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.

INTRODUCTION – (1/3): Life of *Ribeirinhos* in rural Amazon

Image of rural Amazon: "traditional", "Indigenous", "remote", "dense forest"

In reality,

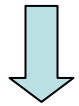
1. Majority of inhabitants
   = mixed ethnicity (*Ribeirinhos= Indigenous + European +African)*

2. Increasing number of *Riberirinhos* inhabited in urban environment, have access to regional markets, and play a major role in the development of the region.

INTRODUCTION – (2/3): Subsistence change, nutritional transition and their biological effects

Transition

Diet： Indigenous → Industrial products
Activity: Subsistence-based to waged labor



Nutritional Transition (Popkin, 2001)
e.g., obesity and associated health issues

Q. At what point along the transition do we see the biological effects of these lifestyle change?

INTRODUCTION – (3/3): Subsistence change, nutritional transition and their biological effects

On the basis of data for growth and nutritional status of 7 *Ribeirinhos* communities,

Goals are to clarify:

1. Ecology of health of *Riberirinhos* (the majority of inhabitants in the region, very little is known).
2. How their involvement in the market economy is affecting their nutritional status and to determine if they are showing sings of nutritional transition.

Seven communities of *Ribeirinhos*

8-10 h by small motorboats from Portel (town), 2 days by larger boat from Belem (the state capital).

No electricity
No running water
A few pit toilets

Home: palm fronds, ceramic tile or industrialized materials (*Brazilite*)

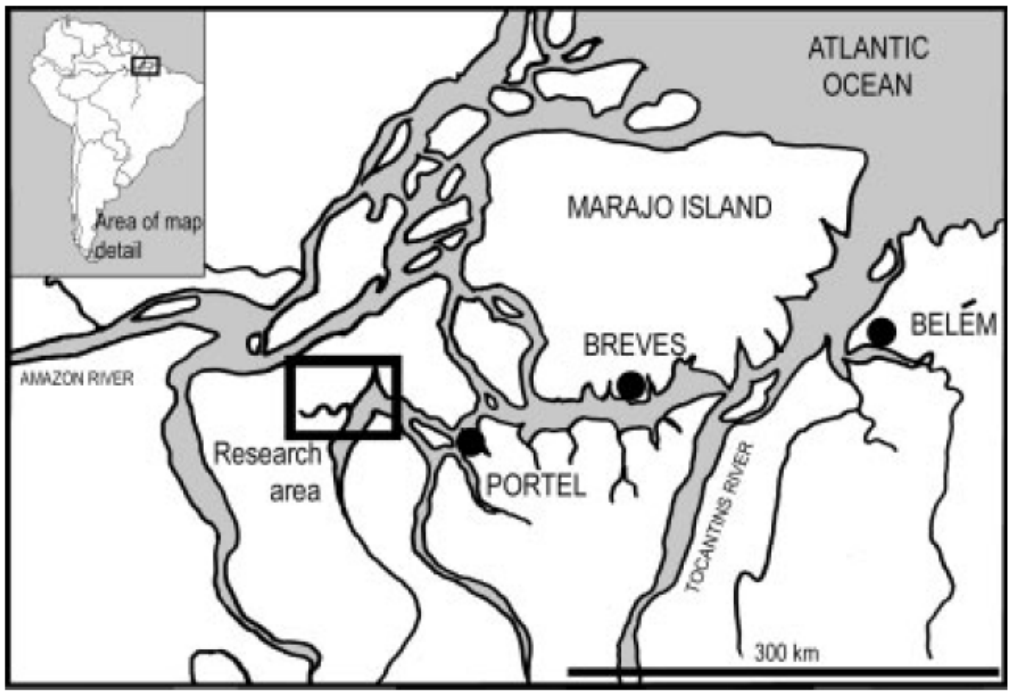


Fig. 1. Map of the field site.

Black-water system (=low productivity)]

Subsistence:

1. Slush and burn agriculture with bitter manioc (*farinha*)
2. Fish, hunted game, Açaí (*Euterpeoleracea)*

1, 2: Male and female

2. Male

Housework and childcare: female

http://www.udr.org.br/frutas16b.jpg

Regional market economy:

Trade of manioc (*farinha*) and Açaí for sugar, coffee cokking oil, salt, soap, and motor oil.

Portel,
Boat merchants

Waged labors in scientific field station or small-scale timber extraction operations

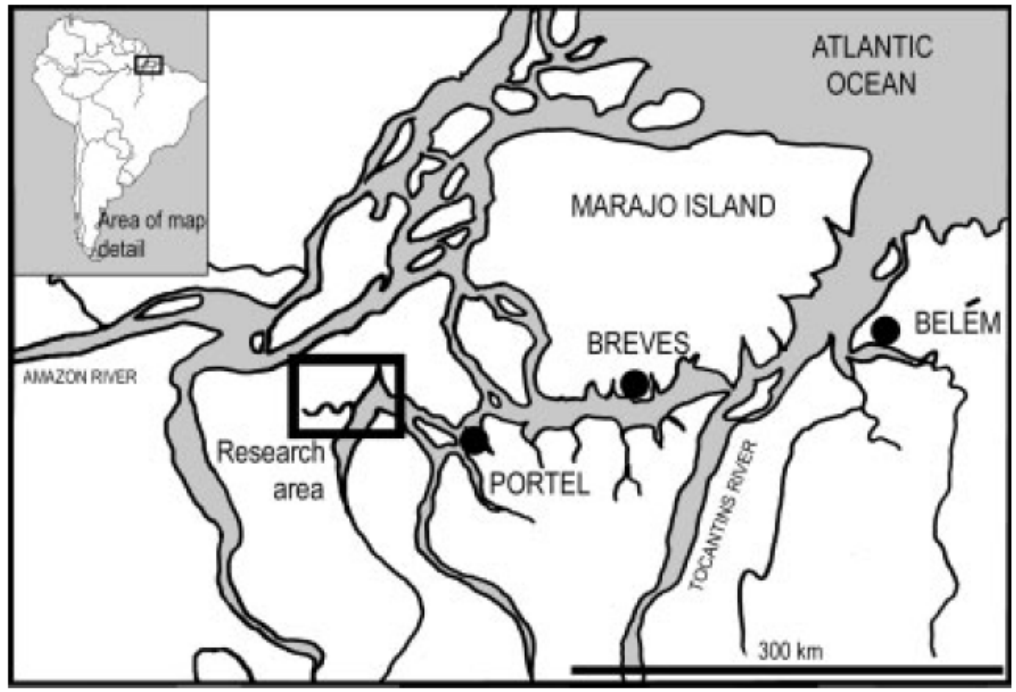


Fig. 1. Map of the field site.

