

# Associations of Body Mass Index and Percentage Body Fat by Bioelectrical Impedance Analysis with Cardiovascular Risk Factors in Japanese Male Office Workers

Noriyuki NAKANISHI<sup>1\*</sup>, Koji NAKAMURA<sup>2</sup>, Kenji SUZUKI<sup>3</sup>,  
Yoshio MATSUO<sup>1</sup> and Kozo TATARA<sup>1</sup>

<sup>1</sup>Department of Social and Environmental Medicine, Course of Social Medicine, Osaka University Graduate School of Medicine, F2, 2–2 Yamada-oka, Suita-shi, Osaka 565-0871, Japan

<sup>2</sup>Medical Office, Osaka Main Office, Takenaka Corporation, 4–1–13 Honmachi, Chuo-ku, Osaka 541-0053, Japan

<sup>3</sup>Japan Labor and Welfare Association, 1–24–4 Ebisu, Shibuya-ku, Tokyo 150-0013, Japan

*Received December 13, 1999 and accepted April 5, 2000*

**Abstract:** To determine whether body mass index (BMI, kg/m<sup>2</sup>) or percentage body fat (%BF) by bioelectrical impedance analysis (BIA) better reflects the cardiovascular risk profile, we examined the associations among BMI, %BF by BIA, and cardiovascular risk factors (systolic blood pressure (SBP), diastolic blood pressure (DBP), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), LDL-C/HDL-C ratio, and triglycerides (TG)) in 1,217 Japanese male office workers aged 25 to 59 years. From stepwise regression analyses of cardiovascular risk factors on age, BMI, alcohol intake, and cigarette smoking, significant correlates were, in the order of relative importance: age, BMI, and alcohol intake for SBP and DBP (the cumulative percentage of variation; 14.9% and 21.3%, respectively); age, BMI, and alcohol intake (negative) for LDL-C (11.0%); BMI (negative), alcohol, and cigarette smoking (negative) for HDL-C (19.9%); BMI, alcohol intake (negative), age, and cigarette smoking for LDL-C/HDL-C ratio (23.1%); and BMI, age, cigarette smoking, and alcohol intake for Log TG (21.7%). From stepwise regression analyses using %BF by BIA as an independent factor, %BF by BIA was also significantly associated with each cardiovascular risk factor, but the decrease in explained variance for each cardiovascular risk factor was 0.2–4.5%, compared with the model using BMI as an independent factor. These results suggest that BMI may better reflect blood pressure or serum lipid profile than %BF by BIA.

**Key words:** Japanese men, Office workers, Body mass index, Percentage body fat, Bioelectrical impedance analysis, Health habits, Cardiovascular risk factors

## Introduction

Body composition is a powerful predictor of mortality and morbidity<sup>1</sup>. Body mass index (BMI, kg/m<sup>2</sup>), or Quetelet's index, calculated from height and weight has been commonly used as an easy index for body composition in clinical settings

and in epidemiological studies<sup>2</sup>. As reported in numerous previous studies<sup>3–11</sup>, BMI was found to be an independent factor for cardiovascular risk factors such as hypertension and dyslipidemia. However, BMI has been actually developed as a measure of weight that is independent of height and not as an index of obesity<sup>12, 13</sup>. This entails a potential misclassification of fat content (percentage that is fat) by BMI.

Debate over the value of BMI for the estimation of body

\*To whom correspondence should be addressed.

fat has led some investigators to recommend the use of new technologies for the direct measurement of body fat<sup>14</sup>. For epidemiological studies with large samples, bioelectrical impedance analysis (BIA) has been recently used to estimate body fat. Based on the principles governing the electrical impedance of body tissues, BIA provides a rapid, noninvasive, and relatively accurate estimation of total body water, from which body composition is derived<sup>14-16</sup>. However, whether BMI or percentage body fat (%BF) by BIA better reflects the cardiovascular risk profile remained to be answered<sup>17, 18</sup>. A study of Japanese men and women found that %BF by BIA better reflected serum lipid profile than BMI<sup>17</sup>. On the other hand, a study of three populations of West African heritage living in different environments found that %BF by BIA was not a better predictor of blood pressure or waist or hip circumference, compared with BMI<sup>18</sup>.

