

Central Obesity and Health-related Factors among Middle-aged Men: a Comparison among Native Japanese and Japanese-Brazilians Residing in Brazil and Japan

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Abstract The objective of this study was to investigate the influence of different cultural environments on the development of obesity by examining the association of central obesity, lifestyle, and selected coronary risk factors among people with identical Japanese genetic backgrounds living in Japan and Brazil. One hundred and four native Japanese and 286 Japanese-Brazilians residing in Brazil and Japan aged 35 years or over were studied. Obesity, metabolic risk factors for coronary disease, and history of regular sports activity, daily physical activity, and eating habits were assessed. The results showed Japanese-Brazilians residing in Brazil with significantly higher waist circumference values, and greater prevalence of central obesity compared to native Japanese and Japanese-Brazilians residing in Japan. The risk of developing central obesity was found to be 2.8 times higher among Japanese-Brazilians residing in Brazil. However, this association was no longer found to be significant after adjusting for lifestyle factors in the logistic model. Additionally, waist circumference was found to be significantly associated with metabolic risk factors for coronary disease. These findings suggest substantial variation in measures of central obesity among the three groups of Japanese ancestry, and underscore the heterogeneity of risk factors among communities of Japanese ancestry living in different cultural environments. The results also suggest that immigrant men exposed to the Brazilian cultural environment are more susceptible to the development of central obesity, and it seems to be associated with various lifestyle items and metabolic risk factors for coronary disease. *J Physiol Anthropol* 26(3): 339–347, 2007 <http://www.jstage.jst.go.jp/browse/jpa2>

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Introduction

Obesity is a condition that represents a serious worldwide threat to public health and has been found to increase the risk of various comorbidities, including coronary heart disease and type-2 diabetes (Haslam and James, 2005). Body mass index (BMI) is often used to reflect total body fat amount, while waist circumference (WC) is used to measure the degree of central fat distribution. Central distribution of body fat is an indicator of abdominal visceral fat, which has been found to be an important predictor of cardiovascular morbidities in men; therefore, it is thought to be a more specific risk factor for health problems than BMI alone (Japan Society for the Study of Obesity, 2002; Kobayashi et al., 2001; Lakka et al., 2001; Zhu et al., 2005).

Epidemiological studies have demonstrated that lifestyle choices, accumulated across the life course, greatly influence the risk of developing obesity (Haslam and James, 2005). Greater consumption of high-fat and energy-dense food is generally considered to be associated with the increasing prevalence of obesity (Howarth et al., 2006; Schrauwen and Westerterp, 2000). Also, increases in energy expenditure through sports and other forms of physical activity have been reported as important lifestyle factors that enhance overall

health and prevent the development of central obesity (Jakicic and Otto, 2006; Kay and Fiatarone Singh, 2006; Miyatake et al., 2002). Another contributory factor for the development of obesity is an individual's genetic background. Large differences in prevalence of obesity have been reported across different ethnic groups (McNeely et al., 2001; Tanaka et al., 2003; World Health Organization, 2000a).

Obesity was reported to be associated with the development of a number of chronic diseases in the Japanese population, even within relatively mild levels of obesity (Kanazawa et al., 2002). For instance, studies of Japanese immigrants in the United States report a high prevalence of both obesity and several risk factors for obesity-related diseases compared to native Japanese (Curb and Marcus, 1991; Miura et al., 2006; Nakanishi et al., 2004; Yano et al., 1988). Additionally, changes in disease patterns have been observed in successive generations of people of Japanese ancestry residing in Brazil, suggesting that factors associated with the migration process and cultural environment may influence the risk of developing some diseases (Cardoso et al., 1997; Ferreira et al., 2002; Gimeno et al., 2005; Lunes et al., 1994; Tsugane et al., 1995).

