Lippincott Williams & Wilkins
a Wolters Kluwer business

EUROPEAN SOCIETY OF CARDIOLOGY®

Original Scientific Paper

A comparison of the prevalence of the metabolic syndrome and its components among native Japanese and Japanese Brazilians residing in Japan and Brazil

Andiara Schwingel[a], Yoshio Nakata[a,b], Lucy S. Ito[c,d], Wojtek J. Chodzko-Zajko[e], Ryosuke Shigematsu[f], Christopher T. Erb[e], Sueli M. Oba-Shinjo[c], Tomoaki Matsuo[a], Samuel K. Shinjo[c,d], Miyuki Uno[c], Suely K.N. Marie[c] and Kiyoji Tanaka[a,b]

[a]Graduate School of Comprehensive Human Sciences, Sports Medicine, [b]Center for Tsukuba Advanced Research Alliance, University of Tsukuba, Ibaraki, Japan, [c]Department of Neurology, School of Medicine, São Paulo University, São Paulo, [d]Japanese Brazilian Health Professional Volunteer Group, São Paulo, Brazil, [e]Department of Kinesiology and Community Health, University of Illinois, Urbana-Champaign, Illinois, USA and [f]Faculty of Education, Mie University, Tsu, Mie, Japan

Received 20 April 2006 **Accepted** 2 October 2006

Background **This study investigated the prevalence of risk factors associated with the metabolic syndrome (MetSyn) among individuals of Japanese descent exposed to different cultural environments.**
Design **A cross-sectional study to assess component risk factors for the diagnosis of MetSyn was undertaken in urban areas in Japan and Brazil. A total of 773 men and women aged 35 years or over were included in three groups: 249 native Japanese, 269 Brazilian individuals of Japanese ancestry residing in Japan, and 255 Brazilian individuals of Japanese ancestry residing in Brazil.**
Results **Higher rates of metabolic abnormalities with respect to central obesity and serum lipid profiles were observed among Brazilian individuals of Japanese ancestry residing in Brazil compared with those residing in Japan and native Japanese. Likewise, an increased risk of hypertension was observed among Japanese Brazilian individuals residing in Japan. The prevalence of MetSyn in men was significantly higher among Brazilians of Japanese ancestry residing in Brazil (37.5%) compared with those residing in Japan (25.3%) or native Japanese (21.4%), whereas no significant difference was observed among women. In the logistic model, Brazilian individuals of Japanese ancestry residing in Brazil were twice as likely to develop MetSyn compared with native Japanese, whereas no significant differences were found among those residing in Japan.**
Conclusions **These findings underscore the significant heterogeneity in risk factors among communities of Japanese ancestry residing in Brazil and Japan, and suggest that immigrants exposed to the Brazilian cultural environment are more susceptible to the development of risk factors associated with MetSyn than native Japanese.** ***Eur J Cardiovasc Prev Rehabil*** **14:508–514 © 2007 The European Society of Cardiology**

European Journal of Cardiovascular Prevention and Rehabilitation 2007, **14**:508–514

Keywords: Brazil, Japan, Japanese Brazilian, immigrant, metabolic syndrome, risk factor

Introduction

The Japanese have the longest healthy life expectancy among World Health Organization member countries, a fact that has been attributed to low rates of heart disease and a traditionally low-fat diet [1]. However, reports of Japanese immigrants exposed to western cultures show them to have a higher prevalence of non-communicable diseases and mortality, which is strongly associated with changes in diet and physical activity [2–5]. Approximately 1.3 million individuals of Japanese ancestry live in Brazil, and the city of São Paulo hosts the largest Japanese community outside

Correspondence to Kiyoji Tanaka, University of Tsukuba, Graduate School of Comprehensive Human Sciences, Sports Medicine, 1-1-1 Tennodai, Tsukuba (shi), Ibaraki (ken) 305-8574, Japan
Tel: +81 29 853 5600 (ext. 8366); fax: +81 29 853 6507;
e-mail: tanaka@sports.taiiku.tsukuba.ac.jp

1741-8267

of Japan. When the 80th anniversary of the first wave of Japanese immigration was celebrated (1988), Brazil was facing rampant inflation and unemployment, whereas Japan was requiring workers for its growing industries. Therefore, back-immigration of Japanese Brazilian individuals began with the support of the Japanese government. There is currently an estimated population of nearly 300 000 Brazilians residing in Japan (mostly of Japanese ancestry), which is 15% of Japan's foreign population [6]. Health-related behaviours adopted by individuals of Japanese ancestry residing in Brazil have been observed to be associated with an increase in risk factors for diseases [7–10], and the overall pattern of causes of mortality has been reported to be closer to the Brazilian profile than the Japanese [11]. Native Japanese not only live longer than Brazilian individuals (12-year longer life expectancy at birth), but they also have a 15-year longer healthy life expectancy [12]. It is unclear whether this is a characteristic that remains true for Japanese immigrants to Brazil and subsequent generations. Whereas mixed cultural heritage and the experience of living in two countries have been shown to be associated with an increased likelihood of psychological disorders [13] and emotional conflicts [14] among Brazilian individuals of Japanese ancestry residing in Japan, there is a lack of previously published data regarding risk factors for chronic diseases among immigrants in Japan.