In this report on a cross-sectional population study based on annual health examinations at workplace, we have made an attempt to determine whether BMI or %BF by BIA better reflects blood pressure or serum lipid profile, controlling for age, alcohol intake, and cigarette smoking, since body composition would be affected by age, alcohol intake, and cigarette smoking<sup>19-23</sup>.

## Materials and Methods

A survey was conducted in 1999 among employees of T Corporation, which is one of the biggest building contractors in Osaka, Japan. The participants in the 1999 survey consisted of 2,196 Japanese male office workers aged 25 to 59 years, and the participation rate was 99.9%. Out of the population, 1,217 men (55.4%) were selected as study subjects, using the three eligibility criteria: (1) participation in health examinations at 09:00 to 12:00 h; (2) overnight fasted serum sample; and (3) no drugs for cardiovascular reasons.

The survey included a questionnaire, physical examinations, blood pressure measurement, and collection of blood samples for laboratory analysis. Data on alcohol intake and cigarette smoking were obtained by interview. An interviewer assessed the usual weekly intake of alcohol in units of "go" (a traditional unit of measurement, by volume, corresponding to 23 g to ethanol), which were converted to go per day. One go is 180 ml of sake, and it corresponds to one bottle (633 ml) of beer, two single shots (70 ml) of whisky, or two glasses (180 ml) of wine. An interview was conducted to ascertain the number of current cigarettes smoked per day. Weight and height were measured with the subjects in typical indoor clothing but without shoes; weight to the nearest 0.5 kg, height to the nearest cm. BMI was then

calculated as weight (in kg) over height (in m<sup>2</sup>). %BF was estimated by BIA using the standard tetrapolar technique according to the manufacturer's instructions for distal electrode placement on both wrists (a stand-on model, AD-6311, A and D Co., Ltd., Tokyo, Japan). The correlation between fat-free mass by BIA and by hydrodensitometry has been reported to be 0.865 in healthy Japanese men aged 20 to 56 years (n=81)<sup>24</sup>. %BF was 19.3 ± 5.1% (mean ± s.d.), ranging from 10.0 to 31.4% for BIA, and 18.0 ± 6.6%, ranging from 6.5 to 35.0% for hydrodensitometry. The correlation between %BF by BIA and by hydrodensitometry was 0.750, with a standard error of the estimate of 0.48%. Blood pressure was measured to the nearest 2 mmHg with a standard sphygmomanometer on the right arm of subjects sitting after 5 min rest, and Korotkoff phases I and V were taken to represent systolic blood pressure (SBP) and diastolic blood pressure (DBP), respectively. After the blood pressure measurement, fasting blood samples were drawn from an antecubital vein. Concentrations of low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) were determined enzymatically on the Olympus AU-5200 auto analyzer (Olympus Japan Co., Ltd., Tokyo, Japan) by FALCO Biosystems Tokyo Co., Ltd., Tokyo, Japan. LDL-C concentration was measured directly, using the direct N-geneous LDL-C assay<sup>25</sup>, and serum LDL-C/HDL-C ratio was calculated in all subjects. Quality control of the laboratory was maintained by internal method, and the coefficients of variation were all within 3% for LDL-C, HDL-C, and TG. Characteristics of the study population are shown in Table 1.

