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Nutritional Status of *Ribeirinhos* in Brazil and the Nutrition Transition

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KEY WORDS Amazon; anthropometry; growth; market economy

ABSTRACT Anthropometric and household data (size, composition, economic activity) were collected from a population of *Ribeirinhos* living in a rural setting in the eastern Amazon. Data are compared to international reference standards and to other Amazonian populations with the goals of increasing our understanding of the Amazon's largest ethnic group and identifying the relationship between changes in subsistence strategies and nutritional status. Data on height, weight, skinfolds, and circumferences were collected from 471 adults and subadults. The population showed a high degree of stunting with an average HAZ below −2.0 for all age groups over 3 years, and 60% of adult men and 70% of adult women were stunted. Wasting was rare. Average skinfold thicknesses and upper-arm muscle area were near or below average but within the normal range compared to the reference standard, indicating adequate energy and protein stores. Thirty-one percent of males and 29% of females were overweight/obese, and the highest average BMIs were found among men and women in their 40s. Adult males who participated in wage labor had higher weights, BMIs, and UMA values, and were more likely to be overweight and obese compared with those who did not work in wage-labor jobs. Children of fathers who worked in wage labor had higher BMI and UMA values, but there was no significant effect on the nutritional status of other adults in these same households. Signs of the nutrition transition were most noticeable among adult males involved in wage labor because of changes in their diet and activity patterns. Am J Phys Anthropol 133:868–878, 2007. © 2007 Wiley-Liss, Inc.

For most people, the mention of the Amazon Basin conjures up images of remote, dense forests and native peoples living traditional lifestyles similar to those described during the periods of initial European contact. These images stand in stark contrast to what the region is like today. First, the majority of inhabitants living in the Amazon Basin are indigenous peasants of mixed ethnicity (Indigenous Amazonian/European/African) (Murrieta et al., 1999) referred to locally as *Ribeirinhos* or *Caboclos*. This mixed ethnicity population was created during the colonization of the Amazon and has largely replaced indigenous populations in the region. Second, a large and increasing number of *Ribeirinhos* live in more urbanized environments, and even those living in rural communities are intimately linked to regional markets, upon which they are dependent for a wide array of goods. Therefore, while the term *Ribeirinho* typically refers to rural, indigenous peasants, *Ribeirinhos* now practice a wide-range of economic activities, live in both rural and urban environments, and play a major role in the development of the region (Ross, 1978; Moran, 1981; Parker, 1985; Cleary, 1993; Nugent, 1993).

As these people become increasingly dependent on the market, their diets and activity patterns shift from those associated with a subsistence-based economy to one dependent on wage labor and industrial products. We should expect to see accompanying changes in their health and nutritional status. The increase in obesity and associated health issues with this lifestyle change is often referred to as the "nutrition transition" (Popkin, 2001). The rate of this transition has been high in Latin America (Popkin, 2003) and, thus, a topic of much interest in the recent academic and public health literature including among Brazilian populations (Sichieri et al., 1994; Doak et al., 2000; Florêncio et al., 2001; Batista Filho and Rissin, 2003; Kain et al., 2003). The question is that at what point along this transition do we see the biological effects of these lifestyle changes?

This paper reports data on the growth and nutritional status of *Ribeirinhos* living in seven rural Amazonian communities and has two goals. The first is to improve our understanding of the ecology and health of the region's most numerous inhabitants for, with the exception of a handful of studies (Giugliano et al., 1981, 1984; Silva et al., 1995, 2006; Murrieta et al., 1998), very little is known. The second goal is to understand how their involvement in the market economy is affecting their nutritional status and to determine, through comparisons with other populations, if they are showing signs of the nutrition transition.

MATERIALS AND METHODS

People and field site

The people included in this study self-identified as *Ribeirinhos* and lived in seven, upper-land (*terra firme*)

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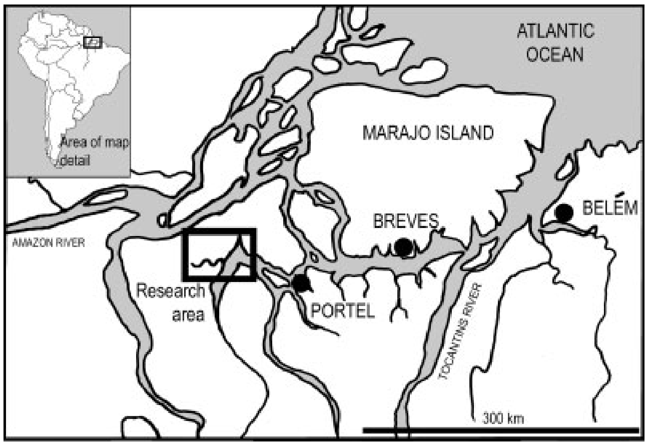

Fig. 1. Map of the field site.

communities located in and around the Caxiuanã National Forest in the Brazilian State of Pará (Fig. 1). The communities are rural, located ~8–10 h by small motorboat from the nearest town, Portel, and 2 days by much larger boat from Belém, the state capital. None had electricity or running water, and only a few households had pit toilets; the majority used the forest and river for waste disposal. Water for cooking was collected from the river or, in a few cases, from hand-dug wells, and trash was burned, buried, or dumped in the river. Homes sat on stilts, were made of wood and covered with one of three materials, palm fronds, ceramic tile, or an industrialized, fire retardant material referred to as *Brasilite*. Most homes consisted of three small rooms; a kitchen, a bedroom, and a living room, which was converted into a bedroom at night as people hung their hammocks to sleep.

The region in general is considered part of a black-water river system, although there was variability in water pH and clarity due to the daily and seasonal influence of the Caxiuanã Bay (Costa et al., 2002). In general, black-water rivers are known for their relatively low productivity (Moran, 1993). All the people practiced slash and burn agriculture with bitter manioc (*Manihot esculenta* Crantz) as their staple crop. Manioc was consumed primarily in the form of *farinha*, a toasted meal, and was the most important source of calories and carbohydrates in the diet (Murrieta and Dufour, 2004; Piperata, 2005). Fish, and to a lesser extent hunted game, were the most important sources of protein, and *açai* (*Euterpe oleracea*), a local palm fruit consumed primarily in the form of a juice, was an important seasonal source of calories (Piperata, 2005). Work associated with the cultivation and processing of manioc was shared between men and women and often included the help of older children. Fishing and hunting, as well as the collection of *açai*, were primarily male activities. However, it was the women who prepared the fish and wild game and extracted the *açai* juice. Women were responsible for all housework and childcare, and it was common for female children to assist with these tasks.