Japan and Brazil have experienced two major immigration movements. First was Japanese immigration to Brazil, which began in 1908, and generated a community of approximately 1.3 million people of Japanese ancestry living in Brazil. More recently (beginning about 20 years ago) there has been a movement of back-immigration to Japan, which resulted in a community of nearly 300,000 Japanese-Brazilians living in Japan. Considering the great number of Japanese immigrants, there is little information available in the literature concerning risk factors for developing central obesity and its health consequences among Japanese-Brazilian men. Therefore, this study investigated the influence of different cultural environments (Japan and Brazil) on the development of obesity by examining the association of central obesity, selected coronary risk factors, and lifestyle characteristics, such as sports activity, physical activity in daily life, and nutritional habits among people with identical Japanese genetic backgrounds. This investigation clarifies our understanding of the impact of cultural environment on a number of important chronic disease and lifestyle characteristics known to be important for public health.

Methods

Study population

The present study was undertaken in 2004 and 2005 to investigate the health status and health-related behaviors of people aged 35 years and over in urban and suburban areas of Japan and Brazil. This study involved native Japanese and Japanese-Brazilians, with both parents of Japanese ancestry, who were raised in Brazil. Participants of this study were volunteers in apparently good health. Thirty-eight participants were excluded from the analysis (both parents were not of Japanese ancestry in 30 cases, and 8 cases were excluded due

to problems with data collection). In total, data from 390 men ranging in age from 35–79 years (53.7 ± 10.4 yr) were included in the study. Among those were 104 native Japanese (J-J group) residing in the central area of Japan (Kanto). None of the participants in this group had left the country for more than three consecutive months during their lifetime. Additionally, 178 Japanese-Brazilians residing in Japan (JB-J group) were included in the study. The majority of participants in this group were from the second generation of Japanese descent (Table 1). At the time of data collection, all participants in this group had been living in Japan (Kanto area) for a length greater than one year, with 59.6% ($n=106$) living in Japan for a period greater than five years. Finally, 108 Japanese-Brazilians residing in São Paulo city, Brazil, (JB-B group) were enrolled in this study. The majority of participants in this group were from the second generation of Japanese descent, as shown in Table 1.

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 prior to 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 in the variables measured for this study. The survey consisted of both quantitative clinical examinations and qualitative information assessed through self-administered questionnaires checked by trained researchers.

Data collection was conducted in the morning, following a period of at least 12 hours in which no food or medication was taken by the participants. A sample of venous blood was drawn from each participant and collected in vacuum tubes. The blood samples were stored at 4°C until they were delivered to the laboratory for analysis (Kotobiken Medical Laboratories, Inc., Tsukuba, Japan). For samples collected in Japan, all analyses were conducted within 72 hours 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 in Brazil, frozen blood samples were transferred to Japan to be analyzed by the same procedure in the same laboratory. Serum total cholesterol was measured by the cholesterol oxidase HDAOS method (Wako Pure Chemical Industries, Ltd.), high-density lipoprotein (HDL) cholesterol using a modified enzymatic method (Kyowa Medex Co., Ltd.), and triglycerides by a GPO-HDAOS method, a glycerol blanking method assay (Daiichi Pure Chemicals Co., Ltd.). The low-density lipoprotein (LDL) cholesterol was calculated according to the method of Friedewald et al. (1972). A homogeneous method based on an innovative detergent technology (A&T Corporation) was assessed for fasting plasma glucose.

Systolic and diastolic blood pressure was measured in the sitting position after 10 minutes of rest using an automatic device (Omron HEM-762, expressed as mmHg). Weight to the nearest 0.1 kg 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).

Among the metabolic risk factors for coronary disease, obesity was operationally defined according to the criteria of the Japanese Society for the Study of Obesity (Kanazawa et al., 2002): total obesity as BMI ≥ 25 kg/ m^2 , and central obesity as WC ≥ 85 cm. Hypertension was defined as systolic blood pressure ≥ 140 mmHg, and/or diastolic blood pressure ≥ 90 mmHg, and/or receiving current medication for this condition (Japanese Society of Hypertension Guidelines Subcommittee for the Management of Hypertension, 2001). Fasting plasma glucose ≥ 126 mg/dl and/or receiving current medication for this condition was the criterion for hyperglycemia (The Committee of the Japan Diabetes Society on the diagnostic criteria of diabetes mellitus, 2002). Following the Report of the Japan Atherosclerosis Society (2002), hypertriglyceridemia was defined as serum triglyceride ≥ 150 mg/dl, hypercholesterolemia as total cholesterol ≥ 220 mg/dl, hypo HDL-cholesterol as HDL cholesterol < 40 mg/dl, hyper LDL-cholesterol as LDL cholesterol ≥ 140 mg/dl, and/or receiving current medication for these conditions. Dyslipidemia was defined as the presence of any one of the four risks listed above (hypertriglyceridemia, hypercholesterolemia, hypo HDL-cholesterol, or hyper LDL-cholesterol). A morbidity index was calculated as a sum of the scores of the following items (one point for each item): hypertension, hyperglycemia, and dyslipidemia.

