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AUXOLOGY OF SRI LANKAN CHILDREN, AGE 5 TO 18 YEARS: 1. HEIGHTS, WEIGHTS AND GROWTH INCREMENTS

S. AMARASINGHE[1] AND T. W. WIKRAMANAYAKE[1]

SUMMARY. Heights and weights of 8,610 children, age 5 to 18 years, have been measured and their height and weight increments calculated.

Differences in heights and weights of the two major ethnic groups, Sinhalese and Tamils, were not significant. There were marked differences due to varying socio-economic-educational levels, especially in the age groups 5 to 10 years.

There has been a marked secular change in heights and weights during the past 50 years, the increase being more marked among the lower socio-economic groups than among the affluent. The weights of Sri Lankan children are below the NCHS medians. Affluent Sri Lankans are taller than the NCHS population till age 7, for boys, and age 6, for girls. Thereafter, the curves diverge, the NCHS population being taller.

Absolute increments in height and weight between 5 and 10 years are socio-economic dependent, but not between 10 and 18 years. During adolescence the height increment of the lower socio-economic group is greater than among the affluent. Pre-adolescent malnutrition does not appear to affect linear growth during adolescence. Sri Lankan and Chinese children, who have peak height velocities early, have lower adult heights than the Irish and NCHS populations.

Key words: Heights, Weights, School children, Socio-economic-educational status, Growth Increments, Peak-height velocity, Secular change.

INTRODUCTION

In 1936 Nicholls reported that the height-distance curve for boys attending Royal College, Colombo was above that of British boys. The boys at Royal College at that time were drawn from families of a high socio-economic-educational level. Those attending other fee-levying English-medium schools had a curve below that of the Royal College boys. Below this was the height-distance curve for boys attending fully state-aided, non-fee-levying vernacular schools in which the medium of instruction was Sinhala or Tamil (1).

In 1949 Cullumbine and co-workers (2,3) showed that Tamils were significantly taller and heavier than the Sinhalese. The Tamil population measured by them were from the maritime provinces, mainly from the north and east, while the Sinhalese population was more widespread, a significant number included being from urban and rural inland areas such as Ratnapura, Bibile, Welimada, Kandy, Kegalle and Rambukkana. Factors other than ethnicity might have contributed to differences in body size between the two ethnic groups.

About 35 years later Balasuriya and Fernando (4) found that the Sinhalese were heavier and slightly taller than the Tamils but the difference was not statistically significant. The Tamil children in their study sample were from schools in urban Jaffna, Kandy, and Nuwara Eliya, and the Sinhalese children were those living in the towns of Kandy and Nuwara Eliya. At all ages and in both sexes, the mean weights and heights observed by them were below the 2.5 centile of the NCHS reference values.

The aims of the present study were (*a*) to compare the heights and weights of children of different ethnic groups and different socio-economic-educational levels (*b*) to compare

1. Food and Nutrition Unit, University of Kelaniya.

the data with the NCHS reference values and data from other populations (*c*) to compare the height-velocity and weight-velocity curves of Sri Lankan children with those of the NCHS population. and (*d*) to look for secular changes in heights and weights of Sri Lankan children.

STUDY POPULATION AND METHODS

The study group consisted of 4,157 girls and 4,453 boys born between 1970 and 1983 living in the City of Colombo and its suburbs. They were measured between 8.30 a.m. and 12 noon during the first 3 months of 1988.

The schools selected were (1) two fee-levying, non-state-aided schools in Colombo, St. Bridget's Convent (SBC) and Holy Family Convent (HFC), which cater to girls of affluent, educated families, most of whom live in the city.

(2) St. Thomas' College, Mt. Lavinia and St. Thomas' College, Kollupitiya, which like SBC and HFC are fee-levying, non-state-aided schools attended by boys from affluent, educated families in the city and suburbs.

(3) Wesley College, Colombo, which is state-aided and non-fee-levying, attended by boys from middle and low-income families, a majority of whom live in the city.

(4) Three state-aided non-fee-levying schools at Kadawatha attended by boys and girls from families of middle and low income levels, living in a semi-urban/rural location about 15 km from Colombo.

The children were measured bare-footed and in school uniforms. Their dates of birth were obtained from the schools' attendance registers and age computed according to WHO recommendations (5). The equipment used and precautions taken when measuring them have been described earlier (6).

RESULTS

Table 1 indicates the number of children studied in each school, grouped according to sex and ethnicity. The Sinhalese form the major ethnic group with Tamils coming second. Among 'Others' are included Sri Lankan Moors and Malays, Burghers and Chinese.

TABLE 1. The distribution according to ethnicity of the children in the different schools studied

School	Boys				Girls			
	Total	Sinhalese	Tamils	Others	Total	Sinhalese	Tamils	Others
St. Thomas' College (STC)	2382	1925	392	65	—	—	—	—
St. Bridget's Convent (SBC)	—	—	—	—	1554	1177	170	207
Holy Family Convent (HFC)	—	—	—	—	2122	1477	436	209
Wesley College (WC)	1611	780	280	550	—	—	—	—
Kadawatha Schools	460	460	—	—	481	481	—	—

Ethnic differences

Holy Family Convent (HFC) and Wesley College (WC) had higher percentages of children of the minority ethnic groups than the other schools visited. Data from these two schools were therefore used to study differences, if any, due to ethnicity. As the children in each school were drawn from households of similar socio-economic-educational levels and lived mainly in the City of Colombo, it was assumed that differences between them could be attributed to ethnicity.

TABLE 2. Comparison of heights (in cm) of girls of different ethnic groups attending Holy Family Convent (mean and s. d)

Age Group Yrs	Sinhalese n	Mean	S.D.	Tamil n	Mean	S.D.	Others n	Mean	S.D.
5—	66	111.9	5.20	—	—	—	18	113.3	5.00
6—	65	117.0	6.53	16	118.0	4.12	16	116.3	3.72
7—	101	122.0	6.24	42	120.5	5.64	19	121.6	4.82
8—	99	127.0	8.08	42	126.0	4.01	10	127.3	5.55
9—	150	131.5	6.02	43	132.3	6.86	15	134.7[a]	5.10
10—	120	137.9	6.75	34	137.7	6.60	17	140.4	7.16
11—	115	144.3	6.94	30	143.9	5.49	15	146.4	9.10
12—	136	150.1	5.76	42	149.5[b]	5.50	14	153.0	5.79
13—	130	155.1	6.16	46	153.7	6.45	14	155.1	4.35
14—	126	154.4	7.06	39	156.6	6.45	10	156.7	4.26
15—	124	154.8	6.68	27	155.1	6.53	20	156.0	6.35
16—	132	154.9	6.28	40	157.0	5.77	23	155.4	5.06
17—	86	156.1	5.81	35	156.6	4.73	18	157.9	4.83
18—	26	155.5	6.11	—	—	—	—	—	—

[a] $p <= 0.05$ Sinhalese/Others

[b] $p <= 0.005$ Tamils/Others

Table 2 shows the heights of HFC girls of different ethnic groups. In all age groups differences in height between the Sinhalese and Tamils are not significant, although the Sinhalese appear to be taller than the Tamils. The Sinhalese are shorter than 'Others' in the age 9 group.

