Quantitative Estimates of the Relative Contributions of Secular Trend and Community Type to Variation in Adolescent Growth in the Andean Highlands

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Introduction

In high altitude populations, children's growth is affected by several factors including poor nutrition, genetics, and hypoxia. In the Andean *altiplano*, subsistence agro-pastoralism in rural areas is associated with heavy physical labor and seasonal food shortage, stressors less likely to be experienced in urbanized communities.

Such persistent rural poverty drove increasing rural out-migration to urban and peri-urban communities throughout the 1980s and 1990s. During these periods and since there have been efforts by governmental and other entities to improve living conditions, economic options, and children's nutrition and overall health. However, it is rarely the case that such programs are implemented either continuously or evenly across communities.[1a]

Over time, various reports suggest that child growth is improving in the Andes.[1b,c] But site-specific longitudinal studies are rare,[2] making it difficult to disentangle the relative benefits of different community types (rural versus urbanized) from the impacts of regional secular (i.e., time dependent) trends in children's growth.

In this analysis we investigate the relative contributions of rural-urban community differences versus wider regional improvements that have occurred over time in living conditions and economic opportunities, to Andean children's growth (height-for-age). We use height (often called the "biological standard of living"[2b]) to assess children's growth because this anthropometric is notably sensitive to socioeconomic conditions

We focus on adolescents (ages 11-14 years), who have been less studied than adults or younger children.

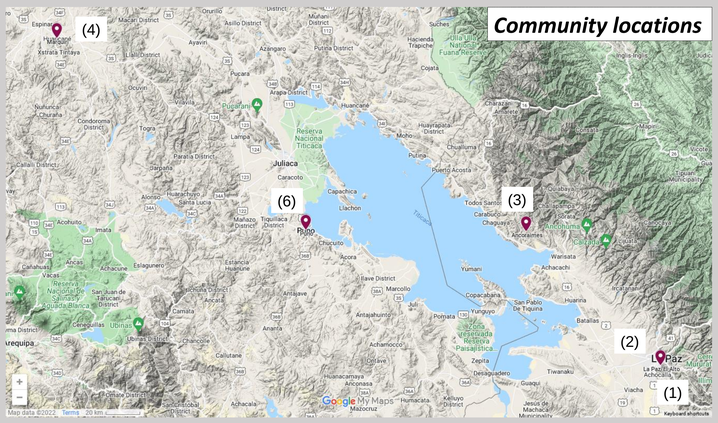
Study Design

Anthropometrics were measured for n=100 children (n=60 girls, n=40 boys), aged 11 to 14.9 years, enrolled in grades 7-8 at a school principally serving low-income neighbor-hoods in El Alto, Bolivia (altitude 4150m), a peri-urban community adjacent to La Paz (the national capital and largest city in the *altiplano*). We compared this sample with 5 published samples of Andean children (Table 1).

TABLE 1: Analytical Samples [ages 11.0-14.9yrs]

(KEY: place, community/sample type, altitude, collection year, Number of females, Number of males, [source])

(1) El Alto, Bolivia (peri-urban, 4150m, 2003): 60f, 41m [3]
(2) La Paz, Bolivia (urban, 3750m, 1983): 130f, 136m [4]
(3) Ancoraimes, Bolivia (rural, 3800-4000m, 1977): 55f, 131m [5]
(4) Marquiri, Peru (rural, 1997-98, 4100m): 79f, 53m [6]
(5) MESA, Bolivia (national sample, 2005-7): 3,445 adolescents [7]
(6) Puno, Peru (regional sample, 2016, 3821-4349m): 240f, 168m [8]



