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# Nutritional status of Japanese-Brazilian subjects: comparison across gender and generation

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for the Japanese-Brazilian Diabetes Study Group†

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The present paper describes a nutritional survey carried out among Japanese-Brazilian subjects living in Bauru, south-eastern Brazil. Data were from a cross-sectional population-based study of 1283 first-generation Japanese-Brazilian subjects (Japan-born; 127 men and 121 women) and second-generation Japanese-Brazilian subjects (Brazil-born; 456 men and 573 women) aged 30–90 years. Anthropometric measurements and % body fat were measured and BMI and waist:hip ratio calculated. Dietary assessment was performed using a validated food-frequency questionnaire. A considerable proportion of men (51 %) and women (47 %) had excess weight (BMI>24·9 kg/m$^2$). A greater waist circumference in men and women (age-adjusted by covariance analysis) was observed among Brazil-born participants. In general, only 10 % of the participants reported current practice of sports or other vigorous physical activity. Age-adjusted mean energy intakes and % energy from macronutrients were found to be similar across generations. The age-adjusted mean daily % energy intake from fat were similar across generations: among Japan-born participants, they were 31·5 (95 % CI 30·6, 32·4) % for men and 32·6 (95 % CI 31·7, 33·5) % for women. The respective figures for Brazil-born subjects were 32·1 (95 % CI 31·6, 32·6) % and 33·2 (95 % CI 32·7, 33·5) %. These values are quite different from the usual intakes reported in Japan during the last decades (about 25 %). Taking into account the traditional Japanese diet, a high energy density diet and a sedentary lifestyle may be implicated in the high prevalence of central obesity and metabolic syndrome observed among Japanese-Brazilian subjects across gender and generations.

**Nutrition survey: Dietary patterns: Abdominal obesity: Japanese-Brazilians**

Nutritional status has been implicated in the aetiology of diabetes and associated diseases in many populations including Asian migrants. High age-adjusted prevalence rates of diabetes (>12 %) have been reported in Japanese migrants living in the Americas (Fujimoto *et al.* 1987; Ferreira *et al.* 1996), suggesting that the exposure of Japanese subjects to a different lifestyle brought out an inherent tendency to develop diabetes and abdominal obesity (Fujimoto *et al.* 2000).

Differences in dietary patterns constitute a major component in the environmental changes experienced by migrant populations, and have been associated with several diseases with contrasting prevalence rates in the US, Brazil and Japan (Kagan *et al.* 1974; Huang *et al.* 1996; Cardoso *et al.* 1997). Intervention studies (Feskens *et al.* 1995) have provided evidence confirming earlier suggestions of a role for dietary composition in determining the development of diabetes independent of obesity. Dietary fat in particular

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may be relevant to the pathophysiology of the disease (Meyer *et al.* 2001).

Japanese migration to Brazil was extensive between 1926 and 1935. Nowadays, Brazil has the largest Japanese population living outside Japan. A previous nutritional survey conducted on a sample of Japanese-Brazilian adults in the city of São Paulo found marked changes in their diet when compared with traditional Japanese dietary habits (Cardoso *et al.* 1997). Bauru is another developed city in São Paulo state with one of the most important Japanese communities in Brazil. First- and second-generation Japanese-Brazilian subjects living in this city were shown to be at high risk for metabolic syndrome: age-adjusted prevalence of type 2 diabetes did not differ between men and women for Japan-born migrants (12·4 *v.* 11·6 % respectively), but it became different for Brazil-born descendants (21·7 *v.* 11·4 % respectively, $P<0·03$) due to an increased rate among men (Ferreira *et al.* 1996).

The present study describes a nutritional survey carried out in a large sample of Japanese-Brazilian subjects living in Bauru. Differences in relation to the traditional Japanese diet, anthropometric indices and body composition between first- and second-generation Japanese-Brazilian subjects are discussed with emphasis on nutritional features currently implicated in the aetiopathogenesis of metabolic syndrome.

## Material and methods

### *Study population*

In 1993, a cross-sectional population-based study was conducted on a representative sample of Japanese-Brazilian subjects living in Bauru to estimate the prevalence of diabetes mellitus and associated diseases. At that time, 647 subjects of Japanese ancestry, aged 40–79 years, either Japan-born (first generation, 37·3 %) or Brazil-born (second generation, 62·7 %) were included. Sampling strategies, participation rates and results of such survey were reported elsewhere (Ferreira *et al.* 1996; Franco, 1996; Gimeno *et al*. 2000).