While the people cultivated, fished, hunted, and collected the majority of the food they consumed, they were actively involved in and dependent upon the regional market economy. Participation in the market was primarily through the trade of *farinha* and *açai* for industrialized products such as sugar, coffee, cooking oil, salt, soap, and motor oil. This was done either by traveling to the town of Portel or by trading with boat merchants (*regatão*) who traveled between the towns and rural communities. In addition, males in some households had begun working in wage-labor jobs, further increasing their involvement in and dependence upon the market economy. The two major sources of employment in the area were the scientific field station operated by the Goeldi Museum [Estação Científica Ferreira Penna, (ECFPn)] and small-scale timber extraction operations.

Subjects

A total of 471 people between birth and 77 years participated in the study. All data collection methods were reviewed and approved by the Human Research Committee at the University of Colorado-Boulder (HRC no. 1001.2) and by similar bodies in Brazil. Data used in these analyses were collected between March and August of 2002.

Age and anthropometry

The age of all subadults was determined through interviews with the parents of the child and by using birth certificates when available. Individuals were measured in family groups to help recall ages, and most parents were easily able to recall the birthdates of their children, since birthdays were celebrated events. On three occasions there was disagreement among family members regarding a child's age, these three children were not included in the study. Adult ages were based on the individual's recall and, when available, were crosschecked with legal documents such as government-issued identification cards. Anthropometric measurements were taken at either the local schoolhouse or in individual homes. The schoolhouses had level, cement floors. When anthropometric data were collected in an individual's home, a level was used to find the most appropriate area for taking the measurements. All measurements were taken following standardized procedures (Lohman et al., 1988). Infant length (<2 years of age) was measured to the nearest 0.5 cm using a length board (SMM133-1/4 infantometer) and infant weight was measured to the nearest 100 g using a hanging spring balance (Perspectives Enterprises, model PE-HS-25). Heights and sitting heights of adults and children over 2 years were recorded to the nearest 0.1 cm using a Seca portable stadiometer. Weights were measured to nearest 0.5 kg using a Taylor spring balance. Skinfolds were measured in triplicate to the nearest 0.5 mm using Lange skinfold calipers, and circumferences were taken in duplicate to the nearest 0.1 cm using a flexible tape. Some of the anthropometric measures listed earlier were used to calculate additional anthropometric indices: body mass index (BMI) = weight (kg)/height (m^2), and upper-arm muscle area (UMA) = $[\text{circumference} - (3.1416 \times \text{triceps skinfold})]^2/12.57$). Percent body fat was estimated for the adults based on the sum of the triceps and subscapular skinfolds, using the equations of Durnin and Womersley (1974).

Household characteristics

Data on household composition and economic activities were collected through structured interviews with the male and female heads of household. In each interview, the heads of household were asked how many people currently lived in the home and their ages. If adult kin

TABLE 1. Correlations between duplicate measurements and coefficients of reliability for anthropometric dimensions

Anthropometric measure	Correlation coefficient	Coefficient of reliability
Height (cm)	1.00	0.99
Sitting height (cm)	0.99	0.99
Weight (kg)	1.00	0.99
Skinfolds (mm)		
Triceps	0.99	0.99
Subscapular	0.99	0.99
Circumferences (cm)		
Midupper arm	0.99	0.99

TABLE 2. Age and sex distribution of the sample

Age category	Males (*n*)	Females (*n*)
Infants (0–2 years)	33	38
Children (3–6 years)	37	36
Juveniles (♂ 7–11 years, ♀ 7–10 years)	35	35
Adolescents (♂ 12–17 years, ♀ 11–17 years)	40	43
Adults (18–24 years)	24	28
Adults (25–29 years)	8	19
Adults (30–39 years)	23	17
Adults (40–49 years)	15	15
Adults (50–59 years)	8	6
Older adults (60+ years)	7	4
Total	*230*	*241*

were included, the interviewees were asked to clarify if that person was a permanent resident or only temporarily staying in the home. Only those who were permanent members were included in the final household number. Households that had two adults and at least two additional members who were 15 years or older were classified as mature. Households with less than two adults and no children 15 years or older were classified as immature.

Heads of household were asked a series of questions about their economic activities, which included the following: Do you sell anything? Does anyone in the household work outside the home? What type of work? How often do they work? What percent of the year do they work?

Data analysis

Repeatability measures were completed on a subsample of 49 individuals, which included adult and subadult males and females. In all cases the anthropometric data were collected for the first time, and then a second time within 0.5 h. Correlations and coefficients of reliability were calculated following Marks et al. (1989). The repeatability results are listed in Table 1.

EPINFO (1978) was used to calculate *z*-scores for height-for-age (HAZ), weight-for-height (WHZ), and upper-arm muscle area (ZUMA), and the National Health and Nutrition Examination Surveys (NHANES I and II) reference values provided in Frisancho (1990) were used to calculate the *z*-scores for the triceps skinfold (ZTSF). HAZ and WHZ were used as indicators of long-term and short-term nutritional status (WHO, 1995), respectively. Stunting was defined as a low HAZ (*z*-score ≤ -2) and wasting as a low WHZ (*z*-score ≤ -2) (WHO, 1995). The UMA was used as an estimate of protein reserves, and a low *z*-score (≤ -2) was assumed to be indicative of malnutrition (Frisancho, 1990). The TSF was used as an indicator of body fat stores in both adults and subadults. For those anthropometric indices that were not converted to *z*-scores, low was defined as below the 5th-percentile and high was defined as above the 95th-percentile (Frisancho, 1990). BMI values were categorized as follows: <18.5 as underweight, 18.6–24.9 as normal, 25–29 as overweight, and $\geq$30 as obese (WHO, 1995). The sample was divided in age categories based on life history stages that were both biologically and socially significant. Table 2 summarizes the age and sex distribution of the sample.

