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Original Research Article

Nutrition Transition in Amazonia: Obesity and Socioeconomic Change in the Suruí Indians from Brazil

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ABSTRACT The purpose of this study was to assess the nutritional status of the adult Suruí population, an indigenous society from the Brazilian Amazon, as it relates to socioeconomic conditions. Fieldwork was carried out in February–March 2005, including 252 individuals (88.1% of the total eligible subjects older than 20 years of age in the villages surveyed). Anthropometric measurements were performed following standard procedures, and percentage of body fat (%BF) was measured by bioimpedance. To classify the Suruí according to socioeconomic status (SES), an index was constructed based on a group of variables to characterize socioeconomic differentiation. Evaluated by body mass index (BMI), the majority of Suruí 20–49.9 years of age were overweight (42.3%) or obese (18.2%). The frequency of obesity for women (24.5%) was twice that recorded for men. Subjects classified as overweight or obese also showed high %BF and waist circumference (WC). Women in the high SES category showed higher anthropometric values (including weight, BMI, arm fat area, and WC) and %BF than those of lower SES. This study shows that the Suruí are undergoing a rapid process of nutrition transition. This transition is closely associated with the emergence of intragroup differences in SES which have impacted diet and physical activity patterns. In research in indigenous peoples in Amazonia, greater attention should be paid to the human biological outcomes of socioeconomic transformations related to the growing involvement of native societies in the market economy. Am. J. Hum. Biol. 20:564–571, 2008.

Since 1990s, a growing number of studies have called attention to the trend of rapid weight gain and obesity among indigenous peoples in Amazonia (Coimbra and Santos, 2004; Santos and Coimbra, 1996, 1998, 2003; Tavares et al., 2003). This seems to be caused by a rapid process of "nutrition transition" (Popkin, 1993), that is, major shifts in the nutritional profile of populations associated with modifications in their dietary intake and nutrient expenditure patterns, caused by an interplay of economic, demographic, environmental, and cultural changes. The adoption of "western" diets (i.e., high in saturated fats, sugar, and refined carbohydrate), a trend toward reduced levels of physical activity, and increased use of alcohol are important aspects of the nutrition transition in Amazonian indigenous peoples.

A major outcome of this transition is the emergence of lifestyle-related chronic noncommunicable diseases, such as hypertension, diabetes mellitus type II, coronary heart disease, dyslipidemia, gallbladder disease, and certain types of cancer, that are being observed at an increasing rate in indigenous groups (Coimbra and Santos, 2004). In the Brazilian Amazonia, as well as in other countries of the region, these diseases are increasingly prevalent while under-nutrition in children and infectious and parasitic diseases still remain important causes of morbidity and mortality (Coimbra and Santos, 2004; Coimbra et al., 2002; Hurtado et al., 2005), which results in an increasingly complex epidemiological profile.

The nutrition transition that is taking place in indigenous populations in Amazonia results from a conjunction of sociocultural and environmental transformations, to a large extent associated with the commoditization of indigenous economies. In recent years, this has become an important research topic in lowland South America (Dangour, 2003; Godoy et al., 2005a,b; Santos and Coimbra, 1996, 1998). These studies have shown anthropometric indicators of nutritional status in adults to be positively associated with wealth and income inequality.

The goal of this article is to investigate socioeconomic changes in Amazonia as it relates to body size and composition by analyzing cross-sectional anthropometric data on the adult Suruí Indians from southwestern Brazilian Amazonia. By focusing on the occurrence of internal socioeconomic differentiation in a previously egalitarian society and its association with nutrition transition, this study also provides important baseline anthropometric information to the growing literature on the relationships between involvement in market economies and health and nutrition outcomes among indigenous peoples.

POPULATION AND METHODS

Fieldwork and setting

Fieldwork was carried out among the Suruí, a Tupí-Mondé-speaking indigenous society of southwestern Brazilian Amazonia that inhabits the Sete de Setembro Indian Reserve, located on the border between the states of Rondônia and Mato Grosso (~60°–61° W longitude; 10°–12° S latitude).

In 1990s, the process of environmental and economic transformations in Suruí society intensified. At present, coffee farming and lumbering persist as important economic activities. Because of the overexploitation of hardwoods (mainly *Swietenia* sp. and *Cedrela* sp.), now the

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Suruí sell mainly second class timber, which is used for fencing in the large cattle raising farms that dominate the rural areas of Rondônia state. In recent years, Suruí have also been earning salaries through the public service (local school teacher, Indian health agent, and Indian administrative agent) and receiving government pensions, which were not as common in the 1980s. The differential access to financial resources, which has led to the development of the intragroup socioeconomic stratification analyzed in previous studies (Coimbra, 1985, 1989; Santos and Coimbra, 1996, 1998), has become a keystone feature of contemporary Suruí society.

At the time of fieldwork in February–March 2005, the Suruí totaled 993 individuals (355 $\geq$ 20 years old) distributed in 11 villages of various sizes, nine of which were included in this study, representing 87% of the total adult population (310 $\geq$ 20 years old). The two major village complexes (Linha 14-Placa and Linha 11), which account for nearly 80% of the total Suruí population, were included. No specific sampling technique was used; we tried to include in the study all willing residents $\geq$20 years old, of both sexes. No one refused to take part in the study, but 34 subjects from the visited villages were not evaluated because they were absent. Anthropometric data from non-Indian subjects (usually female spouses to Suruí men), pregnant women, and the physically disabled were not considered (n = 24). Ages were provided by the local Indian health service.