**Table 1. Characteristics of 1,217 Japanese male office workers**

Variable	Mean	Standard deviation
Age (years)	43.6	10.2
Body mass index (kg/m <sup>2</sup> )	22.9	2.9
Percentage body fat by bioimpedance (%)	19.5	3.0
Alcohol consumption (go/day)	0.92	0.82
Current drinking (%)	83.2	
Cigarette smoking (cigarettes/day)	16.1	15.6
Current cigarette smoking (%)	44.8	
Systolic blood pressure (mmHg)	127.3	14.3
Diastolic blood pressure (mmHg)	78.5	10.8
LDL cholesterol (mg/dl)	116.4	29.0
HDL cholesterol (mg/dl)	55.3	13.4
LDL/HDL cholesterol ratio	2.25	0.82
Log triglyceride (mg/dl)	4.62	0.55

LDL: low-density lipoprotein, HDL: high-density lipoprotein.

For statistical assessment, Pearson’s correlation coefficients were used to show relationships between two variables. Stepwise multiple regression analyses were performed to examine an independent association of factors and their relative importance as determinants of the levels of blood pressure and serum lipids. In the statistical analyses, the logarithm for TG (because of the non-gaussian distribution of the frequency for this variable) was used.

Data analysis was performed with the SPSS/PC statistical package (Marija J. Norusis, SPSS Inc., Chicago, IL, USA). All reported P-values are two-tailed and a P-value of less than 0.05 was considered significant.

**Results**

Table 2 shows means of BMI and %BF by BIA and Pearson’s correlation coefficients between BMI and %BF by BIA by 5-year age group. Means of BMI and %BF by BIA differed significantly among seven age groups (F value:

6.40, P<0.001 for BMI and F value: 3.47, P<0.001 for %BF by BIA). Means of BMI and %BF by BIA tended to increase slightly but progressively from age 25 to 50, but this trend was reversed from age 50. BMI was obviously correlated with %BF by BIA (r=0.755–0.810) in all age groups.

Table 3 shows Pearson’s correlation coefficients between cardiovascular risk factors and age, BMI, %BF by BIA, alcohol consumption, and cigarette smoking. SBP, DBP, and Log TG level were significantly positively associated with age, BMI, %BF by BIA, alcohol intake, and cigarette smoking. LDL-C level and LDL-C/HDL-C ratio were significantly positively associated with age, BMI, %BF by BIA, and cigarette smoking, and were significantly negatively associated with alcohol consumption. As for HDL-C, HDL-C level was significantly negatively associated with age, BMI, %BF by BIA, and cigarette smoking, and was significantly positively associated with alcohol consumption. Compared with %BF by BIA, BMI was better correlated with each cardiovascular risk factor level.

**Table 2. Means and standard deviations of body mass index and percentage body fat by bioimpedance and Pearson’s correlation coefficients between body mass index and percentage body fat by age**

Age (years)	no.	Body mass index (kg/m <sup>2</sup> )		Percentage body fat (%)		r*
		Mean	Standard deviation	Mean	Standard deviation	
25–29	144	22.1	2.6	18.8	3.0	0.770
30–34	218	22.4	2.7	19.1	3.1	0.773
35–39	117	23.3	3.1	19.6	2.9	0.801
40–44	96	23.4	2.7	19.8	2.9	0.755
45–49	200	23.6	3.2	20.1	3.3	0.810
50–54	268	23.1	2.6	19.4	2.9	0.794
55–59	174	23.0	2.8	19.6	2.7	0.766

\*Pearson’s correlation coefficients between body mass index and percentage body fat. P<0.001 for all.

**Table 3. Pearson’s correlation coefficients between cardiovascular risk factors and age, body mass index, percentage body fat by bioimpedance, alcohol consumption, and cigarette smoking**