Subjects: n=471, 0-77 years of age

Fieldwork: March-August, 2002

Age estimation:

Children: recall by family members + birth certificate (3 cases of disagreements among family members → excluded)

Adults: recall by an individual + legal documents

Anthropometry measurements:

Standardized procedures (Lohman et al., 1988)

UMA (upper-arm muscle area)

$=[\text{circumference} - (3.1416 \times \text{triceps skinfold})]^2/12.57$

Durnin and Womersley (1974)

Materials and Methods, Household characteristics (1/2, 2/2)

Data on household composition and economic activities:

- structured interviews with the male and female heads of HH

  - How many members? (permanent members)
  - How old?

"Mature" household = two or more adults (18+) + (or?) two or more children (15+)
"Immature" household = less than two adults + (or?) no children (15+)

  - Do you sell anything?
  - Does anyone in the household work outside the home?
  - What type of work? How often?
  - What % of the year do they work?

Materials and Methods, Data Analysis (1/2)

Repeatability measures for 49 individuals (within 0.5 h interval btw two measurements)

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

different times (4). Reliability can also be expressed as

$$R = \frac{s^2 - S_r^2}{s^2}$$

where s^2 is the sample or interindividual variance and S_r^2 is the intrasubject (unreliability) variance (7, 17) which corresponds to the "true test unit" reliability of Haggard (5) with one replicate measure and no statistical interactions between the differences in the measurement replicates and the replicate means. It is equivalent to

Marks et al (1989) AJE, 130:578-87.

Materials and Methods, Data Analysis (2/2)

EPINFO

Z-scores for height-for-age, weight-for-height, upper-arm muscle area (UMA)

NHANES I & II (Frisancho, 1990)

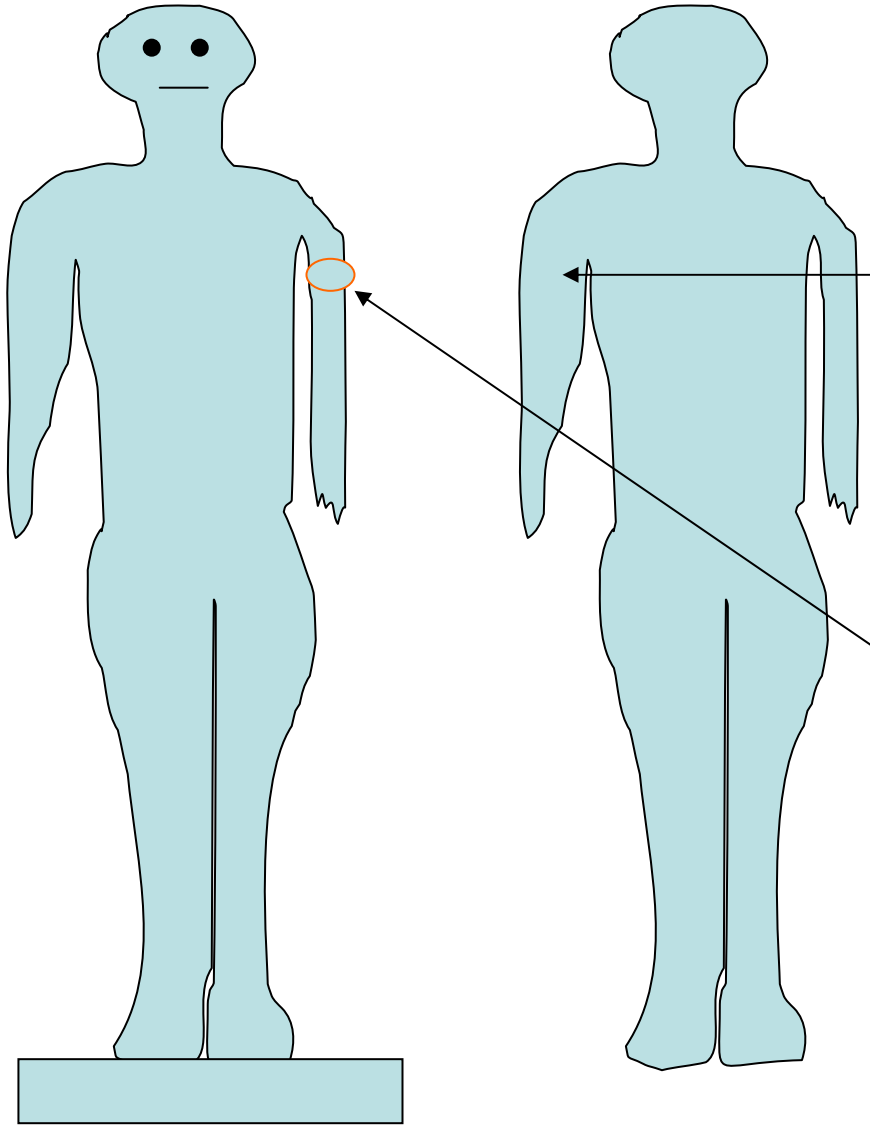
Z-scores for triceps skinfold (TSF).

HAZ < -2SD ---- long-term nutritional status (stunting)
WAZ < -2SD ---- short-term nutritional status (wasting)
UMA --- an estimate of protein reserves, <-2SD: malnutrition
TSF --- an indicator of body fat stores.
BMI<18.5 (underweight), 18.6-24.9, 25-29.9 (overweight), 30<BMI (Obesity)

(WHO, 1995)

For your memory

Height
Long-term
Stunting



Triceps skinfold

Body fat stores

Upper-arm circumference
Protein reserve, malnutrition

Body weight short-term nutritional status, wasting

Materials and Methods, Data Analysis (2/2)

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*

ANOVA (+ Sheffe post-hoc test)

Y: anthropometry indices (continuous)
X: age group, sex （categorical)

T-test

Y: anthropometry indices (continuous)
X: adult males or adult female（categorical)

Pearson's *r* coefficient

Y: anthropometry indices (continuous)
X: Age (continuous)