Statistical analysis

A one-way ANOVA followed by the Scheffe *post-hoc* test was used to identify significant differences in anthropometry between all age groups and sexes. Independent sample *t*-tests were used to identify differences in anthropometric indices between adult males and females. Pearson's *r* was used to identify age-related changes in anthropometry. A χ^2 analysis was used to test the hypothesis that overweight and obesity among males were associated with their participation in wage labor. A multilinear regression model that considered age, sex, household size, maturity level, and participation in wage labor was used to determine the effect that participation in wage labor had on nutritional status. For all statistical tests, an α level of 0.05 was used. SPSS version 13.0 was used for all statistical analyses.

RESULTS

Anthropometry of children and comparisons across life stages

The *z*-scores for height-for-age, weight-for-age, UMA, and TSF are reported in Table 3 along with the results of the age and sex comparisons for each of these anthropometric indices.

Height-for-age. The average HAZ for males and females 1–17 years were −2.1 and −1.90, respectively. Fifty-three percent of subadult males and 50% of subadult females were classified as stunted. Figure 2a,b shows the growth of males and females from 1 to 17 years compared to the NHANES reference data. Subadult males and females fall on or below the 5th percentile for stature at all ages, except during the first year of life. While the average HAZ during the first year falls above the 5th percentile, there is a significant reduction in HAZ ($r = -0.66$, $P < 0.01$) over the first 2 years. This pattern continues throughout childhood as seen in Figure 3a, which plots average HAZ by age group. By age three, both sexes have average HAZ below −2.0, and the average remains below −2.0 for all other age groups. For males, a one-way ANOVA showed a significant ($F = 12.6$, $P \leq 0.01$) difference in HAZ scores between age groups with male infants under 1 year having significantly higher HAZ than males in all other age categories (Table 3). Females exhibited the same pattern, with female infants under 1 year having a significantly higher HAZ than females in any other age group ($F = 18.6$, $P \leq 0.01$) (Fig. 3a). No significant differences were found in HAZ between males and females in the same age category (Table 3).

Weight-for-height. The occurrence of wasting in this population was low. Only 1.7% ($n = 2$) of subadult males

TABLE 3. Comparison of mean z-scores for height-for age (HAZ), weight-for-height (WHZ), upper-arm muscle area (ZUMA), and triceps skinfold (ZTSF) between sexes and age-groups

Age group	HAZ ♂	HAZ ♀	HAZ *P*	WHZ ♂	WHZ ♀	WHZ *P*	ZUMA-age ♂	ZUMA-age ♀	ZUMA-age *P*	ZTSF ♂	ZTSF ♀	ZTSF *P*
Infant (<1 year)	−0.2 ± 1.0[a]	−0.2 ± 1.3[b]	n.s.	0.1 ± 0.9	0.0 ± 1.0	n.s	–	–	–	–	–	–
Older infants (1–2 years)	−1.9 ± 0.8	−1.8 ± 1.7	n.s.	−0.6 ± 1.1	−0.4 ± 1.0	n.s.	−0.8 ± 0.7[c]	−0.7 ± 0.8[d]	n.s.	−0.9 ± 0.6	−1.0 ± 0.5	n.s.
Children (3–6 years)	−2.4 ± 1.1	−2.2 ± 1.0	n.s.	−0.4 ± 0.8	−0.3 ± 0.8	n.s.	−0.6 ± 0.6	−0.7 ± 1.0	n.s.	−0.6 ± 0.5	−0.6 ± 0.7	n.s.
Juvenile (♂ 7–11 years, ♀ 7–10 years)	−2.1 ± 1.0	−2.0 ± 1.1	n.s.	−0.1 ± 0.8	−0.2 ± 0.9	n.s.	−0.7 ± 0.5	−0.4 ± 0.6	n.s.	−0.9 ± 0.3	−0.8 ± 0.5	n.s.
Adolescent (♂ 12–17 years, ♀ 11–17 years)	−2.2 ± 0.9	−2.1 ± 0.9	n.s.	0.0 ± 0.6	0.2 ± 0.8	n.s.	−1.0 ± 0.5	−0.3 ± 0.7	0.01	−0.7 ± 0.2	−0.7 ± 0.7	n.s.
Adults (18+)	−2.3 ± 1.0	−2.5 ± 0.8	n.s.	0.0 ± 1.3	−0.4 ± 1.1	n.s.	0.2 ± 0.9	0.7 ± 0.9	< 0.01	−0.9 ± 0.5	−1.2 ± 0.6	< 0.01

One-way ANOVA with Sheffe multi-comparison test. *P*-values represent sex differences by age category.
[a] Significant difference in HAZ between boys in the six age categories with infant males having significantly higher HAZ than males in any other age category ($P \leq 0.01$).
[b] Significant difference in HAZ between females in the six age categories with infant females having significantly higher HAZ than females in any other age category ($P \leq 0.01$).
[c] Significant difference in ZUMA between males in the six age categories with adult males having significantly higher ZUMA than adolescent, juvenile, and male children ($P \leq 0.01$).
[d] Significant difference in ZUMA between females in the six age categories with adult females having significantly higher ZUMA than all other females ($P \leq 0.01$).