Differences in weight are also slight (Table 3). Sinhalese girls are heavier than Tamil girls in most age groups, but differences are significant only in age 7 and 8 groups. The 'Others' are heavier than the Sinhalese in age groups 5, 9 and 12 and heavier than the Tamils in age groups 7 and 9.

Tables 4 and 5 compare the heights and weights of boys of the 3 ethnic groups in Wesley College. The Sinhalese boys are slightly taller and heavier than Tamil boys in most age groups but differences are significant only in age groups 8, 12, and 14 (for height) and age groups 8 and 14, for weight.

TABLE 3. Comparison of weights (in kg) of girls of different ethnic groups attending Holy Family Convent (mean and s. d)

Age Group Yrs	Sinhalaese n	Mean	S.D.	Tamil n	Mean	S.D.	Others n	Mean	S.D.
5—	66	17.4	3.88	—	—	—	18	19.5a	3.59
6—	66	19.5	4.42	16	19.2	2.09	16	19.0	2.90
7—	101	21.9b	4.59	42	20.0	4.62	19	23.2c	4.21
8—	99	25.1d	5.78	42	23.0	3.97	10	25.6	5.82
9—	150	25.9	4.77	43	26.5	5.24	15	31.5e	5.75
10—	120	31.2	8.12	34	30.0	7.55	17	33.5	8.12
11—	115	34.7	8.29	30	33.0	6.10	15	35.2	8.14
12—	136	39.2	8.07	42	38.9	8.25	14	43.6f	11.58
13—	130	43.9	9.12	46	43.6	8.91	14	47.1	13.76
14—	126	46.1	9.74	39	47.2	8.07	10	48.2	14.80
15—	124	45.3	8.29	27	45.2	6.71	20	46.2	7.59
16—	132	45.3	8.12	40	48.1	9.56	23	47.7	8.02
17—	86	47.4	7.37	35	45.7	6.21	18	49.9	9.72
18—	26	48.1	8.81	—	—	—	—	—	—

a $p <= 0.03$ Others/Sinhalese
b $p <= 0.03$ SinhaleseTamils
c $p <= 0.02$ Others/Tamils
d $p <= 0.05$ Sinhalese/Tamils
e $p <= 0.001$ Others/Sinhalese, Others/Tamils
f $p <= 0.05$ Others/Sinhalese

Analysis of variance confirmed that the differences in heights and weights of girls in the different ethnic groups is not significant ($p>0.05$). In the case of boys, the differences between Tamils and Sinhalese are not significant. However, the 'Others' differ significantly from the Tamils and Sinhalese ($0.05>p>0.01$). The 'Others' form only a small proportion of the population studied, especially at STC, being composed mainly of Sri Lankan Moors and Malays. The 'Others' also from a small proportion of the general population. Therefore, the differences between ethnic grops have been ignored, and, for the studies that follow, all children in each school have been considered as forming a single, homogeneous group.

TABLE 4. Comparison of heights (in cm) of boys of different ethnic groups attending Wesley College (mean and s. d)

Age Group Yrs	Sinhalese n	Mean	S.D.	Tamil n	Mean	S.D.	Ogthers n	Mean	S.D.
5—	51	112.0	5.0	23	110.8	4.9	22	111.0	5.1
6—	70	116.5	5.3	19	114.1	4.8	28	116.3	6.1
7—	63	121.0	5.4	24	120.6	4.4	43	121.8	4.4
8—	83	127.4ab	5.1	32	122.4	5.0	50	125.3c	4.7
9—	83	131.9	6.3	13	130.1	7.3	50	130.2	5.1
10—	93	135.2	5.6	19	136.3	5.3	68	135.1	6.4
11—	63	140.0	7.8	30	137.8	5.3	57	139.8	5.8
12—	50	147.9d	7.9	22	144.2	5.8	41	145.2	6.7
13—	63	151.0	9.0	26	149.2	7.2	45	153.0e	7.7
14—	62	159.2fg	7.8	25	154.6	9.4	64	155.6	8.2
15—	52	161.8	5.9	29	64.2	7.9	46	163.0	6.1

a $p < 0.001$ Sinhalese/Tamils
b $p < 0.02$ Sinhalese/Others
c $p < 0.01$ Others/Tamils
d $p < 0.05$ Sinhalese/Tamils
e $p < 0.05$ Others/Tamils
f $p < 0.02$ Sinhalese/Tamils
g $p < 0.01$ Sinhalese/Others

TABLE 5. Comparison of weights (in kg) of boys of different ethnic groups attending Wesley College (mead and s.d.)

Age group	Sinhalese			Tamil			Others		
	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
5—	51	17.9	2.7	23	17.7	3.4	22	17.6	1.9
6—	70	19.0	2.8	19	18.0	2.1	28	19.1	3.8
7—	63	20.5	3.1	24	20.2	2.7	43	21.2	3.4
8—	83	23.8a	4.5	32	21.1	3.1	50	23.3a	4.8
9—	83	25.7	5.3	13	25.0	7.1	50	25.2	4.9
10—	93	27.3	5.7	19	26.4	4.4	68	27.4	5.9
11—	63	30.3	5.8	30	29.3	5.1	57	30.5	5.8
12—	50	34.8	8.8	22	33.1	5.4	41	33.3	7.3
13—	63	35.3	7.3	26	36.4	8.4	45	39.2c	8.5
14—	62	43.6de	10.4	25	38.0	6.9	64	40.2	6.0
15—	52	45.3	8.1	29	45.2	11.2	46	47.0	6.5

a $p < = 0.01$ Sinhalese/Tamils

b $p < = 0.02$ Others / Tamils

c $p < = 0.02$ Others/Sinhalese

d $p < = 0.05$ Sinhalese/Others

e $p < = 0.02$ Sinhalese/Tamils

Nutritional Status

The Waterlow classification was used for the assessment of nutritional status of children attending each school. As there were no significant differences between heights and weights of girls at SBC and HFC, these two schools have been grouped together. For the same reason, the boys at St. Thomas' College, Mt. Lavinia have been grouped together with those at St. Thomas' College, Kollupitiya, and are listed under STC.

Table 6 indicates the diffierences in nutritional status between schools. Boys at STC are better nourished than those at WC or in the Kadawatha schools. There are more undernourished girls in the Kadawatha schools than in SBC and HFC.

This was confirmed by a clinical examination of samples of children of all age groups selected at random, at St. Thomas' College, Mt. Lavinia, and at SBC and all the children in the Kadawatha schools. A number of boys and girls at Kadawatha had blemishes of malnutrition, such as xerosis of the eye, Bitot's spots, phrynoderma and crazy pavement epithelium over the lower limbs, than at STC. None of these blemishes were seen among the SBC girls (Table 7).

TABLE 6. Nutritional status, according to the Walterlow classification, of children in the schools studied

School	Nutritional status of children			
	Normal %	Wasted %	Stunted %	Wasted & Stunted %
SBC+HFC	89.8	1.8	1.4	0
STC	93.5	5.2	1.3	0
WC	90.7	6.9	2.3	0.1
Kadawatha				
Boys	72.0	11.8	14.0	2.2
Girls	71.5	13.4	8.4	6.7

SBC = St. Bridget's Convent. HFC = Holy Family Convent.
STC = St. Thomas College. WC = Wesely College.