In 1999, a second survey was carried out following the same protocol, except that dietary patterns were assessed using a validated food-frequency questionnaire developed for Japanese-Brazilian subjects. In addition to the participants enrolled in the first survey, the whole Japanese-Brazilian population >30 years of age was invited to participate (1751 subjects). Data collection from 1330 subjects was completed in December 2000. A total of 394 individuals studied in 1993 (60·9 %) participated in the second survey. Of the original study sample, sixty-nine subjects (10·6 %) had died, fifty-seven (8·7 %) had moved and 127 (19·7 %) refused to participate. Among the new participants (*n* 1104), the % non-responders was 15·2 (*n* 168), including twenty-three deaths (2·1 %) that occurred after the beginning of data collection.

In this second survey, higher proportions of subjects were observed in all categories of glucose intolerance than those found in 1993. Prevalence rates of impaired fasting glycaemia, impaired glucose tolerance and diabetes were 19·3 (95 % CI 17·2, 21·5), 23·4 (95 % CI 21·1, 25·8) and 36·2 (95 % CI 33·6, 38·8) % respectively. Similarly to 1993, a higher prevalence of diabetes ($P<0·05$) was found in men compared with women (25·5 *v.* 19·9 % in 1993; 40·6 *v.* 32·4 % in 2000), but non-significant changes were found within generations (19·7 and 24·4 % in 1993, 39·3 and 35·5 % in 2000 for first- and second-generation subjects respectively; Gimeno *et al.* 2003).

The results shown here refer to 1283 participants (73·3 % of those eligible) who completed all the information for the nutrition survey (Fig. 1). The study was approved by the Institutional Ethics Committee and written informed consent was obtained from all participants.

### *Demographic variables*

Data on age, gender, generation, educational level, usual job, physical activity, smoking and drinking habits were

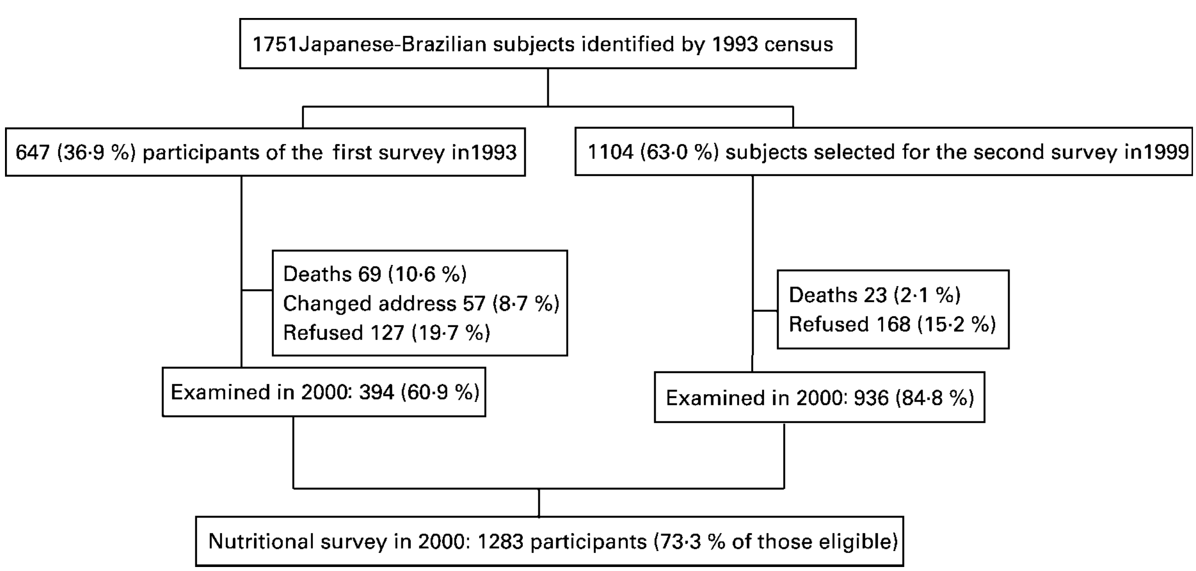


**Fig. 1.** Sample sizes related to recruitment and response rates to the surveys.

obtained using a structured questionnaire. Participants were interviewed at home by trained personnel and scheduled for clinical examination.