Variable	Systolic blood pressure (mmHg)		Diastolic blood pressure (mmHg)		LDL cholesterol (mg/dl)		HDL cholesterol (mg/dl)		LDL/HDL cholesterol ratio		Log triglyceride (mg/dl)	
	P value	<0.001	P value	<0.001	P value	<0.001	P value	<0.001	P value	<0.001	P value	<0.001
Age (years)	0.283	<0.001	0.375	<0.001	0.230	<0.001	- 0.058	0.042	0.202	<0.001	0.288	<0.001
Body mass index (kg/m <sup>2</sup> )	0.253	<0.001	0.288	<0.001	0.228	<0.001	- 0.362	<0.001	0.373	<0.001	0.381	<0.001
Percentage body fat (%)	0.200	<0.001	0.224	<0.001	0.216	<0.001	- 0.321	<0.001	0.338	<0.001	0.316	<0.001
Alcohol consumption (go/day)	0.158	<0.001	0.159	<0.001	-0.080	0.005	0.204	<0.001	- 0.185	<0.001	0.079	0.006
Cigarette smoking (cigarettes/day)	0.124	<0.001	0.144	<0.001	0.066	0.022	- 0.133	<0.001	0.145	<0.001	0.198	<0.001

LDL: low-density lipoprotein, HDL: high-density lipoprotein.

**Table 4.** Stepwise regression analysis of cardiovascular risk factors on age, body mass index, alcohol consumption, and cigarette smoking

Dependent variable	Independent variables	Regression coefficient	Standard error	Standardized regression coefficient	T value	P value	Cumulative R <sup>2</sup> *
Systolic blood pressure (mmHg)	Age (years)	0.310	0.039	0.221	64.5	<0.001	0.080
	Body mass index (kg/m <sup>2</sup> )	1.117	0.134	0.223	69.6	<0.001	0.129
	Alcohol consumption (go/day)	2.553	0.478	0.146	28.5	<0.001	0.149
Diastolic blood pressure (mmHg)	Age (years)	0.335	0.028	0.316	143.2	<0.001	0.141
	Body mass index (kg/m <sup>2</sup> )	0.934	0.097	0.247	92.5	<0.001	0.200
	Alcohol consumption (go/day)	1.565	0.347	0.118	20.4	<0.001	0.213
LDL cholesterol (mg/dl)	Age (years)	0.673	0.080	0.237	70.8	<0.001	0.053
	Body mass index (kg/m <sup>2</sup> )	2.049	0.278	0.202	54.5	<0.001	0.093
	Alcohol consumption (go/day)	- 4.670	0.991	- 0.132	22.2	<0.001	0.110
HDL cholesterol (mg/dl)	Body mass index (kg/m <sup>2</sup> )	- 1.660	0.122	- 0.352	186.2	<0.001	0.131
	Alcohol consumption (go/day)	4.092	0.438	0.249	87.4	<0.001	0.174
	Cigarette smoking (cigarettes/day)	- 0.141	0.023	- 0.164	37.8	<0.001	0.199
LDL/HDL cholesterol ratio	Body mass index (kg/m <sup>2</sup> )	0.099	0.007	0.345	183.9	<0.001	0.139
	Alcohol consumption (go/day)	- 0.263	0.026	- 0.263	98.7	<0.001	0.174
	Age (years)	0.015	0.002	0.185	47.0	<0.001	0.218
	Cigarette smoking (cigarettes/day)	0.007	0.001	0.125	21.6	<0.001	0.231
Log triglyceride (mg/dl)	Body mass index (kg/m <sup>2</sup> )	0.067	0.005	0.347	182.3	<0.001	0.145
	Age (years)	0.011	0.001	0.205	56.9	<0.001	0.205
	Cigarette smoking (cigarettes/day)	0.003	0.000	0.089	10.8	0.001	0.214
	Alcohol consumption (go/day)	0.039	0.018	0.058	1.7	0.031	0.217

\*Percentage of variation accounted for =  $R^2 \times 100$ . R: multiple correlation. LDL: low-density lipoprotein, HDL: high-density lipoprotein.