TABLE 7. Incidence of clinical manifestations of undernutrition among children attending the Kadawatha schools and St. Thomas' College (STC) Mt. Lavinia

School	Number examined	% with clinical manifestations of undernutrition						
		Xerosis	Bitot's spots	Gutter pigmentation	Phryno-derma	Crazy pavement epithelium	Angular stomatitis	Goitre
Kadawatha	941	20.6	0.6	0.1	12.8	5.5	0.2	0.4
STC	569	6.9	—	0.1	2.8	1.2	—	—

Heights and Weights

The heights and weights of boys and girls in the different schools are given in Tables 8 and 9. In Figs 1, 2, 3 and 4 the mean height and weight curves of Sri Lankan children are compared with those of American children (NCHS).

TABLE 8. Heights (in cm) and weights (in kg) of girls at St. Bridget's and Holy Family Convents (SBC/HFC) and in the Kadawatha schools (mean and s.d.)

Group Yrs.	SBC & HFC					Kadawatha				
	Height			Weight		Height			Weight	
	n	Mean	S.D.	Mean	S.D.	n	Mean	S.D.	Mean	S.D.
5—	174	111.6	5.1	17.8	3.4	29	105.4	5.0	14.7	1.54
6—	245	117.0	5.4	19.3	3.7	29	112.5	4.6	17.0	2.25
7—	333	122.0	5.9	22.1	4.9	47	115.7	4.3	17.9	1.78
8—	285	127.0	5.6	24.1	5.3	44	120.1	4.2	19.0	2.25
9—	306	132.9	6.5	27.3	5.8	30	126.9	5.6	21.9	2.66
10—	303	138.3	6.7	31.1	8.2	49	131.2	6.8	24.8	4.46
11—	338	144.6	7.7	35.0	8.7	51	137.7	5.7	28.7	4.53
12—	318	150.1	6.0	39.8	8.8	29	140.1	7.5	30.6	4.17
13—	305	153.7	7.7	44.2	9.7	22	145.6	7.4	33.6	6.61
14—	286	154.6	9.0	45.9	9.7	39	149.8	6.5	38.1	7.03
15—	208	155.2	6.5	45.4	8.1	69	161.9	11.6	40.4	5.66
16—	284	156.7	5.9	47.1	7.3	9	155.4	10.7	42.9	6.74
17—	243	156.8	6.1	47.3	7.8	17	155.7	7.2	44.9	6.29
18—	144	157.0	6.6	47.5	8.4	17	156.0	6.5	43.8	5.70

TABLE 9. Heights (in cm) and weights (in kg) of boys at St. Thomas College (STC), Wesley College (WC) and in Kadawatha Schools (mean and s.d.)

Age Group y	STC					WC					Kadawatha				
		Height		Weight			Height		Weight			Height		Weight	
	n	Mean	S.D.	Mean	S.D	n	Mean	S.D	Mean	S.D	n	Mean	S.D	Mean	S.D.
5—	108	111.7	5.1	18.3	3.3	96	111.5	5.0	17.8	2.7	33	106.7	5.7	15.5	2.2
6—	215	118.7	5.3	20.3	3.8	117	116.4	5.4	19.0	3.0	31	113.2	7.4	16.9	1.9
7—	255	123.5	6.2	22.6	4.2	130	122.2	4.5	21.2	3.1	42	118.3	6.1	18.4	2.2
8—	176	127.1	6.1	24.7	5.1	165	126.8	5.2	23.5	4.2	39	123.3	10.7	20.3	2.8
9—	170	132.5	5.9	26.5	5.3	146	132.4	6.0	26.2	5.2	36	126.4	5.8	22.5	2.4
10—	228	135.1	6.7	30.3	7.2	180	135.7	5.5	27.2	5.0	49	130.9	6.2	23.6	2.8
11—	176	141.9	8.1	34.2	8.5	150	140.6	6.4	30.7	5.1	60	134.2	7.2	26.8	4.0
12—	245	149.1	8.7	38.5	11.5	113	146.8	7.4	34.2	7.9	24	139.5	6.8	28.9	4.7
13—	175	154.7	8.6	40.7	9.9	134	152.3	8.0	37.6	7.7	21	140.7	7.4	29.7	5.6
14—	221	159.9	8.6	44.4	10.3	151	158.6	8.2	42.8	8.8	47	150.1	8.5	36.6	8.1
15—	146	165.2	8.4	48.2	11.8	127	163.5	6.6	46.6	8.0	62	163.3	13.2	39.2	6.7
16—	107	169.2	6.9	55.6	12.8	52	163.7	6.7	48.6	7.9	16	170.0	17.1	43.5	7.5
17—	87	170.6	6.6	54.9	10.1	25	165.0	7.1	50.7	7.9	—	—	—	—	—
18—	73	170.6	5.4	55.9	8.3	25	165.0	7.4	52.3	9.1	—	—	—	—	—

