Growth Patterns among Indigenous Qom Children of the Argentine Gran Chaco

Original Research Article

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OBJECTIVES: This study describes and compares the growth strategies of rural (Western) and peri-urban (Eastern) Qom indigenous children from Argentina.

METHODS: Height and weight were cross-sectionally assessed in Western (n = 263) and Eastern Qom (n = 512) individuals aged 0-18.9 years. Height-for-age (HAZ), weight-for-age (WAZ), and BMI-for-age (BMIZ) z-scores were calculated with an LMS software. Results were organized into four age categories: infancy, childhood, juvenility, and adolescence. Between-group comparisons of HAZ, WAZ, and BMIZ were carried out by age and sex categories and compared with Student’s t or Mann Whitney tests. Nutritional status was classified based on BMIZ following WHO recommendations and was compared with x² tests.

RESULTS: In both groups, height and weight followed the typical human growth curve. Mean HAZ scores in both groups were within two standard deviations from the international reference, and increased from infancy to juvenility. WAZ and BMIZ scores were high during infancy and showed a general declining trend with age. Overall, Western Qom had higher HAZ scores. WAZ and BMIZ score comparisons showed only a handful of statistically significant differences, which, along with the analysis of BMI categories, indicated an association between peri-urban environments and a higher prevalence of overweight and obese individuals (P < 0.01).

CONCLUSION: Among the Qom, low HAZ and high WAZ scores during the early years of development allow for the attainment of a relatively high adult stature. Their adaptive life-history strategy seems to be to divert energy toward body mass during early development, and catch-up with linear growth at a later stage of development. Am. J. Hum. Biol. 00:000–000, 2016. © 2016 Wiley Periodicals, Inc.

Human growth variability results from the complex interaction between constitutional (e.g., genetic) and extrinsic factors (Bogin, 1999; Eveleth and Tanner, 1991; Hallgrímsson, 2003; Metcalfe and Monaghan, 2001). Consequently, there is extensive variation in the timing, duration, and final outcome of growth across individuals and populations. Examples of this variability are differences in age at menarche (Eveleth and Tanner, 1991; Ellis, 2004; Gluckman and Hanson, 2006; Wood, 1994), average adult height (Bogin, 1999), and child-juvenile growth velocity and timing (Walker et al., 2006).

Plasticity in growth dynamics leads to a variety of phenotypes that biomedical and adaptationist approaches interpret as the result of short-term responses, which can be adaptive or maladaptive (e.g., small-but-healthy vs. small-but-unhealthy; Bogin et al., 2007; Seckler, 1982; Schell and Magnus, 2007). Similar to the adaptationist approach, life-history theory recognizes that humans have evolved to withstand environmental hardship, such as energy crises, by responding in ways that would maintain some evolutionary fitness, even if responses are suboptimal (Hochberg, 2009). However, unlike the biomedical and adaptationist approaches, life-history theory examines variations in growth as a matter of resource allocation strategies in a time-integrated fashion. Thus, life-history theory expands our understanding of growth beyond the adaptive/maladaptive dichotomy (Charnov, 1993; Schell and Magnus, 2007; Stearns, 1992) by analyzing changes in phenotypic trajectories in terms of trade-offs between maintenance and production (Jones, 2005; Hochberg, 2009; Hochberg et al., 2011; Kuzawa, 2007; Metcalfe and Monaghan, 2001; Worthman and Kuzara, 2005).

Possible trade-offs between linear growth (height) and growth in body mass (weight and BMI) have been identified in a few indigenous lowland populations in South America. This pattern of linear growth deficits, but not necessarily body mass deficits, seems to be widespread among indigenous children in Argentina (Mbya-Guarani-Orden and Oyenart, 2006; Zonta et al., 2010), Bolivia (Tsimane-Foster et al., 2005; Tanner et al., 2014), Brazil (Campos et al., 2015; Ferreira et al., 2012; Karapoto et al., 2009) and Ecuador (Shuar-Uracher et al., 2016). This trade-off between body-mass and body-height has been explained by poverty, marginalization, market integration, and parasitism. Thus, when compared to international growth standards, many of these populations have high prevalence of low height-for-age (HAZ) measures (Benefice et al., 2007; Blackwell et al., 2009; Foster et al., 2005) and, increasingly, overweight and obesity (Duran et al., 2006; de Onis et al., 2012; Uhler et al., 2016; Zonta et al., 2010). This dual nutritional burden has been associated with later risk of metabolic disease and short adult stature (Barker et al., 2002; Bateson et al., 2004). In this study, a life-history approach is used to assess the impact that the interaction between the sociocultural and...
biological contexts have on growth trajectories and outcomes in two indigenous groups in northern Argentina: the Eastern and Western Qom. The goal of this analysis is twofold: first, to provide a descriptive overview of children's growth and nutritional status in these indigenous groups that can be used for comparative purposes, and, second, to evaluate the possible associations between early life-history traits and the environmental variables that may lead to potential trade-offs that shape infant and child growth. Based on the existing literature, a Westernized lifestyle is associated with indexes of positive energy balance. Thus, we predict differences between rural and peri-urban populations, so that children who are closer to urban centers will be taller and more likely to be overweight or obese than those who live in rural environments and follow a more traditional lifestyle.