### *Dietary assessment*

Food consumption was assessed using a food-frequency questionnaire developed and validated for the Japanese-Brazilian community (Cardoso *et al.* 2001). Subjects were asked the usual consumption frequency of foods and food groups listed (122 items) during the previous year. Four portion sizes were given for selection: small, medium, large and extra large. Questions concerning use of sauces, frequency of visible fat intake and type of fat used in cooking procedures were also included. Complete rechecking of the coding, as well as double keying, was performed for every questionnaire. In addition to standard range edits, internal consistency edits and nutrient calculations for the diets were performed using the Dietsys 4·01 software (National Cancer Institute, Bethesda, Maryland, USA; Block *et al.* 1994). The nutrient database used was based primarily on US Department of Agriculture publications supplied by Dietsys, supplemented by the most recent edition of standard food composition tables of Brazil and Japan (Fundação Instituto Brasileiro de Geografia e Estatística 1996; Resources Research Council, Science and Technology Agency, 1993).

Since all dietary variables are measured with an expected error, in the present study we considered the intakes of nutrients with correlation coefficients $>0{\cdot}4$ based on the previous validation of our food-frequency questionnaire (Cardoso *et al.* 2001). Data on food intakes were categorized into the food groups computed by the Dietsys 4.01 software.

### *Anthropometric, body fat and blood pressure assessments*

Body weight was measured while subjects wore light clothing and no shoes using calibrated electronic scales. Height was measured with a fixed stadiometer. Waist and hip circumferences were measured at the level of the umbilicus and the trochanter major respectively. The cut-off values used to define overweight for both genders were BMI $\geq 24{\cdot}9\,kg/m^2$ (World Health Organization, 1995). Central obesity was defined as a waist circumference $\geq 0{\cdot}80$ m for women and $\geq 0{\cdot}90$ m for men (World Health Organization, 2000).

Body-fat mass was estimated with a single-frequency (50 kHz) bioimpedance analyser (model BIA 101Q; RJL System, Clinton Township, MI, USA), using tetrapolar electrode placement. Fasting subjects rested supine for 15–20 min in a thermoneutral room, without touching any metallic object; jewellery was removed. The skin at the sensor-pad sites was cleansed with alcohol. In addition to measured bioelectrical impedance values, weight, height, age and gender were entered into the bioimpedance analyser in order to calculate body composition, using the manufacturer's equations.

Blood pressure was measured three times, with the subjects in the sitting position, after a 10 min rest, using an automatic device (model HEM-712C; Omron Healthcare, Inc, Vernon Hills, IL, USA). The average of the two last measurements was used to express systolic and diastolic blood pressures.

### *Analytical procedures*

Blood samples were obtained after an overnight fast ($\geq$10 h). Blood samples were immediately separated and analysed. Total cholesterol and its fractions, and triacylglycerol and uric acid were measured enzymatically. The cut-off values used for definition of dyslipidaemia were total cholesterol $\geq 5{\cdot}17$ mmol/l, LDL-cholesterol $\geq 3{\cdot}36$ mmol/l or triacylglycerol levels $\geq 1{\cdot}79$ mmol/l. Upper limit of normality for uric acid was 0·35 and 0·41 mmol/l for women and men respectively.

### *Statistical analysis*

Due to non-normal distributions, several dietary variables were transformed using their natural logarithms or the Box–Cox transformation before statistical analysis. Age-adjusted mean values and 95 % confidence intervals of the nutritional data were calculated by gender and generation using linear models for covariance analysis (Kleinbaum *et al.* 1988). We calculated age-adjusted means using either all the study population or excluding extreme age intervals in the covariance analysis. As the age-adjusted means obtained did not differ, we show here the results using all the study subjects. Mean values were compared using the $F$ test. Statistical analyses were performed with SPSS for Windows (version 10·0; SPSS Inc. Woking, Surrey, UK). Values of $P<0{\cdot}05$ were taken as significant.

## Results

The study variables were considered according to four groups defined by gender and generation. The general characteristics of Japanese-Brazilian subjects are presented in Table 1. The age of the 1283 participants ranged from 30 to 90 years. As expected, Japan-born subjects were older than Brazil-born subjects. The majority of Brazil-born participants achieved the highest education levels, in contrast to almost half of Japan-born men with the lowest education rates. These data were in agreement with the distribution of job categories. The most frequent current occupation among Japan-born men was 'pensioner'. More than half had worked in skilled manual occupations (craftsman or farm labourer) before retiring. The great majority of the Japanese-Brazilian women were housewives, particularly those born in Japan. Lower rates of current smokers were found among women when compared with men. The proportion of current alcohol drinkers was greater among men than women. In general, the study population was sedentary, with very low frequencies of current practice of sports or other vigorous physical activity.