A questionnaire about health-related behaviors, including personal data about education and immigration history for the Japanese-Brazilians, was completed by each participant. Participants were classified into three groups (J-J, JB-B, JB-J) by residence and according to their history of immigration. Those engaged in sports activity in a typical week for more than 3 hours per week were included in the 'regular sports activity' category, others were categorized as 'no regular sports activity'. Daily physical activity spent in a typical week was based on responses to questions about occupation (whether a participant's job was physically demanding), household activities (cleaning, gardening, cooking, and shopping), and transportation (bicycle or walking as transportation for moving around the city). All three items were assessed using a four-point scale (none, low, moderate, high). Those that reported no or low levels of daily activity were classified as 'low daily physical activity'. For eating habits, participants were asked to report their usual weekly intake of fish (fillet, sticks, sushi, and others), meat (hamburger, steak, roast beef, meatloaf, and others), fried snacks (dumplings, tempura, French fries, and others), fat spread (butter, margarine, mayonnaise, and others),

sweets (cakes, cookies, pies, pastries, chocolate candies, ice cream, and others), and alcoholic beverages (wine, beer, liquor, Japanese *sake*, Brazilian *cachaça*, vodka, and others).

Statistical analysis

Chi-square tests were used for the analyses of differences between groups for the categorical variables, and post hoc Mantel-Haenszel tests were applied when necessary (for the comparison between each pair of groups). Age-adjusted analyses of covariance (ANCOVA) were used to analyse differences between groups for the continuous variables. Age-adjusted regression analyses were performed for WC with the sum of metabolic risk factors for coronary disease (morbidity index) for each group, and for the overall data (four models). Logistic regression analyses (model 1) were conducted using central obesity (85 cm as a WC cut-off point) as the dependent variable (presence=1, absence=0), including groups (native Japanese as the reference) and age (years) as the independent variables. Additionally, a second model was tested adjusting for the following lifestyle factors that were shown to significantly vary across groups: regular sports activity, daily physical activity, and eating habits (fish, meat, fried snacks, and fat spread). All statistical analyses were performed using SPSS 13.0 for Windows and statistical significance was set at $p < 0.05$.

Results

As shown in Table 1, the majority of the Japanese-Brazilians (JB-J and JB-B groups) were from the second generation of Japanese descendants. An analysis comparing first, second, and third generations of Japanese descendants within the JB-J and JB-B groups did not find significant differences between generations with respect to mean values of WC (data not shown). Accordingly, data for three generations were pooled for each of the three subject groups. The level of education varied significantly among groups, with higher levels of education among the JB-B men. Because participants in the JB-J group were significantly younger than those in the other two groups, the analyses were adjusted for age.

Figure 1 confirmed significantly higher mean values of WC in the JB-B group (90.3 cm) compared with the J-J (84.4 cm) and the JB-J (87.6 cm). Among various metabolic risk factors (Table 2), the J-J group showed a lower prevalence of total obesity and dyslipidemia compared to the other groups. Hypertension and hyperglycemia did not differ significantly among groups. Absence of regular sports activity was significantly higher in the JB-J group; however, this group reported higher daily physical activity compared to the other groups. The J-J reported significantly more frequent consumption of fish and lower consumption of meat and other fatty food items compared to the JB-J and JB-B groups. Table 3 shows a significant ($p < 0.001$) correlation between WC and the morbidity index in each group and for the overall analyses.