Epidemiological studies have demonstrated that lifestyle choices, accumulated across the life course, greatly influence the risk of developing non-communicable diseases, such as hypertension, obesity, dyslipidaemia, and diabetes mellitus [15,16]. Studies assessing the aetiology of these diseases have increasingly focused on genetic and environmental factors [17–19]. Immigrant studies are particularly valuable for the analysis of the interaction between lifestyle and genetic factors in relation to health status [5,20–22]. There is some evidence to suggest that health status declines after a period of living in an adopted country [23–26], a fact that may be related to immigrants taking on health-related behaviours that are typical of the adopted country [3,4,8,27].

The metabolic syndrome (MetSyn) is a clustering of abnormalities including glucose intolerance, central obesity, atherogenic dyslipidaemia, and hypertension [28], whose prevalence varies according to ethnic origin [29–31], even within a single country [32,33]. This study compared the prevalence of MetSyn and its components among three communities of Japanese descent exposed to different cultural environments: Japanese, Brazilian, and a combination of both.

Methods

Study population

This cross-sectional study was undertaken in urban areas in Japan and Brazil. All participants shared Japanese ethnicity from both parents. The sample was restricted to individuals over the age of 35 years in order to permit the assessment of the impact of long-term lifestyle effects on chronic disease risk factors. Among Brazilians of Japanese ancestry, we selected individuals who were raised in Brazil, allowing us to assess the long-term influences of the Brazilian culture on health patterns. A total of 111 participants were excluded from the analysis (parents were not of Japanese ancestry in 85 cases, 17 had problems with blood assessment, and nine were aged less than 35 years). In total, 773 participants of Japanese and Brazilian Japanese ancestry (372 men and 401 women), ranging in age from 35 to 79 (53.6 ± 9.6) years were included in the study.

Participants were recruited through newspapers, local newsletters, and community centres; including Nippon–Brazilian schools, restaurants, stores, and local television stations for Japanese Brazilians living in Japan. Data were collected in community centres located in industrial towns close to major metropolitan cities in Japan and Brazil (Tokyo, Osaka and São Paulo). A total of 249 (98 men and 151 women) native Japanese (J-J group) living in Chiba, Ibaraki, and Mie provinces were measured on weekends in October and November of 2005. None of the native Japanese had left the country for more than 3 months during their lifetime. Japanese Brazilian individuals residing in Japan (JB-J group) were measured during weekends in October and November of 2004. A total of 269 participants (170 men and 99 women) living in Gunma, Saitama, and Gifu provinces were measured. The majority of participants were from the second generation (*nisei*) of Japanese descent (130 men and 73 women); in addition there were seven men from the first generation (*issei*) and 59 men and women ($n = 33$ and 26, respectively) from the third generation (*sansei*). All participants in this group were living in Japan for a period of longer than 1 year, including 38.7% living longer than 10 years. The length of stay did not differ between men and women. However, 49 participants (18.2%) had been living in Japan for less than 3 years. As no differences in age or generation group (*issei*, *nisei*, *sansei*) were found as a function of the length of stay in Japan, we elected to include all participants in the analyses. In addition, 255 (104 men and 151 women) Japanese Brazilian individuals residing in Brazil (JB-B group) were measured during March and April of 2005. They were all living in neighbourhoods surrounding São Paulo city, and had not recently left the country for a period longer than 3 months. The majority were *nisei* (67 men and 97 women), in addition to 39 *issei* (18 men and 21 women) and 52 *sansei* (19 men and 33 women).

Protocol

The overall protocol was approved in Brazil by the ethical committee of the School of Medicine, University of São Paulo, and in Japan by the Human Investigation Review

Committee at the School of Comprehensive Human Sciences, University of Tsukuba. A statement of informed consent (available bilingually in Japanese and Portuguese) was obtained from all participants before the initiation of the data collection. Data collection was carried out for all groups during mild seasons (spring or autumn), in order to avoid the influence of climatic factors on the variables measured for this study. Personal information was assessed through self-administered questionnaires checked by trained researchers.

Data collection was conducted in the morning, following at least a 12-h period in which no food or medication was taken by the participants. Weight was measured using a digital scale balance (TBF-551; Tanita, Tokyo, Japan) and height to the nearest 0.1 cm using a wall-mounted stadiometer (YG-200; Yagami, Nagoya, Japan). Body mass index (BMI) was calculated as weight (kg) by squared height (m^2). Waist circumference (WC) was measured at the umbilical level (cm). After 10 min of rest, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured three times (with 1 min between each reading) by an automatic device (Omron HEM-762; Omron Healthcare, Bannockburn, Illinois, USA; expressed as mmHg), and the mean value was used. Samples of venous blood were drawn from each participant and collected in vacuum tubes. Samples were stored at 4°C until they were delivered to the laboratory for analysis (Kotobiken Medical Laboratories, Inc., Tsukuba, Japan), and all analyses were conducted within 72 h of the blood collection. For samples collected in Brazil, blood tubes were immediately centrifuged to obtain plasma and serum, and frozen at −80°C. After data collection was completed in Brazil, frozen blood samples were transferred to Japan to be analysed by the same procedure in the same laboratory.