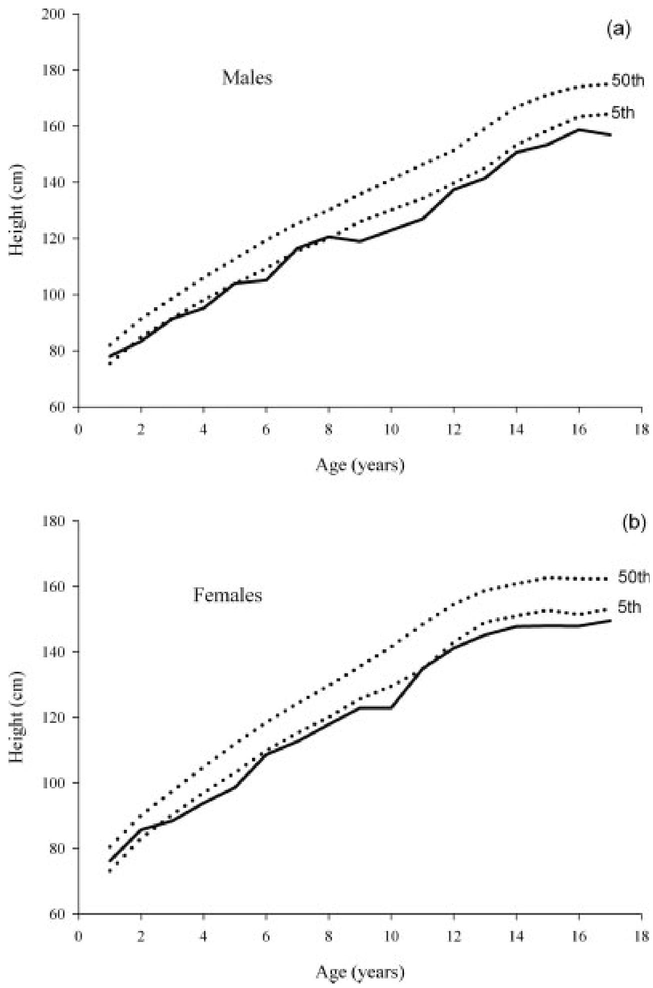

Fig. 2. Stature of males (**a**) and females (**b**) ages 1–17 compared to NHANES reference data.

and 2.2% ($n = 2$) of subadult females were considered wasted. In terms of age categories, all wasted individuals fell between 1 and 5 years (older infants and children). Figure 3b plots the mean WHZ by age for males and females. Averages for all age groups fell between −1 and 1. No significant differences were found in WHZ between age categories or sexes (Table 3).

Upper-arm muscle area. Figure 3c shows the ZUMA for males and females in each age category. While females show a steady rise in ZUMA from infancy to adulthood, males show an increase through the juvenile stage, a decline in adolescence, and then an increase in adulthood. Significant differences were found between age categories, with adult males having a significantly higher average ZUMA than male children, juveniles and adolescents ($P \leq 0.01$), and adult females having a significantly higher average ZUMA than females in any other age category (Table 3). Finally, significant differences were also found between male and female adolescents and adults with females having significantly higher ZUMA averages than their male counterparts ($P \leq 0.01$).

Body fat. Figure 3d plots the ZTSF of males and females by age group. For all ages, average *z*-scores fell between 0 and −1.0, except for the adult females who aver-

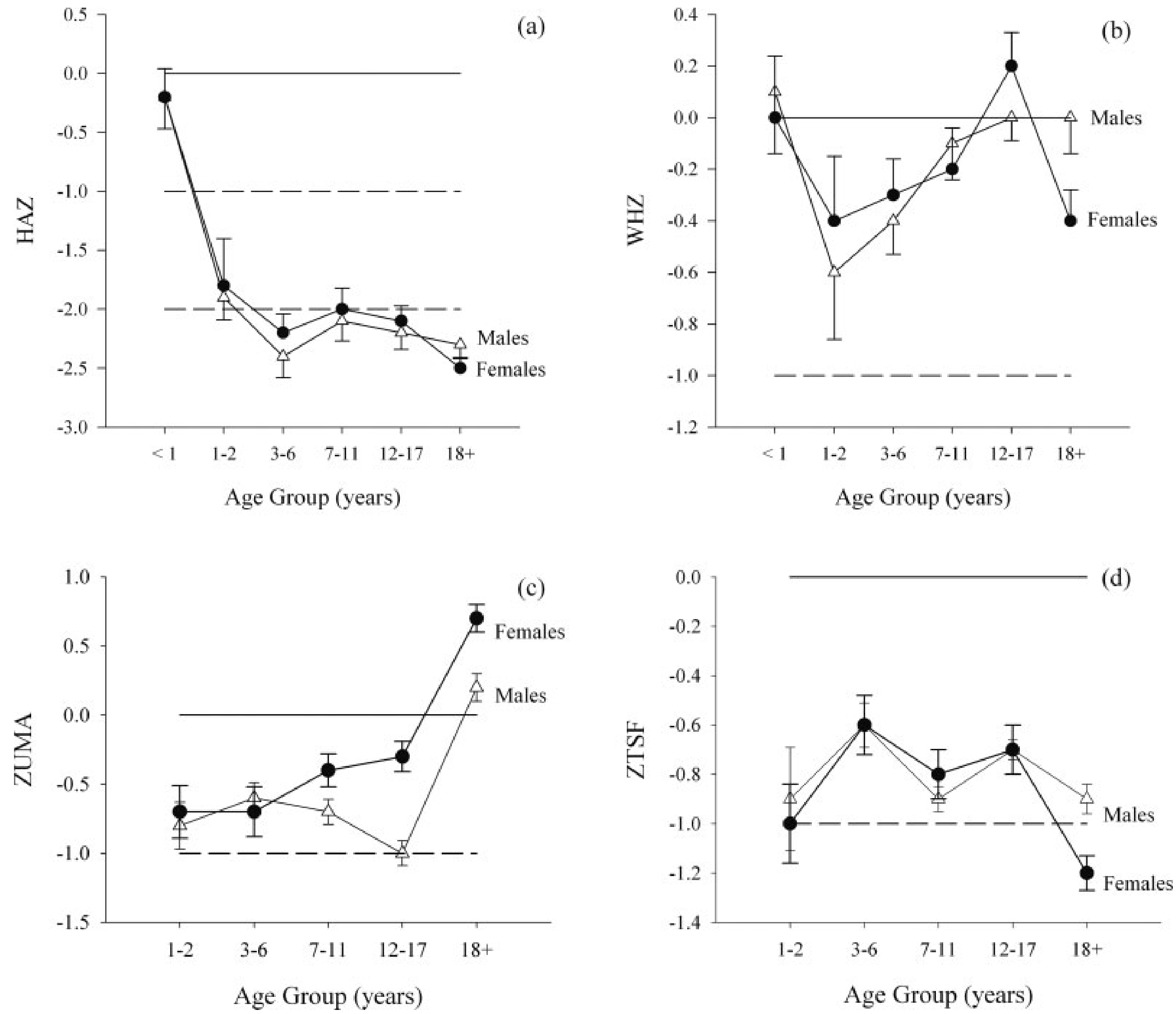

Fig. 3. *Z*-scores (**a:** HAZ, **b:** WHZ, **c:** ZUMA, **d:** ZTSF) for males and females by age group.

aged −1.2. Significant differences in ZTSF were only found between adult males and females (Table 3).