Prevalence of central obesity was significantly higher in the

Table 1 Characteristics of the participants

	J-J	JB-J	JB-B	χ^2
Participant, n	104	178	108	
Age, mean (SD)	58.2 (12.0)*	48.7 (6.8)	57.7 (10.1)*	
Japanese generation, n (%)				
First-generation	104 (100.0)	7 (3.9)	20 (18.5)	16.97 [†] (df=2)
Second-generation	...	136 (76.4)	70 (64.8)	
Third-generation	...	35 (19.7)	18 (16.7)	
Education, n (%)				
Primary (\leq 8 yr)	40 (38.5)	35 (19.7)	20 (18.5)	22.23 [‡] (df=4)
Secondary (9–11 yr)	34 (32.7)	68 (38.2)	26 (24.1)	
University (\geq 12 yr)	30 (28.8)	75 (42.1)	62 (57.4)	

J-J, Native Japanese; JB-B, Japanese-Brazilian residing in Brazil; JB-J, Japanese-Brazilian residing in Japan. *Significantly different from JB-J ($p < 0.001$).

[†]Significant difference in a comparison between JB-B and JB-J groups ($p < 0.001$). [‡]Significant difference among all groups ($p < 0.001$).

Table 2 Prevalence of metabolic risks and lifestyle factors among groups

	J-J (n=104)	JB-J (n=178)	JB-B (n=108)	χ^2	post hoc
	n (%)	n (%)	n (%)		
Total obesity	34 (32.7)	87 (48.9)	52 (48.1)	8.12*	†‡
Hypertension	55 (52.9)	89 (50.0)	54 (50.0)	0.23	
Hyperglycemia	5 (4.8)	9 (5.1)	13 (12.0)	5.95	
Hypertriglyceridemia	19 (18.3)	50 (26.8)	41 (38.0)	10.15*	†
Hypercholesterolemia	29 (27.9)	69 (38.8)	20 (18.5)	13.84*	§
Hypo HDL-cholesterol	5 (4.8)	20 (11.2)	41 (38.0)	48.75**	†§
Hyper LDL-cholesterol	26 (25.0)	66 (37.1)	12 (11.1)	25.31**	†‡§
Dyslipidemia [‡]	46 (44.2)	106 (59.6)	64 (59.3)	7.34*	†‡
No regular sports activity	55 (52.9)	167 (93.8)	65 (60.2)	57.25**	†‡§
Low daily physical activity	40 (38.5)	7 (3.9)	53 (49.1)	86.29**	†‡§
Eating habits (frequency >5 times/wk)					
Fish	22 (21.2)	13 (7.3)	5 (4.6)	17.95**	†‡
Meat	0 (0.0)	45 (25.3)	24 (22.2)	19.94**	†‡
Fried snacks	1 (1.0)	21 (11.8)	7 (6.5)	7.21*	‡
Fat spreads	12 (11.5)	76 (42.7)	39 (36.1)	19.41**	†‡
Sweets	9 (8.7)	22 (12.4)	8 (7.4)	1.82	
Alcoholic beverages	62 (59.6)	86 (48.3)	50 (46.3)	4.11	

J-J, Native Japanese; JB-B, Japanese-Brazilian residing in Brazil; JB-J, Japanese-Brazilian residing in Japan. * $p < 0.05$; ** $p < 0.001$. [†]Difference between J-J and JB-B, [‡]Difference between J-J and JB-J, [§]Difference between JB-B and JB-J. [‡]Any one of the four risks listed above.

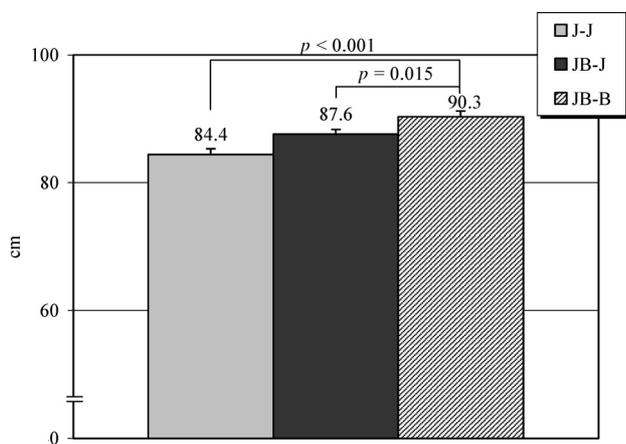


Fig. 1 Waist circumference among groups (age-adjusted mean and SE). J-J, Native Japanese; JB-B, Japanese-Brazilian residing in Brazil; JB-J, Japanese-Brazilian residing in Japan.