Serum high-density lipoprotein (HDL) cholesterol and triglyceride levels were measured by a modified enzymatic method (Kyowa Medex Co., Ltd., Tokyo, Japan), and by a glycerin-3-phosphatoxidase *N*-(2-hydroxy-3-sulfopropyl)-3,5-dimethoxyaniline sodium salt method, a glycerol blanking method assay (Daiichi Pure Chemicals Co., Ltd., Tokyo, Japan), respectively. A homogeneous method based on an innovative detergent technology (A&T Corporation, Kanagawa, Japan) was used to test for fasting plasma glucose (FPG).

MetSyn was defined by WC of 85 or 90 cm or greater (men and women), plus any two of the following three features: (i) triglycerides 1.7 mmol/l or greater or HDL-cholesterol less than 1.03 mmol/l; (ii) SBP/DBP 130/85 mmHg or greater; (iii) FPG 6.1 mmol/l or greater (or in drug treatment for specific risk factors), in accordance with the criteria of the Japanese Committee for the Diagnostic Criteria of Metabolic Syndrome (JC) [34].

Statistical analysis

Analyses of variance were used to assess differences among groups for the continuous variables. Adjustments for age differences were performed using analysis of covariance. Bonferoni adjustments were used to control for multiple comparisons for all analyses. Data were not adjusted for medication. Each dependent variable was found to be normally distributed, and assumptions of homogeneity of variance were confirmed using Levene's test of equality of error variance. Chi-squared tests were used for the analyses of categorical variables among all groups, and post hoc Mantel–Haenszel tests were applied for the comparison between each pair of groups. A logistic regression analysis was conducted using MetSyn as the dependent variable (presence 1, absence 0), and the following as the independent variables: sex (male 1, female 0), age (continuous), and population group (J-J as reference). Because Japanese generation (*issei*, *nisei*, and *sansei*) was proportionally distributed among the Japanese Brazilian groups (JB-J and JB-B), and no difference in the prevalence of MetSyn was observed among the generations, the three generations were analysed together. Sample size estimations were computed using an alpha level of 0.05, and a minimum power of 0.8 [35]. Based upon distributions from data published in previous studies among native Japanese and Japanese Brazilians [36–38], an estimated sample size of 222 per group was identified as necessary in order to ensure sufficient statistical power to detect significant differences for the key MetSyn variables included in the study. All statistical analyses were performed using SPSS 13.0 for Windows (SPSS Inc., Chicago, Illinois, USA) and statistical significance was set at $P < 0.05$.

Results

Table 1 shows the distribution of participants by group and sex for the anthropometric variables and for the component risk factors for the diagnosis of MetSyn. Because the men and women from the JB-J group were significantly younger than those in the other two groups, analyses were adjusted for age differences between groups. BMI was similar among groups for both men and women. WC in men from the JB-B group was significantly higher, followed by JB-J and J-J. SBP was significantly higher among participants from the JB-J group than among men from the JB-B group, and among women from both the JB-B and J-J groups. DBP was significantly higher in JB-J men than JB-B men. Participants from JB-B had significantly higher levels of triglycerides than those in the J-J group. JB-B had the lowest levels of HDL-cholesterol in men and women, followed by JB-J and the J-J group.

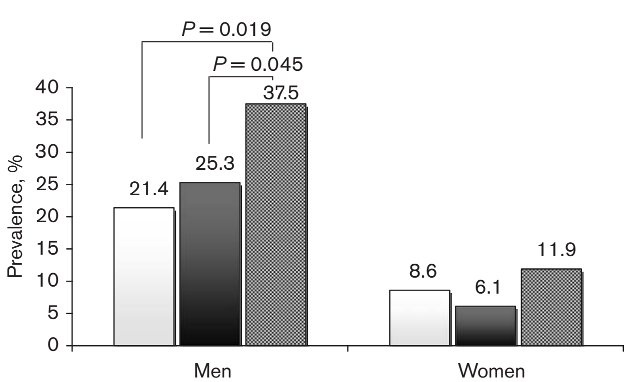
The overall prevalence of MetSyn (Fig. 1) was significantly higher in men from the JB-B group (37.5%), followed by JB-J (25.3%) and J-J (21.4%). The prevalence

Table 1 Mean and 95% confidence interval of anthropometric variables, blood pressure and serum lipid levels in men and women by group

