ANTHROPOMETRIC AND BIOENERGETIC CHARACTERISTICS IN HIGHLAND BOLIVIAN CHILDREN OF HIGH AND LOW SOCIO-ECONOMIC STATUS.

Obert P.*, G. Falgairette*, M. Bedu, N. Fellmann**, E. Van Praagh*, H.C.G. Kemper***, B. Post***, G. Parent****, A. Quintanilla****, V. Tellez**** , H. Spielvogel**** and J. Coudert**.**

*Laboratoire de la performance motrice, UFRSTAPS, Aubière, France ; **Laboratoire de physiologie, Faculté de médecine, Clermont-Ferrand, France, Faculty of Human Movement Sciences, Amsterdam, The Netherlands, ****ORSTOM / Instituto Boliviano de Biologia de Altura, La Paz, Bolivia.

Abstract

The aim of this study was to compare the biometric and bioenergetic characteristics of high-altitude Bolivian children of high and low socio-economic status. The sample consisted of 67 children (11 years old) residing in La Paz, Bolivia (3600 m). All children were born and raised at altitude (>3000 m). Twenty-three children were from upper-class families (HA1) and 44 were from lower-class families (HA2). Selected anthropometric characteristics (height, weight, 4 skinfolds, upper arm muscle circumference) were determined in each group by the same researcher. The maximal oxygen uptake (VO2 max) was determined by a continous and progressive exercise on a Brue cycle ergometer. The maximal anaerobic power (Pmax) was determined by a force-velocity test and the mean power (P30s) was determined by a Wingate test. In addition, we assessed the nutritional status of each subject from biochemical and hematological analyses. HA1 children were taller, heavier, fatter and had a higher upper arm muscle cicumference than HA2 children. Pmax and P30s expressed in W, W/kg and W/kg lean body mass (LBM) were significantly ($p<0.05$) lower in HA2 than in HA1. However, there was no significant difference for VO2 max (ml/min/kg, ml/min/kg LBM). The serum ferritin, serum iron, pre-albumin and transferrin saturation were the only biochemical and hematological parameters significantly lower in HA2 than in HA1. These results suggest that among highland Bolivian children, the nutritional status has a determinant role in the process of the development of certain body dimensions, in Pmax and P30s and has no impact on VO2max (ml/min/kg, ml/min/kg LBM).

INTRODUCTION

In previous studies (Fellmann et al. 1988, Falgairette et al. 1989, Bedu et al. 1991) the effect of high altitude on aerobic and anaerobic metabolism of boys has been studied in children of the upper socio-economic class of La Paz, Bolivia (3600m). However, no work has investigated the effect of the socio-economic level of boys living at high altitude on maximal oxygen uptake and anaerobic power. Moreover, numerous studies (Leonard 1989, Greska et al. 1984) have demonstrated that at high altitude the biometric development is influenced by the socio-economic level of children. The aim of the present study was to compare the biometric and bioenergetic characteristics in highland Bolivian children of high and low socio-economic levels.

SUBJECTS AND METHODS

The sample consisted of 67 children (11 years old) residing in La Paz, Bolivia (3600m). All children were born and raised at high altitude (>3000m). Twenty-three children were from upper-class families (HA1) and 44 were from lower-class families (HA2).
The anthropometric characteristics took into account the height, weight and the upper arm muscle circumference determined according to the method of Jelliffe (1966). The percentage of body fat mass was evaluated from 4 skinfold thicknesses and lean body mass was determined from the weight and the body fat mass. Biochemical and hematological analyses (hemoglobin, hematocrit, serumferritin, serum iron, pre-albumin and transferrin saturation) were realised in order to assess current nutritional deficiency. The boys took part in 3 tests. Each exercise bout was conducted on a Brue cycle ergometer. The maximal oxygen uptake (VO2 max) was determined by direct method during a continous and progressive exercise.

Theboys were encouraged to reach exhaustion. The maximal anaerobic power (P max) was determined by a force velocity test. The subjects performed 5 or 6 maximal sprints of 6-8 s against increasing braking forces. A recovery period of 30 s separated 2 sprints. P max was calculated from the force-velocity relationship. The braking force for which P max was obtained corresponded to the optimal force. Forty-five minutes later, the boys performed a 30 s Wingate test. They had to pedal as fast as possible for 30 s against the optimal force determined during the previous test. The mean power (P 30 s) was calculated from the total number of pedal revolutions realised during the test and the optimal force applied.

