The Nutritional Intake of Bolivian Boys

The Relation Between Altitude and Socioeconomic Status

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Abstract

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The nutrition of 57 native Bolivian boys living at high altitude (HA) in La Paz (±4000 m) and of 63 boys living at low altitude (LA) in St. Cruz (±400 m) is described. The dietary information was obtained with a 24-h recall method, by interviewing the child and mother. The food items are listed in household measures and weight if possible. All food items were converted into grams, and nutrients were calculated by using food composition tables of Latin America.

The results show that the energy and nutrient intake of the HSES boys was significantly higher ($p < 0.05$) than the intake of the LSES boys, at both altitudes. At HA the mean energy intake of the HSES boys was about 9.8 MJ per day (±0.7); for the LSES boys an intake was found of 8.4 MJ per day (±0.4). At LA the HSES boys had an energy intake of 10.7 MJ per day (±0.6) and the LSES boys 7.7 MJ per day (±0.3). The daily protein intake was in HAHSES boys 85 g (±8), LAHSES 100 g (±8), HALSES 60 g (±4), and LALSES 52 g (±3). In comparison with the recommended daily requirements the dietary intakes of the HSES boys seem too "rich," and of the LSES boys to some extent too "poor." These results are reflected in smaller body height and body weight of LSES boys and a higher fat mass in HSES boys irrespective of altitude.

Key words

Nutrition, Bolivia, schoolboys, prepubertal, altitude, socioeconomic status

Introduction

Altitude and socioeconomic status of the family are seen as major factors affecting childhood growth (23, 28). The growth pattern of any population cannot be viewed as the result of only environmental factors; it is an end product of the interaction of many factors such as genetic background, nutritional status, disease, stress, and hypoxia at high altitude. During childhood and adolescence, children with similar genetic backgrounds, but different nutritional status, show differences in height; on the other hand, children of different genetic backgrounds and similar nutritional status also show differences in height (8, 12, 18, 25). The fact that adolescents of poor nutritional status are significantly shorter than their counterparts of good nutritional status indicates that under conditions of poor nutrition the role of genetic factors on growth in height can be overridden by the influence of environmental factors (4). On the other hand, nutritional status in less developed countries is strongly influenced by the socioeconomic status of the family.

It is interesting to determine if a lifestyle factor, such as nutrition, is related to health factors such as growth of prepubertal boys, if living at high altitude may influence these factors, and if indeed socioeconomic level has its effect in another way.

This article presents the nutrition of native highland and lowland Bolivian boys, 10- to 12-years-old, living in urban La Paz and Santa Cruz de la Sierra.

Subjects and Methods

Subjects

The study included 120 boys ranging in age from 10- to 12-years (mostly derived from birth certificates).

In La Paz, at high alttitude (HA), a sample of 57 boys was examined in relation to nutrition; 17 boys from high socioeconomic status (HSES) and 40 boys of low socioeconomic status (LSES). In Santa Cruz, at low altitude (LA), the dietary intake of a sample of 63 boys was studied; 23 boys of HSES and 40 boys of LSES.

Nutritional interview

In order to choose the right method for determining the nutritional intake, the following factors had to be considered:

- During the months of July and August about 4 weeks were available to collect data.
- One local nutritionist was available during the study period.
- The expected variance in food items.

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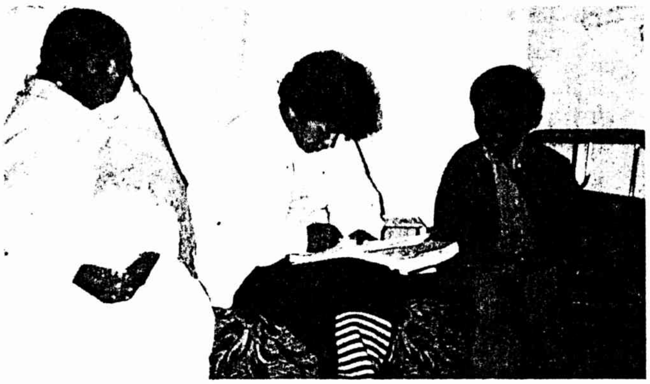
a



b

Fig. 1 a. The 24-h recall interview; **b**. weighing ingredients during the dietary interview at home.