	J-J Men (n=98) Women (n=151)		JB-J Men (n=170) Women (n=99)		JB-B Men (n=104) Women (n=151)		*P* value
Age (years)							
	57.5 (55.2–59.8)[b]		48.9 (47.9–50.0)		56.9 (55.1–58.8)[b]		<0.001
	55.4 (54.0–56.8)[b]		48.0 (46.5–49.5)		55.9 (54.3–57.5)[b]		<0.001
	Unadjusted	Adjusted[a] (95% CI)	Unadjusted	Adjusted[a] (95% CI)	Unadjusted	Adjusted[a] (95% CI)	*P* value
Weight (kg)							
	65.8	67.2 (65.2–69.2)	68.7	67.2 (65.6–68.8)	69.6	70.8 (68.8–72.7)[b,c]	0.010
	54.9	54.9 (53.6–56.2)	57.0	56.8 (55.1–58.5)	56.1	56.2 (54.9–57.5)	0.172
Height (cm)							
	166.1	167.1 (166.1–168.2)[b]	165.8	164.6 (163.7–165.4)	165.9	166.8 (165.7–167.8)[b]	0.001
	154.1	154.5 (153.7–155.3)	154.5	153.1 (152.1–154.1)	152.7	153.2 (152.4–154.0)[b]	0.031
BMI (kg/m^2)							
	24.4	24.5 (23.8–25.1)	25.0	24.9 (24.4–25.4)	25.2	25.3 (24.7–25.9)	0.159
	23.8	23.7 (23.1–24.2)	24.0	24.4 (23.7–25.2)	24.1	23.9 (23.3–24.5)	0.296
WC (cm)							
	83.7	83.8 (82.1–85.6)[b]	86.9	86.7 (85.3–88.1)	90.3	90.4 (88.7–92.1)[b,c]	<0.001
	82.9	82.5 (81.2–83.9)	81.2	82.7 (80.9–84.4)	82.3	81.8 (80.4–83.2)	0.689
SBP (mmHg)							
	139.8	137.3 (133.2–141.3)	140.0	142.8 (139.6–145.9)	132.8	130.5 (126.6–134.4)[b]	<0.001
	133.4	132.0 (128.8–135.1)[b]	135.9	141.2 (137.1–145.3)	130.7	128.7 (125.6–131.9)[b]	<0.001
DBP (mmHg)							
	84.7	84.4 (82.0–86.8)	86.0	86.3 (84.4–88.2)	82.3	82.1 (79.7–84.4)[b]	0.030
	81.5	81.2 (79.3–83.2)	81.4	82.5 (79.9–85.1)	79.5	79.1 (77.1–81.1)	0.105
Triglycerides (mmol/l)							
	1.28	1.31 (1.14–1.49)	1.39	1.35 (1.20–1.49)	1.66	1.69 (1.52–1.86)[b,c]	0.003
	1.00	0.98 (0.88–1.07)	1.02	1.10 (0.98–1.22)	1.25	1.22 (1.13–1.32)[c]	0.001
HDL-cholesterol (mmol/l)							
	1.62	1.61 (1.54–1.69)[b]	1.40	1.42 (1.36–1.48)	1.14	1.13 (1.06–1.20)[b,c]	<0.001
	1.81	1.81 (1.75–1.87)	1.70	1.71 (1.63–1.79)	1.43	1.42 (1.36–1.49)[b,c]	<0.001
FPG (mmol/l)							
	5.61	5.60 (5.31–5.89)	5.30	5.37 (5.18–5.57)	5.48	5.38 (5.13–5.63)	0.402
	5.27	5.25 (5.12–5.38)	4.94	5.03 (4.86–5.20)	5.04	5.00 (4.87–5.13)[c]	0.020

BMI, Body mass index; CI, confidence interval; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL, high-density lipoprotein; JB-B, Japanese Brazilian individuals residing in Brazil; JB-J, Japanese Brazilian individuals residing in Japan; J-J, native Japanese; SBP, systolic blood pressure; WC, waist circumference. [a]Adjusted for age. [b]Different from JB-J. [c]Different from J-J.

Fig. 1



Prevalence of the metabolic syndrome among native Japanese, Japanese Brazilian individuals residing in Japan and Japanese Brazilian individuals residing in Brazil. ☐ Native Japanese (J-J); ■ Japanese Brazilian individuals in Japan (JB-J); ▩ Japanese Brazilian individuals in Brazil (JB-B).

of high WC (70.2%), high triglyceride levels (37.5%) and low HDL-cholesterol (36.5%) seem to be associated with a higher prevalence of MetSyn in men from the JB-B group, whereas the prevalence of high blood pressure in men in the JB-J group (80%) was associated with an increased risk of MetSyn in that group compared with the J-J group (Table 2). Although no significant difference in the prevalence of MetSyn was observed among women (6.1% in JB-J, 11.9% in JB-B, and 8.6% in J-J, $P = 0.278$; Fig. 1), higher levels of triglycerides and lower HDL-cholesterol were observed in the JB-B group compared with the other groups (Table 2). The logistic regression analysis adjusting for age and sex (Table 3) showed the JB-B group to be twofold more likely than the J-J group to develop MetSyn [odds ratio (OR) 1.885, $P = 0.011$, 95% confidence interval (CI) 1.16–3.07]. However, the JB-J group did not show a significantly higher risk of MetSyn compared with the J-J group (OR 1.322, $P = 0.305$, 95% CI 0.78–2.26). Also, the logistic model identified male sex (OR 3.944, $P < 0.001$, 95% CI 2.59–6.01) and age (OR 1.028, $P = 0.013$, 95% CI 1.01–1.15) to be significant risk factors for the development of MetSyn.