Table 3 Age-adjusted standard coefficients of a regression analyze for waist circumference values with morbidity index for coronary risk factors[†]

	β	p
J-J	0.391	<0.001
JB-J	0.337	<0.001
JB-B	0.385	<0.001
Overall	0.373	<0.001

J-J, Native Japanese; JB-B, Japanese-Brazilian residing in Brazil; JB-J, Japanese-Brazilian residing in Japan. [†]The sum of the scores of the following items (one point of each item): hypertension, hyperglycemia, and dyslipidemia (hypertriglyceridemia, or hypercholesterolemia, or hypo HDL-cholesterol, or hyper LDL-cholesterol).

JB-B (70.4%) compared to the JB-J (56.2%) and J-J (46.2%) groups (Fig. 2). Furthermore, Table 4 confirmed the 2.8-fold increased risk of developing central obesity in the JB-B group

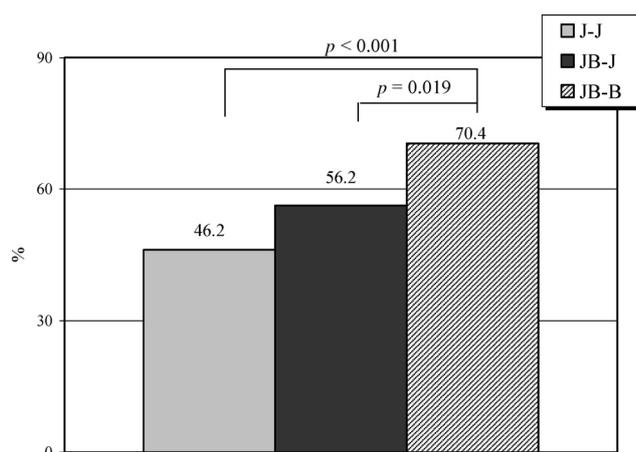


Fig. 2 Prevalence of central obesity (WC=85) among groups. J-J, Native Japanese; JB-B, Japanese-Brazilian residing in Brazil; JB-J, Japanese-Brazilian residing in Japan.

Table 4 Risk of developing central obesity among groups of Japanese ancestries

	Model 1 [†]		Model 2 [‡]	
	Odds ratio (95% CI)	<i>p</i>	Odds ratio (95% CI)	<i>p</i>
J-J	1 (ref)		1 (ref)	
JB-J	1.56 (0.91 to 2.65)	0.104	1.04 (0.48 to 2.27)	0.919
JB-B	2.81 (1.59 to 4.97)	<0.001	1.98 (0.99 to 4.00)	0.058

Values are odds ratio and 95% confidence interval (CI). J-J, Native Japanese; JB-B, Japanese-Brazilian residing in Brazil; JB-J, Japanese-Brazilian residing in Japan. [†]Logistic regression model adjusted for age. [‡]Logistic regression model adjusted for age, regular sports activity, daily physical activity, and selected eating habit items (fish, meat, fried snacks, and fat spread).

compared to the J-J in the logistic model adjusted for age (model 1), whereas for the JB-J group it was not significant. After adjusting the logistic analyses for lifestyle factors (regular sports activity, daily physical activity, and consumption of fish, meat, fried snacks, and fat spread), the JB-B were found to be no longer significantly different in the model ($p=0.058$).

Discussion

The present study has identified important and significant clinical differences in waist circumference and central obesity among the three population groups of Japanese descent, suggesting that immigration and cultural environment are associated with the pathogenesis of obesity. We have found that Japanese-Brazilians who live in Brazil (the JB-B group) have the highest waist circumference, native Japanese living in Japan (the J-J group) have the smallest waist circumferences, and Japanese-Brazilians who are living in Japan (JB-J) have intermediate waist circumferences. The prevalence of central

obesity was found to be associated with increased levels of several metabolic risk factors that are known to be associated with coronary disease. Risk of developing central obesity was found to be higher in the JB-B group compared to the other groups, but the difference was no longer found to be significant once lifestyle factors were taken into account.