Table 1 Mean and standard error ( ) of the nutrient intake and energy output of schoolboys by altitude and socioeconomic status.

Altitude		**High**				**Low**				**Effects #**		
Sodioeconomic status		High		Low		High		Low		A	SES	A × SE
Subjects		N = 17		N = 40		N = 23		N = 40				
	unit	mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)			
Nutrient variables												
Energy	MJ	9.8	(0.7)	8.4	(0.4)	10.7	(0.6)	7.7	(0.3)	NS	**	NS
Energy/kg BW	kJ	250	(21)	268	(13)	284	(21)	248	(10)	NS	NS	NS
Protein	g	85	(7.8)	60	(3.9)	100	(8)	52	(3)	NS	**	**
Protein/kg BW	g	2.1	(0.2)	1.9	(0.1)	2.6	(0.2)	1.7	(0.1)	NS	**	*
Fat	g	62	(7.4)	37	(4.1)	66	(6)	28	(3)	NS	**	NS
Carbohydrate	g	370	(26)	357	(13)	395	(22)	350	(13)	NS	NS	NS
Calcium	mg	1315	(140)	962	(66)	1596	(178)	685	(54)	NS	**	**
Thiamin	mg	0.89	(0.08)	0.67	(0.05)	0.84	(0.06)	0.60	(0.03)	NS	**	NS
Ascorbic acid	mg	170	(45)	71	(10)	135	(20)	84	(13)	NS	**	NS
Activity energy/kg BW	kJ	223	(9.9)	327	(12.4)	247	(11.5)	359	(13.6)	*	**	NS

SE = standard error of the mean; # = Statistical difference $^{*}p \leq 0.05$; $^{**}p \leq 0.01$; NS = not significant

The dietary information was obtained with a 24-h recall method by interviewing the child. The mother, or the person who prepared the dishes at home, was present to provide additional information about details of the meals and ingredients. All the interviews took place during home visits in the morning or in the afternoon and lasted about 30 min. Commonly used utensils, such as plates, bowls, and cups, were examined to estimate the quantities. Ingredients of meals were weighed if possible on a pair of scales. (Fig. 1).

Activity interview

The activities were measured with a 24-h recall method, covering the same 24-h as the food intake. The activities, measured by the interview in duration, ranged in 4 different intensities and converted to energy in kcal: (a) sleep 0.8 kcal/min, (b) light activities (sitting, standing) 1.5 kcal/min, (c) medium activities (walking, cycling) 3.5 kcal/min, and (d) heavy activities (running, carrying loads) 7.0 kcal/min, based on children aged 10–12 years, with a weight of 30–35 kg (3).

Data analysis

The food intake was determined by converting household measures into grams and coding the food items separately. The nutrient composition was obtained primarily from the Bolivian table of food composition (16), supplemented for selected items from the INCAP table (13), and the SVEN table (26), and when no other possibility was left a single item from the Dutch food composition table (19) was taken.

The data were analyzed in terms of nutrient composition and adequacy (compared to recommended daily allowances by FAO/WHO) (5). Energy and protein intakes are given in absolute values and per kg body weight per day.

Results

The average daily energy and nutrient intake, as well as the energy output (kJ per kg body weight) are given in Table 1 for the four groups. The results show in general no

Table 2 Mean and standard error ( ) of the contribution of macronutrients to the energy intake in percentages by altitude and socioeconomic status.

Altitude		High				Low				Effects #		
Socioeconomic Status		High		Low		High		Low		A	SES	A × SES
Subjects		N = 17		N = 40		N = 23		N = 40				
		mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)			
Energy by												
Protein	%	14.4	(0.8)	11.8	(0.4)	15.3	(0.5)	11.1	(0.4)	NS	**	NS
Fat	%	23.1	(1.7)	15.8	(1.1)	23.2	(1.3)	13.2	(1.0)	NS	**	NS
Carbohydrate	%	64.1	(2.0)	72.8	(1.2)	62.4	(1.5)	76.2	(1.1)	NS	**	NS

SE = standard error of the mean; # Statistical significance: *p ≤ 0.05; **p ≤ 0.001; NS = not significant

Table 3 The mean and standard error ( ) of the age and anthropometric characteristics of Bolivian schoolboys by altitudes and socioeconomic status.