Discussion

The major finding of this study is that native Japanese are significantly less susceptible to the development of risk

Table 2 Prevalence of metabolic abnormalities[a] in men and women by group

	J-J *n* (%)	JB-J *n* (%)	JB-B *n* (%)	*P* value	Post hoc
WC					
Men	45/98 (45.9)	92/170 (54.1)	73/104 (70.2)	0.002	b,c
Women	36/151 (23.8)	21/99 (21.2)	28/151 (18.5)	0.530	
SBP/DBP					
Men	65/98 (66.3)	136/170 (80.0)	65/104 (63)	0.003	b,d
Women	82/151 (54.3)	59/99 (59.6)	86/151 (57.0)	0.707	
HDL-cholesterol					
Men	5/98 (5.1)	19/170 (11.2)	38/104 (36.5)	< 0.001	b,c
Women	2/151 (1.3)	5/99 (5.1)	12/151 (7.9)	0.025	c
Triglycerides					
Men	18/98 (18.4)	45/170 (26.5)	39/104 (37.5)	0.009	b,c
Women	11/151 (7.3)	7/99 (7.1)	27/151 (17.9)	0.005	b,c
FPG					
Men	14/98 (14.3)	18/170 (10.6)	16/104 (15.4)	0.461	
Women	9/151 (6.0)	7/99 (7.1)	12/151 (7.9)	0.794	

BMI, Body mass index; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL, high-density lipoprotein; JB-B, Japanese Brazilian individuals residing in Brazil; JB-J, Japanese Brazilian individuals residing in Japan; J-J, native Japanese; SBP, systolic blood pressure; WC, waist circumference. [a]Cutoff among the components of the metabolic syndrome are listed in accordance with the criteria of the Japanese Committee for the Diagnostic Criteria of Metabolic Syndrome: WC ≥ 85 or 90 cm (men and women), triglycerides ≥ 1.7 mmol/l, HDL-cholesterol < 1.03 mmol/l, SBP/DBP ≥ 130/85 mmHg, FPG ≥ 6.1 mmol/l (or in drug treatment for specific risk factors). [b]Difference between JB-B and JB-J. [c]Difference between JB-B and J-J. [d]Difference between JB-J and J-J.

Table 3 Logistic regression model for the metabolic syndrome

	β Coefficient	SE	Wald	df	*P* value	Odds ratio	95% CI
Sex[a]	1.372	0.215	40.673	1	< 0.001	3.944	2.59–6.01
Age (years)	0.027	0.011	6.164	1	0.013	1.028	1.01–1.15
JB-J[b]	0.279	0.273	1.050	1	0.305	1.322	0.78–2.26
JB-B[b]	0.634	0.248	6.523	1	0.011	1.885	1.16–3.07

CI, Confidence interval; df, degrees of freedom; JB-B, Japanese Brazilian residing in Brazil; JB-J, Japanese Brazilian residing in Japan. [a]Male. [b]Native Japanese as reference.

factors associated with MetSyn than Japanese immigrants to Brazil and subsequent generations residing in Brazil. This result is consistent with previous studies showing that native Japanese are on average healthier compared with Japanese immigrants [3–5]. Another finding observed throughout the analysis of Japanese Brazilian individuals is that those currently living in Japan exhibit fewer abnormalities associated with MetSyn than those who remained in Brazil. This provides some insight that cultural and environmental changes may be negatively influencing the health status of individuals of Japanese ancestry who immigrated to Brazil and remain living there. In contrast, returning to live in Japan appears to have a positive influence on health.

Our finding of an increased risk of MetSyn among Brazilian individuals of Japanese ancestry seems to be associated with higher measures of central obesity (WC) in men, and lower HDL-cholesterol and higher triglyceride levels in both men and women from the group of Japanese Brazilian individuals residing in Brazil, and with higher blood pressure from those residing in Japan. Interestingly, higher values of BMI among Japanese Brazilian individuals compared with native Japanese were not observed in the present study, as they have been in previous studies [26,38]. On the other hand, central obesity (as indicated by a higher WC), is closely associated with several manifestations of MetSyn [15]. BMI and WC in men from the JB-B group in the present study were similar to those found by earlier investigations of Japanese Brazilian individuals living in São Paulo state [8,36]. A previous study among Japanese immigrants in São Paulo suggested that high mortality rates from ischaemic heart disease were correlated with increased blood pressure and BMI, and decreased levels of HDL-cholesterol [26]. That study also showed that Japanese Brazilian men (in Brazil) have lower levels of HDL-cholesterol compared with native Japanese from different locations in Japan, which was consistent with the results of our study.