STUDY PARTICIPANTS AND METHODS

Until the 1930s the Qom of the Gran Chaco were semi-nomadic hunter-gatherers, using horticulture on occasion. During the last century, disruptions to their traditional lifestyle forced their migration to urban centers. However, many semi-isolated communities still use the forest and rivers as a source of food and shelter. This situation results in a spectrum of lifestyles and subsistence patterns that range from the more traditionally living rural groups, to transitional, peri-urban villages, as well as market-economy urban “barrios” (Mendoza and Wright, 1989).

In this study, data collection was conducted in two Qom populations (Eastern and Western). The Eastern Qom live in the peri-urban village of Namqom, located 11 km West of the city of Formosa (58° W and 26° S; Fig. 1). The village is located in a mosaic of savannah, marshes, and woodlands. The mean annual precipitation in this region is approximately 1,400 mm (Fernandez-Duque, 2016). Monthly mean rainfall varies significantly during the year, with two rain peaks in April and November, with the lowest average rainfall occurring during the period of June through August. Monthly mean temperatures are lowest between May and August (16–18°C) and highest between October and March (23–27°C). Extreme low (below freezing) and high temperatures (above 40°C) are frequent.

Namqom has a population of approximately 3,000 people, distributed in a 120 ha area. The first Qom families established themselves in this settlement in the early 1970’s, and the village has since then experienced a rapid population growth both as a result of high fertility and immigration from rural areas (Sanchez-Ocasio and Valeggia, 2005). Extended families tend to live close to one other and participate in microeconomic exchanges (Kap-salakis, 2011). There is incipient social stratification, mainly associated with participation in provincial political dynamics. However, all families live below the poverty line and rely mainly on temporary jobs and government subsidies. The health center offers prenatal and child health care, and keeps good health records of the families in the village.

The Western Qom live in a cluster of 12 villages collectively known as Comunidades Aborígenes de Cacique Sombrero Negro, a 35,000-ha rural community located 550 Km West of the city of Formosa (61°–62° W, and 23°–24° S; Fig. 1). The villages are located in a dry woodland environment. Official meteorological sources (https://www.formosa.gob.ar/upca/precipitaciones) indicate a mean annual precipitation of approximately 700 mm a month, but mean rainfall varies significantly during the year (200–1400 mm). The rainy season extends between November and April, and the dry season from June through August. Monthly mean temperatures are lowest between May and August (16–18°C), and highest between October and March (23–30°C). Extreme low (−7°C) and high temperatures (above 42°C) are frequent.

Sombrero Negro has a population of approximately 1,600 people. Ethnohistorical reports indicate that the Western Qom have occupied this area at least for the last couple of centuries (Mendoza, 2002). These villages still rely in part on hunting, gathering, and fishing for subsistence (Lanza and Valeggia, 2005; Sanchez-Ocasio and Valeggia, 2005; Valeggia et al., 2005). Most families live off subsidies from the government and political parties. Socioeconomic stratification is almost non-existent, and their egalitarian concept of leadership persisted until the late 1980’s (Mendoza, 2002). However, association with local political parties has introduced dissonance into their traditional leadership patterns. Extended families live close to each other and individuals tend to marry
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exogamously with members of other historical bands (Mendoza, 2002).

