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Original

Nutrient intake in 5-17-year-old African boys and girls in a rural district of Kenya

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Abstract

Objective: **To investigate relationships between nutritional status and growth among a sample of schoolchildren and adolescents living in a rural district of Kenya.**

Design: **Cross-sectional nutritional and anthropometric survey.**

Setting: **The data are from schools in a rural district of south-western Kenya.**

Subjects: **Schoolchildren and adolescents aged between 5 and 17 years of age. Anthropometric measurements and interviews on dietary intake were carried out in 2001 and 2002 on 1,442 subjects.**

Results: **In this African rural sample, the degree of malnutrition differs with age (increasing with age) and sex (more accentuated in males). Several correlations (P < 0.05) were observed between nutrient adequacy ratios and anthropometric values, particularly in males. There were no correlations between anthropometric characteristics and sodium or vitamin C (in males and females) and vitamin A or potassium (in females).**

Conclusions: **Malnutrition was more evident in subjects at puberty. The diet was deficient in sodium, calcium and potassium. Although weight-for-age (WAZ) and BMI-for-age (BMIZ) did not show significant relationships with nutrients in girls, the anthropometric variables were significantly correlated with micronutrients and thiamine in boys. To develop effective intervention strategies, it is vital to understand both how changes in malnutrition do occur and how different factors influence nutrient intake. The different growth pattern of boys and girls could be caused by sexual differences in environmental sensitivity, access to food and energy expenditure.**

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APORTE DE NUTRIENTES EN CHICOS Y CHICAS AFRICANOS DE 5-17 AÑOS EN UN DISTRITO RURAL DE KENIA

Resumen

A pesar de la emergencia en la prevalencia del sobrepeso en escolares de países en vías de desarrollo, se sigue observando una deficiencia de micronutrientes en la infancia. Algunos estudios realizados en Kenia han notificado algunos efectos beneficiosos de los suplementos dietéticos en algunos escolares pero no en otros. De hecho, estos estudios no detectaban la influencia de la ingesta nutricional sobre el crecimiento de los escolares por edad y sexo. Con el fin de investigar las relaciones entre el estado nutricional y el crecimiento entre escolares y adolescentes, diseñamos un estudio nutricional transversal que recogía datos de escuelas de educación primaria en un distrito rural de Kenia. Los individuos eran niños de entre 5 y 17 años. Se realizaron medidas antropométricas y entrevistas sobre la ingesta diaria en 2001 y 2002 en 1.442 individuos. En esta muestra rural africana, el grado de desnutrición difería con la edad (aumentando con la edad) y el sexo (más acentuado en los chicos). Se observaron fuertes correlaciones (P < 0,05) entre las tasas de adecuación de los nutrientes y los valores antropométricos, particularmente en los chicos. No hubo correlaciones entre las características antropométricas y el sodio o la vitamina C (en chicos y chicas) ni la vitamina A o el potasio (en las chicas). La malnutrición fue más evidente en individuos en la pubertad. La dieta fue deficiente en sodio, calcio y potasio. Aunque WAZ y BMIZ no mostraron relaciones significativas con los nutrientes en las chicas, las variables antropométricas se correlacionaron significativamente con los micronutrientes y la tiamina en los chicos. El diferente patrón de crecimiento en los niños y las niñas podría estar causado por las diferencias sexuales en la sensibilidad ambiental, el acceso a la comida y el gasto de energía.

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Introduction

Good nutrition during childhood is important for healthy growth and development. In addition to affecting physical growth and maturation, a child's nutritional status also influences a number of factors that are central to his or her educational achievements. Micronutrient malnutrition remains one of the most serious nutritional problems worldwide (WHO, 2002; Chopra and Darnton-Hill, 2006), and children are particularly vulnerable to micronutrient deficiency owing to their high nutrient requirements for growth and susceptibility to infectious diseases such as diarrhoea and respiratory infections, which can inhibit nutrient absorption as well as decrease appetite (Ochoa et al., 2004; Gribble et al., 2009).

Several diet studies have been carried out in Kenya over the past 30 years. Kigutha et al. (1995) reported a seasonal influence on energy and nutrient intake among pre-schoolers from low-income rural households in Nakuru district, Rift Valley province (central Kenya). Fujita et al. (2004) examined agricultural and pastoralist samples of the Ariaal and Rendille ethnic groups in northern Kenya and found no seasonal effects of diet in the agricultural populations but seasonality of starch consumption in the pastoralists. Fujita et al. reported that the transition from pastoralism to sedentism was associated with changes in diet, seasonality, morbidity and socio-economic differentiation; for example, starch replaced milk in the sedentary diet.

Neumann et al. (2003), Siekmann et al. (2003) and Grillenbenger et al. (2006) studied the effect of food supplementation in primary schoolchildren and found that growth was positively predicted by energy and nutrients provided in high amounts and in a bioavailable form in milk and meat. Macharia et al. (2004) studied a sample of 6-59-month-old children from Makueni district (Kenyan coast). Some children were supplied with food supplementation and others not. No significant differences were found, contrary to expectations.

These studies dealt with malnourished subjects but did not stratify the sample by age and sex. No data are available concerning the influence of nutritional intake on the growth of Kenyan schoolchildren.

Therefore, we designed a research project to detect the influence of malnutrition on the growth of Kenyan children living in poor conditions. In a preliminary data analysis (Semproli and Gualdi-Russo, 2007), the anthropometric values showed a medium-high prevalence of stunting (low stature for age values) in girls between 12 and 14 years and a very high stunting prevalence in boys 15-16 years old. The prevalence of underweight (low weight-for-age values) increased with age but remained low in girls, while there was a high prevalence in 13-17-year-old boys. Wasting (low weight-for-height values) was low in girls and high in boys after 13 years of age. In addition to a higher prevalence of wasting in males and underweight in females, we observed an emerging problem of overweight in the younger age-groups of both sexes.

The main aims of the present cross-sectional study were to analyse the relationship between nutrient intake and child nutritional status, expressed as Z-scores of height-for-age (HAZ), weight-for-age (WAZ), weight-for-height (WHZ) and BMI (BMIZ), and to identify the nutritional factors mainly responsible for the delay of physical growth in pre-pubertal and pubertal Kenyan children.