There is a lack of a single suitable worldwide definition of MetSyn to apply in epidemiological studies, which limits the extent to which comparisons can be drawn between studies, particularly among different ethnic groups [39,40]. According to the criteria used in our study (JC), MetSyn is defined using central obesity (WC) as a prerequisite risk factor. A diagnosis of MetSyn is made when central obesity plus two of three other risk factors (raised triglycerides or reduced HDL-cholesterol, raised blood pressure, and elevated FPG) are present. The International Diabetes Federation (IDF) has also proposed prerequisite criteria for WC, including ethnically specific values [41]. The diagnosis of MetSyn under IDF criteria using the Japanese cut-offs for WC differs from the JC in three aspects (reduced HDL-cholesterol has a different definition among sexes in IDF, JC does not; triglycerides and HDL-cholesterol are two independent features in the IDF criteria, whereas in the JC either elevated triglycerides or decreased HDL-cholesterol is considered to be indicative of a single risk parameter. In the IDF criteria, evidence of elevated FPG is considered to be above 5.6 mmol/l, in the JC it is 6.1 mmol/l). In our study, we found a slightly higher prevalence of MetSyn among our data when using IDF criteria (for men: 24.5% in J-J, 30.0% in JB-J, and 47.1% in JB-B; for women: 8.6% in J-J, 6.1% in JB-J, and 11.9% in JB-B) compared with the JC. However, a comparative analysis among groups remained similar using both criteria. Therefore, we found the JC to be appropriate for all groups in this study.

A nationwide survey conducted in 2000 among the Japanese population was recently published [42], and the prevalences of MetSyn reported were 12.1 and 1.7%, for men and women, respectively. Our study found slightly higher values compared with their study. Although the criteria used were similar, the study by Arai *et al.* [42] included individuals from 20 to 79 years, which could explain the lower prevalence compared with our study. Furthermore, prevalence rates for MetSyn among Japanese Brazilian men living in Brazil [43] were found similar to our study (36.9%). Although the study by Damiao *et al.* [43] assessed similar age ranges of adults and elderly individuals as our study, the MetSyn criteria used were different. Particularly among women, the prevalence reported was much higher (38.8%) compared with our study. This study also reported an association between protein intake and MetSyn among the participants studied. Likewise, another study reported a close association between increased dietary fat and increased MetSyn prevalence in Japanese Brazilian individuals living in Brazil [7]. Also, the diets of Japanese Brazilian individuals in Brazil were observed to be more similar to western than eastern diets, which may contribute to increased abdominal fat deposition [8]. High energy density diets and sedentary lifestyle profiles have been observed in Japanese Brazilian individuals living in Brazil [8,9,27]. Dietary changes among Japanese immigrants in Brazil, especially low fish and high meat intake, appear to be related to obesity and hypertension in that population [10,38].

Interestingly, our study revealed no differences among women with respect to the prevalence of MetSyn among the three groups. In contrast, significant differences were found between men. These data suggest that men may be especially susceptible to the effects of immigration on the components of MetSyn. Additional research is needed to examine these sex differences further.

The present study has some limitations. First, the group of Japanese Brazilian individuals living in Japan (JB-J) was significantly younger than those in the other two groups. Despite the use of similar recruiting procedures, and specific age inclusion criteria, it was not possible to equalize age across all groups. The disparity occurred because the population of Japanese Brazilian individuals in Japan is composed mostly of economically active younger adults. An additional limitation is that participants were not randomly drawn from the Japanese population in Japan, or from the Japanese Brazilian population in Japan and Brazil. Non-participants may have different characteristics and health status than participants. These findings thus need to be interpreted within the context of these limitations and cannot be generalized to the population as a whole. Finally, social-economic and lifestyle variables were not included for the analyses.

In conclusion, our findings further our understanding of the effects of Japanese immigration in the context of several important public health concerns. Demographic changes in the Japanese population highlight the importance of immigrants to Japan's economic future. At the same time, Brazil is facing an epidemiological transition highlighted by an increasing burden of non-communicable disease. Compared with other groups of Japanese immigrants, there has been little research on the health status of Japanese immigrants to Brazil, particularly among those who migrate back to Japan. A better understanding of their health status and health-related behaviours could help to produce guidelines for policymakers and practitioners, and ultimately promote the enhancement of health among immigrant populations more generally. Further investigation is necessary to explain the effects of health-related cultural factors in Brazil and Japan, such as diet (energy density), food and beverage portion sizes, the impact of physical activity (e.g. transportation and occupation), as well as the effects of different levels of acculturation across generations of Japanese immigrants.

Acknowledgements

The authors would like to express deep thanks to all collaborators from the University of Tsukuba and São Paulo University, and greatly appreciate the participation of all community centres from Japan and Brazil, and to all Japanese and Brazilian individuals who voluntarily enrolled in this study. This work was partly supported by the 21st century Center of Excellence (COE) program (2002–2007 Nishihira Project); grants-in-aid for scientific research (2003–2006 Tanaka Project) and doctoral fellowship (A.S.) from the Japanese Ministry of Education, Culture, Sports, Science and Technology; and research fund (Bunka-Sumitomo Mitsui 2004) from the Brazilian Association of Japanese Culture.

There is no conflict of interest.