The two study groups share the same genetic and ethnohistorical background, as well as most cultural values in terms of social practices. Monogamy is the main mating pattern, with serial monogamy being more common among Eastern than Western Qom. Qom women have had an independent and influential position in their society as a consequence of their central role in the family economy (Braunstein, 1983; Karsten, 1967). Qom mothers breastfeed their children until the following pregnancy is visibly obvious, or until the child weans him/herself at about 2-3 years of age (Olmedo and Valeggia, 2014). The interbirth interval (IBI) is quite similar in both populations, with a median IBI of 29.2 months for the Eastern Qom (Valeggia and Ellison, 2004), and 31.0 months for the Western Qom (Sanchez-Ocasio and Valeggia, 2005). Both populations have access to Western medicine via provincially run health centers in their community, and the majority of births occur at public hospitals, even in the more remote areas (Mirassou, 2013). Infant mortality rates for the provincial departmental divisions in which these populations are located are 22‰ and 16‰ for the Western and the Eastern Qom respectively (Mirassou, 2013). Infant mortality rates for the province of Formosa are the highest in Argentina (Ministerio de Salud, 2014).

Diet has diverged substantially between these two Qom groups. The diet of Western Qom families is much more varied, including foraged items such as fruits and vegetables from the bush, as well as fish, honey, and game (Areñas, 2003). In general, the Western Qom diet is rich in proteins and vitamins. Hunted game include deer, armadillo, wild pigs, and tapir (Alvarsson, 1988; Karsten, 1952). Women gather an array of wild produce including honey, carob pods, cactus figs, wild squash, wild roots, and hearts of palm. These economic activities are complemented by some horticulture of squash and beans (Mendoza and Wright, 1989). Since they do not have specially prepared weaning foods, infants transition from breast-milk directly into the adult diet. Foraged items are supplemented with store-bought items, particularly wheat flour to make dough, rice, pasta noodles, and polenta. The Eastern Qom diet only occasionally includes foraged items (fish, armadillos), but it is overall quite monotonous and highly caloric. Typically, the Eastern Qom eat one meal a day which consists of some kind of stew made with pasta, rice, or polenta, supplemented with onions and potatoes. Meat and dairy products are consumed only during the first week of the month, when they receive their subsidies (Olmedo and Valeggia, 2014). Weaning foods include formula milk, which mothers receive at the local health center, white bread, fried dough, noodle/rice soups and, less frequently, fruits like bananas or apples (Olmedo and Valeggia, 2014).

In general, both populations can be classified as having a moderate to high pathogenic environment. In the Western community, water needs to be fetched from nearby reservoirs or from a central pump and carried to the individual households. The Eastern Qom have access to water provided by the nearby city to a central water tank, and about half of the households have a pipe that receives this water. The rest of the families need to fetch water from smaller tanks distributed around the village. Gastrointestinal and skin infections are common among children in the summer, while respiratory infections, including bronchitis and pneumonia, are more prevalent during the winter months (data not published).

**DATA COLLECTION AND ANALYSIS**

Anthropometric data was obtained from 775 children, ages 0-18 years, from Eastern (n = 512) and Western Qom (n = 263; Supporting Information Table S1). Data collection took place at the children’s house under parental surveillance. Age was reported by the child’s principal caretaker, and confirmed through national identification and/or health center records. Height was measured with a portable stadiometer, and body weight was assessed with a Tanita® TBF scale. The measurements were taken once, thus the technical error of measurement for anthropometry is not available in this study. Based on height and weight, BMI was calculated as weight (kg)/height (m²).

HAZ, weight-for-age (WAZ), and BMI z-scores (BMIZ) were estimated for each participant with the LMS software program (Cole, 1990). Individual Z-scores calculations were based on the chronological age of each participant. HAZ and BMIZ were estimated based on the international reference (WHO, 2006). WAZ scores were calculated based on the Argentine reference (Lejarraga et al., 2009), given that the international reference limits WAZ calculations to children under the age of 10 years. Additionally, individual BMIZ scores were categorized as healthy (within two 2SD for those aged 0–5 years of age, and between −2 and 1SD for individuals aged 6–18 years), severely thin/thin wasted (< −3sd), thin/wasted (−2sd–3sd for those aged 0–5 years of age, and between > −1sd-2SD for those aged 6–18 years of age) or obese (>3SD for individuals aged 0–5 years of age, and > +2SD for those aged between 6–18 years of age), following international recommendations (de Onis and Lobstein, 2010; WHO, 2006).