Socioeconomic index

To classify the Suruí according to different socioeconomic levels, a socioeconomic index was constructed using the same methodology that was developed in 1988 by Santos and Coimbra (1996). In the Suruí it is difficult to use standard income and education variables as socioeconomic indicators for several reasons. The majority of adults have not attended school, so that the number of school years is not a good indicator of internal social differentiation. Most Suruí men are not willing to talk about their income. To circumvent these problems, we identified a group of variables to characterize socioeconomic differentiation in the Suruí community: (1) materials used in house building, including type of flooring, walls, and roof; (2) number of sleeping rooms; (3) presence of modern household appliances, including gas stove, refrigerator, freezer, television set, washing machine, and satellite dish; and (4) presence of western style furniture, including bedstead, sofa, wardrobe, and dining table.

We scored each of these four groups as A, B, or C, according to the level of "westernization." For example, "AAAA" was the maximum score for a household, indicating for each of the four groups (1) house with a tile floor, brick walls, and a tile roof; (2) four or more sleeping rooms; (3) six or more modern appliances; and (4) four or more pieces of western style furniture. On the other hand, "CCCC" indicates the minimum socioeconomic household score, indicating (1) a house with earth floor and palm leaf walls and roof; (2) no internal divisions or one sleeping room; (3) fewer than two modern appliances; and (4) fewer than two pieces of western style furniture. Altogether, there were 81 possible socioeconomic combinations ($3 \times 3 \times 3 \times 3 = 81$).

By analyzing the possible combinations, the Suruí households were classified into three socioeconomic statuses (SES). We defined the following combinations: (1) low SES, indicating a combination of all "Cs" or three "Cs" and a "B" or two "Cs" and two "Bs"; (2) medium SES, including all households not classified as low or high; (3) high SES, indicating a combination of all "As" or three "As" and a "B" or two "As" and two "Bs". The socioeconomic household score was then attributed to all household members.

Anthropometry

All measurements were performed at the health posts of the villages following standard procedures (Lohman et al., 1988). Stature and weight measurements were obtained from subjects wearing light apparel and barefoot. Stature was measured with a free-standing anthropometer (Seca, Hamburg, Germany) and recorded to the nearest 0.1 cm. Body weight was measured by using an electronic scale with maximum capacity of 150 kg and accurate to 100 g (Seca 770, Hamburg, Germany).

Arm circumference (AC) was recorded on the back of the extended right arm, midway between the acromium and the olecranon. Waist circumference (WC) was measured at the narrowest perimeter between the lowest rib margin and the iliac crest, and hip circumference (HC) was measured at the widest part of the buttocks. Measures of circumference were recorded by using a flexible inelastic tape to the nearest 0.1 cm. Triceps skinfold thickness (TST) was measured to the nearest 0.1 mm by using a Lange caliper (Cambridge Scientific Industries, Cambridge, MA) at the same point that the reading for arm circumference was taken.

A single trained observer collected all measurements and 15% of the subjects were measured twice. No statistically significant difference was observed when comparing the average of the two sets of measurements ($P > 0.05$). The first measurement was used for the analysis. For most variables, we found no evidence of rounding error or digit heaping, but for WC and hip circumference there were concentration at 0 and 5 (varying between 17.5 and 25% of the measurements).

The body mass index (BMI) was calculated [weight (kg)/stature $(m)^2$] and classified in accordance with standard growth charts and cut-off points for underweight ($<$18.5 kg/m^2), adequate weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obesity ($\geq$30.0 kg/m^2) (WHO, 1995). Waist-to-hip ratio (WHR) was calculated as WC divided by hip circumference. Arm muscle and fat areas (AMA and AFA) were estimated from arm circumference and triceps skinfold, following Frisancho (1981).

Data provided by Frisancho (1981) were used as reference for the analyses of AC, TST, AFA, and AMA. WC and WHR were analyzed according to the cut-off points recommended by the WHO (2000). Cut-off points of WC to define increased risk for chronic noncommunicable diseases (including hypertension, diabetes mellitus, cardiovascular diseases, and lipemic disorders) for men and women were $\geq$94 and $\geq$80 cm, respectively. For WHR, the cut-off points for men and women were $\geq$1 and $\geq$0.85, respectively.

The percentage of body fat (%BF) was measured by using a leg-to-leg bioimpedance device (Tanita TBF-305, Tokyo, Japan). Since electric power was not available at all villages, bioimpedance measures were possible in only 74.6% (188/252) of the subjects included in the survey. Because of the lack of consensus about the interpretation

TABLE 1. Descriptive statistics (mean values and standard deviations) for age, anthropometric variables, and percentage of body fat measured by bioimpedance for Suruí adults 20–49.9 and ≥ 50 years of age, by sex, Brazilian Amazon, 2005

	20–49.9 Years				≥50 Years			
	Men (n = 109)		Women (n = 106)		Men (n = 16)		Women (n = 21)	
Variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	32.1	8.97	31.5	8.95	68.2	12.64	65.3	11.04
Stature (cm)	160.3	4.55	147.2	4.51	158.2	7.03	146.8	4.14
Weight (kg)	67.5	10.01	58.6	11.36	55.4	7.27	54.2	8.72
BMI (kg/m^2)	26.2	3.50	27.1	5.00	22.2	3.04	25.1	3.40
AC (cm)	29.4	2.35	29.6	3.00	27.3	2.33	28.5	2.82
TST (mm)	14.9	5.51	27.9	8.19	9.8	4.19	22.5	7.67
AMA (cm^2)	49.0	6.69	34.6	5.07	47.0	6.15	37.0	6.61
AFA (cm^2)	20.5	8.33	35.7	12.62	12.8	6.04	28.4	11.07
WC (cm)	89.6	9.45	87.0	11.63	83.9	8.09	90.3	9.33
HC (cm)	94.1	6.00	95.7	8.52	86.7	4.99	91.0	6.73
WHR	0.95	0.06	0.91	0.06	0.97	0.05	0.99	0.06
%BF[a]	22.6	6.05	41.4	9.19	16.5	7.03	37.4	6.86