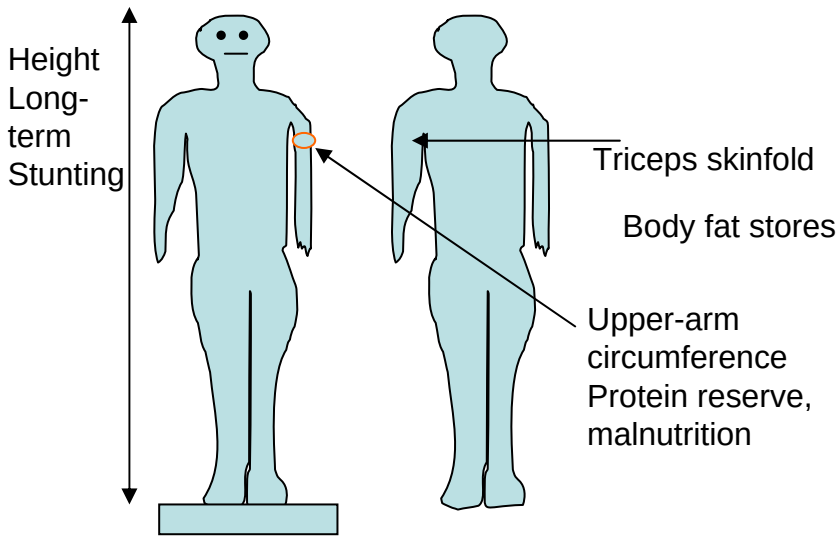
Chi-square test

Y: Obesity or overweight (categorical)
X: participation to wage labor (categorical)

Multilinear regression model: Y=nutritional status

Results（1）

Anthropometry of children and comparisons across life stages



Body weight short-term nutritional status, wasting

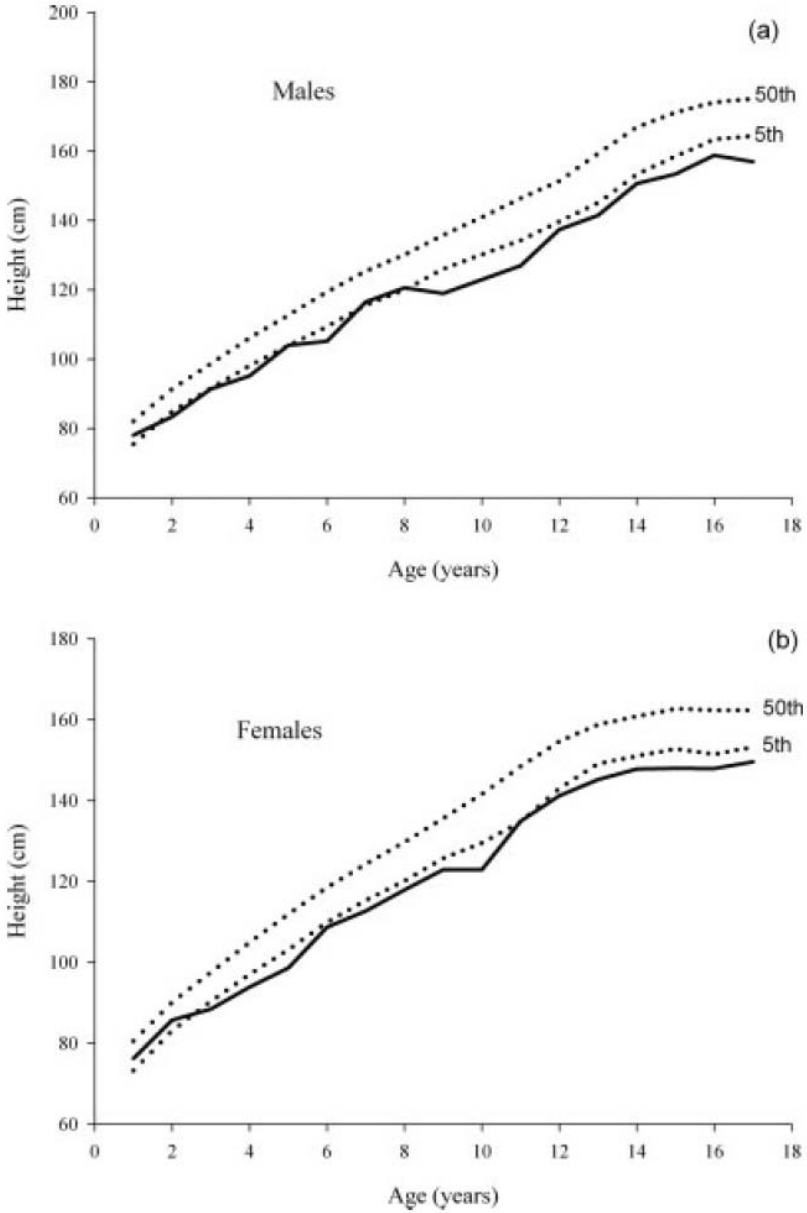


Fig. 2. Stature of males (**a**) and females (**b**) ages 1–17 compared to NHANES reference data.