The increase in the prevalence of obesity is often ascribed to the changing lifestyle in westernized society, a common feature of which is the consumption of high-fat diets. A trend of change in the Japanese diet has been observed (World Health Organization, 2000b), where high consumption of animal fat and animal protein has increased rapidly (Matsumura, 2001). National survey revealed the contrasts of the diet of people living in Japan several decades ago, when 405 g of energy was consumed as carbohydrates and only 21.8 g as fat (Matsumura, 2001). The Japanese dietary pattern had changed considerably by 1996, with consumption of 58.9 g of energy coming from fat (26.5% of total energy) (Matsumura, 2001). Meanwhile, in Brazil, the traditional developing world problem of dietary malnutrition and undernutrition appears to be shifting rapidly to one of dietary excess. Concurrent increases in adult obesity have been observed among all groups of men and women with the greatest increase among lower income families (Monteiro et al., 1995). An increase in lipid content in the diet in less developed regions and of saturated fat in the country as a whole has been observed (Monteiro et al., 1995). This change is associated with a decrease in the consumption of beans, vegetables, fruits, and complex carbohydrates. Furthermore, there has been a simultaneous increase in sugar consumption from 1988 to 1996 in Brazil (Monteiro et al., 2000). These changes underscore the need for more public health initiatives in Brazil that are designed to increase public awareness of the importance of a healthy and nutritionally balanced diet.

Because all groups are originally from a similar Japanese genetic background, the differences in the prevalence of central obesity observed in this study are likely to be related to environmental or behavioral/lifestyle factors. It is well known that obesity is strongly associated with behavioral, cultural, educational, and social factors (Haslam and James, 2005; Paeratakul et al., 2002). This association is reflected in the findings of several migration studies that have shown increasing levels of obesity among populations that migrate (McDonald and Kennedy, 2005; Sundquist and Winkledy, 2000). Obesity has also been shown to be sensitive to the degree to which immigrants assimilate into the local culture (Amato et al., 2003; Klatsky and Armstrong, 1991). A number of lifestyle changes have been proposed as possible explanations for this association, including dietary factors, physical activity, and occupation choices among immigrants. Among the environmental changes impacting Japanese immigrants in Brazil, a study from Freire et al. (2005) suggested that changes in dietary habits were probably among the most important. The high proportion of fat in the Brazilian diet is known to contribute to the development of central obesity. Also, high

amounts of protein intake have been shown to be associated with central obesity in Japanese-Brazilian living in São Paulo state (Ferreira et al., 2002). Likewise, our results showed higher consumption of meat and some fatty food items among Japanese-Brazilians.

Although lower education levels are frequently observed in developing countries, and have been associated with an increase risk for several diseases (Paeratakul et al., 2002; Paek and Hong, 2006), in our study, Japanese-Brazilians living in Brazil had higher education levels when compared to native Japanese. Indeed, other studies have also found that individuals of Japanese ancestry living in Brazil have relatively higher levels of education when compared to the general Brazilian population (Instituto Brasileiro de Geografia e Estatística, 2003). In our study, education levels were not found to be associated with increased risk of the development of obesity among Japanese-Brazilian living in Brazil.

Previous studies have reported a gradual increase in acceptance of the Western culture over time in Japanese immigrants, and an association between acculturation and an increased risk of developing metabolic disorders (Marmot and Syme, 1976; Miura et al., 2006; Tsugane et al., 1995; Yano et al., 1988). In our results, mean values of central obesity did not differ among first-, second-, and third-generations of Japanese-Brazilians. This fact was not widely explored in the present study, but we believe that it could be a consequence of the effect of globalization, and the rapid acculturation to local habits by the first-generation of Japanese immigrants to Brazil.