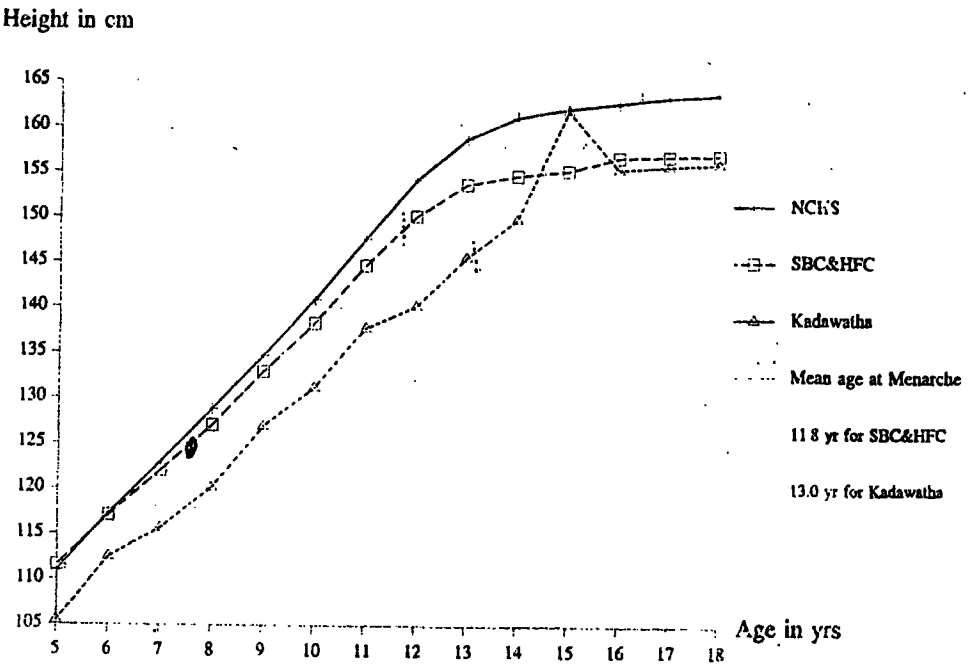

Fig. 1. Height – distance curves of girls

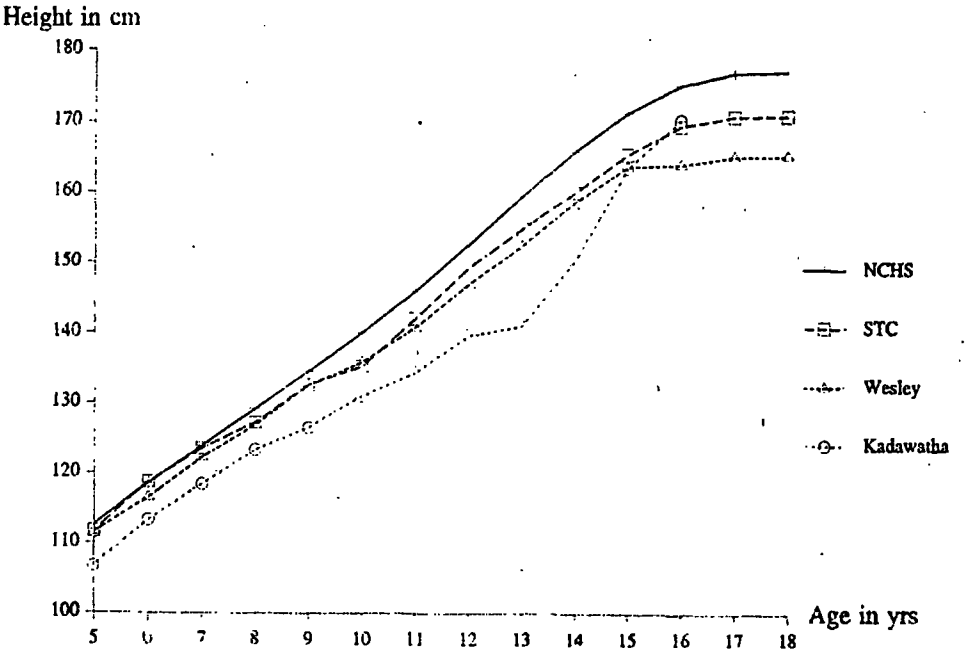

Fig 2. Height – distance curves of boys

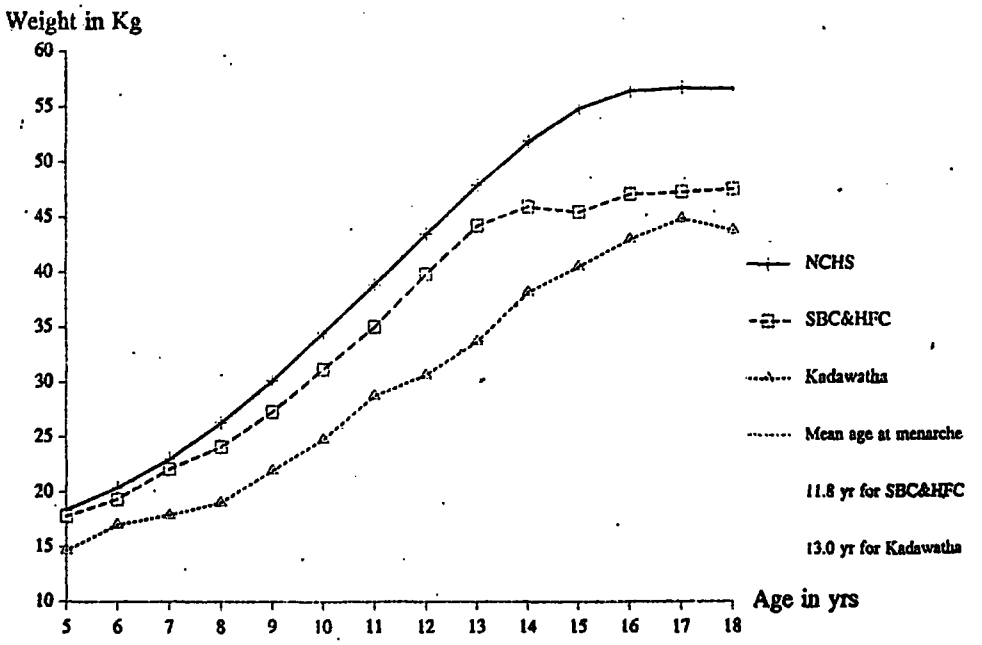

Fig. 3. Weight – distance curves of girls

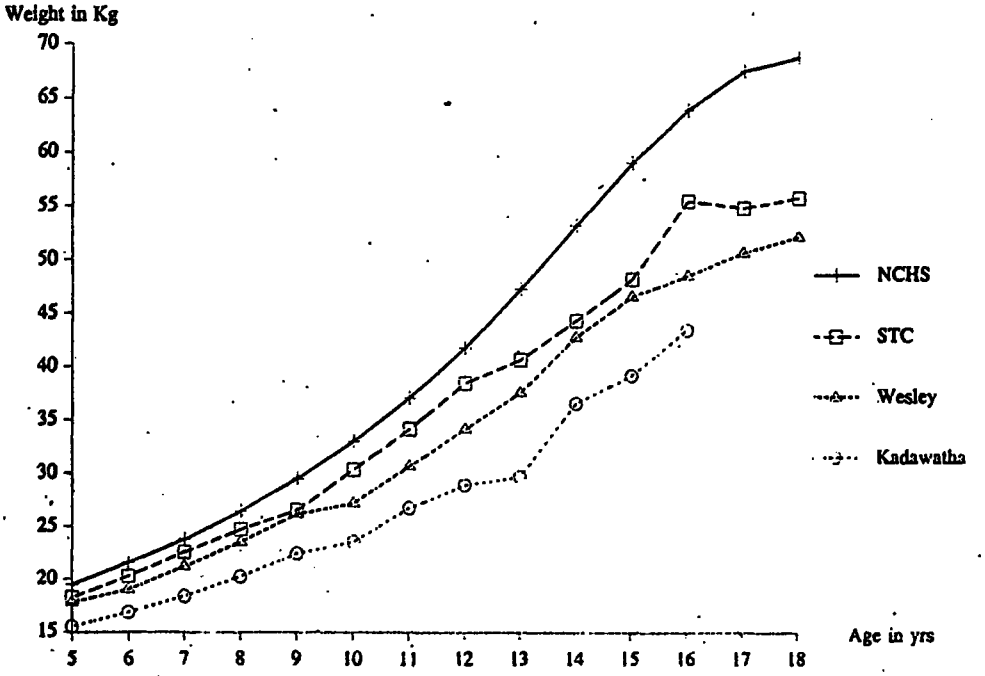

Fig. 4. Weight – distance curves of boys

The affluent girls in Colombo (SBC and HFC) and American girls have similar heights at ages 5 and 6 years (Fig. 1). After age 6.5 y the curves diverge, the Americans being significantly taller ($p<0.001$) after age 8. At age 18, the NCHS value is higher by 6.7 cm, the entire difference being due to gains between 8 and 18 years. At 18 years the affluent Colombo girls have reached 96% of the NCHS value. The Kadawatha girls are shorter than the Colombo girls at all age groups except at age 15 y. Thereafter, both curves level off, the Kadawatha girls being 1 cm shorter at age 18 years, having reached 95% of the NCHS median value.

The height distance curves for boys (Fig 2) show that the Kadawatha boys are much shorter than boys at STC or WC, below age 15 years. Like the Kadawatha girls they catch up with the city children between age 15 and 16 years. The STC boys are as tall as or taller than American boys between ages 5 and 7. Thereafter the NCHS values remain higher, the differences being highly significant ($p<0.001$) above 8 years. At age 18 y the differences in height between Americans and Sri Lankan affluent boys is 6.2 cm, the STC boys having reached 96.5% of the NCHS value. The difference between STC and WC values are highly significant above 16 yrs. At age 18 y WC boys are 5.6 cm shorter, having reached 93% of the NCHS median value.