References

1 World Health Organization. WHO issues new healthy life expectancy rankings, Japan number one in new ‘healthy life’ System, 2000. Available from: http://www.who.int/inf-pr-2000/en/pr2000-life.html. Accessed: 3 March 2006.
2 Kudo Y, Falciglia GA, Couch SC. Evolution of meal patterns and food choices of Japanese-American females born in the United States. *Eur J Clin Nutr* 2000; **54**:665–670.
3 Nakanishi S, Okubo M, Yoneda M, Jitsuiki K, Yamane K, Kohno N. A comparison between Japanese-Americans living in Hawaii and Los Angeles and native Japanese: the impact of lifestyle westernization on diabetes mellitus. *Biomed Pharmacother* 2004; **58**:571–577.
4 Marmot MG, Syme SL. Acculturation and coronary heart disease in Japanese-Americans. *Am J Epidemiol* 1976; **104**:225–247.
5 Worth RM, Kato H, Rhoads GG, Kagan K, Syme SL. Epidemiologic studies of coronary heart disease and stroke in Japanese men living in Japan, Hawaii and California: Mortality. *Am J Epidemiol* 1975; **102**:481–490.
6 Japan Statistical Yearbook 2007, edited by the Statistical Research and Training Institute. Published by the Statistics Bureau, Ministry of Internal Affairs and Communications, 2006. Available at: http://www.stat.go.jp/english/data/nenkan/index.htm. Accessed: 14 December 2006.
7 Freire RD, Cardoso MA, Gimeno SGA, Ferreira SRG. Japanese–Brazilian Diabetes Study Group. Dietary fat is associated with metabolic syndrome in Japanese Brazilians. *Diabetes Care* 2005; **28**:1779–1785.
8 Ferreira SRG, Lerario DDG, Gimeno SGA, Sanudo A, Franco LF. Obesity and central obesity adiposity in Japanese immigrants: role of the Western dietary pattern. *J Epidemiol* 2002; **12**:431–438.
9 Freire RD, Cardoso MA, Shinzato AR, Ferreira SRG. Japanese–Brazilian Diabetes Study Group. Nutritional status of Japanese-Brazilian subjects: comparison across gender and generation. *Br J Nutr* 2003; **89**: 705–712.
10 Mizushima S, Moriguchi EH, Ishikawa P, Hekman P, Nara Y, Mimura G, *et al*. Fish intake and cardiovascular risk among middle-aged Japanese in Japan and Brazil. *J Cardiovasc Risk* 1997; **4**:191–199.
11 Gotlieb SLD. Immigrants mortality – Japanese residing in São Paulo city, Brazil, 1990 [in Portuguese]. *Rev Saude Publica* 1990; **24**:453–467.
12 World Health Organization. *The world health report 2004: changing history*. Geneva, Switzerland: WHO; 2004.
13 Miyasaka LS, Otsuka K, Tsuji K, Atallah AN, Kunihiro J, Nakamura Y, *et al*. Mental health of two communities of Japanese-Brazilians: a comparative study in Japan and in Brazil. *Psychiatry Clin Neurosci* 2002; **56**:55–64.
14 Tsuji K, Miyasaka L, Otsuka K, Honda G, Kato S, Abe Y. Panic disorder cases in Japanese-Brazilian in Japan: their ethnic and cultural confusion. *Psychiatry Clin Neurosci* 2001; **55**:127–130.
15 Grundy S, Hansen B, Smith S, Cleeman JI, Kahn RA. American Diabetes Association. Clinical management of metabolic syndrome: report of the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to management. Circulation 2004; **109**:551–556.
16 Minehira K, Tappy L. Dietary and lifestyle interventions in the management of the metabolic syndrome: present status and future perspective. *Eur J Clin Nutr* 2002; **56**:1–6.
17 Hunter D. Gene–environment interactions in human diseases. *Nature* 2005; **6**:287–298.
18 Austin MA, Edwards KL, McNeely MJ, Chandler WL, Leonetti DL, Talmud PJ, *et al*. Heritability of multivariate factors of the metabolic syndrome in nondiabetic Japanese Americans. *Diabetes* 2004; **53**:1166–1169.
19 Evenson KR, Sarmiento OL, Macon ML, Tawney KW, Ammerman AS. Environmental, policy, and cultural factors related to physical activity among Latina immigrants. *Women Health* 2002; **36**:43–57.
20 Zsembik BA, Fennell D. Ethnic variation in health and the determination of health among latinos. *Soc Sci Med* 2005; **61**:53–63.
21 Pavan L, Casiglia E, Braga LC, Winnicki M, Puato M, Pauletto P, Pessina AC. Effects of a traditional lifestyle on the cardiovascular risk profile: the Amondava population of the Brazilian Amazon. Comparison with matched African, Italian and Polish populations. *J Hypertens* 1999; **17**:749–756.
22 Yano K, MacLean CJ, Reed DM, Shimizu Y, Sasaki H, Kodama K, *et al*. A comparison of the 12-year mortality and predictive factors of coronary heart disease among Japanese men in Japan and Hawaii. *Am J Epidemiol* 1988; **127**:476–487.