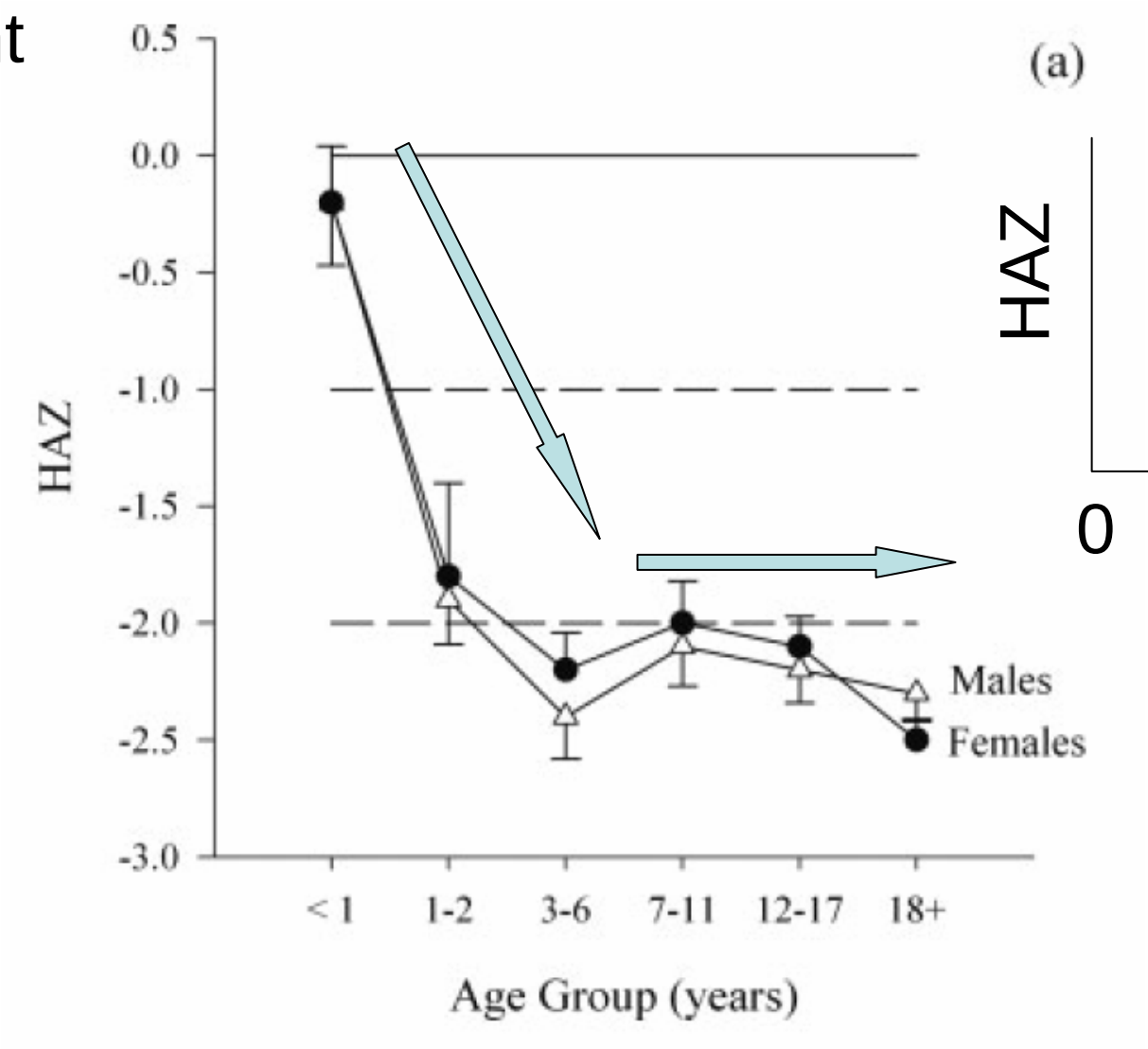
Height

HAZ (1-17y)
= -2.1 (male)
= -1.9 (female)

53% (male)=stunted
50% (female)=stunted

Below 5th%tile except the period of infant

Height



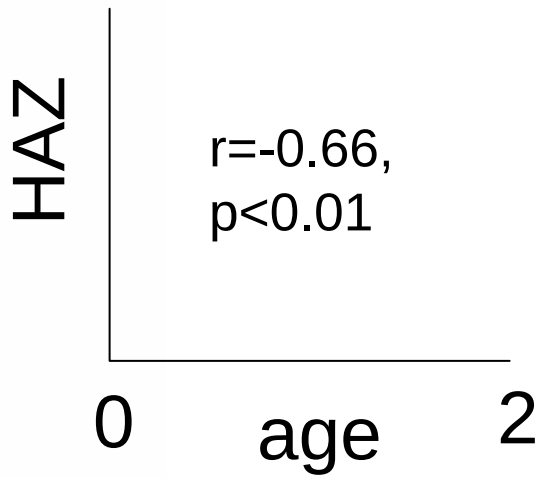


Fig. 3. Z-scores (a: HAZ, b: WHZ, c: ZUMA, d: ZTSF) for males and females by age group.

Results, Anthropometry of children and adults (1/5): Height-for-age

Table 3. Comparison of mean z-scores for HAZ, WHZ, ZUMA, and ZTSF between sexes and age-groups