Anthropometry of adults

Height. The average HAZ for adult males and females were −2.3 ± 1.0 and −2.5 ± 0.8, respectively (Table 3). Sixty percent of adult males and 70% of adult females were considered stunted. There were no significant differences in HAZ between adult men and women in this population ($t = 1.5$, $P = 0.14$) (Table 3). Despite the high degree of stunting among adults, the difference in male and female stature was large, and males were on average 13.7 cm taller than females, with a male/female height ratio of 1.09. Table 4 reports data on stature, sitting height, and subischial length (SIL) of adult men and women by age cohort. The SIL was used to identify secular change in adult stature, to control for the effects of compression of the spinal column that comes with age. An ANOVA of SIL by age cohort among adults showed no positive secular changes in stature in either males ($F = 0.6$, $P = 0.6$) or females ($F = 0.1$, $P = 0.9$).

Body mass index. Figure 4a,b shows the BMI of adult men and women compared to the NHANES percentiles. Males in their late teens and early 20s maintained a BMI close to the 50th percentile. After this point there was a drop, and males between 25 and 39 had average BMIs closer to the 25th percentile. There was a substantial increase in BMI among 40–44-year-old males who averaged above the 50th percentile. As age increased beyond 44, there was a steady decline and, at older ages, the averages hovered closer to the 25th percentile. Fifty-eight percent of all adult males had normal BMIs, 26% were overweight, 5% were considered obese, and 11% were underweight.

Females maintained a BMI above the 50th percentile until age 29, then there was a decline between the 25th and 50th percentile for women between 30 and 34 years (Fig. 4b). Beginning at age 35 there was a steady increase in average BMI, and women in their 40s had

TABLE 4. Adult height, sitting height, and subischial length by sex and age cohort

		Age		Stature (cm)		Sitting height (cm)		Subischial length (height – sitting height) (cm)	
Age Group	*n*	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Men									
≤35	49	25.6	5.6	161.6	6.4	83.9	3.5	77.7	4.6
36–45	11	40.5	2.6	161.4	6.8	84.4	4.9	77.0	4.3
46–55	15	49.9	3.6	159.0	8.9	81.9	4.0	77.1	6.5
56–65	5	61.6	2.6	154.0	6.5	79.3	3.8	74.7	3.6
<65	3	70.0	6.1	156.1	5.1	79.8	4.3	76.3	1.7
Total	*83*	*35.8*	*14.3*	*160.4*	*7.1*	*83.2*	*4.0*	*77.3*	*4.8*
Women									
≤35	54	24.5	4.8	147.4	4.5	78.8	2.8	68.6	3.4
36–45	19	40.1	3.2	145.5	8.5	77.1	3.1	68.4	7.7
46–55	6	49.3	3.2	144.0	3.3	76.0	3.0	68.0	4.4
56–65	9	59.7	3.1	145.6	4.9	76.0	2.5	69.6	2.8
<65	1	66	–	141.7	–	73.5	–	68.2	–
Total	*87*	*32.9*	*12.8*	*146.5*	*5.6*	*77.9*	*3.1*	*68.6*	*4.6*

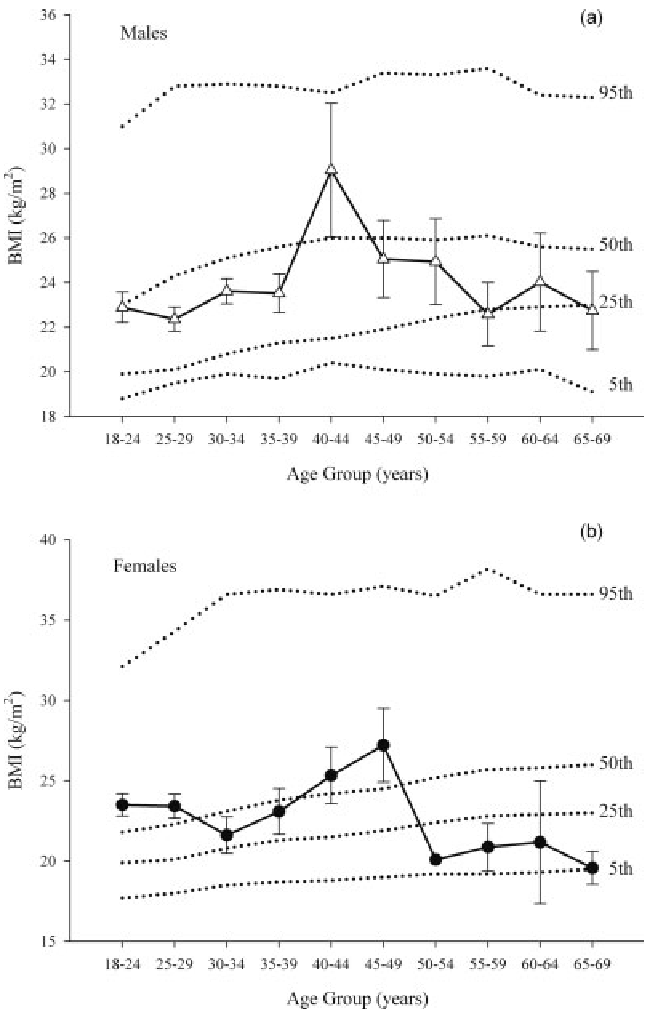

Fig. 4. BMI of adult males (**a**) and females (**b**) compared to the NHANES reference data.

averages that exceeded the 50th percentile. After age 44 there was a sharp decline, and average BMI values fell between the 5th and 25th percentiles. Sixty percent of adult women had normal BMIs, 22% were considered overweight, 7% were considered obese, and 10% were underweight. When all age categories were combined, there were no significant differences in BMI between adult males and females in this population ($t = 0.74$, $P = 0.46$).

Upper-arm muscle area. Adult males had significantly greater UMA values than adult females ($t = 10.2$, $P < 0.01$). However, once converted to *z*-scores females have higher overall ZUMA averages in all age groups ($F = 3.9$, $P < 0.01$), with the exception of the 50–54-year-old group, compared to males.

Body fat. The average percent body fat for adult males and females were 14.7% and 24.8%, respectively. Females had significantly higher amounts of body fat than males ($t = 11.5$, $P < 0.01$), and both males and females showed a significant increase in body fat with age ($r = 0.52$, $P < 0.01$ and $r = 0.24$, $P = 0.02$, respectively).