Table 4 shows the results of stepwise regression analyses for cardiovascular risk factors on age, BMI, alcohol consumption, and cigarette smoking. Significant correlates with SBP, DBP, LDL-C level, HDL-C level, LDL-C/HDL-C ratio, and Log TG level were, in the order of relative importance: age, BMI, and alcohol intake for SBP and DBP; age, BMI, and alcohol intake (negative) for LDL-C level; BMI (negative), alcohol, and cigarette smoking (negative) for HDL-C level; BMI, alcohol intake (negative), age, and cigarette smoking for LDL-C/HDL-C ratio; and BMI, age, cigarette smoking, and alcohol intake for Log TG level. The cumulative percentages of variation for SBP, DBP, LDL-C level, HDL-C level, LDL-C/HDL-C ratio, and Log TG level were 14.9%, 21.3%, 11.0%, 19.9%, 23.1%, and 21.7%, respectively.

Table 5 shows the results of stepwise regression analyses for cardiovascular risk factors, using %BF by BIA as an independent factor in the model. The same significant correlates with each cardiovascular risk factor and orders of relative importance were observed as in the model using BMI as an independent factor. However, the cumulative percentage of variation for each cardiovascular risk factor was decreased, compared with the model using BMI as an independent factor, (13.2% for SBP, 19.3% for DBP, 10.9%

for LDL-C level, 17.4% for HDL-C level, 21.5% for LDL-C/HDL-C ratio, and 18.5% for Log TG level).

## Discussion

In this study, BMI was highly correlated with %BF by BIA ( $r=0.755-0.810$ ) in all age groups, and both BMI and %BF by BIA were found to be independent factors for increased SBP, DBP, LDL-C level, TG level, and LDL-C/HDL-C ratio and reduced HDL-C level, controlling for age, alcohol intake, and cigarette smoking. Percentages of variations of BMI and %BF by BIA were 3.2% to 6.0% for SBP, DBP, and LDL-C level, but were more than 10% for HDL-C level, LDL-C/HDL-C ratio, and Log TG level. These results suggest that obesity indicated by BMI or %BF by BIA is particularly associated with increased LDL-C/HDL-C ratio and TG level and reduced HDL-C level. As for the difference of explained variance between BMI and %BF by BIA, the decrease in explained variance for each cardiovascular risk factor was 0.2–4.6% in the model using %BF by BIA as an independent factor, compared with the model using BMI as an independent factor. Our data indicate that BMI might better reflect blood pressure or serum lipid profile than %BF by BIA.

**Table 5. Stepwise regression analysis of cardiovascular risk factors on age, percentage body fat by bioimpedance, alcohol consumption, and cigarette smoking**

Dependent variable	Independent variables	Regression coefficient	Standard error	Standardized regression coefficient	T value	P value	Cumulative R <sup>2*</sup>
Systolic blood pressure (mmHg)	Age (years)	0.329	0.039	0.234	71.9	<0.001	0.080
	Percentage body fat (%)	0.865	0.128	0.181	45.7	<0.001	0.112
	Alcohol consumption (go/day)	2.569	0.483	0.147	28.3	<0.001	0.132
Diastolic blood pressure (mmHg)	Age (years)	0.351	0.028	0.331	154.6	<0.001	0.141
	Percentage body fat (%)	0.716	0.093	0.199	59.0	<0.001	0.179
	Alcohol consumption (go/day)	1.578	0.351	0.119	20.2	<0.001	0.193
LDL cholesterol (mg/dl)	Age (years)	0.700	0.080	0.246	77.3	<0.001	0.053
	Percentage body fat (%)	1.922	0.263	0.199	53.4	<0.001	0.091
	Alcohol consumption (go/day)	- 4.624	0.991	- 0.130	21.8	<0.001	0.107
HDL cholesterol (mg/dl)	Percentage body fat (%)	- 1.408	0.117	- 0.314	144.3	<0.001	0.103
	Alcohol consumption (go/day)	4.061	0.444	0.247	83.5	<0.001	0.143
	Cigarette smoking (cigarettes/day)	- 0.156	0.023	- 0.182	45.2	<0.001	0.174
LDL/HDL cholesterol ratio	Percentage body fat (%)	0.087	0.007	0.317	154.4	<0.001	0.114
	Alcohol consumption (go/day)	- 0.264	0.027	- 0.264	97.1	<0.001	0.147
	Age (years)	0.016	0.002	0.200	54.0	<0.001	0.198
	Cigarette smoking (cigarettes/day)	0.007	0.001	0.138	25.8	<0.001	0.215
Log triglyceride (mg/dl)	Percentage body fat (%)	0.054	0.005	0.294	127.9	<0.001	0.100
	Age (years)	0.012	0.001	0.222	64.3	<0.001	0.170
	Cigarette smoking (cigarettes/day)	0.004	0.000	0.103	13.8	<0.001	0.180
	Alcohol consumption (go/day)	0.038	0.018	0.057	4.3	0.038	0.185