Altitude		High				Low				Effects #		
Socioeconomic status		High		Low		High		Low		A	SES	A × SES
Subjects		N = 17		N = 40		N = 23		N = 40				
		mean	(SE)	mean	(SE)	mean	(SE)	mean	(SE)			
Age	yrs	11.1	(0.2)	10.9	(0.2)	10.5	(0.1)	10.7	(0.1)	*	NS	NS
Body weight	kg	40.7	(2.4)	32.0	(0.9)	38.9	(1.7)	31.8	(0.8)	NS	**	NS
Body height	cm	144.8	(1.6)	134.5	(1.3)	141.2	(1.3)	134.1	(1.2)	NS	**	NS
Skinfolds (sum of 4)	mm	53.8	(6.5)	29	(1.4)	52.8	(4.9)	33.1	(1.8)	NS	**	NS

SE = standard error of the mean; # Statistical significance: *p ≤ 0.05; **p ≤ 0.01; NS = not significant

differences between groups living at different altitudes, but significant differences between groups of high and low socioeconomic status: the HSES schoolboys have higher energy and nutrient intakes than their LSES counterparts. Almost all the nutrients are significantly ($p \leq 0.01$) higher in the HSES than in the LSES boys, except the energy intake per kg body weight and the carbohydrate intake. The results of the ANOVA indicate also significant interaction effects between altitude and socioeconomic status for protein and calcium intakes ($p \leq 0.01$). A tendency to significance is found for energy intake per kg body weight ($p = 0.09$).

The data of the activity interview, calculated as energy per kg body weight, showed a significantly ($p \leq 0.01$) higher activity level of LSES boys compared to their HSES counterparts. Also an effect of altitude could be demonstrated; boys at low altitude were significantly ($p \leq 0.05$) more active than the boys at high altitude.

In Table **2** the contribution of energy by protein fat, and carbohydrate are given. The differences between SES groups are statistically significant ($p \leq 0.01$). The nutrition of HSES boys contributed higher percentages of energy from protein (ca. 15 %) and fat (ca. 23 %) compared to the LSES boys (ca. 11.5 % and ca. 14.5 %), but lower energy from carbohydrate (ca. 63 % vs ca. 74.5 %), at both altitudes. The lowest contribution from protein (11 %) and fat (13 %) to the energy intake was found in the LSES boys at LA. A tendency of an interaction effect between altitude and socioeconomic status was only found for the percentage energy from carbohydrate ($p = 0.08$).

Table **3** presents the age and the anthropometric characteristics of the four groups. The mean age of the boys was 11 years. The HA boys were significant older ($p = 0.04$) than the LA boys. No other age differences were found. The data indicate that HSES boys are significantly taller, heavier, and show a greater sum of four skinfolds then the LSES boys. No significant effects of altitude or interaction effects could be demonstrated.

Discussion

Dietary measurement method

In this study a 24-h dietary recall was used to estimate the daily food intake. Garn et al. (8) describe that a single-day dietary survey tends to overestimate levels of nutritional deficiency, or underestimate the daily variation, because they fail to account for intraindividual variation in intakes. Indeed, it is well-known that in well-to-do countries there will be a big day-to-day difference. However, in a developing country like Bolivia it has been demonstrated that there is much less variability in meal patterns and possibilities for food choices than in Western diets.

Another possible interfering factor in the food intake could be the seasonal variation, especially in poor families. Leonard and Thomas (14) described seasonal differences of 15 %–20 % of the daily energy intake, namely because of the pre- and postharvest availability of locally produced foods in Peru. Leonard (15) indicated that the availability is highest between June and August in the Nuñoa highlands, in southern

Peru next to Bolivia. Our study took place both years in the months of July and August.

So for the purpose of this study within the limitations of the field conditions a 24-h recall was seen to be a suitable and preferable method.