BMI, body mass index; AC, arm circumference; TST, triceps skinfold thickness; AMA, arm muscle area; AFA, arm fat area; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; %BF, percentage of body fat.
*Obs.: For %BF samples were as follows: 88 men 20–49.9 years; 74 women 20–49.9 years; 10 men ≥ 50 years; 16 women ≥ 50 years.

of bioimpedance results across different populations, we followed the method proposed by Gallagher et al. (2000). This includes computing linear regression for each sex, with %BF as the dependent variable and BMI as the independent one. The cut-off points for the classification of nutritional status by %BF were calculated by entering the cut-off point for obesity (BMI = 30.0 kg/m^2) in the equations derived from the linear regression.

Ethics considerations

This study is part of a broader project about the health of the Suruí Indians. Its major focus is the epidemiology of tuberculosis, but it also includes the nutritional assessment of the population (Basta et al., 2006; Orellana et al., 2006). Guidelines for research in humans determined by the Brazilian National Committee on Research Ethics (CONEP) of the Ministry of Health were followed. A research permit was also obtained from the National Indian Foundation (FUNAI). A consent form was signed by the leaders of the surveyed villages. All field procedures were undertaken in the company of a local Suruí health agent chosen by the community, who helped to explain the objectives of the research plan and acted as interpreter when necessary.

Statistical analysis

One-way ANOVA were used to assess differences in mean values of anthropometric variables and %BF by SES. P-values < 0.05 were considered statistically significant. Data from individuals ≥50 years old were analyzed separately because their mean values of anthropometrics and body composition were significantly smaller than those observed in younger adults. Statistical analyses were performed using the R software version 2.1.0 (available at http://www.r-project.org).

RESULTS

A total of 252 individual of both sexes were evaluated, which corresponds to 88.1% of the eligible adults ≥20 years of age who live in the villages surveyed. We were able to ascertain the socioeconomic index of a subsample of 233 subjects (19 subjects had missing values, which prevented us from computing the index for them).

TABLE 2. Classification of the nutritional status of Suruí adults 20–49.9 and ≥50 years of age according to body mass index (BMI), by sex, Brazilian Amazon, 2005

		Sex		
Age groups	BMI categories	Men (%)	Women (%)	Total
20–49.9 years	Underweight	–	–	–
	Adequate	41 (37.6)	44 (41.5)	85 (39.5)
	Overweight	55 (50.5)	36 (34.0)	91 (42.3)
	Obesity	13 (11.9)	26 (24.5)	39 (18.2)
	Total (100%)	109	106	215
≥50 years	Underweight	2 (12.5)	–	2 (5.4)
	Adequate	12 (75.0)	11 (52.4)	23 (62.2)
	Overweight	2 (12.5)	8 (38.1)	10 (27.0)
	Obesity	–	2 (9.5)	2 (5.4)
	Total (100%)	16	21	37
Total		125	127	252

Table 1 shows descriptive statistics of anthropometric and body composition variables for the two age groups. Ages ranged from 20.0–85.2 years.

The majority of Suruí adults 20–49.9 years of age were overweight (42.3%) or obese (18.2%) (Table 2). The frequency of obesity in women in this age group (24.5%) was twice that recorded for men. Among subjects ≥50 years of age, 27.0% were overweight and 5.4% obese, with nearly 50% of women overweight or obese while a much lower percentage of men (12.5%) fell in these categories.

The combination of BMI and bioimpedance results pointed to cut-off points for obesity of 29% of body fat in men (%BF = 1.68 × 30 − 21.8) and of 46% in women (%BF = 1.65 × 30 − 3.9) (see Fig. 1). When applying these cut-off points, 13.6% (12/88) of the males and 33.8% (25/74) of the females in the 20–49.9 years old group were classified as obese (Table 3). These figures are slightly higher than those derived from evaluation of BMI only (10.2% or 9/88 for males and 27.0% or 20/74 for women, respectively). This was also true for the group ≥50 years of age, where the frequency of obesity was higher when applying impedance cut-off points (Table 3).

In subjects 20–49.9-year-old with BMI ≥25 kg/m^2, 27.9% (19/68) of the males and 93.5% (58/62) of the females presented WHR values suggestive of increased risk for chronic noncommunicable diseases. In those individuals with BMI ≥30 kg/m^2, 53.8% (7/13) of the males