Materials and methods

Subjects

The study was conducted in a rural area of Suba district, Nyanza province, south-western Kenya, on the north-eastern shore of Lake Victoria, in three of the four divisions of the district: Mbita, Gwassi and Central. The morphological characteristics of the land give this area a high potential for agriculture, although the inadequate water supply system prevents its full development. Thus, only a few crops are available and the general living conditions are poor..

The data were collected from December 2001 to March 2002, in the dry season.

The subjects were primary school students in grades 1-8 from 12 public schools. The recruiting was done by teachers of the schools, who asked students to volunteer for some body measurements and an interview concerning food. Parental permission was required for each student willing to participate. A total of 1,383 students participated in the study: 702 boys (51%) and 681 girls (49%). No subject refused the anthropometric measurements or interview on dietary intake. However, cases of dubious date of birth (~4% of the original sample of 1,442 children) were excluded from the database. The excluded cases concerned some of the children in the youngest age-groups and/or orphans; their date of birth was not available in the school registers and it was not possible to obtain information from their families. The subjects were between 5 and 17 years of age. The data were collected with the local support of a non-governmental organization that provides assistance to poor children (Saint Margarita Development Centre).

All experimental procedures were approved by the Committee of the Science Faculty (University of Bologna) in 2001, which granted permission to undertake the project.

Dietary intake

The food intake data were collected by 24-hour recall interviews, assisted by a local interpreter. To assist the fieldworker in quantifying the portion sizes

Table I
Summary of Kenyan boys' anthropometric characteristics

Age (years)	*Subj No. (WHZ)*	*Height[a] (cm)*	*Weight[a] (kg)*	*BMI (kg/m^2)*	*WAZ[a]*	*HAZ[a]*	*BMIZ[a]*	*WHZ*
5	10 (10)	107.6 (6.7)	23.2 (6.1)	19.0 (1.8)	1.1 (1.9)	-0.3* (1.4)	1.8 (2.1)	1.7 (2.1)
6	19 (16)	113.3 (14.1)	24.2 (4.5)	18.0 (2.0)	0.8 (1.3)	-0.4 (2.8)	1.4 (1.8)	1.8 (1.2)
7	55 (26)	124.5 (10.3)	29.7 (6.0)	18.6 (2.8)	1.2 (1.1)	0.4 (1.9)	1.4 (1.1)	1.3 (1.6)
8	49 (20)	126.3 (11.3)	30.2 (9.0)	18.4 (2.5)	0.6 (1.1)	-1.3* (1.8)	1.8* (1.5)	1.5 (0.6)
9	51 (9)	131.0 (10.2)	31.7 (8.2)	18.7 (2.3)	0.2 (1.2)	-0.5 (1.7)	1.3 (1.9)	1.1 (1.6)
10	60	136.0 (10.1)	37.0 (17.9)	19.1 (2.9)	0.4 (1.1)	-0.5 (1.6)	0.8 (1.0)	
11	45	136.7* (8.7)	34.5* (6.4)	18.4 (3.0)	-0.5 (1.4)	-1.0* (1.3)	0.0* (1.0)	
12	64	142.2 (7.1)	39.8 (7.2)	19.8 (3.1)	-0.3 (0.9)	-1.0 (1.0)	0.4 (1.1)	
13	78	144.1 (13.6)	42.2 (7.8)	19.6 (3.2)	-0.6 (1.0)	-1.6 (1.8)	0.3 (1.0)	
14	94	148.6* (14.7)	44.5* (8.8)	19.9 (3.1)	-1.0* (1.3)	-1.8* (1.4)	0.0 (1.2)	
15	81	154.2* (9.4)	48.7* (10.5)	20.9 (2.9)	-1.1* (1.3)	-1.9* (1.1)	-0.0 (1.0)	
16	51	157.8 (9.6)	53.4 (11.2)	23.1 (3.1)	-1.1* (1.5)	-2.0* (1.2)	0.0 (1.1)	
17	19	163.5 (9.6)	57.1 (11.3)	24.5 (3.1)	-1.2* (1.7)	-1.6* (1.2)	-0.3* (1.1)	

HAZ: Height-for-age Z-score; WAZ: Weight-for-age Z-score; WHZ: Weight-for-height Z-score.
Values are expressed as mean (standard deviation).
[a]ANOVA significant values ($p < 0.05$) among ages.
*$p < 0.05$ between boys and girls (t-test).

of food eaten by children, a specially designed kit with food model aids was used for food quantification throughout the interviews. This kit included samples of commonly eaten food items, household utensils, dry food (e.g. beans) as well as empty containers.

Anthropometric assessment

A single trained fieldworker followed standardized and internationally accepted methodologies (Weiner and Lourie, 1981; Lohman et al., 1997) to take each subject's height and weight plus several other body measurements reported previously (Semproli and Gualdi-Russo, 2007). Height and weight were taken with a portable anthropometer and a portable electronic scale, respectively.

Data analysis

The nutrient adequacy ratio (NAR,%) was calculated for each of 10 micronutrients (sodium, potassium, iron, calcium, phosphorus, thiamine, niacin, riboflavin, vitamins A and C), energy, protein, carbohydrate and total fibre. NAR was calculated as the intake of a nutrient divided by the recommended intake for that nutrient (RNI), based on the WHO/FAO recommended intakes (2002), set at two standard deviations above the average requirements, and the Dietary Reference Intake (DRI, 2002-2005).

The anthropometric data, i.e. Z-scores of height-for-age (HAZ), weight-for-age (WAZ), BMI-for-age (BMIZ) and weight-for-height (WHZ), were compared with those of the US National Center for Health Statistics (HNANES III, Kuczmarsky et al., 2000) reference population according to World Health Organization suggestions (1986) for international use.

Descriptive statistics (means and standard deviations) were calculated for all anthropometric data and nutrient groups. All data were normalized when independent t-tests (two-tailed) with unequal sample size were used to compare boys and girls in each age-group. ANOVA was applied to each variable to detect the variability among age-groups. Pearson correlation tests were performed between the anthropometric values and NARs.

Statistical tests were considered significant at the 95% confidence level. The statistical analysis was carried out with "Statistica" for Windows, Version 5 (2000; StatSoft Italia srl, Vigonza, Padua, Italy).