The mean weight for age curve for Kadawatha girls is lower than that of city girls at all ages between 5 and 18y (Fig. 3). American girls remain heavier than Colombo affluent girls at all ages, the differences at age 18 y being 9.2 kg.

Similarly, the NCHS median weight curve for boys is always above the STC curve which diverges further from the latter after 13 years, Americans being 13 kg heavier than affluent Colombo boys at 18 years. Both the WC and the Kadawatha curves are below the STC curve (Fig. 4).

Fig. 5, 6, 7 and 8 compare the data from the present study with results obtained by Nicholls about 52 years earlier. The secondary schools (SS in Figs 5, 6 and 7) studied by Nicholls included schools like we, SBC and HFC, and the vernacular schools (VS in Figs. 5, 6, 7, and 8) would have been similar to the Kadawatha schools. It is clear that children of all socio-economic groups have increassed in height and in weight during the past 50 years. The affluent girls are 6.5 cm taller and 1.2 kg heavier, at age 5 y in 1988 than they were in 1936. At age 18 y the difference in height is 5.7 cm and in weight, 4.1kg. The Kadawatha girls are taller in 1988 than the affluent girls were in 1936, in most age groups (Fig. 5). In weight the Kadawatha girls have caught up with the affluent girls of 1936 (Fig. 7). Affluent girls in 1936 reached a peak height at about age 16. In 1988 the curve reaches a higher plateau at about 18 y (Fig. 5).