Household characteristics and nutritional status

Economic interviews were conducted with the heads of 85 households. The average household size for the seven communities combined was nine, and ranged between 3 and 15. Of the 85 households, 47 (55%) were considered mature and 38 (45%) were considered immature. When asked if they sold anything, 100% of the household heads responded "yes" and all mentioned *farinha* as the most important and frequently sold item. *Açai* was also mentioned and was sold seasonally by ~20% of the households. Other less frequently mentioned items included beans, watermelon, Brazil nuts, bananas, honey, and hand-woven baskets. While all households sold things, there was a great deal of variation in the amount they sold, and many heads of household had difficulty accurately recalling the frequency and quantity of items sold. In addition, since they usually did not receive money but rather trade credit, it was not possible to quantify how much a household actually earned. Owing to the universality of market participation and the inability to quantify sales, this variable was not included in the multiple linear regression model.

Eighty-one of the 85 adult males (95%) interviewed were able to provide data on their wage-labor activities. Of these 81 males, 64 (79%) were considered heads of household. The remaining 17 (21%) were adult males still living at home with their parents. The amount of

TABLE 5. Anthropometry of the 81 adult males by wage labor status

	Wage labor, Mean ± SD (n = 25)	No wage labor, Mean ± SD (n = 56)	t-test
Age (years)	35.0 ± 15.0	38.1 ± 12.5	$t = 1.0, P = 0.34$
Height (cm)	162.8 ± 7.0	160.0 ± 6.3	$t = 1.8, P = 0.08$
Weight (kg)	71.3 ± 13.5	57.1 ± 7.2	$t = 4.9, P < 0.01$
BMI (kg/m^2)	26.9 ± 5.0	22.3 ± 2.4	$t = 4.4, P < 0.01$
UMA (cm^2)	64.8 ± 11.3	52.2 ± 9.5	$t = 5.2, P < 0.01$
Percent body fat	20.2 ± 6.4	14.1 ± 3.9	$t = 4.4, P < 0.01$

BMI, body mass index; UMA, upper arm muscle area.

time men spent as wage laborers was highly variable. For example, when asked if he worked outside the home one man responded yes. He explained that several months ago he had worked for 6 days on a commercial fishing boat and received part of the catch as his salary. A second man who also responded yes had been working at the ECFPn for the last 3 years, worked 6 days a week, was employed year-round and received a monthly check. In this study, participation in wage labor was defined as working outside the home on a consistent basis for at least 4 months of the year. Based on this definition, 25 (31%) of the 81 adult males were employed in wage-labor jobs. Table 5 reports the anthropometric characteristics of these 81 adult males. Men who participated in wage labor had significantly higher weight ($t = 4.9$, $P < 0.01$), BMI ($t = 4.4$, $P < 0.01$), UMA ($t = 5.2$, $P < 0.01$) and percent body fat ($t = 4.4$, $P < 0.01$) than those who did not participate in wage-labor activities. They were also more likely to be overweight and obese ($\chi^2 = 27.9$, $P < 0.01$) than nonwage laborers.

In addition to looking at the effects that direct participation in wage labor had on adult males, I was also interested in seeing how their participation in wage labor affected the nutritional status of other members of their households. A multiregression model that considered both age and sex was used to determine the relative importance household size, participation in wage labor, and household maturity status had in explaining variation in height, BMI, UMA, and upper-arm fat area in both adults and subadults in this population. The results of the regression analysis are reported in Table 6. Household size and maturity level did not explain a significant amount of the variation in any of the anthropometric variables for the subadults or the adults. However, the participation of an adult male in the household in wage labor was significantly related to an increase in subadult BMI and UMA values. Participation in wage labor did not explain a significant amount of the variation in any of the anthropometric variables of other adult members in their households.

DISCUSSION

Childhood and adult anthropometry

Both adults and subadults in this population show a high degree of stunting and low incidence of wasting, indicating long-term nutritional stress or poor health during the period of growth and development or both (WHO, 1995). UMA and skinfolds of both subadults and adults fell within the normal range when compared to international standards, indicating that they are not under severe energy or protein stress (Frisancho, 1990). This pattern is consistent with that found among other Latin American populations (Victora, 1992; Deonis et al., 1993; Martorell et al., 1998; Uauy et al., 2001), as well as among other Amazonian groups (Guigliano et al., 1981, 1984; Hodges and Dufour, 1991; Martins and Menezes, 1994; Santos and Coimbra, 1996; Murrieta et al., 1998; Alencar et al., 1999; Capelli and Koifman, 2001; Lopes Barboza Ribas et al., 2001; Orr et al., 2001; Foster et al., 2005).

Long-term nutritional status. While other studies have reported stunting, the high degree of stunting in this population was only seen among some of the populations cited earlier. Giugliano et al. (1981, 1984) noted a similar degree of stunting among populations of *Ribeirinho* children and their mothers living along the Rio Solimões and Rio Negro, respectively, and Orr et al. (2001) found a high degree of stunting among adult and subadult Tukanoans but not among the Achuar. Tsimanè (Foster et al., 2005), Shipibo (Hodges and Dufour, 1991), and Parakanã (Martins and Menezes, 1994) children also showed a similar degree of stunting to that found among children in this current study.

Stinson (1996), in a comparison of Chachi Amerindians and Afro-Ecuadorians living in a similar environment, suggested that the greater degree of stunting among the Chachi might be due, in part, to genetic differences between the two populations. Based on these data, we should expect *Ribeirinho* populations to show a lesser degree of stunting than indigenous Amazonian groups living in similar environments, since *Ribeirinhos* are of mixed ancestry. This was not the case, and the current data suggest that environmental factors are playing an important role. The average HAZ for infants under 1 year was in the normal range compared to the international standard, and declined with time indicating that they were not born short. The decline in HAZ during the period of growth and development, also found in other Amazonian populations (Hodges and Dufour, 1991; Stinson, 1996), supports the idea that environmental conditions are affecting growth in this population. The fact that young infants had significantly higher HAZ than all other age categories may be indicative of the protective role of breastfeeding, which in this population, lasted for an average of 14.2 months (Piperata, 2005). While the timing of the introduction of additional foods was highly variable, by 6-months, most infants were receiving foods other than breast milk, albeit in small amounts. The most common supplemental food was *mingau* (gruel made of either rice, wheat, or manioc starch mixed with water and sugar and, when available, powdered milk). By 1 year of age, children began eating adult foods such as fish soup and *farinha*, but the majority of what they consumed, other than breastmilk, was *farinha*, which is both bulky and, when combined with a diet low in fat, may lead to insufficient dietary intakes