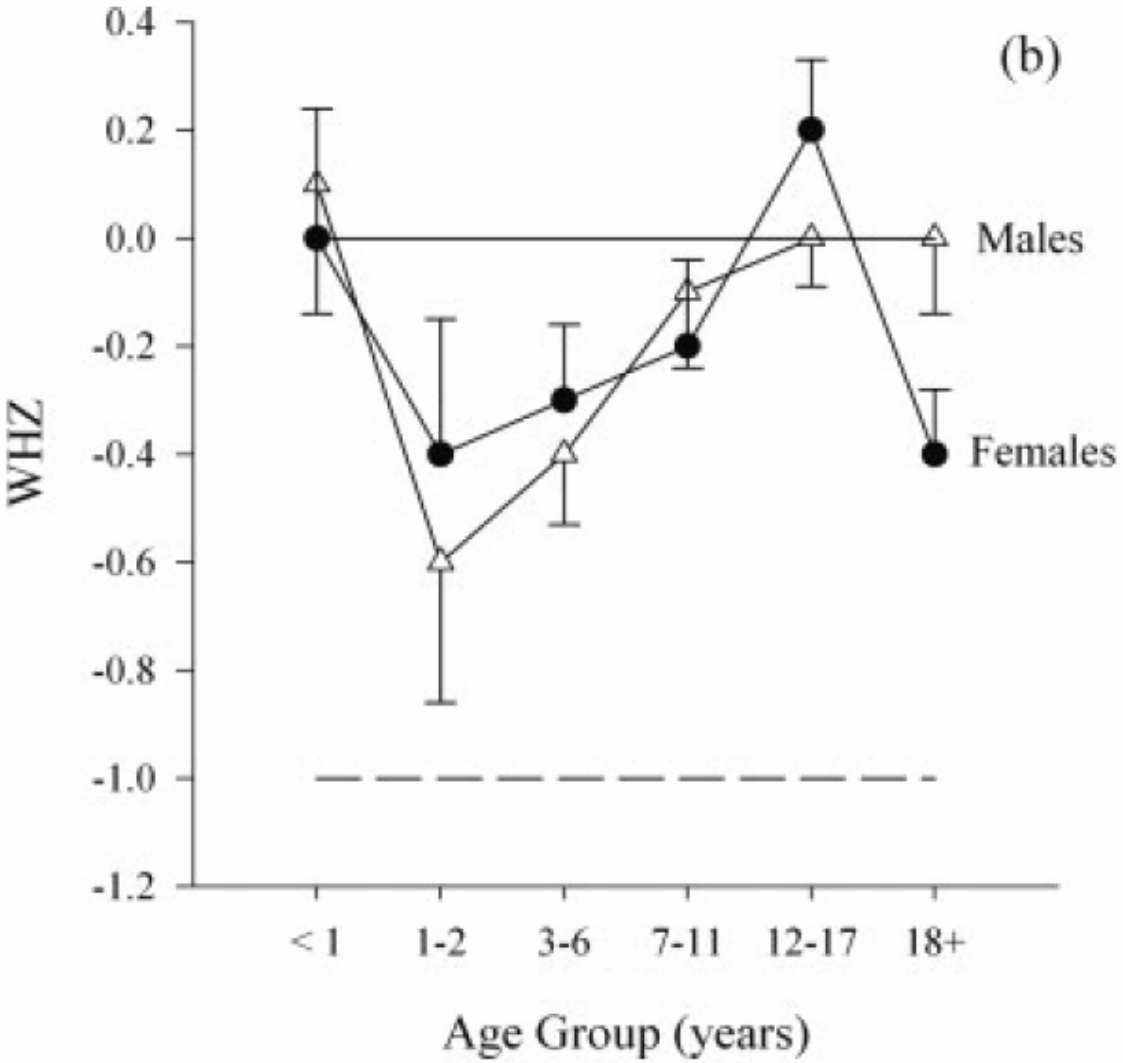
Stunting

Sex

	HAZ		
Age group	♂	♀	*P*
Infant (<1 year)	−0.2 ± 1.0[a]	−0.2 ± 1.3[b]	n.s.
Older infants (1–2 years)	−1.9 ± 0.8	−1.8 ± 1.7	n.s.
Children (3–6 years)	−2.4 ± 1.1	−2.2 ± 1.0	n.s.
Juvenile (♂ 7–11 years, ♀ 7–10 years)	−2.1 ± 1.0	−2.0 ± 1.1	n.s.
Adolescent (♂ 12–17 years, ♀ 11–17 years)	−2.2 ± 0.9	−2.1 ± 0.9	n.s.
Adults (18+)	−2.3 ± 1.0	−2.5 ± 0.8	n.s.

Age groups { ANOVA p<0.01 p<0.01
Sheffe a b

Weight



Wasting (1-17y)
=1.7% (male)
=2.2% (female)

-1SD<WHZ<0

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

Results, Anthropometry of children (1/5): Weight-for-height

Table 3. Comparison of mean z-scores for HAZ, WHZ, ZUMA, and ZTSF between sexes and age-groups

Wasting

Sex

Age group	WHZ ♂	WHZ ♀	*P*
Infant (<1 year)	0.1 ± 0.9	0.0 ± 1.0	n.s
Older infants (1–2 years)	−0.6 ± 1.1	−0.4 ± 1.0	n.s.
Children (3–6 years)	−0.4 ± 0.8	−0.3 ± 0.8	n.s.
Juvenile (♂ 7–11 years, ♀ 7–10 years)	−0.1 ± 0.8	−0.2 ± 0.9	n.s.
Adolescent (♂ 12–17 years, ♀ 11–17 years)	0.0 ± 0.6	0.2 ± 0.8	n.s.
Adults (18+)	0.0 ± 1.3	−0.4 ± 1.1	n.s.

Age groups { ANOVA NS NS
Sheffe - -

Upper-arm circumference (protein reserve)

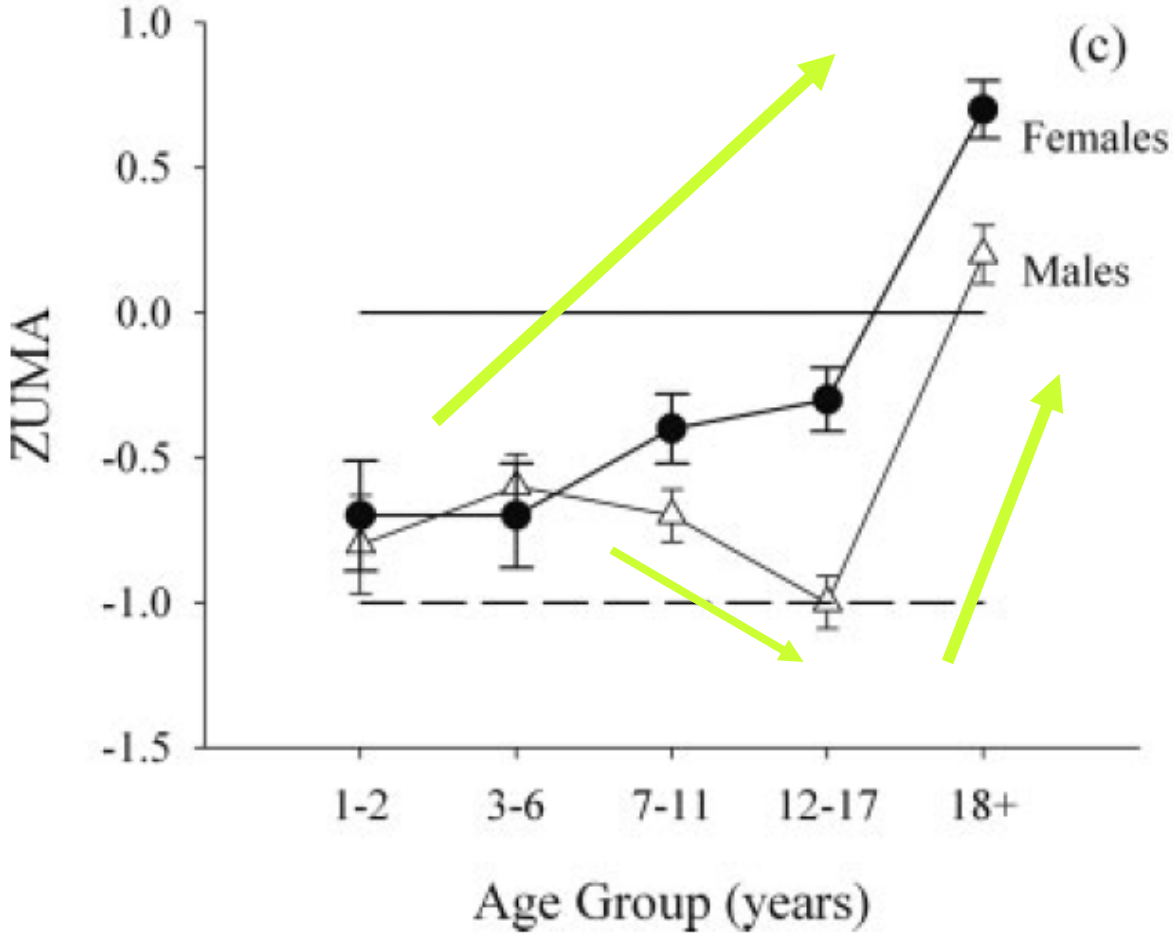


Fig. 3. Z-scores (a: HAZ, b: WHZ, c: ZUMA, d: ZTSF) for males and females by age group.