Dietary quality

The meal pattern of the schoolboys, at both altitudes, was relatively homogeneous. Most children reported a breakfast of a roll and a warm beverage, usually tea or coffee sweetened with sugar. HSES boys more frequently reported the use of a milk product, and the use of butter, margarine, or other spreads. During school time most children consumed a light snack, such as gelatin, bread, and other sweets. At midday usually the largest meal was eaten, commonly a soup with meat or chicken and vegetables. In the more wealthy families, a *segundo* was also served, consisting of meat, chicken, egg, and potato (in La Paz more often chuño) or rice. During the afternoon the boys reported mostly a tea break with a sweetened beverage and bread. If a late evening meal was consumed it consisted of a soup, mostly leftovers from previous meals, or both.

Evaluation of the quality of the schoolboys' diets showed overall levels of energy and nutrient intake relatively high in HSES boys and low in LSES boys. This is reflected in the body composition (Table **3**); HSES boys had a relatively high body weight in relation to their body height, whereas LSES boys were relatively small in relation to their age. The sum of four skinfolds indicated the same direction: HSES boys showed a mean value of 53 mm, and LSES boys of about 30 mm. The FAO/WHO committees (5) recommend a daily energy intake of 9.2 kJ in 10- to 12-year-old boys. Recommendations for the energy requirements of children are based mainly on measurements of the actual food intake of healthy children with a normal growth pattern. In this study the HSES boys showed a higher energy intake (10 kJ per day) (Table **1**). The LSES boys showed a lower energy intake (8 kJ per day).

Obviously, the energy intake of children must allow for satisfactory growth and physical development, and for the high degree of activity that is characteristic in healthy children (3). Tanner (27) pointed out that the first thing that happens in the undernourished child is a slowing down of growth. If satisfactory growth is reflected in body height it is evident that the energy intakes of the HSES boys was in agreement with the mentioned requirements, and that the smaller height of the LSES boys (8–10 cm difference) indicated an energy intake that was too low. Spurr et al. (21) found for 11-year-old normal Columbian boys a height of 138 cm, but the undernourished counterparts showed a mean height of 134 cm. The LSES boys in our study showed the same mean height of 134 cm. Although the ethnic background in the study of Spurr et al. (22) was different (±80 % mestizo ancestry) from our LSES population, he found it justified to use the values obtained from schoolchildren from upper socioeconomic groups as standards. The other factor taken into account is the energy expenditure. It is difficult to measure this in children accurately because of their varied and ever-changing range of physical activities. In our study the 24-h recall of activities was over the same period as the interviewed food intake. Calculated as the amount of energy spent per day per kg body weight, LSES boys showed a significantly higher activity pattern than the HSES boys. It must be recognized that children in developing countries of low socioeconomic families commonly play a significant role in caring for lifestock and in looking after young children (14). Energy should be available for these essential tasks. The LSES boys in our study showed indeed an energy expenditure higher than their energy intake, while the HSES boys, mostly not involved in household tasks, showed a lower energy output compared to their high energy intake. The tendency to a negative energy balance in LSES and a positive energy balance in HSES can explain the differences in body composition between these groups. However, it must be stressed that both energy intake and energy output are measured on a recall basis and over a relatively short period (24 h). Also, the fact that fixed values of energy for the different intensities was chosen for the different activities has to be taken into consideration.

The major source of energy was carbohydrate (65 %–75 %). The energy contribution of fat was very low (13 %–23 %), whereas protein contributed about 11 %–14 %. Moreno-Black (17) studied 7- to 11-year-old boys in La Paz and found in general the same contribution with 77 % of the energy from carbohydrate, but lower from fat (8 %) and higher from protein (15 %). However, this study took place in younger boys and during the period of October to November. So the differences may be partly due to seasonal variation, as well as to the different age of the children.

The energy balance of the body becomes an important factor in determining protein requirements, especially when low energy intakes are found. The recommendation of the FAO/WHO is 34 g protein per day or 1.0 g per kg body weight. The average intakes of the schoolboys in this study easily reached both recommendations. No differentiation is made for animal and vegetable protein. However, it must be considered that the food habits in HSES boys included a high percentage of animal protein, whereas LSES boys mostly consumed protein of vegetable origin. The latter possesses a lower nutritional value. On the other hand, there is a good possibility that the absorption of protein will be disturbed by the presence of parasites in the gut. At LA the feces were analyzed for parasites in both HSES and LSES boys. In HSES boys ca. 31 % and in LSES boys ca. 94 % were infected by polyparasites. The protein absorption will be seriously affected by these parasites, especially in the LSES boys where the prevalence of parasites was the highest in combination with the lowest protein intake and of the lowest nutritive value.