TABLE 6. Regression model for role of household size, maturity level, and wage labor on nutritional status of subadults and adults

Model	Unstandardized coefficient, β	Standardized coefficient, β	*t*-statistic	*P*-value
Height (cm)				
Subadults ($F = 407.04$, $P < 0.01$; $r^2 = 0.91$)				
Constant	76.677		37.977	<0.01
Age	4.882	0.954	41.884	<0.01
Sex	−1.298	−0.031	−1.446	0.150
Household size	−0.157	0.244	−0.643	0.521
Maturity	0.287	0.007	0.225	0.882
Labor	−0.633	−0.019	−0.666	0.506
BMI (kg/m^2)				
Subadults ($F = 44.6$, $P < 0.01$; $r^2 = 0.52$)				
Constant	11.92		18.6	<0.01
Age	0.452	0.661	12.7	<0.01
Sex	0.629	0.112	2.3	0.02
Household size	−0.047	−0.042	−0.63	0.53
Maturity	0.774	0.136	2.0	0.05
Labor	0.873	0.150	3.0	<0.01
Adults ($F = 1.4$, $P = 0.23$; $r^2 = 0.04$)				
Constant	22.054		14.883	<0.01
Age	0.001	.004	0.054	0.957
Sex	−0.600	−0.073	−0.904	0.368
Household size	0.139	0.105	0.950	0.344
Maturity	0.593	0.071	0.644	0.521
Labor	1.129	0.135	1.638	0.103
UMA				
Subadults ($F = 80.9$, $P < 0.01$, $r^2 = 0.76$)				
Constant	5.720		3.361	<0.01
Age	1.724	0.844	17.78	<0.01
Sex	−1.171	−0.068	−1.511	0.133
Household size	−0.010	−0.003	−0.051	0.960
Maturity	1.268	0.071	1.120	0.265
Labor	1.918	0.111	2.413	0.017
Adults ($F = 18.071$, $P < 0.01$; $r^2 = 0.46$)				
Constant	52.841		10.971	<0.01
Age	−0.011	−0.011	−0.149	0.881
Sex	−17.635	−0.651	−8.904	<0.01
Household size	0.519	0.121	1.092	0.277
Maturity	−1.498	−0.054	−0.503	0.616
Labor	3.544	0.131	1.764	0.081
UFA				
Subadults ($F = 15.23$, $P < 0.01$; $r^2 = 0.37$)				
Constant	1.757		1.109	0.269
Age	0.519	0.440	5.750	<0.01
Sex	3.558	0.358	4.934	<0.01
Household size	−0.201	−0.108	−1.112	0.268
Maturity	1.104	0.107	1.049	0.296
Labor	1.072	0.107	1.450	0.149
Adults ($F = 4.418$, $P < 0.01$; $r^2 = 0.17$)				
Constant	7.290		1.974	0.051
Age	0.017	0.027	0.289	0.773
Sex	6.380	0.380	4.201	<0.01
Household size	−0.072	−0.027	−0.197	0.844
Maturity	2.899	0.170	1.271	0.207
Labor	1.449	0.087	0.941	0.349

and growth in children (Dufour, 1992; Uauy et al., 2000). Micronutrient deficiencies may also be playing a role (Allen, 1993), as the diet consisted primarily of *farinha* and fish, and was relatively low in fruits and vegetables, except during the *açai* season when large quantities of this one fruit were consumed.

The continued decline in HAZ scores in 1–6-year-olds is most likely due to the dietary characteristics discussed earlier and an increased parasite burden due to greater interaction with the external environment. Data on parasite loads collected in one of the seven communities indicated a high prevalence of parasitic infection with many individuals (43%) carrying more than one species of parasite (Silva, 2003). Sanitary conditions in these communities were poor. Few people treated the water (either by boiling it or using chlorine), and most people drank water directly from the river where they also washed clothes, dumped trash, bathed and urinated, and children commonly walked barefoot. Of the types of illnesses most often observed in this population, diarrhea and general respiratory infections were the most common and often went untreated, as did parasitic infections, because of very limited access to health care in all communities. Finally, comparisons among adult age-cohorts showed no sign of a positive secular trend indicating that nutritional/health conditions have not changed significantly over the past few generations. In conclusion, the combination of insufficient energy intake, especially for children, poor sanitary conditions, and untreated parasitic, intestinal, and respiratory infections may be the major contributors to the high degree of stunting in this population. Studies on the dietary intakes of Amazonian children are lacking and will be necessary for improving our understanding of the observed growth patterns.

Short-term nutritional status. While this population exhibited a high degree of stunting, the incidence of underweight among adults and subadults was low and similar to other Amazonian populations (Murrieta et al., 1998; Alencar et al., 1999; Capelli and Koifman, 2001; Orr et al., 2001; Foster et al., 2005). It is worth noting that the lowest WHZ average is among 1–2-year-olds, which is the age when children in this population are weaned.

The majority of adult men and women had BMI values that fell into the normal, overweight, or obese ranges. The highest BMI values were among men and women in their 40s. This pattern may be related to a number of factors. Most adults in this age range were still active in subsistence activities, but also had the help of their grown and teenage children in both subsistence work and other household related tasks (cooking, cleaning, childcare). These households were often wealthier than younger households and were often well-established, long-time residents with extensive kinship networks. Additionally, males in these households often participated in wage labor, which will be discussed in greater detail later. Finally, most women in this age category were in their postreproductive years and, thus, did not have the extra energetic burden of pregnancy and lactation.

A decline in BMI occurred in the older age categories, and underweight status was more common among older individuals. This decline (women above age 50 and men above age 60) may be due to the fact that older individuals remained fairly active in subsistence activities, but were often not prioritized at meal times, especially in large households. It was also common to see older people, especially grandmothers, sharing their food with their grandchildren or only snacking at mealtimes rather than sitting down and eating a full meal.

