General Conclusions from the Study on 10- to 12-Year-Old Bolivian Boys and Suggestions for Future Research

H. C. G. Kemper[1], *J. Coudert*[2], *J. L. San Miguel*[3]

[1] Dept. of Health Science, Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam, The Netherlands
[2] Laboratoire de Physiologie et Biologie du Sport, Faculté de Médecine, Université d'Auvergne, Clermont Ferrand, France
[3] Instituto Boliviano de Biologia de Altura, La Paz, Bolivia

Introduction

The effects of resident altitude and socioeconomic status on the physical health and fitness were investigated in 10- and 11-year-old prepubertal boys living at two altitudes (high altitude: ca. 4000 m and low altitude: ca. 400 m) and from a relatively high and low socioeconomic status in Bolivia.

The 143 boys who were investigated were divided into four groups according to the combinations of altitude (HA and LA) and socioeconomic status (HSES and LSES).

Conclusions

Analysis of variance revealed the following results:

1. The physical growth and development of the LSES boys was delayed by approximately 2 years compared to HSES boys; within the same SES there were no differences between HA and LA boys. From this it can be concluded that the physical growth of prepubertal boys is predominantly dependent on socioeconomic status and not on altitude.

2. Pulmonary volumes such as vital capacity and residual volume were higher at HA compared to LA, and also higher in LSES than in HSES boys.

3. HA boys irrespective of socioeconomic status showed higher hematocrit, serum iron, hemoglobin, ferritin, transferrin saturation, and red cell protoporphyrien than LA boys. Although HSES boys showed higher values than LSES boys in all groups, the iron status was within the normal range.

4. Among the biochemical markers of nutritional status, prealbumin concentrations were lower in LSES than in HSES boys and albumin concentrations were higher at HA than at LA.

5. Maximal oxygen uptake ($\dot{V}O_2max$) relative to body weight was 11% lower in HA boys than in LA boys. Absolute $\dot{V}O_2max$ was greater in HSES than in LSES boys, but there was no significant effect of SES on $\dot{V}O_2max$ relative to body weight.

6. Maximal (Pmax) and mean (P) anaerobic power, determined respectively by the force-velocity test and 30-s Wingate test, were not different between HA and LA boys for the same socioeconomic status. However, in LSES boys Pmax and P, expressed in both absolute and relative terms, were lower than in HSES boys.

7. Blood lactate concentrations (L) obtained in recovery after maximal and supramaximal exercise were lower at HA than at LA and in LSES boys than in HSES boys. This can partly be explained by a lower gonadal maturation, evaluated by salivary testosterone concentration.

8. The nutritional intake, estimated by a 24-h recall, revealed influences by socioeconomic status but not by altitude: HSES boys consumed higher amounts of protein and fat than LSES boys. Although the protein intake in LSES boys did not seem too low, the high prevalence of parasites in the intestine (ca. 94%), could cause a malabsorption of the available proteins.

9. Habitual physical activity, measured by 24-h heart rate and from a 24-h recall, showed that LA boys have physical activities of higher intensity than HA boys. The same holds for the LSES boys compared to the HSES boys. Both LA and LSES boys showed an activity pattern that meets the guideline for maintaining good health and endurance fitness.

10. At both altitudes HSES boys had on the average a percentage of body fat that is 21% of their body mass; this can be assumed as a relatively high percentage, taking into account that 15% of the HSES boys showed severe obesity and were not included in this sample. This percentage of body fat is significantly higher than in LSES boys (ca. 17%).
The tendency to overweight in these young HSES boys can be explained by the higher energy intake in combination with the lower energy output in the HSES boys compared to the LSES boys.

Int. J. Sports Med. 15 (1994) S112–S113

The above-described effects of altitude and socioeconomic status are summarized in Table **1**.

Table 1 Overview of the conclusions from the Bolivian boys study: = no difference; + higher values; – lower values.

Characteristics	Altitude	Socioeconomic Status
	High vs low	Low vs high
Biological development (height, weight)	=	–
Anthropometrics (% fat from skinfolds)	=	–
Pulmonary volumes (vital capacity, residual volume)	+	+
Hematology (hematocrit, hemoglobin)	+	=
Biochemical markers (prealbumins)	=	–
Recovery blood lactate (capillary blood)	–	–
Aerobic power ($\dot{V}O_2max$)	–	=
Nutritional intake (total energy, protein, fat)	=	–
Physical activity (24 h HR, 24 h recall)	–	+

In general it can be concluded that the differences in socioeconomic status are of more importance to the health and fitness of prepubertal boys than the effects of residential high altitude.

Suggestions for Further Research

Because no specific tests for ethnic background were used in the studies, it is possible that genetic differences between HSES and LSES boys may have been a confounding factor in the comparison of groups with different SES.

The higher lung volumes, expressed as a percentage of predicted values which are observed in LSES boys need further research: especially lung mechanic measurements should be undertaken to support underlying mechanisms such as emphysema-like alterations or decreased elastic recoil properties.

Moreover, to get a more objective measurement of the individual socioeconomic status of the boys from the different schools a questionnaire about the living conditions, income, education, and occupation of the parents should be added.

The lifestyles that seem important for the health and fitness of the children, habitual physical activity and nutrition, were measured over a relatively short period of 24 h during school days. To get more clear answers about these habits, the measurements should be extended over more days and also during the weekend.

The nutritional intake is strongly influenced by the seasons of the year, because the availability of different agricultural products (fruit, vegetables) is not the same. This study was carried out in the winter and an extension of the nutritional intake also to the other periods of the year should be included in order to get a valid measure of the mean intake over the year.

As far as the heart rate measurement is concerned there is a problem with the interpretation of the data with respect to energy output. Individual calibration of the heart rate/oxygen uptake relationship is necessary. This could be realized by careful steady-state measurements of the children in activities that are often encountered in their daily life, such as lying, sitting, standing, walking, running etc.

Furthermore, it is hypothesized that hypoxia at HA and intestinal parasitosis could impair nutrient absorption; therefore, studies on amino acid and protein metabolism, using a stable isotope tracer method, are planned.

Prof. H. C. G. Kemper
Dept. of Health Science
Faculty of Human Movement Sciences
Vrije Universiteit
v.d. Boechorststraat 7–9
NL-1081 BT Amsterdam
The Netherlands