The calcium intake (mean 685 mg/day) of the LALSES boys must be considered too low. Although some recommendations are 650 mg/day (26), others (2) stated that at least 900 mg/day are necessary in growing children. A low calcium intake can have serious consequences on the growth rate, especially when the pubertal growth spurt is involved.

Dietary quality and altitude

Although people who are suddenly exposed to high altitudes suffer anorexia, weight loss, and a reduction in aerobic capacity, these are temporary effects that disappear with acclimatization. Greksa et al. (10, 11) found that hypoxia and/or the cold as the principle stressors may actually have a significant impact on statural growth. At high altitude the slowed rate of statural growth and a smaller body size of Andean children have generally been viewed as adaptive responses with the role of nutrition as negligible or secondary (9). Freyre and Ortiz (6) found somewhat greater heights and weights in male (and female) adolescents at sea level compared to those at high altitude. Haas et al. (12) found 25% more adipose tissue in La Paz than in Santa Cruz in infants of the same age (6 to 12 months). In this study such a difference between both altitudes was not observed.

The differences in nutritional intakes were not statistically significant between HA and LA groups, indicating that altitude has relatively little effect in explaining the growth and weight gain patterns of the residents. Thus, there is no evidence that the requirements for energy and protein are altered in those who habitually live at high altitudes. The higher activity pattern in boys at LA compared to HA can be explained by other environmental differences, such as temperature and oxygen pressure of the air.

Our findings suggest that altitude does not seem to affect to such a great extent the nutritional intake, that high altitude schoolboys consume significantly less than their counterparts at low altitude. The only significant differences were found for the protein and calcium intake, but they proved to be interaction effects of altitude and socioeconomic status. In relation to growth there seems to be no influence of altitude.

Dietary quality and socioeconomic status

The boys of the higher SES families showed a dietary intake with higher energy and nutrient values than the food intake of the boys with lower SES. Tables **1** and **2** show this to be highly statistically significant, and this is reflected in body composition (Table **3**). The LSES boys were on the average about 7 cm shorter than their age-related counterparts. The height in HSES boys indicates a normal growth rate for their age. Freyre and Ortiz (6) found at sea level as well as at an altitude of 3400 m in 11-year-old boys of middle to high socioeconomic class a height of 141 cm. In our study the same mean height was found at LA for HSES boys, but at HA the HSES were even taller. However, we have to consider that these HSES boys at HA were significantly older than the HSES boys at LA. The HSES boys in the Stinson growth study in La Paz (24) showed also a height of about 141 cm at the age of 11 years. In terms of body weight, Freyre and Ortiz found a weight of about 35/36 kg for HSES boys; Stinson indicated about 35 kg. The HSES boys in this study showed a body weight between 39 and 41 kg, whereas LSES boys weighed only 32 kg.

The greater sum of four skinfolds of the HSES schoolboys, as an estimation of body fat, indicates that these boys had a more than adequate energy intake. This result is also reflected in the lower activity pattern of the HSES boys. The situation in LSES boys showed a somewhat borderline energy intake, although the sum of four skinfolds of about 30 mm in these boys does not indicate a serious energy deficiency. Given the higher socioeconomic status in the HSES boys it was assumed that the better nourished boys were healthier than the boys of lower SES, but this assumption does not seem to be realistic. According to anthropometric data the HSES boys showed a tendency toward becoming overweight, partly due to inactivity, which might affect their health as is found in the rich parts of the world.

Conclusion

This study demonstrates that in 10- to 12-year-old Bolivian boys the nutritional intake is influenced by socioeconomic status, and not by altitude. Improvement of living conditions is thought to cause a secular trend toward greater stature and body weight for LSES children. HSES boys consume greater amounts, especially more protein and fat, and they are taller, but also fatter. LSES boys consume less energy than the HSES boys, which is mostly contributed by carbohydrates. While the total contribution of protein in LSES boys (ca. 11%) does not seem too low, a possible malabsorption can be caused by the high percentage of polyparasites in their feces. The physical activity of LSES boys was higher than that of the HSES boys; this lifestyle seems to be healthier compared to the HSES boys.

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