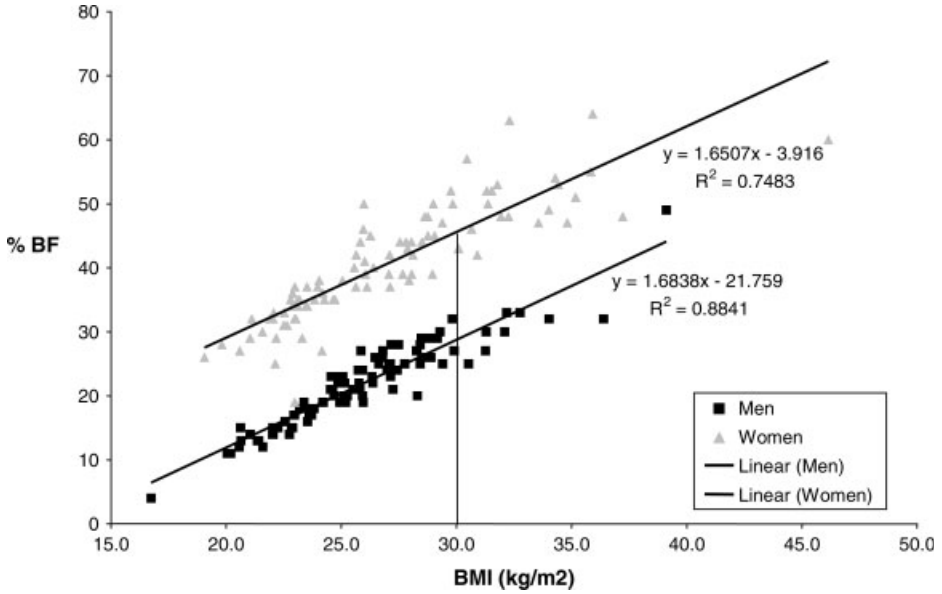

Fig. 1. Linear regression results of percentage of body fat (%BF) values by body mass index (BMI) in 188 Suruí adults ≥20 years of age, by sex, Brazilian Amazon, 2005.

TABLE 3. Nutritional status of Suruí adults 20–49.9 and ≥50 years of age derived from the percentage of body fat (%BF) by nutritional status derived from the body mass index (BMI), by sex, Brazilian Amazon, 2005

		Classification by %BF					
		Men			Women		
Age groups	BMI categories	*n* (%)	Adequate (%)	Obesity (%)	*n* (%)	Adequate (%)	Obesity (%)
20–49.9 years	Underweight	–	–	–	–	–	–
	Adequate	31 (35.2)	31 (40.8)	–	26 (35.1)	26 (53.1)	–
	Overweight	48 (54.5)	43 (56.6)	5 (41.7)	28 (37.8)	21 (42.9)	7 (28.0)
	Obesity	9 (10.3)	2 (2.6)	7 (58.3)	20 (27.1)	2 (4.0)	18 (72.0)
	Total (100%)	88	76	12	74	49	25
≥50 years	Underweight	1 (10.0)	1 (11.1)	–	–	–	–
	Adequate	7 (70.0)	7 (77.8)	–	10 (62.5)	10 (71.4)	–
	Overweight	2 (20.0)	1 (11.1)	1 (100)	5 (31.3)	4 (28.6)	1 (50.0)
	Obesity	–	–	–	1 (6.2)	–	1 (50.0)
	Total (100%)	10	9	1	16	14	2

and 96.2% (25/26) of the females showed WHR values above cut-off points. All subjects with BMI ≥ 30 kg/m^2 showed WC values suggestive of increased risk for chronic noncommunicable diseases.

Mean values of AC, TST, AFA, and AMA in women 20–49.9 years of age fell between the 50th and the 75th percentiles of the reference population. For men, values of TST and AFA also fell between the 50th and the 75th percentiles, while mean values of AC and AMA were close to the 15th and 25th percentiles, respectively. In those subjects with BMI ≥ 25, mean values of TST and AFA were above the 75th percentile and beyond the 85th percentile for women. In those individuals ≥50 years of age, mean values of those four variables fell between the 25th and the 50th percentiles (with the exception of AC in men, which was below the 15th percentile).

No significant differences were observed between villages in the prevalence rates of overweight and obesity, as evaluated by BMI.

Suruí subjects were classified into 28 combinations of the SES index, distributed as 27.6, 42.7, and 29.6% into low, medium, and high SES groups, respectively (Table 4).

For women 20–49.9 years of age, there were statistically significant differences across SES groups for most of the variables investigated, with the exception of WHR (Table 5). Mean values increased with SES for all variables, with the exception of stature. Women in the high SES group weighed on average 8.8 kg more than those of low SES; their BMI was on average 3.7 kg/m^2 higher than that of low SES women. For men, statistically significant differences across SES groups were not observed for any variable, with the exception of AMA (data not shown). It is worth noting that, despite not being statistically significant, for most variables mean values were higher in the high SES group. Men in the higher SES group weighed on average only 1.0 kg more than those of low SES. However, their BMI was actually 0.4 kg/m^2 lower than that of low SES men.

TABLE 4. Distribution of the socioeconomic status (SES) index in Suruí adults 20–49.9 years of age, Brazilian Amazon, 2005

Low SES			Medium SES		High SES	
		n		*n*		*n*
BBCC		30	AABC	3	AAAA	3
BCBC		2	ABCB	2	AABB	7
BCCB		6	ABCC	2	ABBA	4
BCCC		4	BACB	4	ABBB	1
CBCC		3	BACC	5	BAAA	2
CCCC		10	BBBB	22	BAAB	4
			BBBC	30	BABA	3
			BBCA	1	BABB	8
			BBCB	12	BBAA	7
			BCBB	3	BBAB	10
			BCCA	1	BBBA	10
Total	20 men; 35 women	55	46 men; 39 women	85	33 men; 26 women	59

TABLE 5. Descriptive statistics (mean values and standard deviations) for age, anthropometric variables, and percentage of body fat measured by bioimpedance for Suruí adults women 20–49.9 years of age by socioeconomic status (SES), Brazilian Amazon, 2005