Results, Anthropometry of children (1/5): upper-arm circumference

Table 3. Comparison of mean z-scores for HAZ, WHZ, ZUMA, and ZTSF between sexes and age-groups

Protein reserve

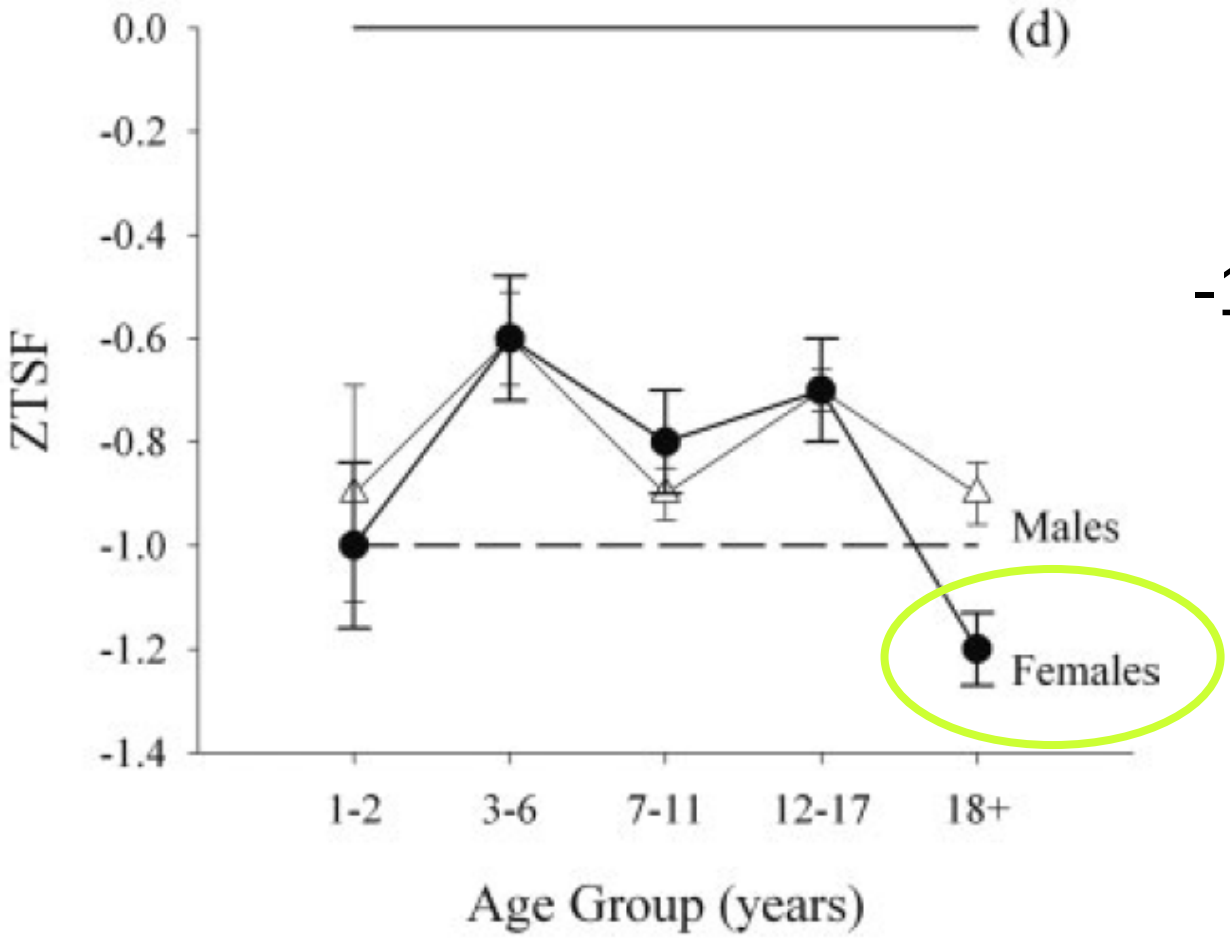
Sex

Age group	ZUMA-age ♂	ZUMA-age ♀	*P*
Infant (<1 year)	–	–	–
Older infants (1–2 years)	−0.8 ± 0.7[c]	−0.7 ± 0.8[d]	n.s.
Children (3–6 years)	−0.6 ± 0.6	−0.7 ± 1.0	n.s.
Juvenile (♂ 7–11 years, ♀ 7–10 years)	−0.7 ± 0.5	−0.4 ± 0.6	n.s.
Adolescent (♂ 12–17 years, ♀ 11–17 years)	−1.0 ± 0.5	−0.3 ± 0.7	0.01
Adults (18+)	0.2 ± 0.9	0.7 ± 0.9	< 0.01

Age groups

ANOVA	P<0.01	P<0.01
Sheffe	Adults	Adults

Triceps skinfold (=body fat)



-1SD<ZTSF<0

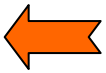
Fig. 3. Z-scores (a: HAZ, b: WHZ, c: ZUMA, d: ZTSF) for males and females by age group.

Results, Anthropometry of children (1/5): Triceps skinfold

Table 3. Comparison of mean z-scores for HAZ, WHZ, ZUMA, and ZTSF between sexes and age-groups

Body Fat stores

Age group	ZTSF ♂	ZTSF ♀	*P*
Infant (<1 year)	–	–	–
Older infants (1–2 years)	−0.9 ± 0.6	−1.0 ± 0.5	n.s.
Children (3–6 years)	−0.6 ± 0.5	−0.6 ± 0.7	n.s.
Juvenile (♂ 7–11 years, ♀ 7–10 years)	−0.9 ± 0.3	−0.8 ± 0.5	n.s.
Adolescent (♂ 12–17 years, ♀ 11–17 years)	−0.7 ± 0.2	−0.7 ± 0.7	n.s.
Adults (18+)	−0.9 ± 0.5	−1.2 ± 0.6	< 0.01



ANOVA		NS	NS
Sheffe		-	-

Summary of Results（1）

Anthropometry of children and comparisons across life stages

1. 53% (male)=stunted, HAZ= -2.1
   50% (female)=stunted, HAZ= -1.9
   Inadequate energy intake during 1-6 years of age?