Results

The main characteristics of the sample are summarized in table I and table II. The detailed anthropometric data have been published elsewhere (Semproli and Gualdi-Russo, 2007). One-way ANOVA of the WAZ, HAZ and BMIZ Z-scores showed that the degree of malnutrition changed with age in both sexes. The mean HAZ values of boys and girls were closer to the reference data values at earlier ages and showed a different pattern in boys and girls during growth. HAZ was particularly low in boys from 14 to 17 years. WAZ values became negative from 11 years in both sexes. Girls showed an increase from 14 to 17 years while the mean Z-score in boys continued to decrease until age 17. The

Table II
Summary of Kenyan girls' anthropometric characteristics

Age (years)	*Subj No. (WHZ)*	*Height[a] (cm)*	*Weight[a] (kg)*	*BMI (kg/m²)*	*WAZ[a]*	*HAZ[a]*	*BMIZ[a]*	*WHZ*
5	16 (11)	116.3 (13.5)	24.8 (6.5)	18.1 (1.9)	1.6 (1.1)	1.5* (2.6)	1.4 (0.8)	1.4 (0.7)
6	19 (17)	115.7 (11.3)	24.1 (4.3)	18.0 (2.5)	0.9 (1.1)	0.2 (2.5)	1.3 (0.9)	1.5 (0.8)
7	46 (29)	121.8 (6.8)	28 (5.3)	18.9 (3.0)	0.9 (1.2)	0.4 (1.2)	0.7 (4.2)	1.4 (0.9)
8	56 (21)	125.6 (7.7)	29.5 (5.4)	18.6 (2.4)	0.6 (0.9)	-0.4* (1.3)	0.9* (0.8)	1.4 (1.0)
9	46 (9)	130.5 (9.9)	32.1 (7.9)	18.6 (2.6)	0.3 (1.1)	-0.5 (1.6)	0.7 (0.8)	0.9 (0.9)
10	68 (2)	135.0 (7.9)	35.6 (6.8)	19.4 (2.8)	0.2 (1.0)	-0.5 (1.2)	0.7 (1.0)	0.9 (1.4)
11	81 (1)	139.8* (7.3)	37.8* (7.1)	19.3 (3.0)	-0.1 (0.9)	-0.6* (1.0)	0.4* (0.9)	0.9 (0.0)
12	71	143.5 (8.4)	40.9 (9.5)	19.7 (3.4)	-0.4 (1.2)	-1.1 (1.1)	0.3 (1.0)	
13	79	147.6 (8.8)	43.7 (9.8)	19.9 (3.1)	-0.5 (1.2)	-1.4 (1.3)	0.2 (0,9)	
14	81	153.4* (8.5)	48.3* (9.3)	20.5 (3.4)	-0.4* (1.1)	-1.1* (1.3)	0.0 (1.2)	
15	64	157.3* (7.4)	52.8* (10.6)	21.2 (3.5)	-0.2* (1.5)	-0.7* (1.1)	0.1 (1.6)	
16	30	159.3 (8.3)	56.7 (10.5)	22.2 (3.0)	-0.1* (1.6)	-0.5* (1.3)	0.0 (1.0)	
17	9	163.6 (6.8)	65.6 (9.5)	24.5 (3.6)	0.8* (0.8)	0.1* (1.1)	0.8* (0.7)	

HAZ: Height-for-age Z-score; WAZ: Weight-for-age Z-score; WHZ: Weight-for-height Z-score.
Values are expressed as mean (standard deviation).
[a]ANOVA significant values ($p < 0.05$) among ages.
*$p < 0.05$ between boys and girls (t-test).

male BMIZ values started at a higher mean than the female values and then decreased below the girls' values at 11 years of age and again from 14 to 17 years. WHZ showed a similar pattern in both sexes. The high values of WHZ at some age-groups were mainly due to the low height with respect to age.

Table III and table IV show the NARs of individual nutrients in the children's diet. Nutrients with a mean NAR of at least 100% were carbohydrate, thiamine, vitamin A and vitamin C in both sexes. Riboflavin met the requirements at all ages only in girls while the NAR was lower at ages 10-17 in boys. Energy had low NARs from 10 to 17 in boys and from 11 to 17 in girls. Iron and niacin had low NARs from age 7 and phosphorus from age 9 to 17 in both sexes. The mean NARs for total fibre never met the requirements (except age 6 in girls) but showed reasonable values, while sodium, potassium and calcium were too low, i.e. less than 17% for sodium, less than 58% for potassium and less than 48% for calcium at all ages in both sexes.

In boys (table V), the anthropometric variables were correlated with the NARs for energy, protein, carbohydrate, iron, thiamine and niacin at all ages, with those for fibre and phosphorus at younger (5-6) and older (10-17) ages, and with those for potassium, calcium and vitamin A mainly at the central ages (respectively 10-14, 9-14, 10-11 years). In girls (table VI), the correlations between anthropometric characteristics and NARs were generally less significant than in males. There were significant correlations between the anthropometric values and NARs of energy, protein, carbohydrate, total fibre, iron, phosphorus, thiamine, riboflavin and niacin at 7 years and from 10 to 15 years, and between the Z-scores and calcium from 12 to 16 years of age (table VI).

Nutrients with little or no correlation with the anthropometric variables were sodium and vitamin C in both sexes, and potassium and vitamin A in girls.

Discussion

The anthropometric features of the sample were characterized by negative Z-scores for height and weight, showing that the values were skewed to the left, i.e. there was a high degree of stunting in the schoolchildren in general and of underweight at the older ages. The degree of malnutrition appeared to be higher in boys than in girls during puberty.

Similar values were observed by various authors in Kenya (Neumann et al., 2003, 6-14-year-old children; Bwibo and Neumann, 2003, 8-9-year-old children) and in other countries: Namibia (Vahatalo et al., 2005, 8-15-year-old children), South Africa (Steyn et al., 2006, 1-8-year-old children). The pattern of poor growth performance observed in the Kenyan children is common in African populations (Bénéfice, 1993; Monyeki et al., 2000; Zverev and Gondwe, 2001; Pawloski, 2002; Olivieri et al., 2008) and is probably related to malnutrition. Stunted height associated with appropriate weight-for-height and BMI-for-age is typically found in cases of sufficient energy intake but chronic poor-quality nutrition (Keller, 1991; Dewey et al., 2008).