	Low SES (n = 35)		Medium SES (n = 39)		High SES (n = 26)		
	Mean	SD	Mean	SD	Mean	SD	*P*
Age (years)	32.0	9.59	29.7	8.36	33.2	8.15	NS
Stature (cm)	148.0	3.67	145.5	4.84	148.8	4.55	**
Weight (kg)	56.4	11.12	56.8	9.28	65.2	12.80	**
BMI (kg/m^2)	25.7	4.49	26.9	4.62	29.4	5.56	*
AC (cm)	28.7	2.86	29.5	2.51	31.3	3.11	**
TST (mm)	26.5	8.44	27.5	6.64	31.6	8.78	*
AMA (cm^2)	33.1	4.46	34.7	4.93	36.4	5.42	*
AFA (cm^2)	33.0	12.42	34.8	10.02	42.1	14.19	*
WC (cm)	83.7	11.44	85.6	9.89	93.5	11.39	**
HC (cm)	93.8	8.84	94.6	6.98	100.7	8.92	**
WHR	0.89	0.06	0.90	0.06	0.93	0.06	NS
%BF	37.0	8.40	40.5	7.72	46.1	9.81	**

BMI, body mass index; AC, arm circumference; TST, triceps skinfold thickness; AMA, arm muscle area; AFA, arm fat area; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; %BF, percentage of body fat.
P-values refer to One-way ANOVA results; NS refers to "not significant" or $P > 0.05$; *refers to $P < 0.05$; **refers to $P < 0.01$. Obs.: For %BF, samples sizes for low, medium, and high SES are 15, 31, and 23, respectively.

DISCUSSION

It was only in the mid-1990s that studies conducted in the Brazilian Amazon began to systematically analyze how socioeconomic and environmental changes prompted by participation in the market economy impacted the health, demography, and human biology of indigenous peoples (Coimbra et al., 2002; Dufour, 1991, 1992; Gugelmin and Santos, 2001; Santos and Coimbra, 1996, 1998, 2003). These changes might affect access to financial resources, dietary habits, gender roles, physical activity, household composition, and settlement characteristics. All this can in turn have an impact on health and nutrition, with the emergence of lifestyle-related chronic noncommunicable diseases. Recent attention to these issues has also been paid by researchers working elsewhere in indigenous lowland South America (Benefice et al., 2007; Dangour, 2003; Godoy and Cárdenas, 2000; Godoy et al., 2005a,b,c; Orden and Oyhenart, 2006).

The Suruí case study demonstrates an association between socioeconomic stratification and the appearance of nutritional differentials in an Amazonian indigenous society. Those individuals enjoying greater SES display higher average weights, BMI, and body fat. Women of higher SES weigh an average of 8.8 kg more than those of lower SES. We also see sharp differences in SES for other variables such as BMI, arm and waist circumferences, skin folds, and percentage of body fat (%BF). Men of higher SES also tend to display greater weight, BMI, and body fat indicators when compared with those of lower SES, although such differences are not as pronounced as in women.

Santos and Coimbra (1996, 1998) documented the initial phase of socioeconomic stratification in Suruí society and investigated how it was reflected in the anthropometric indicators of the adult population. These authors argued that the Suruí had been predominantly egalitarian in economic terms until the mid-1980s, in agreement with the pattern commonly described for most of the other Amazonian indigenous societies. Traditionally, the extended family constituted the unit of production in Suruí society, which engaged in slash-and-burn horticulture, supplemented by hunting and gathering. Their large palm-thatched longhouses were inhabited by dozens of people connected by complex kinship networks. In the mid-1980s, coffee farming and logging brought the concentration of wealth, prompting a process of intracommunity economic differentiation, with the curtailment of traditional subsistence practices and their substitution by cash-oriented activities. More recently, social benefits like government pension payments to the elderly and salaries have also become an important source of income for Suruí families. Differentiation has found expression in a number of ways. Families have undergone nuclearization and begun living in smaller households; the extended family no longer predominates and construction materials range from wood-boards to brick, depending on the family's wealth. Physical activity levels have decreased and dietary habits have changed with industrialized items, such as sugar, coffee, salt, pasta, soft drinks, crackers, and cooking oil, playing a central role in everyday meals.

Although the results of this study confirm previous findings by Santos and Coimbra (1996, 1998) on the relation between socioeconomic stratification and morphological differentiation in the Suruí, some new aspects deserve attention. First, data from the late 1980s reported by these authors revealed differences in anthropometric indicators by SES for both men and women. This study shows that differentials among men have tended to disappear, while they are still quite pronounced among women. Second, on average, Suruí adult men and women are 11.3 and 8.6 kg heavier in 2005 when compared with 1988, while BMI increased from 22.3 to 26.3 in men and from 23.4 to 27.1 in women, pointing to a swift process of nutrition transition.

The available data do not allow for a definite explanation for the observed gender differences in anthropometrics and %BF according to SES. Nevertheless, some hypotheses may be advanced. In the past, women's daily routine included attending their family gardens with their children and the gathering of forest products, often facing several kilometers of walking. The processing of food collected and/or gathered took place immediately upon their return to the village. Since the Suruí longhouses were densely inhabited, this meant peeling, grating, and grinding large amounts of food. Women's tasks also included fetching water from the river and collecting firewood from

abandoned gardens near the village (Coimbra, 1985, 1989). At present, Suruí women spend the bulk of their time at home, in the village, making handicrafts, taking care of the children, and housekeeping. Most food consumed is bought at small shops in nearby towns which border the southern portion of the reservation, and is cooked in gas stoves. The "westernization" of Suruí diet and their decreased involvement in the subsistence economy correlate with women's SES. Therefore, one observes a combination of factors that not only favors an increase in overweight and obesity levels over time among Suruí women, but also an association between increased levels of fatness and SES.