Anthropometric, body-fat mass, blood pressure and biochemical variables are shown in Table 2. BMI, waist and hip circumferences, waist:hip ratio and body-fat mass were significantly higher in Brazil-born men and women than in Japan-born. Marked proportions of weight excess were detected in men (51 %) and women (47 %).

**Table 1.** Age and lifestyle characteristics of the Japanese-Brazilians by gender and generation‡
(Mean values with standard deviations)

| | Female (*n* 696) | | | | Male (*n* 587) | | | |
|---|---|---|---|---|---|---|---|---|
| | Japan-born (*n* 21) | | Brazil-born (*n* 573) | | Japan-born (*n* 127) | | Brazil-born (*n* 456) | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Mean age (SD) | 69·8 | 9·2 | 54·4* | 10·9 | 68·9 | 10·2 | 53·7* | 11·3 |
| Smoking (%) | | | | | | | | |
| Never | 64·2 | | 69·6 | | 68·7 | | 70·5 | |
| Former | 21·9 | | 18·3 | | 20·6 | | 16·6 | |
| Current | 13·8 | | 12·0 | | 10·6 | | 12·7 | |
| Current alcohol drinkers (%) | 20·3 | | 23·4 | | 56·1 | | 58·4 | |
| Education level (%) | | | | | | | | |
| <1 year | 50·8 | | 4·7††† | | 48·5 | | 0·8††† | |
| 1–8 years | 45·9 | | 53·2 | | 42·4 | | 36·3 | |
| >8 years | 3·3 | | 2·1 | | 9·1 | | 62·8††† | |
| Physical activity (%) | | | | | | | | |
| Vigorous activity (≥3 h/week)§ | 9·8 | | 2·9††† | | 6·8 | | 11·2††† | |
| Current job (%) | | | | | | | | |
| Pensioner, housewife | 82·7 | | 55·6††† | | 59·2 | | 21·0††† | |
| Craftsman, labourer, farm labourer | 9·2 | | 15·3 | | 17·0 | | 20·4 | |
| Sales, transport, communications | 7·1 | | 12·0††† | | 19·6 | | 31·3††† | |
| Professional and technical work | 1·0 | | 17·1††† | | 4·2 | | 27·3††† | |

Mean values were significantly different from those of the Japan-born group for each gender (*t* test): *$P<0·05$.
Mean values were significantly different from those of the Japan-born group for each gender ($\chi^2$ test): †††$P<0·001$.
‡ For details of procedures, see p. 706, 707.
§ Leisure- and work-time physical activity.

Considering the WHO criteria of nutritional status for Asian populations (World Health Organization, 2000), all the groups exhibited age-adjusted mean BMI greater than the normal range (18·5–22·9 kg/m$^2$). Whereas a higher proportion of central obesity was observed in Brazil-born when compared with Japan-born men (42 *v.* 29 %, $P$=0·0), similar proportions (45 %) were found in both generations of women. Blood pressure levels were significantly ($P<0·05$) higher in Brazil- than Japan-born men; in contrast, Brazil-born women showed lower values than the first generation. A similar pattern was observed for total and LDL-cholesterol and triacylglycerol, which were lower among Brazil-born women, while Brazil-born men had greater levels compared with Japan-born men. High prevalence rates of dyslipidaemia were found in both Japan- and Brazil-born participants: 83·3 and 86·0 % for men, and 87·0 % and 79·4 % for women respectively ($\chi^2$ test, $P>0·05$). Greater age-adjusted mean values for serum uric acid were found in Brazil-born subjects, independent of gender. However, the prevalence rates of hyperuricaemia were higher for Japan-born (40·2 %) and Brazil-born (51·0 %) men when compared with women (28·5 and 28·6 % respectively).

Age-adjusted nutrient intakes are shown in Tables 3 and 4. Alcohol-derived energy was included in their daily energy intake. The dietary intake of nutrients and food groups was significantly different between genders, except for Ca and meat-group intakes, whose mean values were similar for men and women. No significant difference was observed concerning daily energy intake or proportions of energy derived from macronutrients across gender and generation. In agreement with a higher proportion of alcohol drinkers in men, age-adjusted mean value for intake of alcoholic drinks (mainly beer) was found to be significantly ($P<0·05$) greater in men of both generations (122·4 g/d for Japan-born and 68·9 g/d for Brazil-born subjects) than in women (3·6 and 9·1 g/d respectively).