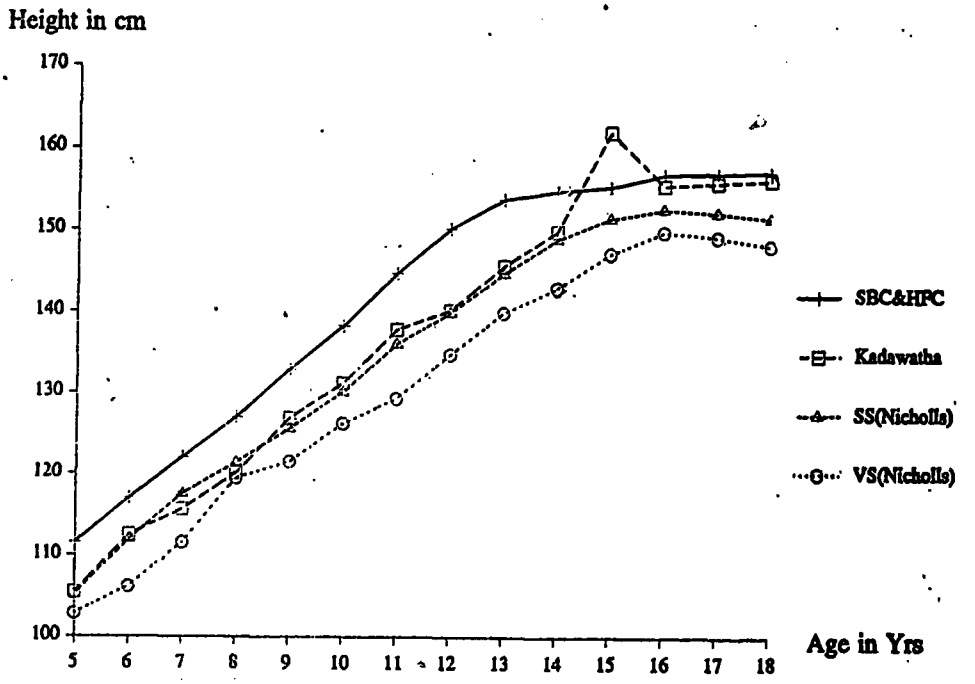

Fig. 5. Secular change in heights of girls

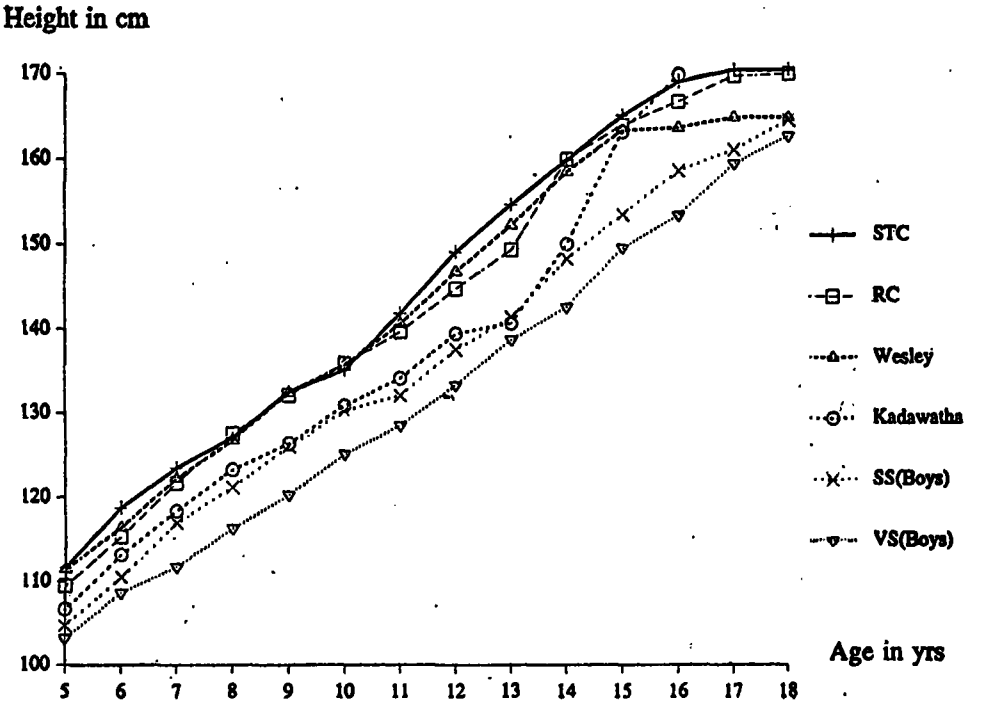

Fig. 6. Secular change in heights of boys

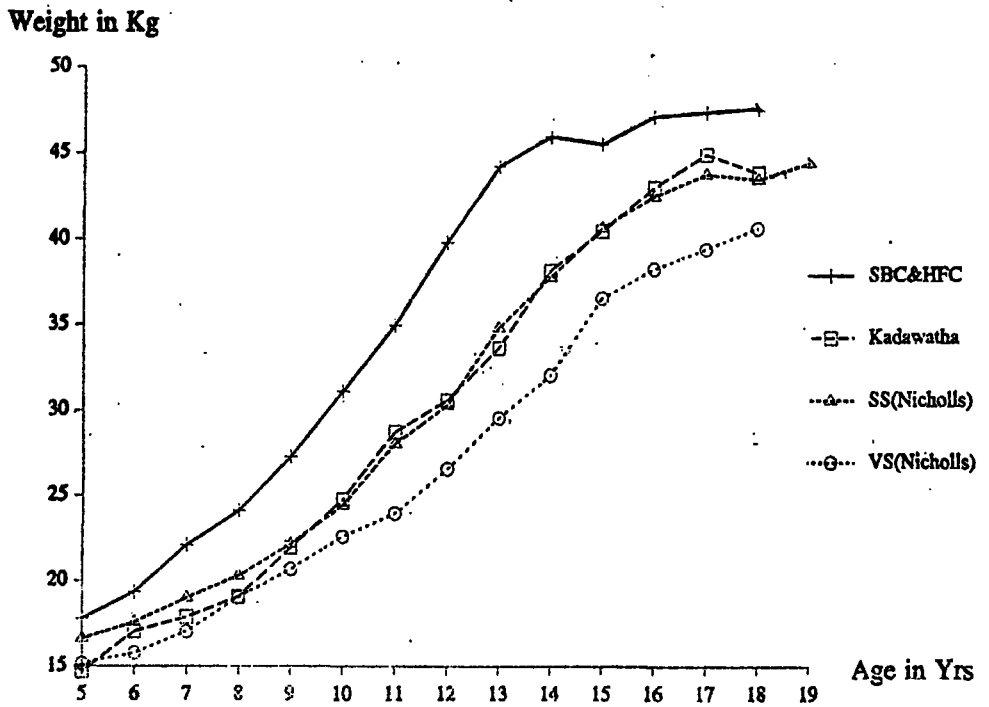

Fig. 7. Secular change in weights of girls

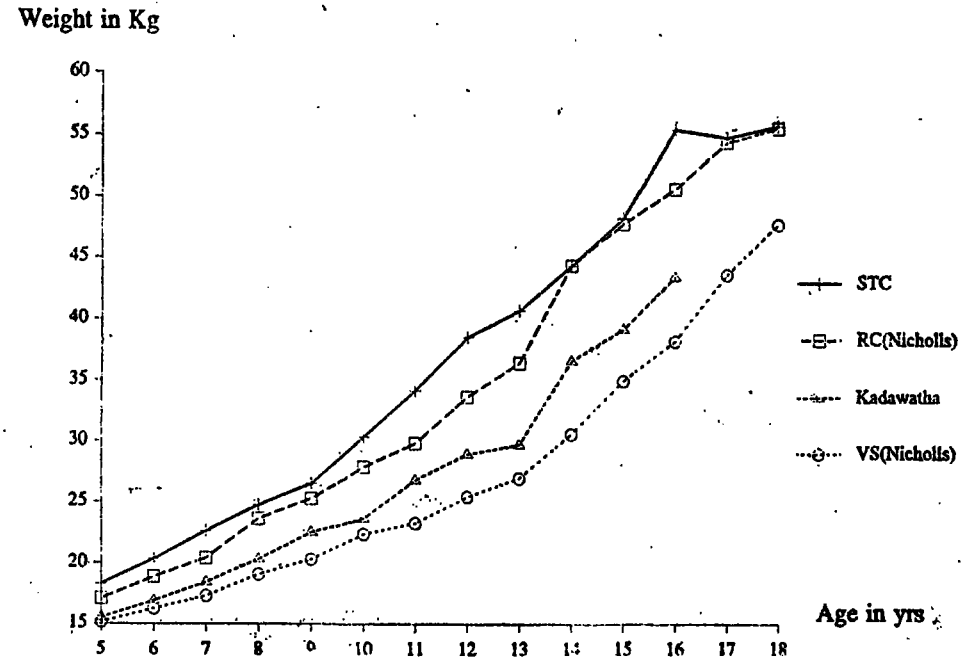

Fig. 8. Secular change in weights of boys

Boys of a relatively low socio-economic level also show similar changes in both height and weight (Figs. 6 & 8). The differences between the STC boys of 1988 and Royal College (RC) boys of 1936 are not so marked. STC boys are slightly taller in most age groups except ages 8, 9, 10 and 14 when the curves coincide (Fig. 6). Both curves reach a similar maximum height by age 18. Fig. 8 indicates that STC boys are heavier than the RC boys at most age groups. Both curves attain the same maximum by age 18.

Figs. 9 and 10 compare the heights and weights of boys and girls. At age 9.0 y the affluent girls become taller than the STC boys, and remain so till about 12.5 y, after which the boys are taller than the girls. The Kadawatha girls catch up with the Kadawatha boys about the 9th year and remain taller till age 14 y. Both the affluent girls and those at Kadawatha reach maximum heights about 1 y earlier than the boys. Girls tend to be heavier than the boys between 9 and 15 years (Fig. 10).

Increments in height and weight

Fig. 11 compares the height velocity curves for Sri Lankan girls with that of the the NCHS population. The affluent Colombo girls (SBC and HFC) show a steady fall in height velocity from 5 y and two peaks, a minor one at about 8.5 y and the large peak at 10.5 y. A few of them reach menarche between 9 and 10 y but the mean age at menarche is 11.8 y for the two schools (6). The Colombo girls start their adolescent spurt from a lower height velocity than the American girls, so that they reach a lower adult height than the latter. The height velocity curve for the Kadawatha girls have several peaks indicating a population that is more mixed, as regards socio-economic-educational status, than the SBC and HFC populations. The mean age at menarche of the Kadawatha girls is 13.01 years(6). The sudden acceleration in growth at 14.5 y explains the increased height of Kadawatha girls at age 15 seen in Fig. 5. However, as the spurt begins at a lower height velocity, the adult height of Kadawatha girls is less than that of their more affluent counterparts (SBC & HFC). Affluent Sri Lankan girls appear to reach zero height velocity 1 1/2 years earlier than the NCHS girls.

The height-velocity of boys at STC and at Kadawatha are higher than that of the NCHS boys at ages 5 and 6 y (Fig. 12). While the velocity of the NCHS population remains high, the deceleration of growth of the Sri Lankan boys is more rapid, so that the NCHS curve is at a higher level between ages 6 to 7 y. The STC curve has 2 peaks, indicating that a proportion of the boys begin their growth spurt a few years ahead of the rest. The main peak, at about 11.5 y is about 1 y ahead of the NCHS peak. Although the STC peak is higher than the NCHS, the slower height velocity between ages 7 and 10 y prevents the STC boys from catching up with the NCHS boys, so that there is a marked difference between the adult heights of the two populations. The mean age at spermarche of affluent Sri Lankan boys is not known. The median age of spermarche for a mixed population in Sri Lanka is 15.1 y, 1% attaining age by year 11 and 60.1% in the 15th year (7).