The absence of difference in the variables related to fatness among Suruí men according to SES may stem from the emergence of new forms of male sociability that were developed in the last two decades. Today, Suruí men no longer engage in hunting excursions, whereas in the past they could spend several days trekking. They no longer clear trees for new gardens as they formerly did every year as part of the agricultural cycle (Coimbra, 1985, 1989). Nowadays, it has become quite usual for groups of men to undertake 1-day trips to the nearest town of Cacoal (some 50 km away from the reservation). This high mobility is made easier by the availability of community-owned pick-up trucks and public transportation destined to serve colonists settled at small plots around the reservation. When in town, Suruí men have their meals at bars or other places where cheap-food is sold; their plates often consist of generous portions of rice, noodles, deep-fried food (chicken, fish), and soft drinks or beer. Reciprocity is commonplace on these occasions, with those who have money paying for their close kin who do not. Since making constant trips to town is practically universal among young and middle-age men, this may help "homogenize" men's exposure to dietary risk factors for obesity, whatever their SES, including increased consumption of high-fat-high-sugar diets and alcohol.

Recent research conducted in some indigenous communities in Brazil has found an extremely high prevalence of obesity in adults, reaching up to 40% in some cases (Capelli and Koifman, 2001; Cardoso et al., 2001; Coimbra et al., 2002; Leite et al., 2006; Lima et al., 2001; Ribas et al., 2001; Tavares et al., 2003). The few studies that have also analyzed the anthropometric profile of the same indigenous population at different moments have confirmed the rapid pace and pervasiveness of the ongoing nutrition transition [see, for instance, the studies carried out by Coimbra et al. (2002) and Gugelmin and Santos (2001) among the Xavánte of Central Brazil]. Authors unanimously agree about the association between the emergence of overweight and obesity with the monetarization of indigenous economies, bringing about the westernization of indigenous diets and the reduction of physical activity levels. Not surprisingly, chronic metabolic disorders and cardiovascular diseases are also rapidly becoming part of the health-disease profile of indigenous people in Brazil (Coimbra and Santos, 2004).

At present, prevalence rates of obesity in the Suruí are well above those recorded for non-Indians in Brazil. Among Suruí women age 20–49.9 years, the prevalence of obesity is two times higher than the prevalence observed among nonindigenous Brazilian women (13.1%), according to a nationally representative survey conducted in 2002 and 2003 (IBGE, 2004). Among Suruí men, the prevalence of obesity (11.9%) is also higher than that (8.9%) observed among nonindigenous adult Brazilian men (IBGE, 2004).

In consonance with the ongoing trend in Latin America (Kain et al., 2003; Martorell et al., 1998, 2000), the general Brazilian population has experienced a rapid rise in the prevalence of obesity among the most underprivileged, especially women (Monteiro et al., 2004). A comparison of data on Brazilian women gathered from nationally representative surveys carried out in 1975 and 1997 shows a reversing trend in the relation between obesity and SES (Monteiro et al., 2004). In 1975, when the overall prevalence of obesity in adult women was 7.4%, 4.7% of the 25% poorest women were obese, while the prevalence of obesity was 9.8% in the 25% richest women. Two decades later, when 12.7% of the adult women in the national population were obese, the opposite trend was observed, with obesity higher in the 25% poorest compared to the 25% richest (12.6 and 10.9%, respectively). To explain this trend, Monteiro et al. (2003) based their argument on Sobal and Stunkard's analyses (1989). According to these authors, the most common scenario nowadays (even in poor countries) is a relatively abundant supply of cheap, highly palatable energy-dense foods combined with a lifestyle characterized by overall low levels of physical activity. In urban Brazil and elsewhere in Latin America, the more privileged social strata appear to be better able to cope with and prevent obesity, not only because they have better education and access to information about its consequences, but also because social and family pressures favor a trim body image, consistent with western society's current esthetic values (Monteiro et al., 2003; Peña and Bacallao, 2002).

Increased levels of obesity among indigenous peoples parallel increased levels among the poorest segment of Brazil's nonindigenous population. Thus the nutritional situation in indigenous populations can be seen as part of the general trend toward greater obesity among the poor, similar to what has been described throughout Latin America. The Suruí case shows that even in the midst of poverty, food insecurity, precarious living conditions, and poor sanitation, one can still observe a positive relationship between SES and obesity. Therefore, while the thesis that obesity is growing among the poor holds true for the overall set of indigenous people, this relationship may be different within specific indigenous societies, with a positive relationship between obesity and SES at the local level.

Research among the Suruí included a small sample of individuals $\geq$50 years of age. It was observed that the nutritional profile for this age group is similar to that of the 20–49.9 age bracket, although the magnitude of obesity is less pronounced. Of those examined in this age group, 11.3% were classified as obese, with a concentration of such cases among women.

It has been suggested that intrauterine malnutrition and nutritional stunting in children may cause a number of long-lasting consequences that might predispose to obesity and several chronic noncommunicable diseases later in life (Godfrey and Barker, 2001; Peña and Bacallao, 2002; Sawaya and Roberts, 2003). Lower energy expenditure, higher susceptibility to the effects of high-fat diets, lower fat oxidation, and impaired regulation of food intake are some of the physiological alterations caused by stunting that might be associated with obesity. It is worth mentioning that most Suruí adults in our sample were born

from 1965 to 1985. These adults constitute the cohort of Suruí children born during or immediately after the establishment of permanent contact with Brazilian national society (1969). Their childhood took place in an extremely difficult time, when nearly two-thirds of the Suruí population died due to epidemics of infectious diseases. Coimbra (1989) found that the infant mortality rate in the 1980–1987 period was close to 250 per 1,000. Famine was common in Suruí villages in the 1980s due to the rapid changes in their traditional subsistence practices and the invasion of their reservation land by squatters, resulting in a number of cases of severely undernourished children (Coimbra, 1985, 1989; Santos and Coimbra 1991). Coimbra and Santos (1991) found that 43% of children below age five were stunted in 1987–1988. Therefore, if the hypothesis that postulates that nutritional stress in childhood might be related to increased risks of obesity later in life is valid, it is possible that the social deprivation and overall poor nutritional and health conditions that the present-day Suruí adults faced in their infancy might play a role in the sharp increase in the prevalence of obesity.