\*Percentage of variation accounted for = R<sup>2</sup> × 100. R: multiple correlation. LDL: low-density lipoprotein, HDL: high-density lipoprotein.

As reported in previous studies<sup>9, 26-29</sup>, daily alcohol consumption was found to be significantly associated with increased SBP, DBP, HDL-C level, and TG level. Furthermore, alcohol consumption showed the significant inverse association with LDL-C level and LDL-C/HDL-C ratio. It can therefore be suggested that alcohol has an anti-atherogenic effect by altering both HDL-C and LDL-C in Japanese male office workers. However, clinical opinion holds that abstinence from alcohol is fundamental to the control of hypertension and hypertriglyceridemia.

As for smoking, recent investigations into the effects of smoking on blood pressure have variously found that it is either unrelated<sup>30, 31</sup> or related<sup>32, 33</sup> to hypertension. In this study, smoking habits showed no significant relationship with SBP and DBP. On the other hand, many studies have noted an inverse relationship between smoking and HDL-C level<sup>34, 35</sup>, which is one suggested mechanism whereby smoking increases the risk of coronary arteriosclerosis. TG level in whole serum and a very low density lipoprotein fraction have been found to increase with cigarette smoking<sup>35</sup>. We also showed that cigarette smoking was significantly associated with reduced HDL-C level and increased LDL-C/HDL-C ratio and TG level. In the population surveyed for

this study, nearly half of our participants smoked cigarettes. Associations with increased risks of serum lipid profile warrant the promotion of smoking cessation at workplace.

In conclusions, our results suggest that BMI may better reflect blood pressure or serum lipid profile than %BF by BIA and that body fatness of Japanese male office workers may be simply predicted from body height and weight. As for the clinical use of BIA, BIA may promise at least one other measure of body composition that can be applied to large populations, since it is fast, is inexpensive, and does not require extensive operator training. However, several limitations should be taken into consideration. %BF by BIA is affected by individual and environmental factors such as posture and time of measure, consumption of food or beverage, sweating, and physical activity<sup>36</sup>. Since BIA equations may not be easily transferred from one population to another if the populations differ in important determinants such as sex, age, obesity, and illness, specific equations must be developed for various subgroups of such study populations. If more sophisticated treatment of these factors would be developed to improve the precision and accuracy of BIA further, BIA might become a useful method of estimating body composition in the field.

## Acknowledgments

We would like to express our appreciation to all the employees and the Medical Office of the Osaka Main Office of Takenaka Corporation for their valuable cooperation for this study. We are also grateful to Ryuichi Kaneko and his colleagues at the Japan Labor and Welfare Association for their accurate collecting and coding of the data.