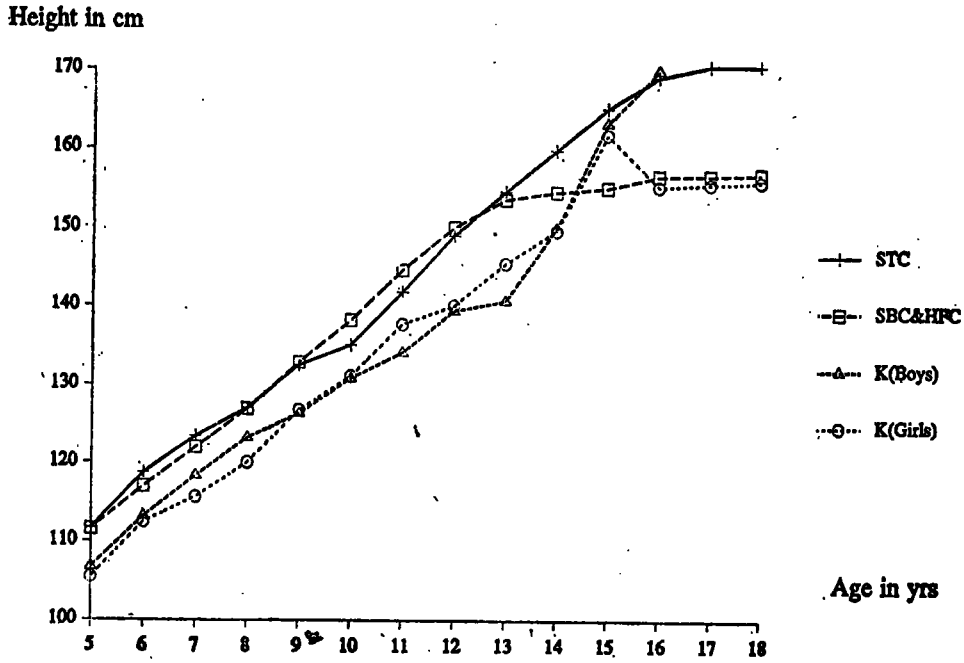

Fig. 9. Comparison of height – distance curves of boys and girls

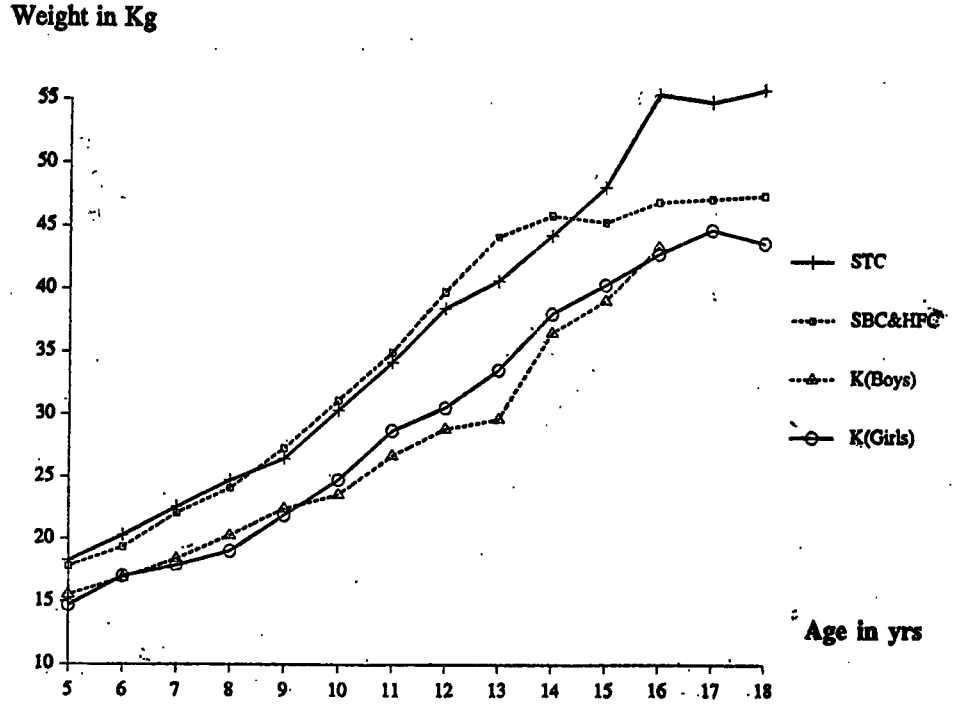

Fig. 10. Comparison of weight – distance curves of boys and girls

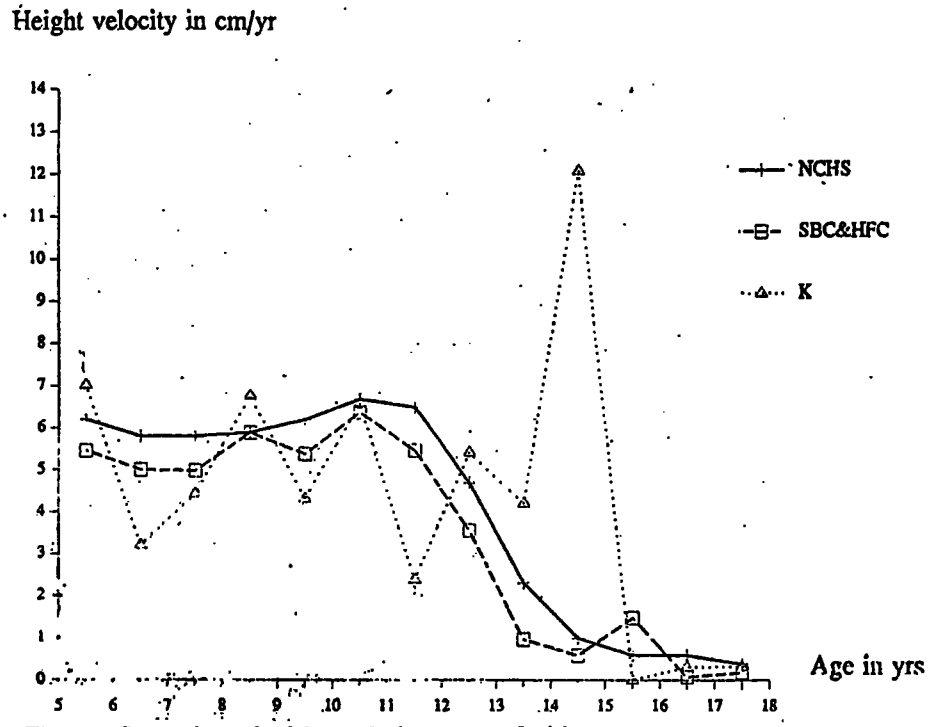

Fig. 11. Comparison of height – velocity curves of girls

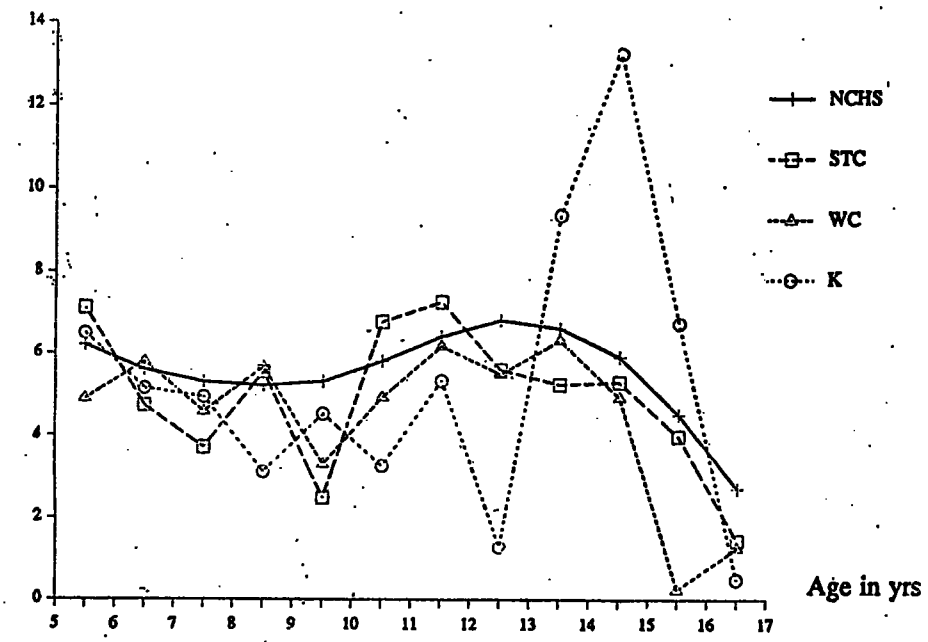

Fig 12. Comparison of height – velocity curves of boys

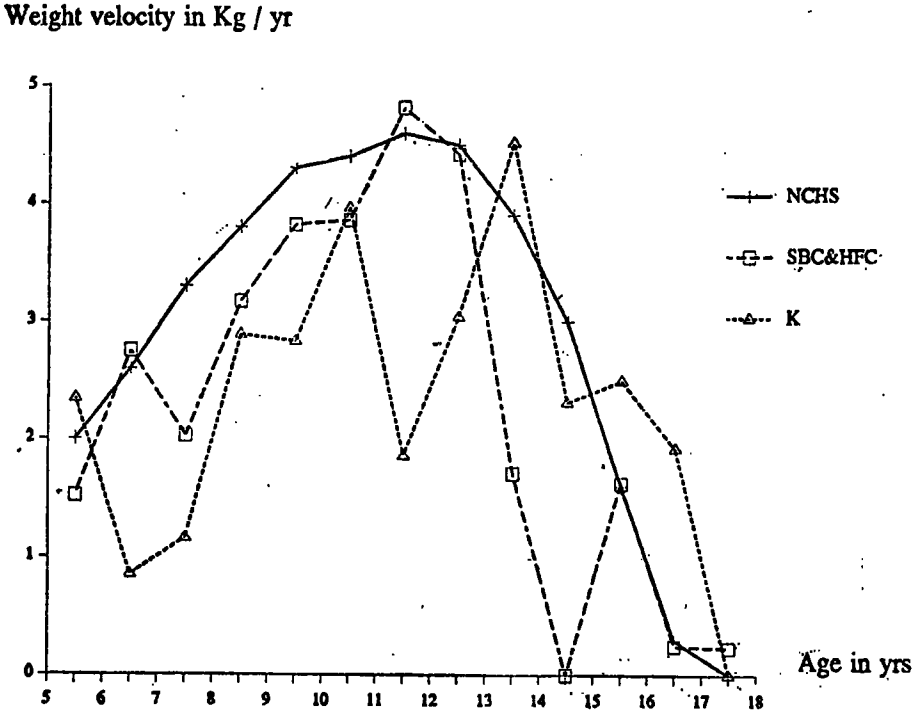

Fig. 13. Weight – velocity curves of girls

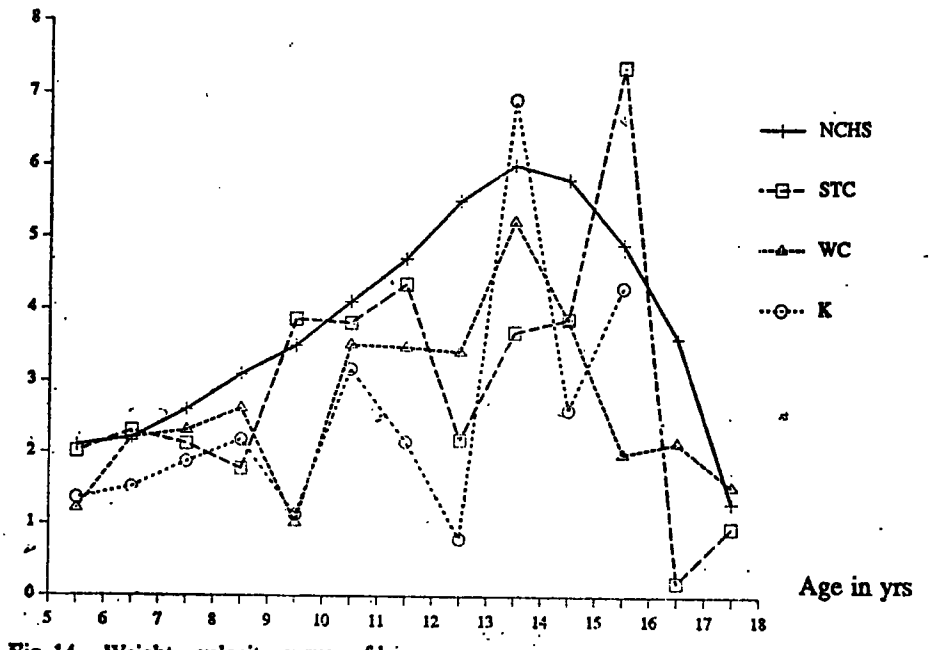

Fig. 14. Weight – velocity curves of boys

The height velocity curve for WC boys is similar to that of the STC boys; it remains below the NCHS and STC curves between 10 and 13 y There are 3 peaks, the highest being at age 13.5 yr. The deceleration of growth thereafter is more rapid than that of STC boys. The Kadawatha height velocity curve keeps low until age 12.5 y when there is a rapid acceleration of growth which makes the Kadawatha boys taller than STC and WC boys at age 16 y (Fig. 2). All 3 height velocity curves appear to reach a near-zero level before the NCHS curve.

The mean weight increments of Sri Lankan girls have been compared with those of American girls in Fig. 13. A similar comparison of boys is shown in Fig. 14. The NCHS curve is in general at a higher level than the other curves, for both boys and girls. The curve for Kadawatha girls is always below the NCHS curve. The affluent Colombo girls have a weight velocity nearer that of the NCHS girls. The curve plunges downwards very sharply after age 13 and remains low thereafter, so that the older girls weigh much less than the Americans of the same age (Fig. 3).