The average *z*-scores for the ZTSF was below 0 for all age groups, indicating that these *Ribeirinho* people were leaner than the international reference population. Average *z*-scores for the ZUMA were below 0 for all subadult age categories; however, adults had values above 0 and adult females had the highest ZUMA. Compared with Tsimanè (Foster et al., 2005), Achuar, and Tukanoan children (Orr et al., 2001), *Ribeirinho* children had less upper-arm muscle mass. The high ZUMA values among adults are most likely due to the greater physical activity levels associated with subsistence work compared with the more sedentary reference population.

Impact of household characteristics on subadult and adult anthropometry

While household size and maturity did not explain a significant amount of the variation in subadult and adult anthropometry, the participation of a male household member in wage labor did have an affect on nutritional status. Males who participated in wage labor had significantly higher weights, BMI, and UMA values and were more likely to be overweight and obese than their nonwage laborer counterparts. Men eagerly sought the few wage-labor opportunities available in their local communities, which they associated with an easier and more modern life and the income necessary to purchase high status items such as clothing, shoes, radios, and household furnishings. In addition, the available wage-labor jobs gave men a totally different work experience, and many noted the greater variety of tasks and the enjoyment of working in male work groups.

Most of the full-time jobs at the ECFPn in the Caxiuanã National Forest were less physically demanding than subsistence work, and included activities such as grounds keeping, laundry, cooking, and serving as motor boat drivers and field assistants for visiting researchers. Jobs in timber extraction were typically more physically demanding than those at the Scientific Station, and included clearing forests, cutting trees, and operating the heavy equipment used to remove the cut timber. Operating heavy equipment is less energetically demanding than other timber-related jobs and was held by more mature workers, typically those in their 30s–40s. Jobs at the Scientific Station and the timber camps provided the workers with food, which consisted of *farinha,* rice, pasta, beans, dried/salted and canned fatty meats, as well as fresh fish and chicken. At the Scientific Station, men typically ate breakfast and lunch. Meals were served buffet style, and men were allowed to eat as much as they liked. At the timber camps, men were required to spend periods of time, sometimes up to a month, away from home. They were fed three meals a day. In some cases, the costs of these meals were deducted from their salaries. In summary, wage-labor jobs tended to be less physically demanding than subsistence-related tasks. Food consumption, by wage laborers, both in terms of the amount and type of foods, differed dramatically from what was experienced in the household. Therefore, it appears that the combination of lower energy expenditure and especially the higher consumption of energy dense food had a direct effect on the nutritional status of the male wage laborers.

While children of wage laborers had higher BMI and UMA values than those of nonwage laborers, the participation of a male in wage labor did not explain a significant amount of the variation in the nutritional status of their wives or other adult household members. In many cases, despite their husbands' participation in wage labor, female heads of household continued to work in subsistence activities, in order to feed themselves and their children and did so without the labor input of their spouses. This was also the case for other adult members in the household.

The improved nutritional status of their children is more difficult to explain. Workers at the Scientific Station earned approximately US $110 a month, which was above the Brazilian minimum wage and a high salary for the area. Upon receiving their check they would travel to Portel to cash it and would spend most of the money immediately. This meant that for $\sim$1 week after their return there would typically be a lot of purchased food in the household and everyone would eat well. After this first week, food supplies would dwindle and the households would become more and more dependent on their own subsistence activities for food. This same pattern was seen among timber workers, although they received their salaries on a more irregular basis and in some cases never received cash, but rather food items from the timber company's store. As purchased food supplies declined, women spent more time in subsistence work in order to feed their families. Owing to the absence of their spouses, many of these women struggled to meet their household's subsistence needs. When a household experienced a food shortage, women prioritized their children at meal times and in doing so women often ate small amounts or skipped a meal altogether. Therefore, children may have benefited more from their father's salaries than their mothers.

Evidence of the nutrition transition

Since many groups in Brazil are in the midst of a nutrition transition it is useful to ask if the rural *Ribeirinho* groups of this study are part of that transition as well. The prevalence of obesity among adult males in the study population was similar to that found in the 1989 Brazilian national survey (4.8%), an increase of 190% over the 1974/75 survey (Sichieri et al., 1994). However, the rate of obesity of women in this current study (7%) was lower than that of Brazilian women in the 1989 survey (11.7%) and closer to the rate found in 1974/75 (6.9%) (Sichieri et al., 1994). This male/female difference is unusual; the common pattern in Brazil and elsewhere is for higher rates of overweight/obesity among women (Sichieri et al., 1994; Florêncio et al., 2001; Uauy et al., 2001; Batista Filho and Rissin, 2003; Kain et al., 2003). In the current study, this seems to be related to the work environment of adult males, which was not shared with other household members.

Based on data from the 1989 Brazilian national survey, the rate of childhood overweight/obesity was 4.6% (Monteiro et al., 1995), which is similar to the rate seen in this study. This is the same value (4.6%) obtained from the 1974 survey, indicating no increase in childhood obesity between 1974 and 1989.

According to Popkin (2001), a reduction in active play and more time spent watching television is associated with obesity rates in children. Only two communities had televisions, and they only functioned sporadically based on the availability of electricity derived from a generator in one community and solar panels in the other. Children in all communities spent a lot of time in active play. However, during the last month of field research in 2004, one community received a large generator capable of providing electricity to all 11 households. The effect of this new source of energy on the activity patterns of all community members remains to be seen.

With the increases in adult body weight in Brazil, the prevalence of stunting between 1975 and 1989 in urban areas in Northern Brazil declined from 39% to 23% (Batista Filho and Rissin, 2003). The current prevalence of stunting in urban areas of northern Brazil is in sharp contrast to the high level found in the rural *Ribeirinho* groups studied (60–70%).

Overall, this population is showing some signs of a nutrition transition. Obesity rates, especially among adult males, are close to the recent national average and are related to changes in dietary and activity patterns associated with wage labor. However, the effects of this change in subsistence pattern are not as marked in other household members, since the changes in dietary and activity patterns are experienced mostly by the males. The high degree of stunting among all age groups in this population is of concern, as it indicates a suboptimal environment during the period of growth and development. These conditions may predispose individuals to long-term health problems in adulthood, especially as people from these communities alter their dietary and activity patterns as they become further integrated into the market economy.

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