extended previous studies and provides more detailed information on the changes in BMI.

The increase in BMI and the prevalence of overweight in Japanese men aged ≥ 30 and women aged ≥ 60 years may be due to changes in several factors such as dietary, social and demographic, and behavioural factors. Our study suggests that smoking, alcohol consumption and daily life physical activity had only a small effect on mean level of BMI (Table 3). Changes in diet may have the strongest effect. The Japan National Nutrition Surveys in 1980 and 1989 indicated that the percentage of calories supply from fat increased from 22.6% to 25.7%, while that from cereals decreased from 48% to 45.1%. Fish and bean consumption has changed little, while meat, milk and milk product consumption has gradually increased in

Japanese from 1980 to 1989³⁾. The reason for the decrease in BMI among young women is not clear. It is possible that young Japanese women may have prevented overweight by paying attention to their diet over the past 10 years. However, among both genders who were aged less than 70 years, the associations between aging and increased BMI (birth-cohort effect) suggest that both effects of aging and changes in lifestyles on BMI should be considered in public health programme for control of body weight.

The present study also shows a decrease in prevalence of hypertension, and increases in prevalence of diabetes and hypercholesterolaemia from 1980 to 1990 (Table 4). Several studies have confirmed that the decrease in prevalence of hypertension is mainly because of improvements in the control of high blood pressure in both lifestyle changes (such as decrease in salt intake), and medical treatment^{1, 20, 21)}. However, the increases in prevalence of diabetes and hypercholesterolaemia are strongly suggested to be associated with changes in dietary habits (such as increase in fat intake), and increase in body weight over the past 10 years^{3, 5, 22)}.

Body mass index and risk of hypertension, DM and hypercholesterolaemia

Hypertension, DM and hypercholesterolaemia are well-established risk factors for coronary heart disease. A local study in Kyushu, Japan, reported that increased BMI was significantly associated with a high risk of diabetes²²⁾. In our study, we confirmed that increased BMI was significantly associated with the risk of hypertension, DM and hypercholesterolaemia in both men and women. The association between BMI and DM showed some complicated or inverse associations in those aged 30-59 the 1990 survey (Table 5), while these results may be due to chance ($P>0.05$). In our present study, a possible limitation was that the definition of DM was based on the subject's self-reported medical history and the results of a urinary glucose test. There were no further examinations to confirm disease status. Therefore, misclassification or underestimation of the prevalence of DM might have occurred⁵⁾.

Body mass index and lifestyle factors

Smokers tend to weigh less and have a lower BMI than never smokers, and people who stop smoking tend to gain weight and have an increased BMI^{23, 26)}. Some studies have also indicated that among smokers, BMI is positively associated with an increase in the number of cigarettes smoked^{23, 26)}. The results in our study are consistent with these previous results. The mechanism of the association between BMI and smoking is not completely understood²⁷⁾. One explanation is that smoking reduces the appetite. Among smokers, however, heavy smoking may be part of a cluster of substance-abuse behaviours, including over-eating and

alcohol consumption^{23, 28)}.

Previous reports on the associations between BMI and alcohol consumption are inconsistent^{23, 26)}. For example, Rasky et al. reported that alcohol consumption was significantly associated with a high relative weight in men, whereas no such relation was found in women²³⁾. Tavani et al²⁶⁾ found no significant differences in age-adjusted mean BMI between drinkers and nondrinkers. Our study shows a positive relationship between BMI and alcohol consumption in men. One reason may be that most Japanese male drinkers are moderate or heavy drinkers, and they often eat more fatty food than never drinkers and light drinkers. Among women, however, a significant negative association between BMI and drinking was observed in cu-smokers aged 30-59 years. One of the explanations is that most Japanese female drinkers have light drinking habits. It should be noted that, in the present study, categories of drinking habits in 1980 and 1990 surveys were not well comparable (Table 1) due to the different definitions in their questionnaires. In the 1990 survey, prevalence of cu-drinkers may have been under-estimated for both men and women, and some of cu-drinkers (especially, light drinkers) may have been classified as never drinkers³³⁾. This limitation may lead to under- or over-estimate the associations between alcohol consumption and BMI, and other factors. To keep this in mind, the present results may provide some evidence for further studies.

An inverse association between daily life physical activity and BMI in men and women has been supported by some studies^{23, 29-32)}. In our study, after adjusting for survey year, age, smoking and alcohol consumption, this inverse association was seen in men. In women, however, BMI was positively associated with daily life physical activity, and this association was significant in those aged 30-59 years. It should be noted that in the present study, physical activity was generally classified according to the subject's occupational and leisure time physical activity, because detailed information on physical activity was not available from the 1980 and 1990 surveys. Therefore, from the study, we can not make a conclusion regarding this association between BMI and physical activity in Japanese.

In conclusion, despite of some limitations, using the most recent large Japanese surveys, our results show that both BMI and the prevalence of overweight increased in men aged ≥ 30 and in women aged ≥ 60 years. In young adult women, however, mean BMI and the prevalence of overweight have decreased. Further studies are required to examine the possible determinants. Our findings also suggest that even in the Japanese population who are characterized by relative low BMI, and with a low incidence and mortality from coronary heart disease, BMI is significantly associated with several established risk factors of coronary heart disease, such as hypertension, diabetes, hypercholesterolaemia and heavy smoking.

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