The absolute consumption of protein, cholesterol, vitamin A and Fe differed between generations. Brazil-born subjects had somewhat lower protein, cholesterol, vitamin A and Fe intakes when compared with Japan-born subjects. The most substantial dietary difference was related to the miso soup (typical Japanese soup), which was more commonly consumed by Japan-born immigrants (Table 4). On the other hand, the Brazil-born subjects consumed oils and fat significantly ($P<0·05$) more often than the Japan-born immigrants. Higher frequencies of meat-group intakes were seen in Japan-born women and Brazil-born men, who also had greater serum total cholesterol, LDL-cholesterol and triacylglycerol levels than their counterparts (Table 2).

Consumption of other Japanese foodstuffs, such as soyabean products, pickled vegetables and green tea, was rare in both generations of Japanese-Brazilian subjects (results not shown).

## Discussion

The alarming prevalence rate of disturbances in glucose tolerance in Japanese-Brazilian subjects justifies the search for aetiological factors. A previous report suggested that a deleterious role for environment might be greater among men, since they showed the highest rates of diabetes

**Table 2.** Anthropometric, blood pressure and biochemical variables in Japanese-Brazilian subjects by gender and generation†‡
(Age-adjusted mean values and 95 % confidence intervals)

| | Women (*n* 696) | | | | Men (*n* 587) | | | |
|---|---|---|---|---|---|---|---|---|
| | Japan-born (*n* 121) | | Brazil-born (*n* 573) | | Japan-born (*n* 127) | | Brazil-born (*n* 456) | |
| | Mean | 95 % CI | Mean | 95 % CI | Mean | 95 % CI | Mean | 95 % CI |
| BMI (kg/m$^2$) | 23·2 | 22·7, 23·7 | 24·5*** | 24·2, 24·8 | 23·9 | 23·5, 24·4 | 25·3*** | 25·0, 25·6 |
| Waist circumference (m) | 0·791 | 0·773, 0·809 | 0·802*** | 0·795, 0·810 | 0·846 | 0·829, 0·864 | 0·894*** | 0·886, 0·903 |
| Hip circumference (m) | 0·936 | 0·926, 0·946 | 0·956*** | 0·951, 0·962 | 0·954 | 0·944, 0·964 | 0·974*** | 0·968, 0·980 |
| Waist:hip ratio | 0·82 | 0·81, 0·83 | 0·84** | 0·83, 0·84 | 0·90 | 0·89, 0·90 | 0·91** | 0·90, 0·91 |
| Body-fat mass (%) | 28·1 | 27·2, 29·1 | 29·4* | 28·9, 30·0 | 20·8 | 19·8, 21·8 | 22·1* | 21·5, 22·7 |
| Systolic blood pressure (mmHg) | 134·9 | 130·6, 139·1 | 130·4*** | 128·6, 132·3 | 129·9 | 125·9, 134·0 | 136·7*** | 134·6, 138·8 |
| Diastolic blood pressure (mmHg) | 78·5 | 76·0, 80·9 | 76·8* | 75·7, 77·9 | 79·3 | 76·9, 81·7 | 81·8* | 80·6, 83·0 |
| Serum cholesterol (mmol/l) | 5·76 | 5·55, 5·96 | 5·56*** | 5·47, 5·64 | 5·23 | 5·04, 5·43 | 5·56*** | 5·46, 5·66 |
| Serum HDL-cholesterol (mmol/l) | 1·32 | 1·28, 1·36 | 1·34 | 1·31, 1·36 | 1·25 | 1·21, 1·3 | 1·27 | 1·25, 1·3 |
| Serum LDL-cholesterol (mmol/l) | 3·54 | 3·36, 3·72 | 3·39* | 3·31, 3·47 | 3·16 | 2·98, 3·34 | 3·34* | 3·25, 3·43 |
| Serum triacylglycerol (mmol/l) | 2·14 | 1·92, 2·39 | 1·99*** | 1·90, 2·09 | 2·13 | 1·91, 2·37 | 2·63*** | 2·49, 2·78 |
| Serum uric acid (mmol/l) | 0·29 | 0·28, 0·30 | 0·31** | 0·30, 0·31 | 0·38 | 0·37, 0·40 | 0·41** | 0·40, 0·42 |

Mean values were significantly different between generations and genders: * $P<0·05$, ** $P<0·01$, *** $P<0·001$.
† For details of subjects and procedures, see Table 1, Fig. 1 and p. 706, 707.
‡ Mean values were adjusted for age using analysis of covariance.

in the Japanese-Brazilian community (Ferreira *et al.* 1996). Differences on acculturation levels between generations of Japanese immigrants could also be associated with different impact in health status (Iunes *et al.* 1997).