After the Z-scores were individually calculated based on chronological age, participants were grouped into four age-based categories: infancy, childhood, juvenility, and adolescence (Bogin, 1999; Hochberg, 2012). These life-history stages have been defined based on behavioral and biological traits: (1) *Infancy* (birth to 2.9 years-of-age) is a period of rapid, but steeply decelerating growth rate, where fifty percent of the metabolic rate is directed to brain growth and function. Individuals are breastfed and, thus, are highly dependent on their mothers; (2) *Childhood* (3.0 to 6.9 years-of-age) starts after weaning and is characterized by a moderate, but steady, growth rate. Around the age of 6 years, the mid-childhood growth spurt takes place; (3) *Juvenility* (7.0 to 10.9 years of age in girls, 7.0 to 12.9 years of age in boys) is a slow-growth period marked by adrenarche and a cognitive shift. Juveniles are semi-independent individuals who can provide most of their own food and protect themselves from most danger; and (4) *Adolescence* (11.0 to 19 years of age in girls, 13.0 to 21.0 years of age in boys) is marked by gonadarche. As a result, endocrine changes ensue, secondary sexual characteristics develop and growth velocity accelerates, leading to the adolescent growth spurt (Bogin, 1999; Hochberg, 2012). These life-history stages are assumed to be universal, but there is ample evidence showing that there is substantial variation in growth trajectories that should be incorporated into our
models (for example, Walker et al., 2006). For our data, however, we considered that this classification was broadly applicable for the purposes of our analysis.

Statistical analyses were conducted in SPSS 21.0 (IBM Corp., 2012). Descriptive statistics were used to characterize the height, weight, and BMI of Eastern and Western Qom by sex and age (in years). Means and standard deviations were calculated for all z-scores (HAZ, WAZ, and BMIZ). Eastern and Western Qom boys and girls were compared based on their mean HAZ, WAZ, and BMIZ scores by age category (infancy, childhood, juvenility, and adolescence). When the variable examined showed a normal distribution (based on Kolmogorov-Smirnoff Lilliefors tests) in both Qom groups, between-group comparisons were conducted with parametric statistics (Student’s t-test). For cases in which the variables deviated from normality, between-group comparisons were conducted with Mann-Whitney U tests. HAZ scores deviated from normality among East Qom girls in the childhood category (P < 0.05). In boys, deviations from normality were identified in HAZ scores among Eastern Qom infants (P < 0.01) and juveniles (P < 0.05), and Western Qom adolescents (P < 0.05). No deviations from normality were identified for WAZ scores, and in the case of BMIZ scores, deviations from normality are restricted to the juvenile Western Qom boys. The frequency of healthy, severely thin, thin, overweight, and obese BMIZ scores were calculated in each group and compared between groups as a total (not separated by age categories), in order to have a general assessment of the nutritional status of both groups. Between-group comparisons of BMIZ categories were carried out with chi-square (x^2) tests.

RESULTS

Girls

Height and weight followed the typical human growth pattern in both groups (Supporting Information Table S1). When grouped by age category (infancy, childhood, juvenility, and adolescence), Eastern and Western Qom girls presented mean HAZ scores that were within the normal range (>-2SD). However, the mean HAZ score changed by age category, so that in both groups we observe an increase in HAZ scores from infancy through juvenility. However, while HAZ scores for Eastern Qom girls plateau between juvenility and adolescence, Western Qom girls maintained an upward trend. (Fig. 2a; Supporting Information Table S2). Overall, mean HAZ scores were consistently higher among Western Qom girls in comparison to Eastern Qom girls. Between-group comparisons, however, revealed no statistically significant difference in HAZ scores between juvenility and adolescence (P > 0.05). During adolescence, a significant difference in their HAZ scores (Student’s t = 3.449, df = 111, P < 0.01) was found, indicating that Western Qom girls had significantly higher HAZ scores than their Eastern Qom peers. Thus, we do not observe a clear urban-to-rural gradient in the HAZ scores of girls.