2. WHZ (indicator of wasting), ZUAC (protein reserve), ZTSF (fat store) were within the normal range.

Results（2）

Anthropometry of adults

Mean HAZ= -2.3 (male), -2.5 (female)
60% (male) and 70% (female) were stunted

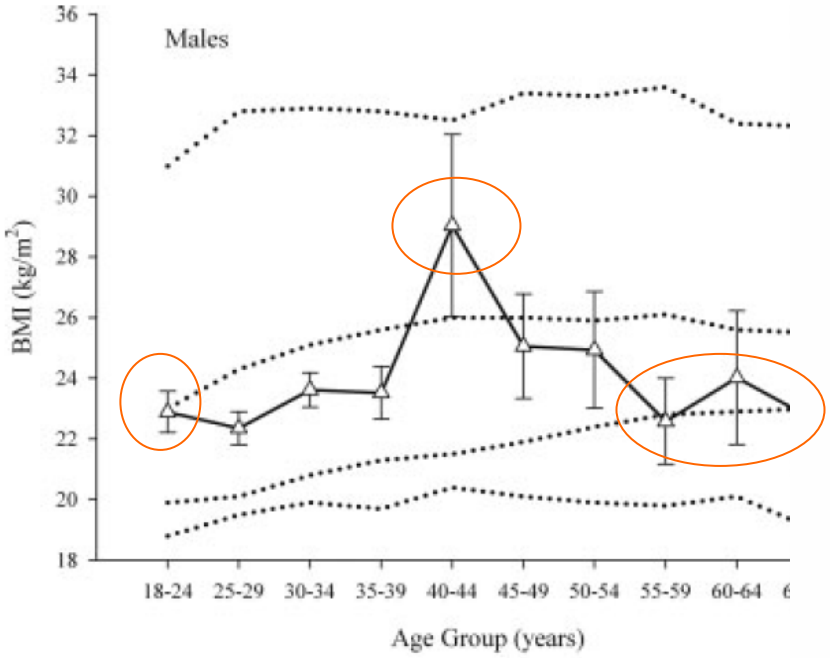
下肢長

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

Age Group	*n*	Age		Stature (cm)		Sitting height (cm)		Subischial length (height – sitting height) (cm)	
		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*

Free from the effects of compression of the spinal column that comes with age; no secular trend was observed (P=0.6 male, P=0.9 female)

Body Mass Index



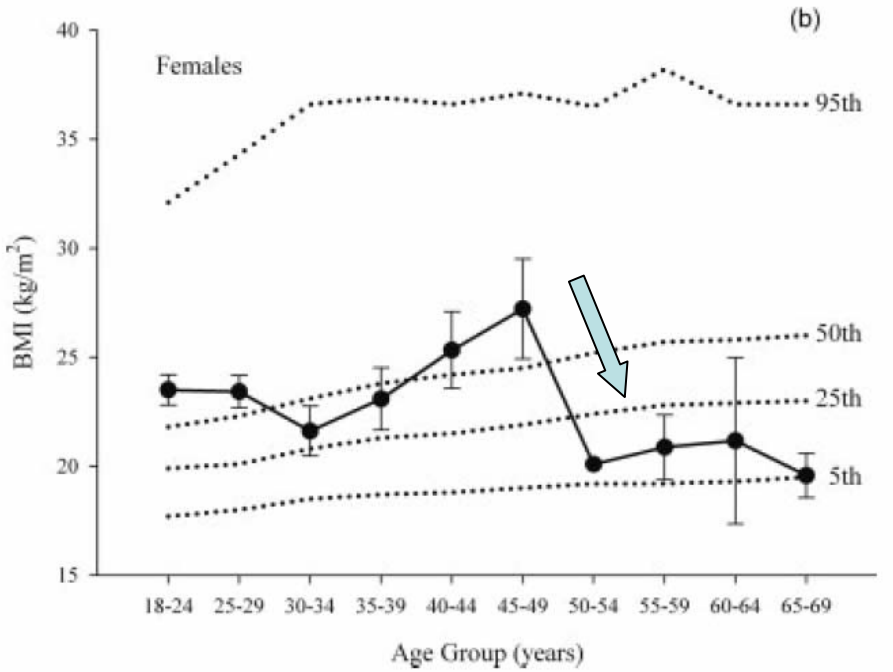


Fig. 4. BMI of adult males (**a**) and females (**b**) compared to the NHANES reference data.

58%=normal
26%=overweight
5%=obese
11%=underweight

60%=normal
22%=overweight
7%=obese
10%=underweight

Summary of Results（2）

Anthropometry of adults

1. 60% (male) and 70% (female) were stunted
2. No secular trend in stature
3. 31% (male) and 29% (female) were overweight/obese
4. BMI peaked in their 40s (male/female)

Results（3）

Household characteristics and nutritional status

85 households interviewed (47 “mature” and 38 “immature”)
All HH answered that they have sold *farinha, Açaí*, beans, watermelon, nuts….

81 HH provided data on wage-labor activities:
25 participated wage labor and 56 did not.

Participation to wage labor: working outside the home on a consistent basis for at least 4months of the year

Comparison of anthropometry between wage laborers (n=25) and non wage laborers (n=56)

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.

Effect of wage labor on the other members of the household

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

continue

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
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

Summary of Results（3）

Household characteristics and nutritional status

1. Weight, UMA, BMI, %fat
Wage laborers > Non wage laborers

2. Subadults (1-17y) in the households with wage laborers had higher BMI and UMA values than those in the households without wage laborers.

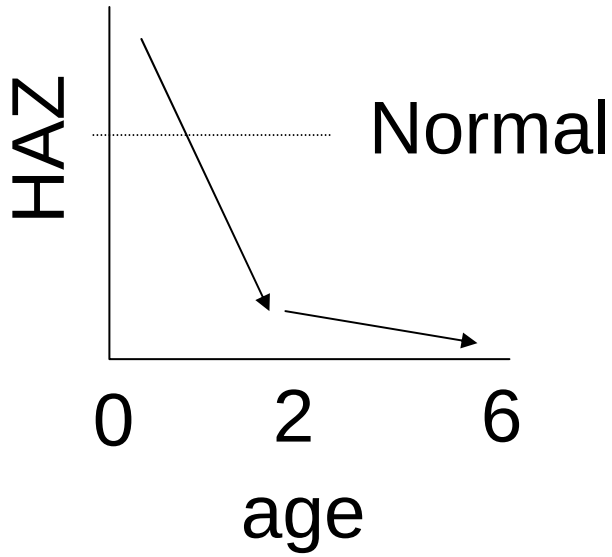
3.No wage labor effects on other adult members in the household

Discussion (1) Childhood and adult anthropometry

Severe stunting but low incidence of wasting

Nutritional stress or poor health status during the period of growth and develop

Also found in other Latin American populations (16 references cited)