In this population-based study among Japanese-Brazilian subjects, comprising almost 1300 subjects, the main findings were that a common Brazilian dietary pattern is shared by first- and second-generation Japanese immigrants, despite significant differences in body composition between them. Such differences could not be attributed to energy intake or % energy from macronutrients, which were found to be similar across generations. However, when the diet of Japanese-Brazilian subjects was compared with recent estimates from a nationwide household-based nutrition survey in Japan (Yoshiike *et al.* 1996), it was similar in terms of total energy intake, but greater in terms of % energy from fat (about 32 *v.* 25 % respectively). In both generations of Japanese-Brazilian subjects, transition from the traditional Japanese diet to a more ‘Brazilian’ diet could be observed mainly in the % energy from fat, whose age-adjusted mean values were close to estimates for the general Brazilian population (about 30 %) (Monteiro *et al.* 2000). The hypothesis that dietary fat could be implicated in the genesis of obesity (Ferreira *et al.* 2003) and/or disturbances of glucose metabolism (Costa *et al.* 2000) in this population was not supported by our first cross-sectional survey, which, in contrast, suggested that protein intake may contribute to increase BMI in Brazil-born subjects.

Based on the knowledge that animal protein is particularly rich in cholesterol, several studies investigated the correlation between the frequency of meat consumption and lipoprotein levels. Meat-group intake was positively correlated with the serum total cholesterol and LDL-cholesterol in some studies (Fornés *et al.* 2000; Hu *et al.* 2000). In agreement, the highest age-adjusted means of total and LDL-cholesterol and triacylglycerol were found among Japan-born women and Brazil-born men who also had high intake of meat-group items. We could speculate that men are more exposed than women to the unfavourable environment and older women (Japan-born) could have lost their oestrogenic protection of lipoprotein metabolism during menopause.

Although food-frequency techniques have been used in cross-sectional surveys (Block & Subar, 1992), they are limited by their lack of quantitative accuracy. For this reason, there has been controversy over its use to estimate quantitative variables of a population dietary intake (Thompson & Byers, 1994). Taking into account that our present food-frequency questionnaire was previously validated (Cardoso *et al.* 2001), we can assume that the dietary assessment method used in the present study was able to produce reasonable estimates of population average intakes.

The effects of diets with high energy density associated with physical inactivity on body fatness may occur gradually. Thus, it has been suggested that energy expenditure, and in particular physical activity level, may have a central influence on body composition throughout life (Atkin & Davies, 2000). In developing countries such as Brazil, the energy balance of the individual seems to be dependent

**Table 3.** Daily intakes of energy (including alcohol) and selected nutrients, and contribution to total energy from alcohol and macronutrients of Japanese-Brazilian subjects by gender and generation‡§

(Age-adjusted mean values and 95 % confidence intervals)