RESULTS

HA1 children were taller, heavier, fatter and had a higher upper arm muscle cicumference than HA2 children (HA1: 139.92±7.33, HA2: 131.17±4.62 cm; HA1: 36.8±8.7, HA2: 29.±4.25 kg; HA1: 21.3±5.8, HA2: 16.5±3.3 %; HA1: 19.5±2.2; HA2: 17.4±1.3 cm; respectively). Pmax and P30s (W, W/kg, W/kg LBM) were significantly lower in HA2 than in HA1 (table 1). However, there was no significant difference between the 2 groups for VO2 max (ml/min/kg, ml/min/kg LBM) (table 1). The serum ferritin, serum iron, pre-albumin and transferrin saturation were the only biochemical and hematological parameters significantly lower in HA2 than in HA1 (HA1: 76.7±48.8, HA2: 52.4±30.3 ng/ml; HA1: 166±70, HA2: 133±32 µg/dl; HA1: 23.8±5, HA2: 19.45±6.3 mg/dl; HA1: 39.3±14.3, HA2: 29.2±6%, respectively).

	Pmax			P30s			VO2max		
	W	W/kg	W/kg LBM	W	W/kg	W/kg LBM	l/min	ml/min/kg	ml/min/kg LBM
HA1	251±69	6.9±1.0	8.7±1.2	193±53	5.2±0.8	6.7±1.0	1.4±0.3	37.1±5.6	47.4±6.3
	***	***	***	***	*	**	*	ns	ns
HA2	164±35	5.5±0.8	6.6±1.0	133±34	4.5±0.9	5.4±6.4	1.2±0.2	38.9±6.4	46.7±7.4

Table 1: *Bioenergetic characteristics of HA1 and HA2 children; LBM: lean body mass; * p<0.05, ** p<0.01, *** p>0.001, ns: non significant*

DISCUSSION

Eleven year old HA1 children were taller and heavier than HA2 children of the same age (p<0.001). This is in accordance with previous studies which analysed the effect of the socio-economic level on body size both at high and low altitude (Frisancho et al; 1975, Leonard 1989, Greska et al. 1984). In developing countries, Frisancho (1975) and Greska (1985) have shown that the growth of children of a poor socio-economic and nutritional status was delayed compared to that of children of high socio-economic status and considered nutritionally normal. HA1 children were of the same height and weight as children of the upper socio-economic class of Bogota who were considered nutritionally normal (Spurr et al. 1983A). Moreover HA1 children had similar body sizes and weights to US and French boys of the same age (Hamill et al. 1979, Sempe 1979). HA2 children were on average 2 years behind US and French standards and had similar heights and weights to children of the lower socio-economic level of Bogota who had a past history of malnutrition (Spurr et al. 1983A). According to Trowbridge et al. (1982), differences in the development of children are related to differences in nutritional background and particularly to different levels of nutrition during early childhood. Muscle mass and body fat mass have been widely used to assess the nutritional status of children because they are indirect indicators of calorie and protein reserves of the body (Martorell et al., 1976). In the present study, differences in the upper arm muscle cicumference (which is a good indicator of the total lean body mass) and in the body fat mass between the 2 groups clearly indicated that the boys had a different nutritional status during growth. Moreover, the serum iron, serum ferritin, pre-albumin and transferrin saturation were significantly lower in HA2 than in HA1. This appears to underline current differences in diet between the 2 groups. However, the hematocrit, hemoglobin, serum iron, serum ferritin, pre-albumin and transferrin saturation were within he normal range for boys of this age (Geigy 1963) and indicated no severe malnutrition at he time of the study.

/O2 max (l/min) was significantly lower in HA2 than in HA1. This was primarily due to the mallest boys of the HA2 group and VO2 max expressed in terms of body weight or lean body mass was not different between the 2 groups. Moreover, VO2 max (ml/min/kg) of HA1 and HA2 children reached similar level s to those previously determined in boys of the ipper class families of La Paz (Fellmann et al., 1988). It appeared therefore that the socio-economic and nutritional status did not affect VO2 max among highland children when body weight was taken into account. Spurr et al. (1983B, 1989) came to essentially the same conclusion for boys of different socio-economic levels living in Bogota (altitude : 2600m). P max and P 30s expressed in absolute terms were significantly lower in HA 2 than in HA1. Even when body weight and fat free mass were taken into account, the differences between he 2 groups were significant ($p<0.05$) and were of the same order as those previously determined with the same method in well nourished boys of La Paz (Bedu et al., 1991). There exists no data regarding P max and P 30s for boys of low socio-economic level. When compared with data obtained by Bedu et al. (1991), HA2 children have P max and P 30s similar to those obtained by 9 year old children.