In our sample, certain micronutrients were particularly deficient in the diet, namely sodium, potassium and calcium. Sodium and potassium are vital minerals for the human body. However, the sodium levels were those contained naturally in foods. As sodium is widely

Table III
Nutrient adequacy ratio (NARs%) of Kenyan boys'

Age	Energy	Protein	Carbohydr.	Total Fiber	Sodium	Potassium	Iron	Calcium	Phosphorus	Thiamin	Riboflavin	Niacin	Vit. A	Vit. C
5	135,1 28,6	209,0 56,5	314,6 65,1	97,7 32,4	16,7 7,1	57,7 14,4	131,7 34,9	47,3 9,2	187,5 56,9	341,2 78,3	202,8 59,1	137,9 26,5	228,7 107,5	292,5 155,0
6	122,0 26,9	208,8 58,8	300,9 67,5	80,7 26,3	14,8 9,9	45,4 17,1	115,5 35,5	37,0 16,8	157,9 45,1	318,0 76,1	182,6 76,8	130,7 33,1	214,4 126,0	257,4 196,2
7	117,4 21,6	192,1 37,7	312,8 56,3	84,9 24,8	15,4 5,1	50,1 13,5	88,8 18,9	32,0 10,7	164,5 50,7	219,8 43,7	128,9 27,0	89,0 20,9	210,2 59,1	244,4 86,3
8	117,6 23,1	208,7 39,1	337,9 68,5	94,0 33,2	15,6 4,5	53,0 16,5	95,4 23,3	34,1 11,9	179,9 61,5	239,0 54,1	134,0 26,7	96,1 21,5	213,4 54,1	244,3 78,5
9	103,6 22,2	196,6 49,6	321,3 67,4	66,0 23,7	12,1 6,5	39,4 14,6	87,0 26,3	30,3 14,0	63,1 23,8	222,6 58,1	127,5 42,0	88,7 22,0	211,4 88,5	242,9 139,2
10	90,4 21,0	127,6 34,3	307,3 74,5	62,9 26,6	11,7 5,0	37,7 14,1	51,7 15,7	16,5 6,4	60,9 23,4	158,8 46,1	84,6 24,8	64,3 19,8	164,5 62,6	195,8 97,4
11	84,5 15,2	133,4 26,2	311,0 56,9	63,7 28,0	11,2 5,9	37,9 16,8	51,3 17,0	15,9 8,0	60,6 23,8	160,6 37,3	83,8 28,2	64,3 14,4	164,9 70,1	194,7 109,1
12	80,4 16,0	114,1 29,4	320,5 60,4	71,4 23,4	11,3 5,6	42,5 13,4	55,3 13,4	17,8 6,2	68,8 20,5	169,1 36,0	86,8 23,1	69,2 17,7	160,7 67,9	187,8 109,9
13	74,8 13,1	114,3 25,1	323,9 57,3	70,0 27,4	10,9 5,8	40,1 14,8	54,4 14,9	16,9 7,2	68,2 24,4	171,2 34,3	84,5 24,9	68,9 13,7	155,3 71,9	181,1 111,1
14	68,7 12,9	94,4 22,1	323,1 59,5	53,9 19,6	12,1 5,2	37,9 12,7	53,7 14,5	16,9 6,5	63,8 22,2	167,9 37,5	88,4 23,8	67,7 15,4	172,5 65,0	205,1 104,0
15	63,4 11,9	93,0 23,0	316,8 56,7	53,8 16,2	12,0 5,3	38,4 11,1	41,1 8,8	16,8 5,6	64,1 20,2	165,4 32,5	87,3 23,3	67,2 14,0	169,6 71,7	207,1 110,7
16	61,9 8,8	82,3 16,4	325,6 43,3	54,5 16,7	11,5 5,1	37,6 12,6	41,0 10,0	16,1 6,3	63,2 19,4	169,0 29,2	86,8 22,5	67,5 10,6	170,9 58,1	200,9 96,2
17	60,4 8,0	85,5 11,8	323,1 43,0	53,3 18,0	10,8 4,7	35,9 11,9	40,3 9,7	15,3 6,2	63,5 21,7	168,3 29,8	84,0 19,2	66,8 10,9	162,4 52,8	188,9 85,8

Values are expressed as mean and standard deviation.

Table IV
Nutrient adequacy ratio (NARs%) of Kenyan girls'