| | Women (*n* 696) | | | | Men (*n* 587) | | | |
|---|---|---|---|---|---|---|---|---|
| | Japan-born (*n* 121) | | Brazil-born (*n* 573) | | Japan-born (*n* 127) | | Brazil-born (*n* 456) | |
| | Mean | 95 % CI | Mean | 95 % CI | Mean | 95 % CI | Mean | 95 % CI |
| Energy (MJ) | 7·27 | 7·11, 7·42 | 7·27 | 7·11, 7·42 | 8·82 | 8·62, 9·04 | 8·82 | 8·62, 9·04 |
| Alcohol % TE | 0·26 | 0·16, 0·44 | 0·26 | 0·18, 0·36 | 1·91 | 1·23, 2·96 | 1·87 | 1·46, 2·38 |
| Carbohydrate | | | | | | | | |
| g | 238·5 | 232·7, 244·4 | 238·5 | 232·7, 244·4 | 283·6 | 276·7, 290·7 | 283·6 | 276·7, 290·7 |
| % TE | 53·6 | 52·5, 54·7 | 54·0 | 53·4, 54·6 | 52·8 | 51·8, 53·9 | 53·2 | 52·6, 53·9 |
| Protein | | | | | | | | |
| g | 66·8 | 63·2, 70·5 | 62·5* | 60·5, 64·4 | 77·5 | 73·9, 81·1 | 73·1* | 71·0, 75·2 |
| % TE | 14·2 | 13·8, 14·6 | 13·9 | 13·7, 14·1 | 13·8 | 13·4, 14·2 | 13·4 | 13·2, 13·7 |
| Total fat | | | | | | | | |
| g | 62·6 | 61·0, 64·3 | 62·6 | 61·0, 64·3 | 73·4 | 71·3, 75·6 | 73·4 | 71·3, 75·6 |
| % TE | 32·6 | 31·7, 33·5 | 33·2 | 32·7, 33·5 | 31·5 | 30·6, 32·4 | 32·1 | 31·6, 32·6 |
| Saturated fat (g) | 14·5 | 14·1, 15·0 | 14·5 | 14·1, 15·0 | 17·2 | 16·7, 17·8 | 17·2 | 16·7, 17·8 |
| Oleic acid (g) | 23·6 | 22·9, 24·3 | 23·6 | 22·9, 24·3 | 27·2 | 26·4, 28·1 | 27·2 | 26·4, 28·1 |
| Linoleic acid (g) | 10·2 | 9·9, 10·5 | 10·2 | 9·9, 10·5 | 11·4 | 11·0, 11·7 | 11·4 | 11·0, 11·7 |
| Cholesterol (mg) | 163·5 | 151·4, 176·8 | 143·0*** | 137·3, 149·0 | 209·6 | 194·2, 226·1 | 183·3*** | 175·0, 191·7 |
| Dietary fibre (g) | 15·1 | 14·6, 15·5 | 15·1 | 14·6, 15·5 | 17·3 | 16·7, 17·9 | 17·3 | 16·7, 17·9 |
| Vitamin A (μg) | 2·83 | 2·64, 3·04 | 2·42*** | 2·34, 2·50 | 2·83 | 2·64, 3·04 | 2·42*** | 2·34, 2·50 |
| Folic acid (μg) | 190·2 | 184·4, 196·4 | 190·2 | 184·4, 196·4 | 221·8 | 214·4, 229·5 | 221·8 | 214·4, 229·5 |
| Calcium (mg) | 649·4 | 612·8, 688·1 | 599·4† | 584·1, 615·8 | 649·4 | 612·8, 688·1 | 599·4† | 584·1, 615·8 |
| Iron (mg) | 13·5 | 12·8, 14·2 | 11·7** | 11·4, 12·1 | 15·7 | 14·9, 16·5 | 13·6** | 13·1, 14·0 |

TE, total energy.
Mean values were significantly different between generations and genders: **P*<0·05, ***P*<0·01, ****P*<0·001.
Mean values were significantly different between generations only: †*P*<0·05.
‡ For details of subjects and procedures, see Table 1, Fig. 1 and p. 706, 707.
§ All data were $\log_e$-transformed before analysis, except for iron intakes, whose values were Box–Cox-transformed. Mean values were adjusted for age using analysis of covariance.

on access to food, type of work and level of energy expenditure outside work (Monteiro *et al.* 2001). In the present study, it is reasonable to suggest that a reduction in physical activity level throughout generations, together with marked changes in the traditional Japanese diet, are most likely to be responsible for greater values of BMI, waist circumference and % body-fat mass observed among Brazil-born immigrants.

Although the present study did not address the assessment of energy expenditure, a considerable reduction in physical activity could be expected among Japanese-Brazilian subjects over the past 50 years. After the

**Table 4.** Servings consumed from selected food items for the Japanese-Brazilian subjects by gender and generation‡§

(Age-adjusted mean values and 95 % confidence intervals)