Among girls, mean WAZ scores were within the range of what is considered healthy (between two standard deviations). WAZ scores among girls were higher, and positive, during infancy, rapidly dropping by the time they reached childhood. Among the Western Qom, this drop resulted in negative WAZ scores during childhood and juvenility. Between childhood and juvenility, WAZ scores increased clustering around the Argentine mean in both groups. Between infancy and juvenility, WAZ scores were highest among the Eastern Qom in comparison to the Western Qom girls. However, in adolescence, Western Qom girls had the highest mean WAZ scores. For the most part, weight scores revealed an urban to rural trend (Fig. 2b; Supporting Information Table S2). Among girls, mean WAZ score comparisons showed no statistically significant difference during infancy. During childhood, however, the analysis revealed significant differences between the groups (Student’s t = 2.132, df = 99, P < 0.05) due to Western Qom girls weighing less. Comparisons for the juvenile and adolescent segments do not reveal statistically significant differences between the groups, although the results show that between childhood and juvenility, WAZ scores among Eastern Qom girls rapidly climbed, a trend that continued during adolescence. In contrast, WAZ scores in Eastern Qom girls showed only a moderate increase between childhood and juvenility, although they did increase toward adolescence albeit at a lower rate (Fig. 2b; Supporting Information Table S2).

Mean BMIZ scores among girls were within the normal range, except for the Eastern Qom infant girls who showed a mean BMIZ score that corresponded, marginally, to the overweight category (x=2.02; Supporting Information Table S2). Additionally, mean BMIZ scores for Eastern Qom girls in the childhood category and infant Western Qom girls were normal but above 1SD, which indicates these individuals are at risk for overweight and obesity (de Onis and Lobstein, 2010). However, BMIZ scores showed positive but descending values between birth and juvenility in both groups. While BMIZ scores showed a small decline between juvenility and adolescence in Eastern Qom girls, Western Qom girls showed an upward trend in their BMIZ scores between these two periods. In general, when all age periods are considered, Eastern Qom girls’ BMIZ scores were the highest, except for the adolescent period when Western Qom scores were slightly higher. Thus, BMIZ scores showed an urban-to-rural gradient in which girls who lived closer to urban centers had higher BMIZ scores than those who lived further away (Fig. 2c; Supporting Information Table S2). Between-group BMIZ score comparisons showed no statistically significant difference during infancy. In both childhood and juvenility, BMIZ scores were significantly different between Eastern and Western Qom girls (Student’s t = 3.77, df= 96, P < 0.01, and; Student’s t = 2.765, df= 113, P < 0.01 respectively), with the former having higher BMIZ scores. However, no statistically significant difference was observed between the BMIZ scores of Eastern and Western Qom adolescent girls (P > 0.05), showing that the upward trend in BMIZ scores observed among Western Qom girls between juvenility and adolescence eliminated the differences in BMIZ present in the previous two periods. In summary, during childhood and juvenility, the more urbanized Eastern Qom girls had the highest BMIZ scores. During adolescence, the groups become more similar and no statistical difference between them was identified (Fig. 2c; Supporting Information Table S2).

Further classification of individuals by BMI category, revealed that in both groups over half of the girls had a healthy BMI (66.4% of Eastern Qom and 81.2% of Western Qom; Fig. 3). However, while 27.5% of Eastern Qom girls were overweight, only 17.3% of their Western Qom
peers fell within that category. Moreover, 6.5% of Eastern Qom girls were categorized as obese and only 1.5% of Western Qom girls belonged in that category. No cases of wasting or severe wasting were identified among the girls in these groups. Cross tabulation of these results indicate that there is a statistically significant relation between

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BMI category and group (Chi-square $\chi^2 = 10.46$, $n = 380$, $P < 0.01$, Cramer’s $V = 0.166$). Eastern Qom girls show a prevalence of overweight and obese scores that are 1.6 and 4.3 times (respectively) higher than that of Western Qom girls (Fig. 3).

**Boys**

Mean HAZ scores for boys in both Qom groups fell within the range of normality, (Fig. 2a, Supporting Information Table S2) but were consistently below the international mean throughout their period of growth and development. In both Eastern and Western Qom boys, HAZ scores displayed an upward trend from birth to juvenility. However, between juvenility and adolescence, Eastern and Western Qom seemed to reach a plateau characterized by a slight decline in their HAZ scores. Overall, HAZ scores between groups were similar (Fig. 2a; Supporting Information Table S2). In fact, between-group comparisons among boys showed no statistically significant differences in HAZ scores for any age category ($P > 0.05$).