Age	Energy	Protein	Carbohydr.	Total Fiber	Sodium	Potassium	Iron	Calcium	Phosphorus	Thiamin	Riboflavin	Niacin	Vit. A	Vit. C
5	148,8 31,0	204,9 53,3	316,4 63,4	80,0 22,1	16,6 7,6	49,3 10,9	121,3 28,6	38,2 11,6	157,5 40,8	329,2 75,2	201,8 60,6	133,0 26,7	251,8 107,0	316,5 155,9
6	150,6 23,3	235,9 42,6	338,7 53,5	102,3 34,8	13,9 7,1	55,6 19,9	134,7 36,2	40,6 16,1	189,0 57,8	361,7 72,3	191,9 56,0	144,2 27,4	216,2 85,0	254,6 136,1
7	136,1 32,2	201,1 55,8	333,0 77,5	92,0 36,3	15,9 7,2	52,8 20,1	94,7 28,4	34,5 13,9	176,1 65,7	235,3 60,7	135,7 39,4	94,8 23,3	219,7 85,4	255,0 126,6
8	124,4 26,3	201,1 49,4	331,5 68,4	95,0 33,6	14,4 6,8	52,7 18,8	94,1 26,6	34,2 14,2	184,4 67,5	236,8 56,8	128,4 36,8	94,6 22,1	194,5 74,7	218,5 115,0
9	112,9 22,0	204,8 54,4	324,5 63,1	73,3 24,6	11,2 5,9	35,5 11,7	81,8 23,3	28,7 12,7	61,2 19,6	220,9 53,7	121,1 38,2	91,1 26,5	192,4 84,2	213,3 128,9
10	102,6 19,9	140,1 35,7	319,5 60,2	75,7 20,9	10,8 5,1	36,8 11,2	53,3 13,0	15,3 5,9	62,8 18,5	180,2 39,7	107,3 30,2	66,7 15,7	156,8 60,5	181,6 96,4
11	94,9 15,9	135,7 28,8	318,8 50,4	75,8 20,7	12,0 5,6	38,6 12,6	54,7 13,3	16,0 6,5	62,8 18,1	180,4 33,3	113,6 31,7	68,7 19,5	171,3 58,8	204,6 95,8
12	92,0 15,4	110,8 23,9	331,2 52,3	79,5 20,4	13,9 5,4	41,4 11,0	58,4 13,0	17,4 5,9	65,2 17,8	188,1 34,8	124,1 31,3	71,5 17,8	193,4 62,6	238,3 102,8
13	88,8 16,8	116,6 30,3	329,8 59,4	79,3 21,5	12,4 5,4	39,4 10,9	56,5 11,8	16,4 5,5	65,8 16,9	187,2 39,1	115,0 29,3	71,9 18,5	171,0 66,3	206,6 110,8
14	85,6 13,4	103,9 21,9	331,2 49,8	82,3 21,4	12,5 4,7	39,0 10,1	58,3 11,5	17,3 5,4	68,3 16,8	190,7 31,0	118,2 26,4	70,6 13,8	175,0 57,4	209,1 90,4
15	80,0 17,4	100,5 27,6	315,3 64,3	74,3 23,1	12,0 4,6	37,0 10,8	24,4 6,1	16,2 5,6	62,5 19,7	178,8 39,7	113,4 27,9	67,6 18,2	169,9 52,7	205,1 83,8
16	84,4 18,2	110,4 28,3	333,3 69,3	76,6 23,4	11,8 5,0	37,0 10,8	25,1 6,2	15,5 6,1	63,3 20,2	187,5 42,5	114,8 29,7	71,0 17,1	174,0 57,2	206,5 91,4
17	88,4 14,9	114,0 28,5	351,5 54,9	91,5 28,8	14,1 5,5	42,7 13,0	28,8 6,2	19,2 6,0	73,2 21,1	205,1 38,0	129,1 31,8	74,5 13,1	195,9 73,9	240,7 122,0

Values are expressed as mean and standard deviation.

Table V
Pearson correlation coefficients between nutrient adequacy ratio (NAR) of certain nutrients with height-for-age Z score (HAZ). Weight-for-age Z-score (WAZ) and weight-for-height Z-score (WHZ) of Kenyan boys'