CONCLUSION

The delay of physical growth observed among HA2 children appeared principally to be due to poor socio-economic conditions associated with poor nutritional status during early childhood. At the time of the study, the nutritional status of both groups was within the normal range for children of this age. Boys of low socio-economic level and considered to have had a past history of malnutrition had lower P max and P 30s and the same VO2 max expressed in relative terms as boys of high socio-economic level and considered nutritionally normal. The delay observed in P max and P 30s was the same as that observed in the physical growth (2 years).

This work has been supported by the European Community (contract number : CI 1 */0507-F).

REFERENCES

Bedu M., Fellmann N., Spielvogel H., Falgairette G., Van Praagh E. and Coudert J. (1991) Force-velocity and 30s Wingate tests in boys at high and low altitudes. *J. Appl. Physiol.* 70 : 1031-1037.

Falgairette G., Van Praagh E., Fellmann N., Bedu M., Spielvogel H. and Coudert J. (1989) Effect of high altitude chronic hypoxia on lactate and ventilatory thresholds in healthy young boys. In "Children and exercise XIII", *International Series on Sport Sciences,* Oseid H. and Carlsen K. H. (eds), Human Kinetics Publishers, pp 145-153.

Fellmann N., Bedu M., Spielvogel H., Falgairette G., Van Praagh E., Jarrige J. F. and Coudert J. (1988) Anaerobic metabolism during pubertal development at high altitude. *J. Appl. Physiol.*, 64 : 1382-1386.

Frisancho A. R., Borkan G. A. and Klayman J. E. (1975) Pattern of growth of lowland and highland Peruvian Quechua of similar genetic composition. *Hum. Biol.*, 47 : 233-243.

Geigy. (1963) Documenta, tables scientifiques, Geigy J. R. (eds), S. A., Basel.

Greska L. P., Spielvogel H., Paredes-Fernandez L., Paz-Zamora M. and Caceres E. (1984) The physical growth of urban children at high altitude. *Am. J. Phys. Anthropol.*, 65 : 315-322.

Greska L. P., Spielvogel H. and Caceres E. (1985) Effect of altitude on the physical growth of upper-class children of European ancestry. *Ann. Hum. Biol.*, 12 : 225-232.

Hamill P. V. V., Drizd T. H., Johnson C. L., Reed R. B., Roche A.F. and Moore W. M.

(1979) Physical growth : National Center for Health Statistics percentiles. *Am. J. Clin. Nutr.*, 32 : 607-629.

Jelliffe D. B. (1966) The assessment of the nutritional status of the community. *World Health Organ. Monograph Ser.* No. 53. Geneva.

Leonard W. R. (1989) Nutritional determinants of high altitude growth in Nunoa, Peru. *Am. J. Phys. Anthropol.* , 80 : 341-352.

Martorell R., Yarbrough C., Lechtig A., Delgado H. and Klein R.E. (1976) Upper arm anthropometric indicators of nutritional status. *Am. J. Clin. Nutr.*, 29 : 46-53.

Sempe M. (1979) *Auxologie, méthodes et séquences.* Theraplix (eds), 1, 205p.

Spurr G. B., Reina J. C. and Barac-Nieto M. (1983A) Marginal malnutrition in school-aged Colombian boys : anthropometry and maturation. *Am. J. Clin. Nutr.*, 37 : 119-132.

Spurr G. B., Reina J. C., Dahners H. W. and Barac-Nieto M. (1983B) Marginal malnutrition in school-aged Colombian boys : functional consequences in maximum exercice. *Am. J. Clin. Nutr.*, 37 : 834-847.

Spurr G. B. and Reina J. C. (1989) Maximal oxygen consumption in marginally malnourished Colombian boys and girls 6-16 years of age. *Am. J. Hum. Biol.*, 1 : 11-19.

Trowbridge F. L., Hiner C.D. and Robertson A. D. (1982) Arm muscle indicators and creatine excretion in children. *Am. J. Clin. Nutr.*, 36 : 691-696.