As we previously noted, central obesity (as indicated by WC) has been shown to be associated with an increased risk of coronary disease in men (Japan Society for the Study of Obesity, 2002; Kobayashi et al., 2001; Lakka et al., 2001; Zhu et al., 2005). Our findings are in agreement with this association, and support the use of WC as a simple vital sign that can serve as a predictor of morbidity among people of Japanese ancestry.

Regular sports activity is an important lifestyle behavior associated with improvements in both cardiorespiratory fitness and overall health status (Jakicic and Otto, 2006; Kay and Fiatarone Singh, 2006). A report from the World Health Organization (2002) identifies physical inactivity as the second most important risk factor for disease, after tobacco, highlighting its importance as a preventive strategy in people's daily lives. The native Japanese in our study were more engaged in regular sports activity, the Japanese-Brazilians residing in Japan were the least engaged, and the Japanese-Brazilians residing in Brazil were intermediate. However, those residing in Japan reported much higher levels of daily physical activity in their occupations, household activities, and transportation choices. These results suggest that the cultural environment in Japan may play a positive role in providing opportunities for daily physical activity among back-immigrant Japanese-Brazilians. In most cases, the underlying reason for back immigration to Japan was associated with economic issues. Occupation-related factors appear to be

responsible for the higher levels of daily physical activity found in the Japanese-Brazilians in Japan. Employment in the JB-J group was mainly characterized by blue-collar activities, averaging 59.9–12.2 hours of work per week.

The global tobacco scenario shows that smoking is decreasing in most developed countries. In Japan, the smoking prevalence among men has declined considerably since 1966, when it peaked at 84% (World Health Organization, 1997). The latest data on the prevalence of smoking among the male Japanese population was estimated of 45.9% (Ministry of Health, Labor and Welfare, 2003). Lung cancer became the leading cause of cancer deaths among Japanese men in 1993. Recently, lung cancer rates have continued to climb as the long-term consequences of post-World War II smoking popularity begin to take effect (World Health Organization, 2000b). In Brazil, the proportion of smokers in the population dropped from approximately 32% to 18.8% between 1989 and 2003, and the annual per capita cigarette consumption decreased 42% (Brazilian Ministry of Health, 2004). However, throughout Brazil, consumption trends among women and youngsters are of special concern, as tobacco companies have identified these groups as targets for their marketing strategies. In the present study, however, associations between tobacco and obesity were not investigated.

The results of the present study need to be interpreted within the context of certain limitations. First, 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 the participants. Nonetheless, several studies have shown important evidence of the role of cultural environment on an immigrant's health and lifestyle using a similar recruiting procedure to that of the present study (Evenson et al., 2002; Klatsky and Armstrong, 1991; Kudo et al., 2000; Misra et al., 2005; Namekata et al., 1997; Parzaianello et al., 2005). Second, individuals in the JB-J group were 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 may have occurred due to the fact that the population of Japanese-Brazilians in Japan is composed mostly of economically active young adults. It is possible that this limitation may have underestimated the risk of developing central obesity in the JB-J. Moreover, although WC is strongly correlated with the amount of visceral fat, it is less precise in assessing visceral fat accumulation than computed tomography (CT) and magnetic resonance imaging (MRI). However, WC is frequently used in clinical and epidemiological studies, because of its good prediction of central obesity, low cost, and ease of measurement (Williams et al., 1997). Furthermore, WC is easy to measure in clinical settings and has the potential to serve as a "vital sign" which can predict the onset of obesity-related conditions. An additional limitation to consider was that time spent in sports activity and daily physical activity was evaluated by non-standard methods. However, an advantage of

our study was that we were able to directly measure all metabolic risk factors commonly associated with coronary disease.

In summary, we found substantial variation in measures of central obesity among the three groups of Japanese ancestry. Japanese-Brazilians residing in Brazil had the highest levels of central obesity. The variation between population groups in regard to central obesity illustrates the heterogeneity of risk factors among people of Japanese ancestry living in different cultural environments. Our data further suggest that a number of lifestyle choices may be important factors in the development of central obesity. Finally, there has been relatively little research on the health status of Japanese immigrants to Brazil. Further studies are necessary to explain the effects of different levels of acculturation on health-related factors across multiple generations of Japanese immigrants.

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