## References

- 1) Watkins JC, Roubenoff R, Rosenberg IH (1992) Body composition: The measure and measuring of change with aging. Foundation for Nutritional Advancement, Boston, Mass.
- 2) Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: executive summary (1998) Expert Panel on the Identification, Evaluation, and Treatment of Overweight in adults. *Am J Clin Nutr* **68**, 899–917.
- 3) Kannel WB, Brand N, Skinner JJ Jr, Dawber TR, McNamara PM (1967) The relation of adiposity to blood pressure and the development of hypertension. *Ann Intern Med* **67**, 48–59.
- 4) Beilin LJ (1988) The fifth Sir George Pickering memorial lecture. Epitaph to essential hypertension: a preventable disorder of known aetiology? *J Hypertension* **6**, 85–94.
- 5) MacMahon S, Cutler J, Brittain E, Higgins M (1987) Obesity and hypertension: epidemiological and clinical issues. *Eur Heart J* **8**, 57–70.
- 6) Albrink MJ, Meigs JW, Man EB (1961) Serum lipids, hypertension and coronary artery disease. *Am J Med* **31**, 4–23.
- 7) Grundy SM, Mok HY, Zech L, Steinberg D, Berman M (1979) Transport of very low density lipoprotein triglycerides in varying degrees of obesity and hypertriglyceridemia. *J Clin Invest* **63**, 1274–83.
- 8) Gordon T, Fisher M, Ernst N, Rifkind BM (1982) Relation of diet to LDL cholesterol, VLDL cholesterol, and plasma total cholesterol and triglycerides in white adults: The Lipid Research Clinics Prevalence Study. *Arteriosclerosis* **2**, 502–12.
- 9) Yano K, Reed DM, Curb JD, Hankin JH, Albers JJ (1986) Biological and dietary correlates of plasma lipids and lipoproteins among elderly Japanese men in Hawaii. *Arteriosclerosis* **6**, 422–33.
- 10) Denke MA, Sempos CT, Grundy SM (1993) Excess body weight. An under-recognized contributor to high blood cholesterol levels in white American men. *Arch Intern Med* **153**, 1093–103.
- 11) Despres JP (1994) Dyslipidemia and obesity. *Baillieres Clin Endocrinol Metab* **8**, 629–60.
- 12) Micozzi MS, Albanes D, Jones DY, Chumlea WC (1986) Correlations of body mass indices with weight, stature, and body composition in men and women in NHANES I and II. *Am J Clin Nutr* **44**, 725–31.
- 13) Smalley KJ, Kner AN, Kendrick ZV, Colliver JA, Owen OE (1990) Reassessment of body mass indices. *Am J Clin Nutr* **52**, 405–8.
- 14) Roubenoff R, Dallal GE, Wilson PWF (1995) Predicting body mass: the body mass index vs estimation by bioelectrical impedance. *Am J Public Health* **85**, 726–8.
- 15) NIH Consensus Statement (1996) Bioelectrical impedance analysis in body composition measurement. National Institutes of Health Technology Assessment Conference Statement. December 12–14, 1994. *Nutrition* **12**, 749–62.
- 16) Foster KR, Lukaski HC (1996) Whole-body impedance—What does it mean? *Am J Clin Nutr* **64** (suppl), 388S–96S.
- 17) Nagaya T, Yoshida H, Takahashi H, Matsuda Y, Kawai M (1999) Body mass index (weight/height<sup>2</sup>) or percentage body fat by bioelectrical impedance analysis: which variable better reflects serum lipid profile. *Int J Obes Relat Metab Disord* **23**, 771–4.
- 18) Luke A, Durazo-Arvizu R, Rotimi C, Prewitt TE, Forrester T, Wilks R, Ogunbiyi OJ, Schoeller DA, McGee D, Cooper RS (1997) Relation between body mass index and body fat in black population samples from Nigeria, Jamaica, and the United States. *Am J Epidemiol* **145**, 620–8.
- 19) Baumgartner RN (1993) Body composition in elderly persons: a critical review of needs and methods. *Prog Food Nutr Sci* **17**, 223–60.
- 20) Gruchow HW, Sobocinski KA, Barboriak JJ, Scheller JG (1985) Alcohol consumption, nutrient intake and relative body weight among US adults. *Am J Clin Nutr* **42**, 289–95.
- 21) Albanes D, Jones Y, Micozzi MS, Mattson ME (1987) Associations between smoking and body weight in the US population: analysis of NHANES II. *Am J Public Health* **77**, 439–44.
- 22) Shimokata H, Muller DC, Andres R (1989) Studies in the distribution of body fat. III. Effects of cigarette smoking. *JAMA* **261**, 1169–73.
- 23) Colditz GA, Goivannucci E, Rimm EB, Stampfer M,