Age (years)	Z-scores (n WHZ)	Energy NAR (%)	Protein NAR (%)	Carbohydrate NAR (%)	Total Fiber NAR (%)	Sodium NAR (%)	Potassium NAR (%)	Iron NAR (%)	Calcium NAR (%)	Phosphorus NAR (%)	Thiamin NAR (%)	Riboflavin NAR (%)	Niacin NAR (%)	Vit. A NAR (%)	Vit. C NAR (%)
5 (10)	WAZ	0.90**	0.90**	0.88*	0.78*	0.14	0.65*	0.84*	0.25	0.69*	0.84*	0.40	0.81*	0.27	0.13
	HAZ	0.75*	0.83*	0.67*	0.71*	-0.05	0.42	0.62	0.39	0.78*	0.75*	0.11	0.77*	-0.13	-0.18
	BMIZ	0.78*	0.72*	0.79*	0.61	0.17	0.56	0.72*	0.11	0.48	0.68*	0.42	0.62	0.37	0.20
	WHZ (10)	0.64*	0.58	0.67*	0.51	0.20	0.54	0.64*	0.05	0.35	0.55	0.42	0.49	0.42	0.27
6 (19)	WAZ	0.97**	0.72*	0.96**	0.52*	0.18	0.39	0.62*	0.22	0.54*	0.93**	0.42	0.73*	0.33	0.22
	HAZ	0.72*	0.55*	0.73*	0.65*	0.10	0.48	0.58*	0.29	0.62*	0.73*	0.30	0.55*	0.19	0.14
	BMIZ	0.55*	0.40	0.55*	0.05	0.15	0.04	0.24	0.02	0.11	0.51*	0.26	0.43	0.24	0.16
	WHZ (16)	0.33	0.24	0.32	-0.16	0.10	-0.12	0.05	-0.09	-0.10	0.28	0.16	0.25	0.18	0.11
7 (55)	WAZ	0.95**	0.76**	0.94**	0.22	0.40*	0.03	0.44*	0.10	0.08	0.83**	0.55*	0.87**	0.54*	0.41*
	HAZ	0.56*	0.39*	0.56*	-0.03	0.31	-0.12	0.16	-0.06	-0.14	0.44*	0.36	0.49*	0.44	0.35
	BMIZ	0.64**	0.53*	0.62*	0.16	0.28	0.04	0.31	0.10	0.09	0.56*	0.38	0.58*	0.35	0.27
	WHZ (26)	0.56*	0.47*	0.55*	0.13	0.25	0.02	0.26	0.09	0.06	0.49*	0.33	0.51*	0.32	0.24
8 (49)	WAZ	0.93**	0.73**	0.90**	0.18	0.15	-0.20	0.36	-0.07	0.19	0.85**	0.37	0.76**	0.24	0.00
	HAZ	0.78**	0.57*	0.77**	0.26	0.21	-0.01	0.43	0.05	0.22	0.74**	0.43	0.62*	0.31	0.12
	BMIZ	0.84**	0.73**	0.78**	0.13	0.07	-0.30	0.25	-0.11	0.17	0.75**	0.22	0.70*	0.09	-0.13
	WHZ (20)	0.64*	0.50*	0.62*	-0.11	0.01	-0.36	0.05	-0.26	-0.07	0.52*	0.13	0.53*	0.12	-0.08
9 (51)	WAZ	0.95**	0.94**	0.88*	0.33	-0.44	-0.21	0.13	-0.46	0.28	0.71*	-0.14	0.73*	-0.23	-0.39
	HAZ	-0.03	-0.44	0.13	0.48	-0.56	0.63	0.62	0.63	0.44	0.25	0.59	0.24	0.52	0.51
	BMIZ	0.69*	0.91*	0.54	-0.07	-0.61	-0.49	-0.27	-0.68*	-0.09	0.34	-0.42	0.37	-0.43	-0.54
	WHZ (9)	0.60	0.87*	0.45	-0.15	-0.65	-0.55	-0.36	-0.72*	-0.16	0.25	-0.48	0.28	-0.48	-0.57
10 (60)	WAZ	0.97**	0.86**	0.95**	0.75**	0.21	0.64**	0.76**	0.43*	0.72**	0.90**	0.52**	0.86**	0.28*	0.15
	HAZ	0.57**	0.50**	0.54**	0.43*	0.08	0.34*	0.42*	0.28*	0.49**	0.53**	0.26*	0.56**	0.04	-0.03
	BMIZ	0.71**	0.63**	0.70**	0.54**	0.22	0.50**	0.58**	0.28*	0.46**	0.65**	0.44**	0.59**	0.34*	0.25
11 (45)	WAZ	0.76**	0.53**	0.76**	0.39*	0.34*	0.29	0.47*	0.35*	0.41*	0.66**	0.43*	0.68**	0.33*	0.27
	HAZ	0.59**	0.49*	0.56**	0.32*	0.11	0.18	0.31*	0.24	0.34*	0.49*	0.20	0.50*	0.08	-0.03
	BMIZ	0.70**	0.43*	0.73**	0.42*	0.47*	0.43*	0.56**	0.43*	0.45*	0.67**	0.56**	0.68**	0.48*	0.44*
12 (64)	WAZ	0.99**	0.86**	0.97**	0.54**	0.14	0.17	0.60**	0.27*	0.64**	0.93**	0.32*	0.81**	0.05	-0.05
	HAZ	0.53**	0.47**	0.52**	0.29*	0.11	0.10	0.34*	0.14	0.31*	0.50**	0.20	0.36*	0.09	0.04
	BMIZ	0.75**	0.63**	0.74**	0.42*	0.08	0.14	0.45*	0.22	0.49**	0.70**	0.23	0.65**	0.01	-0.07
13 (78)	WAZ	0.98**	0.84**	0.95**	0.58**	0.00	0.37*	0.61**	0.25*	0.59**	0.89**	0.26*	0.79**	0.03	-0.09
	HAZ	0.36*	0.34*	0.35*	0.22*	-0.07	0.14	0.21	0.04	0.19	0.31*	0.05	0.29*	-0.02	-0.07
	BMIZ	0.68**	0.52**	0.67**	0.40**	0.10	0.31*	0.46**	0.25*	0.44**	0.64**	0.27*	0.58**	0.08	0.00
14 (94)	WAZ	0.98**	0.85**	0.96**	0.69**	0.16	0.45**	0.70**	0.39**	0.70**	0.92**	0.40**	0.87**	0.12	0.02
	HAZ	0.60**	0.51**	0.59**	0.43**	0.06	0.25*	0.41**	0.22*	0.42**	0.56**	0.21*	0.50**	0.05	-0.02
	BMIZ	0.76**	0.66**	0.74**	0.53**	0.16	0.38**	0.55**	0.33*	0.56**	0.71**	0.35*	0.70**	0.12	0.05
15 (81)	WAZ	0.98**	0.83**	0.95**	0.55**	-0.06	0.16	0.53**	0.16	0.57**	0.87**	0.14	0.77	-0.09	-0.17
	HAZ	0.79**	0.65**	0.78**	0.49**	-0.12	0.16	0.44**	0.12	0.50**	0.72**	0.06	0.58	-0.14	-0.18
	BMIZ	0.81**	0.70**	0.79**	0.44**	0.01	0.14	0.45**	0.16	0.46**	0.72**	0.17	0.68	-0.04	-0.11
16 (51)	WAZ	0.97**	0.83**	0.94**	0.55**	0.04	0.21	0.50**	0.25	0.62**	0.85**	0.20	0.86**	-0.05	-0.10
	HAZ	0.82**	0.68**	0.80**	0.41**	0.10	0.12	0.41*	0.18	0.49**	0.73**	0.20	0.73**	0.01	-0.04
	BMIZ	0.79**	0.71**	0.75**	0.51**	-0.02	0.21	0.42*	0.24	0.56**	0.70**	0.13	0.70**	-0.11	-0.14
17 (19)	WAZ	0.87**	0.86**	0.83**	0.52*	-0.01	0.21	0.45	0.28	0.52*	0.74**	0.14	0.75**	-0.15	-0.21
	HAZ	0.67**	0.57**	0.67**	0.47*	0.23	0.36	0.48*	0.36	0.42	0.60*	0.34	0.64*	0.14	0.09
	BMIZ	0.85**	0.81**	0.80**	0.49*	-0.06	0.13	0.41	0.24	0.52*	0.75**	0.08	0.74**	-0.23	-0.28

*p < 0.05; **p < 0.001.

Table V

Pearson correlation coefficients between nutrient adequacy ratio (NAR) of certain nutrients with height-for-age Z score (HAZ). Weight-for-age Z-score (WAZ) and weight-for-height Z-score (WHZ) of Kenyan girls'