23 Wiking E, Johansson S, Sundquist J. Ethnicity, acculturation, and self reported health. A population based study among immigrants from Poland, Turkey, and Iran in Sweden. *J Epidemiol Community Health* 2004; **58**:574–582.
24 Kaplan MS, Chang C, Newsom JT, McFarland BH. Acculturation status and hypertension among Asian immigrants in Canada. *J Epidemiol Community Health* 2002; **56**:455–456.
25 Dunn JR, Dyck I. Social determinants of health in Canada’s immigrant population: results from the National Population Health Survey. *Soc Sci Med* 2000; **51**:1573–1593.
26 Tsugane S, Hamada GS, Souza JM, Gotlieb SLD, Takashima Y, Todoriki H, *et al*. Lifestyle and health related factors among randomly selected Japanese residents in the city of São Paulo, Brazil, and their comparisons with Japanese in Japan. *J Epidemiol* 1994; **4**:37–46.
27 Moriguchi E.H, Moriguchi Y, Yamori Y. Impact of diet on the cardiovascular risk profile of Japanese immigrants living in Brazil: contributions of World Health Organization cardiac and Monalisa studies. *Clin Exp Pharmacol Physiol* 2004; **31**:S5–S7.
28 Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. *Lancet* 2005; **365**:1415–1427.
29 Patel A, Huang KC, Janus ED, Gill T, Neal B, Suriyawongpaisal P, *et al*. Is a single definition of the metabolic syndrome appropriate? – a comparative study of the USA and Asia. *Atherosclerosis* 2006; **184**:225–232.
30 Shiwaku K, Nogi A, Kitajima K, Anuurad E, Enkhmaa B, Yamasaki M, *et al*. Prevalence of the metabolic syndrome using the modified ATPIII definition for workers in Japan, Korea and Mongolia. *J Occup Health* 2005; **47**:126–135.
31 Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: prevalence in worldwide population. *Endocrinol Metab Clin North Am* 2004; **33**:351–375.
32 Florez H, Silva E, Fernández V, Ryder E, Sulbarán T, Campos G, *et al*. Prevalence and risk factors associated with the metabolic syndrome and dyslipidemia in white, black, Amerindian and mixed Hispanics in Zulia State, Venezuela. *Diabetes Res Clin Pract* 2005; **69**:63–77.
33 Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults. Findings from the Third National Health and Nutrition Examination Survey. *JAMA* 2002; **287**:356–359.
34 The Examination Committee of Criteria for ‘Metabolic Syndrome’ in Japan. Criteria for ‘metabolic syndrome’ in Japan [in Japanese]. *J Jpn Soc Intern Med* 2005; **94**:794–809.
35 Motulsky H. *Intuitive biostatistics*. New York: Oxford University Press; 1995. pp. 195–204.
36 Rosenbaum P, Gimeno SG, Sanudo A, Franco LJ, Ferreira SRG. Japanese–Brazilian Diabetes Study Group. Analysis of criteria for metabolic syndrome in a population-based of Japanese-Brazilians. *Diabetes Obes Metab* 2005; **7**:352–359.
37 Anuurad E, Shiwaku K, Nogi A, Kitajima K, Enkhmaa B, Shimono K, Yamane Y. The new BMI criteria for Asians by the regional office for the Western Pacific Region of WHO are suitable for screening of overweight to prevent Metabolic Syndrome in Elderly Japanese workers. *J Occup Health* 2003; **45**:335–343.
38 Mizushima S, Moriguchi EH, Nakada Y, Biosca MDG, Nara Y, Murakami K, *et al*. The relationship of dietary factors to cardiovascular diseases among Japanese in Okinawa and Japanese immigrants, originally from Okinawa, in Brazil. *Hypertens Res* 1992; **15**:45–55.
39 McNeely MJ, Boyko EJ, Shofer JB, Newell-Morris L, Leonetti DL, Fujimoto WY. Standard definition of overweight and central obesity for determining diabetes risk in Japanese Americans. *Am J Clin Nutr* 2001; **74**:101–107.
40 Tan C, Ma S, Wai D, Chew S, Tai E. Can we apply the National Cholesterol Education Program Adult Treatment Panel definition of the metabolic syndrome to Asians? *Diabetes Care* 2004; **27**:1182–1186.
41 Alberti KG, Zimmet P, Shaw J. IDF Epidemiology Task Force Consensus Group. The metabolic syndrome, a new worldwide definition. *Lancet* 2005; **366**:1059–1062.
42 Arai H, Yamamoto A, Matsuzawa Y, Saito Y, Yamada N, Oikawa S. Prevalence of metabolic syndrome in the general Japanese population in 2000. *J Atheroscler Thromb* 2006; **13**:202–208.
43 Damião R, Castro TG, Cardoso MA, Gimeno SGA, Ferreira SRG. Japanese–Brazilian Diabetes Study Group. Dietary intakes associated with metabolic syndrome in a cohort of Japanese ancestry. *Br J Nutr* 2006; **96**:532–538.