Given that obesity seems to be gaining a role as an important issue in the nutritional profile of indigenous people, it is vital that anthropometric data be interpreted adequately. We must remember that weight and BMI do not allow us to evaluate a person's body composition. Since it is possible that indigenous groups engage in a higher level of physical activity than other populations, it would be fitting to ask whether the higher BMI values noted among the Suruí are linked to excess fat or to the amount of fat-free mass (see Gugelmin and Santos, 2006). This is a plausible line of questioning since other studies have observed indigenous South American populations whose body composition differs from that of nonindigenous people (Black et al., 1977; Stinson, 1989). This study, one of the first to use the evaluation of bioelectric impedance in indigenous adults in the Brazilian Amazon, provides strong support that the pronounced prevalence of high BMI levels in Suruí adult derives basically from excess body fat.

In conclusion, this study shows that the Suruí Indians are undergoing a rapid process of nutrition transition, leading to sharp increases in the rates of overweight and obesity in men and women over time. This transition is closely associated with the emergence of intragroup differences in SES which have influenced dietary habits and patterns of physical activity. In bioanthropological and epidemiological research in indigenous peoples in Amazonia, greater attention should be paid to the human biological outcomes of environmental and socioeconomic transformations related to the growing involvement of native societies in the market economy.

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LITERATURE CITED

Black FL, Hierholzer WJ, Black DP, Lamm SH, Lucas L. 1977. Nutritional status of Brazilian Kayapó Indians. Hum Biol 49:139–153.

Basta PC, Coimbra CEA Jr, Escobar AL, Santos RV, Alves LCC, Fonseca LS. 2006. Survey for tuberculosis in an indigenous population of Amazonia. The Suruí of Rondônia, Brazil. Trans R Soc Trop Med Hyg 100:579–585.

Benefice E, Lopes R, Monroy SL, Rodríguez S. 2007. Fatness and overweight in women and children from riverine Amerindian communities of the Beni river (Bolivian Amazon). Am J Hum Biol 19:61–73.

Capelli JCS, Koifman S. 2001. Avaliação do estado nutricional da comunidade indígena Parkatêgê, Bom Jesus do Tocantins, Pará, Brasil. Cad Saude Publica 17:433–437.

Cardoso AM, Mattos IE, Koifman RJ. 2001. Prevalência de fatores de risco para doenças cardiovasculares na população Guarani-Mbyá do Estado do Rio de Janeiro. Cad Saude Publica 17:345–354.

Coimbra CEA Jr. 1985. Estudos de ecologia humana entre os Suruí do Parque Indígena Aripuanã, Rondônia: aspectos alimentares. Boletim do Museu Paraense Emílio Goeldi (Antropologia) 2:57–87.

Coimbra CEA Jr. 1989. From shifting cultivation to coffee farming: the impact of change on the health and ecology of the Suruí Indians in the Brazilian Amazon, Ph.D. dissertation, Indiana University, Bloomington, IN.

Coimbra CEA Jr, Flowers NM, Salzano FM, Santos RV. 2002. The Xavánte in transition: health, ecology and bioanthropology in Central Brazil. Ann Arbor, MI: The University of Michigan Press.

Coimbra CEA Jr, Santos RV. 1991. Avaliação do estado nutricional num contexto de mudança sócio-econômica: O grupo indígena Suruí do Estado de Rondônia, Brasil. Cad Saude Publica 7:538–562.

Coimbra CEA Jr, Santos RV. 2004. Emerging health needs and epidemiological research in indigenous peoples in Brazil. In: Salzano FM, Hurtado AM, editors. Lost paradises and the ethics of research and publication. Oxford: Oxford University Press. p 89–109.

Dangour AD. 2003. Cross-sectional changes in anthropometric variables among Wapishana and Patamona Amerindian adults. Hum Biol 75:227–240.

Dufour DL. 1991. Diet and nutritional status of Amerindians: a review of the literature. Cad Saude Publica 7:481–502.

Dufour DL. 1992. Nutritional ecology in the tropical rain forests of Amazonia. Am J Hum Biol 4:197–207.

Frisancho AR. 1981. New norms of upper limb fat and muscle areas for assessment of nutritional status. Am J Clin Nutr 34:2540–2545.

Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. 2000. Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. Am J Clin Nutr 72:694–701.

Godfrey KM, Barker DPJ. 2001. Fetal programming and adult health. Public Health Nutr 4:611–624.

Godoy R, Cárdenas M. 2000. Markets and the health of indigenous people: A methodological contribution. Hum Organ 59:117–124.

Godoy R, Byron E, Reyes-García V, Vadez V, Leonard WR, Apaza L, Huanca T, Pérez E, Wilkie D. 2005a. Income inequality and adult nutritional status: anthropometric evidence from a pre-industrial society in the Bolivian Amazon. Soc Sci Med 61:907–919.

Godoy R, Reyes-García V, Vadez V, Leonard WR, Huanca T. 2005b. Human capital, wealth, and nutrition in the Bolivian Amazon. Econ Hum Biol 3:139–162.

Godoy R, Reyes-García V, Byron E, Leonard V, Vadez V. 2005c. The effect of market economies on the well-being of indigenous peoples and on their use of renewable natural resources. Annu Rev Anthropol 34:121–138.