Mean WAZ scores in boys also remained within the normal range. The scores stayed relatively stable among Western Qom between infancy and adolescence. In Eastern Qom boys, the mean was also stable and slightly above the Argentine mean during infancy and childhood (Fig. 2b; Supporting Information Table S2). After that period, the average scores rapidly decline to negative values during juvenility and adolescence. Comparisons of WAZ scores revealed no statistically significant differences between the infants of the two groups. The childhood category, however, did show significant differences (Student’s $t = 2.13$, df = 112, $P < 0.05$), indicating that Eastern Qom boys had WAZ scores that were significantly higher than those of their Western Qom peers. In contrast, no statistically significant difference was identified during juvenility or adolescence. Overall, from birth to juvenility, boys showed an urban-to-rural gradient in their WAZ scores so that the more urban and Westernized Eastern Qom had the higher scores. This trend, however, is only statistically significant during childhood, and was reversed during the adolescent period when Western Qom boys had slightly higher WAZ scores.

Mean BMIZ scores remained at or above the international mean in both Eastern and Western Qom boys from infancy to adolescence. During infancy, the mean BMIZ in both groups was above 1SD, which indicates that infant Eastern and Western Qom boys are generally at risk for overweight and obesity (de Onis and Lobstein, 2010). In both groups BMI scores showed a small decline between infancy and childhood. This trend accelerated afterwards, so that by juvenility both Eastern and Western Qom boys showed lower BMIZ scores than in previous age categories. Among Eastern Qom boys, scores continued to decline, so that during adolescence the average score was zero. In contrast, Western Qom boys showed a small increase in their average BMIZ scores between juvenility and adolescence (Fig. 2c; Supporting Information Table S2). BMIZ scores among Eastern Qom boys, the most urbanized, and thus Westernized, group were higher but tended to decline as they moved from infancy into adolescence. Thus, it is only during this last period that BMIZ scores were higher among Western than Eastern Qom (Fig. 2c; Supporting Information Table S2). BMIZ score comparisons showed no significant differences among infants. During childhood, however, the analysis revealed a statistically significant difference (Student’s $t = 3.196$, df = 97, $P < 0.01$). The difference in BMIZ scores between the groups remained significant during the juvenile period (Mann Whitney $U = -3.365$, $P < 0.01$). In both childhood and juvenility, the difference showed that Eastern Qom boys had higher BMIZ scores than their Western Qom peers. No statistically significant difference, however, were identified among adolescents.

In boys, the trends for BMI categories were the same as those observed in girls (Fig. 3). Most Eastern and Western Qom boys had a healthy BMI (65.6% of Eastern and 83.5% of Western boys), but 29.2% of Eastern boys and 13.4% of Western boys were overweight. The rates of
obesity in both groups were similar with a 3.8% of Eastern boys and a 3.1% of Western boy falling within that category. Only 0.5% of Western boys showed wasting and, 0.9% presented severe wasting. No cases of wasting or severe wasting were observed among Eastern boys. Cross-tabulation of these results show statistically significant differences between the groups (chi-square $\chi^2 = 13.98, df = 4, P < 0.01$, Cramer’s V = 0.203). This difference reflects the fact that the prevalence of overweight boys among the Eastern Qom is 2.2 times higher than in Western boys (Fig. 3). BMI categories show a clear urban-to-rural trend, where boys who lived closer to urban centers were more likely to be overweight.

**DISCUSSION**

Indigenous children of the Argentine Gran Chaco, unlike neighboring groups (Ferreira et al., 2012; Horta et al., 2013; Solomons et al., 2015; Tanner et al., 2014) have HAZ and WAZ scores that are mostly within the range of international growth norms. Among girls, we observed an overall higher investment in body mass than in linear growth during infancy. This early investment in mass is followed by an acceleration, or catch-up, of their linear growth during childhood and juvenility. Thus, as Qom girls approached juvenility, mean HAZ scores approached the international median. During juvenility, WAZ scores were also near the international mean, so that in this period, Qom girls presented a pattern of weight and height scores that paralleled each other. However, the investment during juvenility seems to be higher in linear growth than in mass. By the time of adolescence, while Western Qom girl HAZ scores continued to climb, Eastern Qom girls’ scores did not. Interestingly, although BMIZ scores were higher among the more westernized Eastern Qom, which is associated with an increased risk in overweight and obesity, we did not find the same trends in height. The results suggest that further examination of the sociocultural, historical, and political ecologies is required. In a comparative pilot study of Eastern and Western Qom female reproductive patterns (Sanchez-Ocaasio and Valeggia, 2005 and unpublished data), for example, we found earlier ages at first pregnancy and higher adolescent fertility rates among Eastern Qom girls (15.5 ± 1.1 years old and $m_{15} = 0.19$) than among the Western ones (17.8 ± 2.4 years old and $m_{15} = 0.11$). If confirmed in a study that includes a larger sample size (in prep.), this difference in reproductive strategies may account for the lower adolescent HAZ scores, as a result of a deviation of resources away from linear growth and into reproduction (Scholl et al., 1994).