Age (years)	Z-scores (n WHZ)	Energy NAR (%)	Protein NAR (%)	Carbohydrate NAR (%)	Total Fiber NAR (%)	Sodium NAR (%)	Potassium NAR (%)	Iron NAR (%)	Calcium NAR (%)	Phosphorus NAR (%)	Thiamin NAR (%)	Riboflavin NAR (%)	Niacin NAR (%)	Vit. A NAR (%)	Vit. C NAR (%)
5 (16)	WAZ	0.82*	0.56	0.85*	0.30	0.29	0.30	0.54	0.41	0.57	0.74*	0.46	0.69*	0.30	0.18
	HAZ	0.77*	0.46	0.84*	0.43	0.37	0.51	0.63*	0.57	0.50	0.72*	0.55	0.67*	0.42	0.28
	BMIZ	0.00	0.11	-0.06	-0.35	-0.11	-0.41	-0.22	-0.30	-0.01	-0.05	-0.15	-0.05	-0.16	-0.12
	WHZ (10)	-0.14	0.03	-0.22	-0.42	-0.20	-0.48	-0.34	-0.43	-0.11	-0.20	-0.26	-0.18	-0.25	-0.18
6 (19)	WAZ	0.33	0.29	0.30	0.21	-0.01	0.13	0.18	0.13	0.24	0.27	0.07	0.27	-0.04	-0.06
	HAZ	0.38	0.29	0.37	0.12	-0.30	-0.09	0.01	-0.07	0.11	0.20	-0.18	0.25	-0.28	-0.30
	BMIZ	0.02	0.07	0.00	0.04	0.16	0.11	0.10	0.09	0.06	0.06	0.14	0.03	0.14	0.13
	WHZ (16)	-0.01	0.06	-0.04	0.03	0.17	0.11	0.09	0.10	0.05	0.03	0.14	0.00	0.14	0.14
7 (46)	WAZ	0.93**	0.85**	0.92**	0.45*	0.19	0.37*	0.57*	0.24	0.41*	0.82**	0.50*	0.83**	0.35	0.19
	HAZ	0.45*	0.43*	0.44*	0.20	-0.11	0.12	0.19	0.02	0.19	0.36	0.09	0.46*	-0.01	-0.10
	BMIZ	0.86**	0.79**	0.85**	0.39*	0.26	0.34	0.53*	0.24	0.34	0.77**	0.52*	0.74**	0.40*	0.26
	WHZ (26)	0.85**	0.78**	0.84**	0.40*	0.27	0.35	0.54*	0.25	0.35	0.76**	0.53*	0.73**	0.40*	0.26
8 (56)	WAZ	0.19	0.39	0.15	0.03	0.08	0.16	0.08	0.01	0.00	0.07	0.16	0.13	0.23	0.18
	HAZ	0.41	0.47*	0.38	0.10	0.41	0.13	0.26	0.19	0.17	0.32	0.41	0.36	0.45*	0.39
	BMIZ	-0.08	0.13	-0.11	-0.12	-0.13	0.03	-0.12	-0.15	-0.17	-0.17	-0.07	-0.11	0.03	0.01
	WHZ (20)	-0.10	0.11	-0.13	-0.14	-0.14	0.02	-0.14	-0.17	-0.19	-0.19	-0.09	-0.13	0.02	0.01
9 (46)	WAZ	-0.18	-0.31	-0.09	-0.18	-0.10	-0.26	-0.17	-0.26	-0.21	-0.01	-0.01	0.02	0.06	-0.01
	HAZ	0.14	-0.17	0.27	0.06	0.25	0.06	0.29	0.24	0.18	0.40	0.57	0.39	0.35	0.19
	BMIZ	-0.39	-0.37	-0.36	-0.37	-0.19	-0.44	-0.46	-0.49	-0.46	-0.34	-0.33	-0.31	-0.07	-0.05
	WHZ (9)	-0.41	-0.38	-0.38	-0.39	-0.19	-0.46	-0.48	-0.53	-0.49	-0.37	-0.35	-0.33	-0.07	-0.04
10 (68)	WAZ	0.96**	0.77**	0.96**	0.43**	0.13	0.08	0.50**	0.08	0.41*	0.86**	0.37*	0.79**	0.24	0.06
	HAZ	0.64**	0.54**	0.63**	0.26*	0.11	0.06	0.31*	0.07	0.24	0.54**	0.26*	0.53**	0.18	0.06
	BMIZ	0.78**	0.62**	0.79**	0.39*	0.07	0.08	0.43**	0.05	0.38*	0.74**	0.28*	0.65**	0.16	0.01
11 (81)	WAZ	0.86**	0.79**	0.83**	0.37*	0.12	0.08	0.38**	0.08	0.41**	0.72**	0.24*	0.63**	0.10	-0.03
	HAZ	0.40**	0.30*	0.41**	0.14	0.11	0.02	0.18	0.08	0.13	0.34*	0.17	0.26*	0.14	0.05
	BMIZ	0.46**	0.74**	0.72**	0.37*	0.07	0.10	0.35*	0.05	0.42**	0.64**	0.18	0.56**	0.02	-0.06
12 (71)	WAZ	0.76**	0.65**	0.75**	0.62**	0.25*	0.33*	0.57**	0.42**	0.63**	0.74**	0.34*	0.40**	0.15	0.09
	HAZ	0.63**	0.56**	0.61**	0.49**	0.14	0.18	0.43**	0.29*	0.49**	0.62**	0.22	0.29*	0.07	0.01
	BMIZ	0.56**	0.46**	0.55**	0.51**	0.23	0.33*	0.47**	0.39*	0.51**	0.56**	0.30*	0.29*	0.16	0.12
13 (79)	WAZ	0.83**	0.68**	0.82**	0.62**	0.02	0.21	0.56**	0.21	0.70**	0.76**	0.17	0.59**	-0.09	-0.20
	HAZ	0.69**	0.62**	0.67**	0.54**	-0.07	0.15	0.47**	0.14	0.57**	0.65**	0.12	0.46**	-0.08	-0.18
	BMIZ	0.70**	0.55**	0.68**	0.51**	0.07	0.20	0.47**	0.23*	0.61**	0.62**	0.16	0.49**	-0.07	-0.16
14 (81)	WAZ	0.80**	0.64**	0.80**	0.44**	0.19	0.25*	0.48**	0.26*	0.43**	0.73**	0.34*	0.67**	0.17	0.08
	HAZ	0.30*	0.19	0.31*	0.32*	0.12	0.15	0.28*	0.28*	0.32*	0.38**	0.16	0.31*	0.02	0.00
	BMIZ	0.76**	0.65**	0.76**	0.32*	0.14	0.21	0.40**	0.14	0.31*	0.62**	0.31*	0.58*	0.20	0.10
15 (64)	WAZ	0.61**	0.54**	0.62**	0.39*	0.18	0.20	0.43**	0.20	0.38*	0.56**	0.33*	0.49**	0.20	0.01
	HAZ	0.67**	0.55**	0.70**	0.41*	0.30*	0.24	0.49**	0.27*	0.39*	0.62**	0.45**	0.53**	0.34*	0.14
	BMIZ	0.25	0.24	0.24	0.16	0.04	0.08	0.16	0.06	0.17	0.22	0.11	0.22	0.03	-0.05
16 (30)	WAZ	0.36	0.44*	0.29	0.34	0.15	0.05	0.33	0.30	0.41*	0.36	0.20	0.21	0.03	-0.11
	HAZ	0.38*	0.43*	0.32	0.13	0.11	-0.14	0.17	0.11	0.22	0.31	0.13	0.27	0.01	-0.11
	BMIZ	0.33	0.40*	0.27	0.45*	0.13	0.21	0.40*	0.37*	0.50*	0.37*	0.21	0.20	0.01	-0.10
17 (9)	WAZ	0.06	0.19	-0.04	-0.46	-0.10	-0.56	-0.37	-0.42	-0.31	-0.12	-0.18	-0.16	-0.09	-0.11
	HAZ	-0.17	0.20	-0.33	-0.44	-0.41	-0.60	-0.56	-0.58	-0.39	-0.37	-0.51	-0.40	-0.38	-0.36
	BMIZ	0.21	0.12	0.20	-0.18	0.17	-0.19	-0.01	-0.06	-0.05	0.14	0.15	0.12	0.15	0.11