- Rosner B, Speizer FE, Gordis E, Willett WC (1991) Alcohol intake in relation to diet and obesity in women and men. *Am J Clin Nutr* **54**, 49–55.
- 24) Kitagawa K, Takami K, Miyagi O, Sakurai K, Ogawa K (1993) Measurement of body fat mass as a health related physical fitness test. *Jpn J SportsSci* **12**, 655–60 (in Japanese).
- 25) Rifai N, Iannotti E, DeAngelis K, Law T (1998) Analytical and clinical performance of a homogeneous enzymatic LDL-cholesterol assay compared with the ultracentrifugation-dextran sulfate-Mg<sup>2+</sup> method. *Clin Chem* **44**, 1242–50.
- 26) Castelli WP, Doyle JT, Gordon T, Hames CG, Hjortland MC, Hulley SB, Kagan A, Zukel WJ (1977) Alcohol and blood lipids. The Cooperative Lipoprotein Phenotyping Study. *Lancet* **2**, 153–5.
- 27) Ernst N, Fisher M, Smith W, Gordon T, Rifkind BM, Little JA, Mishkel MA, Williams OD (1980) The association of plasma high-density lipoprotein cholesterol with dietary intake and alcohol consumption. The Lipid Research Clinics Program Prevalence Study. *Circulation* **62** (4 Pt 2), IV41–52.
- 28) Frimpong NA, Lapp JA (1989) Effects of moderate alcohol intake in fixed or variable amounts on concentration of serum lipids and liver enzymes in healthy young men. *Am J Clin Nutr* **50**, 987–91.
- 29) Ueshima H, Mikawa K, Baba S, Sasaki S, Ozawa H, Tsushima M, Kawaguchi A, Omae T, Katayama Y, Kayamori Y, Ito K (1993) Effect of reduced alcohol consumption on blood pressure in untreated hypertensive men. *Hypertension* **21**, 248–52.
- 30) Shono M, Kitano T, Futatsuka M (1997) Risk estimation for hypertension based on follow-up health examination data in a small village in Kumamoto Prefecture, Japan. *Environ Health Prev Med* **1**, 206–10.
- 31) Buck CW, Donner AP (1987) Factors affecting the incidence of hypertension. *Can Med Assoc J* **136**, 357–60.
- 32) Reed D, McGee D, Yano K (1982) Biological and social correlates of blood pressure among Japanese men in Hawaii. *Hypertension* **4**, 406–14.
- 33) Kato I, Tominaga S, Matuoka I (1989) A prospective study on the relationship between life style and major adult diseases. *Nippon Kosho Eisei Zasshi* **36**, 662–8 (in Japanese).
- 34) Criqui MH, Wallace RB, Heiss G, Mishkel M, Schonfeld G, Jones GT (1980) Cigarette smoking and plasma high-density lipoprotein cholesterol. The Lipid Research Clinics Program Prevalence Study. *Circulation* **62** (4 Pt 2), IV70–76.
- 35) Phillips NR, Havel RJ, Kane JP (1981) Levels and interrelationships of serum and lipoprotein cholesterol and triglycerides: association with adiposity and the consumption of ethanol, tobacco, and beverages containing caffeine. *Arteriosclerosis* **1**, 13–24.
- 36) Kushner RF, Gudivaka R, Schoeller DA (1996) Clinical characteristics influencing bioelectrical impedance analysis measurements. *Am J Clin Nutr* **64** (suppl), 423S–7S.