Boys’ mean HAZ scores climbed from infancy to juvenility, but remained below the international median. Between the juvenile and the adolescence periods, their scores declined, so that among adolescents we observed HAZ scores that were below the international median, but were overall higher than those observed during infancy. No statistically significant difference was identified between the two groups. However, Western Qom boys were, for the most part, consistently taller than their Eastern Qom counterparts, except during infancy. Given that boys may continue to grow in height, the absence of a statistically significant difference in the HAZ scores of adolescent boys may, in fact, reflect the exclusion of older boys (ages 18–21 years) in this study.

When overall infancy WAZ and HAZ scores are considered, indigenous children of the Argentine Chaco appear to be shorter than the median, and relatively heavy. This phenotype has been found in other Latin American populations (Castro et al., 2010; Duran et al., 2006; Guedes et al., 2010), and can be interpreted as the result of early adaptation to conditions of scarcity (Hochberg, 2009; Hanson et al., 2011; Solomons et al., 2015). However, the hypothesis of an adaptive response to a “bad start” (Kuzawa, 2007; Metcalfe and Monaghan, 2001) does not fit this particular case; first, birth weight is relatively high in this population (3.5 kg for boys and 3.3 kg for girls; Valeggia et al., 2002) and thus there is no evidence of intrauterine growth retardation. Second, although Qom infants’ weight-for-age is relatively high, and their height-for-age is comparatively low, finalized adult stature is among the highest in Native South American groups (Walker et al., 2006). This seems to indicate that the Qom have a different growth strategy, perhaps adaptive, that invests more energy in body mass than in linear growth early during development. Later, there is a shift to investment in linear growth.

While both boy and girls from Eastern and Western Qom communities show adolescent HAZ scores that are close to the international median, they remain consistently below it. This may indicate the presence of a blunted or attenuated adolescent growth spurt. The adolescent growth spurt is considered one of the hallmark-derived traits of our species (Nelson and Thompson, 1999). This trait is, however, plastic and subject to the influences of environmental factors that lead to variations in velocity and timing (Gluckman and Hanson, 2006; Rogol et al., 2002). It is possible that Qom individuals continue to grow into their twenties, as has been observed among other non-westernized groups (Little et al., 1999). Further longitudinal studies are needed to assess variability in growth spurt among the indigenous Qom of the Argentine Gran Chaco. It is possible, however, that social discrimination and the environment experienced by previous generations continue to exert their influences in the growth patterns of these Indigenous groups (Moffat and Galloway, 2007).

HAZ, WAZ, and BMIZ score comparisons showed only a handful of statistically significant differences. In particular, WAZ and BMIZ comparisons showed that ecological differences between peri-urban and rural groups resulted in a gradient where the former showed some of the telltale signs of the transition to a Westernized life style. Changes in diet associated with urbanization have been reported in other studies, where geographic location plays an important role (Lazarou and Kalavana, 2009). Among non-Native Argentine, increased levels of urbanization likely accompanied by dietary changes and low activity levels lead to significantly higher frequencies of obese and overweight individuals (Dahinten et al., 2011; Hirschler et al., 2008; Kovalakys et al., 2011; Ramirez-Zea et al., 2014). Unlike non-Native Argentines, the Qom show a positive association between socioeconomic status and BMI (Valeggia et al., 2010), which has been observed in other Argentine indigenous groups (Orden and Oyhenart, 2006; Romaguera et al., 2008) for whom heavy individuals are regarded as “healthy” (Valeggia et al., 2010). Moreover, a previous study has shown that Westernized Qom adults show a prevalence of obesity that is above 45% (Lagranja et al., 2015). It is important to note, however, that Qom

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WAZ scores are very close to the Argentine median (Lejarraga et al., 2009), which, when contrasted with the high BMIZ scores of these children, indicate that the Argentine reference for weight is skewed toward the right, further highlighting the importance of applying international standards (de Onis and Lobstein, 2010).