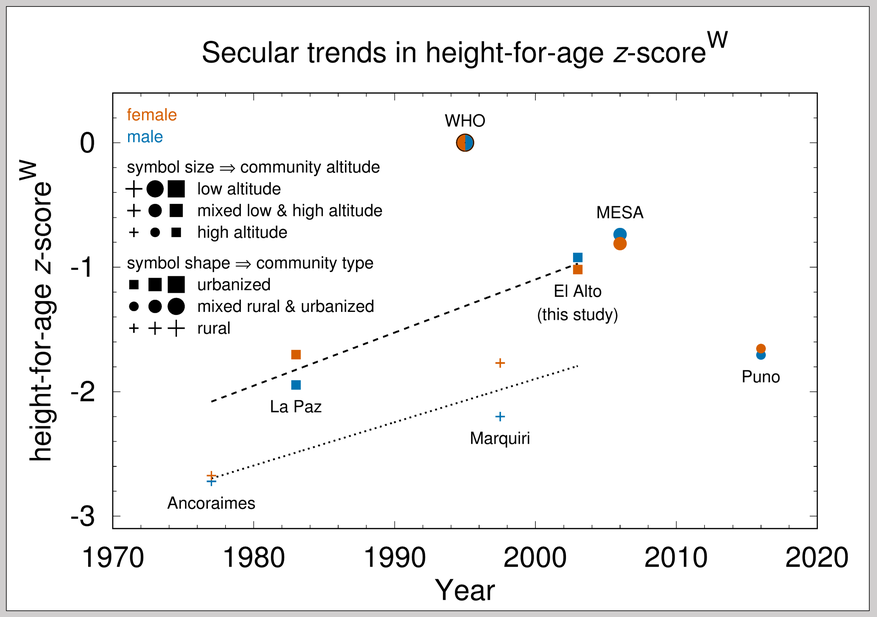


Table 2	Secular trend (z-score^W/decade)	Height-for-age (z-score^W)
Secular Trend (rate of improvement in z-score^W)		
Ancoraimes-to-Marquiri **rural trend line**	0.348	
La Paz-to-El Alto **urban trend line**	0.427	
Mean rate of improvement	0.3875	
Urbanized Locality Effect (urban − rural difference in z-score^W)		
1977: urban trend line − Ancoraimes sample (rural)		0.62
1983: La Paz sample (urban) − rural trend line		0.66
1997.5: urban trend line − Marquiri sample (rural)		0.78
2003: El Alto sample (urban) − rural trend line		0.82
Mean urbanized locality effect		0.72
Total increase in mean height from Ancoraimes to El Alto		1.727
Contribution of mean secular trend (= 0.3875 × 2.6 decades)		1.007 (58% of total increase)
Contribution of urbanized locality effect (= 1.727 − 1.007)		0.720 (42% of total increase)

Analytical Strategy

Mean height-for-age z-scores, relative to the WHO growth reference[9] (z-score^W) were calculated for girls and boys in each sample. Girls and boys' mean z-score^W were averaged; these averages were compared across the analytical samples (Table 1).

Comparing the two rural samples, the increase in z-score^W from Ancoraimes (1977) to Marquiri (1997-98) is attributable to a rural secular trend in height (reflecting general socioeconomic improvements in rural Andean regions over time). The trend line from Ancoraimes to Marquiri (extended forwards to span the entire time range from the Ancoraimes sample to the El Alto sample) is shown as the dotted line in Fig 2. The rate of improvement in z-score^W between Ancoraimes and Marquiri is 0.35 z-score^W/decade.

Likewise, the increase over time in z-score^W between the two urbanized samples, La Paz (1983) and El Alto (2003) (for the purposes of this analysis both are classified as urbanized in contrast to rural communities) is attributed to a secular trend in height for urbanized communities. This trend line (again extended to span the entire Ancoraimes – El Alto time range) is shown as the dashed line in Figure 2; the corresponding rate of improvement in z-score^W between the La Paz and El Alto samples is 0.43 z-score^W/ decade.

Averaging the rural and urbanized secular rates of improvement, the mean rate of improvement in z-score^W is 0.39 z-score^W/decade (Tab. 2).

Note that each of these rates of improvement is only an average over two-plus decades, and should not be assumed to indicate a steady positive secular trend in either rural or urbanized communities during these time periods.

The effect of locality (urbanized versus rural) on adolescent growth was estimated as the average difference in z-score^W (0.72) between the rural and urban trend lines during the entire time span from the Ancoraimes sample (1977) to the El alto sample (2003).

Results

The increase in height (1.73 z-score^W) from rural Ancoraimes (1977) to peri-urban El Alto (2003) can be attributed (Table 2) to a mean regional secular trend over 2.6 decades (about 60% of the total increase) and to the effects of urbanized versus rural locality (about 40% of the total increase).

Conclusions

By comparing data collected at different times in both rural and urbanized communities, we evaluated the potential contributions of temporal changes in living conditions (i.e., positive economic trends occurring throughout the *altiplano*), and urbanized-versus-rural locality effects, to improved growth in Andean adolescents.

Our analyses suggest that regional secular trends were a somewhat greater contributor than local peri-urban conditions per se to the improved growth of El Alto adolescents (2003) relative to rural Ancoraimes adolescents (1977). But given the limitations of the data and regional variability in resources, we cannot generalize this to infer that urbanized regions of the altiplano have generally developed more rapidly than rural areas.

Limitations

Each study used in this analysis was a single cross-sectional sample. Longitudinal studies would allow a much better estimation of in-situ secular growth trends, and could be a useful check on our inter-community comparisons. The incorporation of additional studies, preferably spanning a broad range of communities, altitudes, and typical economic strategies, could allow for separate modeling of lowland versus highland growth patterns, as well as controlling for other confounders. It would be particularly valuable if the MESA sample – a nationally representative sample from all of Bolivia – could be disaggregated into lowland and highland components.

Our sample has n=60 girls but only n=40 boys, whereas the population sex ratio is close to equal. Examination of the distribution of anthropometrics suggests that the shortest boys are under-represented in our sample, possibly due to working instead of being in school. Although we observed only small sex differences in mean height-for-age z-scores, a more representative sample would be informative.

Citations

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