| | Women (*n* 696) | | | | Men (*n* 587) | | | |
|---|---|---|---|---|---|---|---|---|
| | Japan-born (*n* 121) | | Brazil-born (*n* 573) | | Japan-born (*n* 127) | | Brazil-born (*n* 456) | |
| | Mean | 95 % CI | Mean | 95 % CI | Mean | 95 % CI | Mean | 95 % CI |
| Grain (servings (*n*)/d) | 3·6 | 3·5, 3·7 | 3·6 | 3·5, 3·7 | 3·6 | 3·4, 3·7 | 3·6 | 3·5, 3·6 |
| Vegetables (servings (*n*)/d) | 3·3 | 3·1, 3·5 | 3·1 | 3·0, 3·2 | 3·1 | 3·0, 3·3 | 3·0 | 2·8, 3·1 |
| Fruits (servings (*n*)/d) | 2·6 | 2·3, 2·8 | 2·7 | 2·6, 2·8 | 2·5 | 2·3, 2·7 | 2·6 | 2·4, 2·7 |
| Dairy (servings (*n*)/d) | 1·6 | 1·4, 1·7 | 1·6 | 1·5, 1·7 | 1·3 | 1·2, 1·4 | 1·4 | 1·3, 1·4 |
| Meat (servings (*n*)/d)‖ | 3·3 | 3·1, 3·7 | 2·8† | 2·6, 2·9 | 3·0 | 2·8, 3·3 | 3·1† | 3·0, 3·3 |
| Oils and fats (servings (*n*)/d) | 6·7 | 6·2, 7·2 | 7·4* | 7·1, 7·6 | 7·4 | 6·9, 8·0 | 8·1* | 7·8, 8·5 |
| Sweets and desserts (servings (*n*)/d) | 1·6 | 1·5, 1·7 | 1·6 | 1·5, 1·7 | 2·2 | 2·0, 2·4 | 2·2 | 2·0, 2·4 |
| Miso soup (g/d) | 35·3 | 27·4, 45·6 | 12·7*** | 11·1, 14·6 | 24·6 | 19·1, 31·7 | 8·7*** | 7·4, 10·2 |

Mean values were significantly different between generations and genders: **P*<0·05, ****P*<0·001.
Mean values were significantly different between generations only: †*P*<0·05.
‡ For details of subjects and procedures, see Table 1, Fig. 1 and p. 706, 707.
§ Data were $\log_e$-transformed before analysis, except for meat and oils and fats intakes whose values were Box–Cox-transformed. Mean values were adjusted for age and sex using analysis of covariance.
‖ Meat group: meat, poultry, fish, beans, eggs and nuts group.

Immigration Act in 1921, which blocked the entrance of immigrants in the USA, the Japanese came to Brazil to work on the coffee plantations (Franco, 1996). They were young adults aged 20–30 years at their arrival. In 1940, about 87 % of the Japanese-Brazilian subjects were working in agricultural activities. After some time, the number of Japanese immigrants and their descendants working in sales and technical jobs increased (Sociedade Brasileira de Cultura Japonesa, 1992). This fact, in addition to an infrequent practice of recreational physical activities, may contribute to the more sedentary behaviour of the Brazil-born subjects in our present study population.

Since a high risk for metabolic syndrome is shared by Japanese and their descendants settled overseas (Fujimoto *et al.* 1987; Ferreira *et al.* 1996; Huang *et al.* 1996), a general explanation should be based on common factors in this ethnic group. In the present study, the acculturation process of Japanese migrants has resulted in changes from the traditional Japanese diet to a 'western style', characterized by high-fat content, sedentary lifestyle and, consequently, a tendency to gain weight. Although not considered obese according to WHO criteria (World Health Organization, 1995), Japanese-Brazilian subjects tend to accumulate fat in the abdominal area. The high prevalence rates of central obesity detected in the present study have been previously found in the same community (Lerario *et al.* 2002). Although the underlying mechanism linking central obesity to insulin resistance remains unclear (Kahn *et al.* 2001), deleterious effects of the increased non-esterified fatty acid concentration, derived from visceral adipose tissue, on insulin sensitivity have been consistently demonstrated. The role of visceral fat and insulin resistance in the genesis of glucose intolerance seen in many populations was also found in Japanese descendants. A recent prospective study showed that greater visceral fat area determined by computed tomography precedes the development of diabetes type 2 in Japanese-Americans (Boyko *et al.* 2000). In both second- and third-generation subjects, this effect was independent of other measures of total and regional adiposity, family history of diabetes, gender, indices of insulin resistance and secretion, and glycaemia.

In conclusion, a common dietary pattern is shared across gender and generation of Japanese-Brazilian subjects at a high risk for metabolic syndrome. Japan-born immigrants have had high energy expenditure during early adulthood, and the availability of a high energy density diet and sedentary lifestyle adopted nowadays particularly by their descendents born in Brazil, may contribute to elevated BMI, waist circumference and % body-fat mass. In combination with environmental factors, genetic predisposition of this ethnic group plays a role in metabolic disturbances exhibited by this Japanese community in Brazil.

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