*p < 0.05; **p < 0.001.

available among the sample in the form of common salt (sodium chloride), we assume that the sodium needs can be assured for everyone. Calcium is another important component of a healthy diet. The dietary habits indicated that the calcium intake was low among all the children interviewed due to poor access to milk products and the difficulty of keeping them refrigerated. However, a similar trend was constantly observed in studies of USA adult populations, with lower potassium and calcium intake (or excretion) in Blacks than in Whites, with consequent disparities in their health status (Langford and Watson, 1990; Kant et al., 2007).

Despite the high levels of calciferol (vitamin D) due to constant exposure to sunlight, we believe that there is a risk of osteopaenia in the sample. Calcium intake was not significantly correlated with stunting in boys (except at 10 and 14 years), while the correlation coefficients were significant in girls during adolescence (12, 14, 15 years). The highest degree of stunting in boys (from 11 to 17 years) and girls (12-14 years) was correlated with thiamine, niacin, phosphorus and iron, as well as the micronutrients. Iron, phosphorus (only in boys) and niacin intakes appeared to be adequate among younger children (5-8 years old) but decreased drastically with age.

Even though the phosphorus and calcium intakes were deficient, the P/Ca ratio seemed to be favourable to calcium absorption and thus at least partially to its metabolic utilization.

The correlation between underweight and nutrients followed a similar pattern.

In agreement with the findings for South African children (Steyn et al., 2006), the weight-for-age and the BMI-for-age Z-scores did not show significant correlations with nutrients in girls. However, unlike the cited study, our means were correlated with macronutrients and thiamine in boys. Therefore, it seems that body size in boys is sensitive to dietary factors, while the girls' body size is predominantly influenced by other factors (most likely genetic). Greater environmental sensitivity in boys has been hypothesized before (Hiernaux and Hartono, 1980; Corlett, 1986; Bénéfice and Malina, 1996; Monyeki et al., 2002). Our finding of sex differences in anthropometric characters, with a more favourable growth status in girls than in boys, is consistent with previous studies conducted in sub-Saharan Africa (Corlett, 1986; Bénéfice and Malina, 1996; Simondon et al., 1998, Olivieri et al., 2008). In addition to the different environmental sensitivity, this pattern is probably related to the greater access to food of Suba girls (involved in cooking activities) and to the higher energy expenditure of Suba boys (involved in heavy work activities) (Semproli and Gualdi-Russo, 2007).

Most of the mean micronutrient intakes of Suba children are consistent with the results of previous studies conducted in Kenya and higher than those of Namibian and South African children. Low intakes of iron, niacin, riboflavin and calcium have been observed in previous studies on malnourished children from Kenya (Neumann et al., 2003; Bwibo and Neumann, 2003; Gewa et al., 2007), Namibia (Vahatalo et al., 2005) and South Africa (Steyn et al., 2006). In those studies, the inadequate micronutrient intake also involved vitamin A (Neumann et al., 2003; Bwibo and Neumann, 2003; Vahatalo et al., 2005; Steyn et al., 2006), vitamin C (Vahatalo et al., 2005; Steyn et al., 2006) and thiamine (Steyn et al., 2006). Consistent with our findings, adequate energy and protein intakes were previously observed (Christensen et al., 2002; Neumann et al., 2003) in different areas of Kenya, while low energy and protein intakes were observed in Namibia (Vahatalo et al., 2005) and other Kenyan regions (Bwibo and Neumann, 2003; Gewa et al., 2007).

In addition to the deficiencies of certain micronutrients in the examined African children, there was also little variety of the diet. As suggested by Steyn et al. (2005), children with low dietary variety have weight-for-age and weight-for-height Z-scores less than zero and should be regarded as being at risk of undernutrition.

The present study of age-specific patterns of anthropometric characters and nutrient intake in a large sample of children has several limitations that should be considered when interpreting the results.

The accuracy of estimates of energy and nutrient intakes is dependent on a comprehensive food composition table for local foods. We used an international table for these analyses, but this table does not consider two important factors: (a) the maize (staple food for the studied sample) in Kenya is a hybrid, as it has been 'mixed' with maize from Ecuador to enhance the protein content (Christensen et al., 2002); (b) the kidney beans (widely used by the studied sample) are high in protein content. Since the protein intake of the sample appeared adequate according to the international table, the overall outcome of our analyses would have not changed significantly if we had used a local table, as the mean protein intake could only increase in view of the high protein content of the local maize and beans.

Furthermore, the 24-h recall method continues to be the method of choice in research involving dietary assessment in Africa and elsewhere. However, relatively high amounts of foods that children eat outside the home are likely to be missed on a caretaker's 24-h recall of the child's intake, because they may not be aware of the child's consumption of many of these foods. Another limitation of our study was the assessment of foods that children eat outside the home using the child's recall, because school children may not have accurately reported all of them. However, dietary recalls, with or without memory prompts, have been shown to be feasible and relatively reliable among school-aged children, with accuracy levels increasing with the children's age or grade (Gewa et al., 2007).

This study was carried out on a large sample of schoolchildren in a previously unstudied Kenyan area. The analyses were stratified by age and applied to a wide age range. This allowed us to evaluate the state of growth at different growth phases over a wide age range and to precisely identify the targets in need of intervention. Our findings suggest that the physical growth of Suba children (and probably their cognitive function and school performance) would benefit from interventions aimed at enhancing their niacin, phosphorus and iron intake from 7 (niacin and phosphorus) and 9 years of age and at improving the quality of the diet for children of all ages.

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