Gugelmin SA, Santos RV. 2001. Ecologia humana e antropometria nutricional de adultos Xavánte, Mato Grosso, Brasil. Cad Saude Publica 17:313–322.

Gugelmin SA, Santos RV. 2006. Uso do Indice de Massa Corporal (IMC) na avaliação do estado nutricional de adultos indígenas Xavante—Terra Indígena Sangradouro-Volta Grande, Mato Grosso. Cad Saude Publica 22:1865–1872.

Hurtado AM, Lambourne CA, James P, Hill K, Cheman K, Baca K. 2005. Human rights, biomedical science and infectious diseases among South American indigenous groups. Annu Rev Anthropol 34:639–665.

IBGE (Instituto Brasileiro de Geografia e Estatística). 2004. Pesquisa de Orçamentos Familiares 2002–2003: Análise da disponibilidade domiciliar de alimentos e do estado nutricional no Brasil. Rio de Janeiro: IBGE.

Kain J, Vio F, Albala C. 2003. Obesity trends and determinant factors in Latin America. Cad Saude Publica 19 (Suppl 1):S77–S86.
Leite MS, Santos RV, Gugelmin SA, Coimbra CEA Jr. 2006. Crescimento físico e perfil nutricional da população indígena Xavánte de Sangradouro-Volta Grande, Mato Grosso, Brasil. Cad Saude Publica 22:265–276.
Lima MG, Scapulatempo IL, Koifman S, Peixoto M, Noami S, Amaral MC. 2001. Fatores de risco para câncer de mama em mulheres indígenas Teréna de área rural, Estado do Mato Grosso do Sul, Brasil. Cad Saude Publica 17:1537–1544.
Lohman TG, Roche AF, Martorell R. 1988. Anthropometric Standardization Reference Manual. Champaign, IL: Human Kinetics Books.
Martorell R, Khan LK, Hughes ML, Grummer-Strawn CM. 1998. Obesity in Latin American women and children. J Nutr 128:1464–1473.
Martorell R, Khan LK, Hughes ML, Grummer-Strawn CM. 2000. Obesity in women from developing countries. Eur J Clin Nutr 54:247–252.
Monteiro CA, Conde WL, Castro IR. 2003. A tendência cambiante da relação entre escolaridade e risco de obesidade no Brasil (1975–1997). Cad Saude Publica 19 (Suppl 1):S67–S75.
Monteiro CA, Conde WL, Popkin BM. 2004. The burden of disease from undernutrition and overnutrition in countries undergoing rapid nutrition transition: a view from Brazil. Am J Public Health 94:433–434.
Orellana JDY, Coimbra CEA Jr, Lourenço AEP, Santos RV. 2006. Nutritional status and anemia in Suruí Indian children, Brazilian Amazon. J Pediatr (Rio J) 82:383–388.
Orden AB, Oyhenart EE. 2006. Prevalence of overweight and obesity among Guaraní-Mbyá from Misiones, Argentina. Am J Hum Biol 18:590–599.
Peña M, Bacallao J. 2002. Malnutrition and poverty. Annu Rev Nutr 22:241–253.
Popkin BM. 1993. Nutritional patterns and transitions. Popul Dev Rev 19:138–157.
Ribas DLB, Alfredo Sganzerla A, Zorzatoo JR, Philippi ST. 2001. Nutrição e saúde infantil em uma comunidade indígena Teréna, Mato Grosso do Sul, Brasil. Cad Saude Publica 17:323–331.
Santos RV, Coimbra CEA Jr. 1991. Socioeconomic transition and physical growth of Tupí-Mondê Amerindian children of the Aripuanã Park, Brazilian Amazon. Hum Biol 63:795–819.
Santos RV, Coimbra CEA Jr. 1996. Socioeconomic differentiation and body morphology in the Suruí of Southwestern Amazonia. Curr Anthropol 37:851–856.
Santos RV, Coimbra CEA Jr. 1998. On the (un) natural history of the Tupí-Mondé Indians: bioanthropology and change in the Brazilian Amazon. In: Goodman AH, Leatherman T, editors. Building a new biocultural synthesis. Ann Arbor, MI: The University of Michigan Press. p 269–294.
Santos RV, Coimbra CEA Jr. 2003. Cenários e tendências da saúde e da epidemiologia dos povos indígenas no Brasil. In: Coimbra CEA Jr, Santos RV, Escobar AL, editors. Epidemiologia e saúde dos povos indígenas no Brasil. Rio de Janeiro: Editora Fiocruz. p 13–47.
Sawaya AL, Roberts S. 2003. Stunting and future risk of obesity: principal physiological mechanisms. Cad Saude Publica 19 (Suppl 1):S21–S28.
Sobal J, Stunkard AJ. 1989. Socioeconomic status and obesity: a review of the literature. Psychol Bull 105:260–275.
Stinson S. 1989. Physical growth of Ecuadorian Chachi Amerindians. Am J Hum Biol 1:697–707.
Tavares EF, Vieira-Filho JPB, Andriolo A, Sanudo A, Gimeno SG, Franco LJ. 2003. Metabolic profile and cardiovascular risk patterns of an Indian tribe living in the Amazon Region of Brazil. Hum Biol 75:31–46.
WHO (World Health Organization). 1995. The use and interpretation of antropometry: report of a WHO expert committee. Geneva: The WHO (Technical Report Series 854).
WHO (World Health Organization). 2000. Obesity: preventing and managing the global epidemic. Geneva: The WHO (WHO Obesity Technical Report 894).