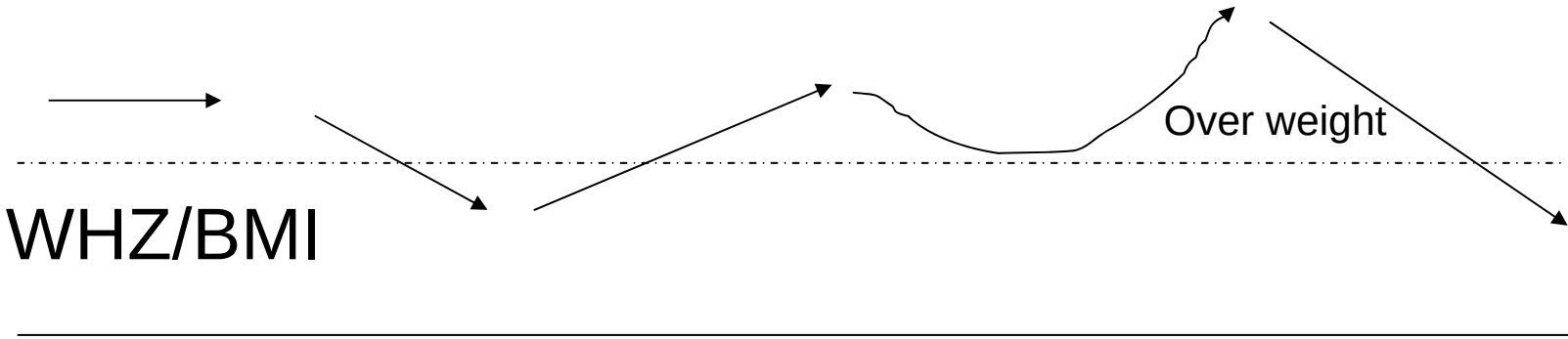
Nutritional stress

1. 14.2 months of breastfeeding
2. Inappropriate weaning foods
   e.g., *farinha* (starch),
   mingau (starch and sugar),
   micronutrients deficiency?

Poor health status

1. parasite infection; 43% carrying more than one parasite (Silva, 2003)
2. Diarrhea and respiratory infections
3. Very limited access to health care

Discussion (1) Childhood and adult anthropometry



Inappropriate weaning foods

Support of the children
Kinship network
Wage labor

Active in subsistence but less prioritized at meal times

next

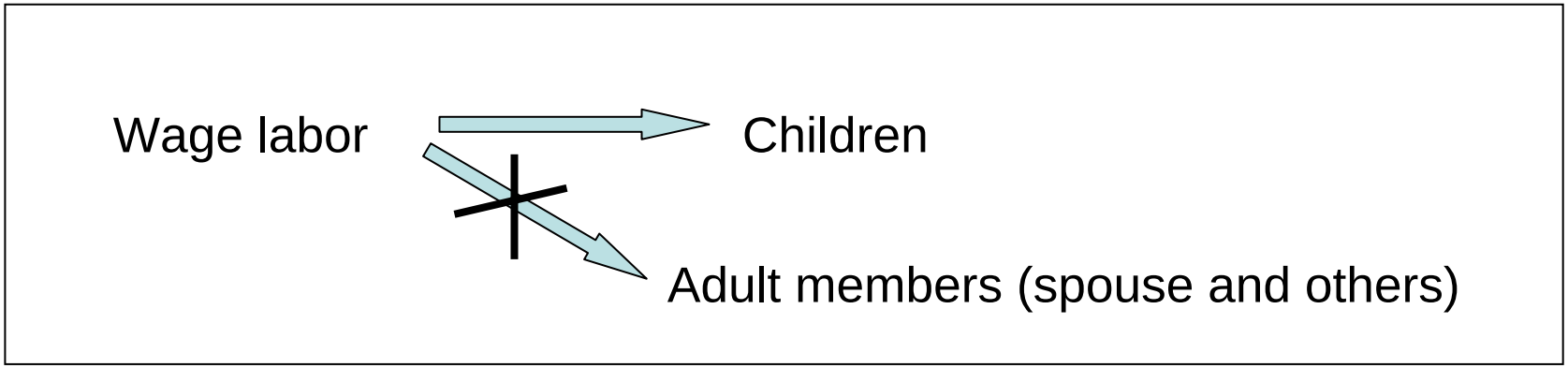
Discussion (2): Impact of household characteristics on subadult and adult anthropometry

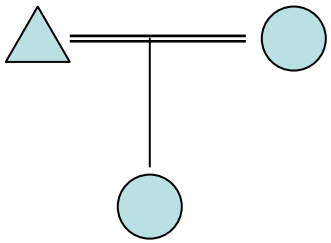
- Wage labors in Scientific Field station or timber company
  : less physically demanding (ground keeping, laundry, cooking, operation of equipments)
- 30s-40s (mature workers): even less energetically demanding jobs
- Meals were served buffet style, the cost of meals were deducted from the salary

⇩

Wage laborers had higher weight, BMI, UMA, %fat

Discussion (2): Impact of household characteristics on subadult and adult anthropometry





The spouse of wage laborers may work in subsistence activities without the labor input of the wage laborers

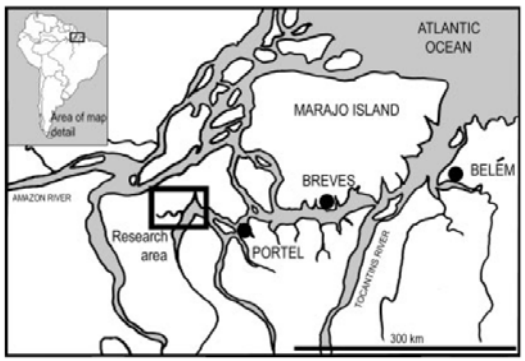


Fig. 1. Map of the field site.

Effects on Children Why???

Discussion (3) and Conclusion: Evidence of the nutrition transition

Findings of the present study

1. Severe stunting due to inappropriate diet and health status during the period of growth and development

2. Prevalence of obesity (male)
   = Brazilian National Survey in 1989,
   higher than 1974/75 survey by 190%
3. Prevalence of obesity (female)
   = Brazilian National Survey in 1974/75,
   lower than the survey in 1989
4. Relatively higher prevalence of obesity in male
   probably because of work environment of adult males

Nutrition transition is evident only in adult males who worked as wage laborers who had contrasting dietary and physical activity patterns to the other adults or children.