As predicted by the research hypothesis, westernized Eastern Qom show, for the most part, higher WAZ and BMIZ scores. Surprisingly, however, HAZ scores were higher among Western Qom. Further studies that include reproductive strategies, e.g., age at first pregnancy, and the inclusion of boys up to 21 years of age, are needed. In particular, an early age at first birth may be indicative of a trade-off between growth and reproduction, which may be part of a reproductive strategy among the Qom. In addition, detailed nutritional studies that assess dietary differences, especially regarding micronutrient content, are necessary to explain why Western and not Eastern Qom children are taller by the time of adolescence. Based on known economic strategies, we propose that the incorporation of hunting, gathering, and fishing, along with store-bought items, among Western Qom provides higher levels of food security and a better dietary quality, that are not available for the more urban Eastern Qom.

Although this work makes an important contribution to our understanding of variation in human growth strategies, it is necessary to note its limitations. First, the cross-sectional nature of this study introduces possible biases in our results. For example, cohort effects may have influenced the z-scores of particular age stages (e.g., adolescence) so that children born around the same time experienced a more (or less) favorable environment, which might shape their growth trajectory differently. Moreover, the relevance of BMI scores must be cautiously assessed. It has become increasingly clear that BMI is not an accurate indicator of nutritional status or body composition, and it is, at best, only a proxy for adiposity (Benecce et al., 2007; Gurn et al., 1986; Hall and Cole, 2006; Maynard et al., 2001; Wilson et al., 2011). Furthermore, given that some of the variation in body fat and BMI is influenced by the child’s age and degree of maturation (Ellis et al., 1999; Freedman and Sherry, 2009; Hall and Cole, 2006; Maynard et al., 2001), future studies among the Qom must include variables that account for these developmental parameters. In this study, BMI tends to be higher among the Eastern Qom, who are overall shorter than the Western Qom. Thus, the difference in the percentages of overweight and obese individuals between these two groups is likely the result of higher levels of adiposity among the Eastern Qom. However, given the limitations of BMI, future studies must include other measures of nutritional status, such as skinfolds and waist circumference, in order to understand the causes behind the shorter stature and higher weight of the Eastern Qom. In addition, our relatively small sample size did not allow for a more detailed description of growth patterns by age. Although the issue of small sample sizes is endemic to those of us working with small-scale populations, future studies of growth strategies should aim at incorporating longitudinal designs.

In this context, it is worth commenting on the use and value of comparing growth trajectories against international (e.g., WHO) and national (e.g., Argentine) standards. The most updated WHO standard growth curves have been constructed based on a cross-population sample of breastfed children living in socioeconomic situations favorable to growth in selected populations in the US, Brazil, Oman, Norway, Ghana, and India. The Argentine growth curves are based on a sample of Argentine children, most of which were not breastfed, and incorporate the WHO growth standards for the infancy age category (Lejarraga et al., 2009). The WHO standards provide a more general picture in which population-specific differences in growth trajectories are smoothed out. The value of using these curves is comparability with other studies and having a sense of where the study population falls in the landscape of human growth in privileged populations. The justification for using more locally derived growth curves is that they are intended to control for ethnicity variables. The construction of these growth standards follows a Western biomedical model of “normality” and the main objective is to provide ways of assessing whether the growth of individual children follow the statistically normal trajectory. Thus, it is based on a dichotomous normal-pathological model which is in clear contrast with a life-history approach and its associated concept of trade-offs during development, for which variation in growth is not taken as “noise” but a source of scientific inquiry. The use of the term “stunting,” which we have avoided here, is a clear reflection of this contrast. For the Western public health world, a child that is 2 SD below the median in height-for-age is considered to be abnormal (i.e., away from the norm) and not growing to her/his potential. A life-history approach considers the costs and benefits of different phenotypes and the traits that compose them, and incorporates the concept of trade-offs that are negotiated at different stages of development. In the case of the native Qom of South America, the deviation from “normal” patterns may inform us about evolutionary strategies that are not necessarily pathological. Among the Qom, we do not observe the co-occurrence of short height and obesity/overweight found in other South American groups. However, the negative HAZ scores in infancy are surprising given their positive WAZ scores. Considering their relatively heavy birth-weight, the Qom seem to have resolved the energy allocation trade-off during infancy by diverting more energetic resources to body mass (particularly, it seems, adipose tissue) than linear growth. However, this strategy changes later during development. Given that their HAZ scores increase through their development up until juvenility, this early investment in mass may help Qom children by improving their ability to attain a final adult stature. Results obtained in this study are in agreement with the principle that growth is a robust, but plastic, process that evolved to provide individuals with the best chances of attaining adulthood under diverse and fluctuating conditions.

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