The weight increment of WC boys at all ages is less than the NCHS values (Fig. 14). The Kadawatha curve is below the WC curve but shows a sharp spurt between ages 13 and 14. The STC curve is near the NCHS curve till age 11.5 yrs, when it falls and than rises to a peak at 15.5 yr. However, like the curve for the affluent girls, the STC curve also shows a marked deceleration after the peak, going well below the NCHS curve. This is reflected in the weight distance curve (Fig. 4), the NCHS curve being very close to the STC curve till age 13, after which the curves diverge markedly.

Comparison with other countries

The height for age and weight for age curves for affluent Sri Lankan children (SBC, HFC and STC) have been compared with data obtained in the mid-1980 s for Chinese children in Hong Kong(8), Irish children in and around Dublin(9) and affluent adolescent girls in New Delhi (10).

Sri Lankan girls are taller than the Chinese and the Irish until 9 y (Fig. 15), after which the Chinese become taller, although the adult height reached by both groups is the same. The Irish become taller than the Chinese at age 12 y, which is the time of their adolescent spurt, and catch up with the NCHS curve at age 15 y. The New Delhi girls are taller than the Sri Lankans at all ages between 9 and 18y.

Affluent Sri Lankan boys, like the girls, are taller than the Chinese and the Irish till age 9.5 y and thereafter remain shorter (Fig. 16). At age 18 y the Sri Lankans and the Chinese reach the same height. The gap between the NCHS curve on the one hand, and the Chinese and Sri Lankan curves on the other, widens after the age of 10 y.

Sri Lankan boys and girls are slightly heavier than the Chinese till age 8 and 13 y respectively (Figs. 17 and 18). After age 13 y they are lighter than all the other groups.

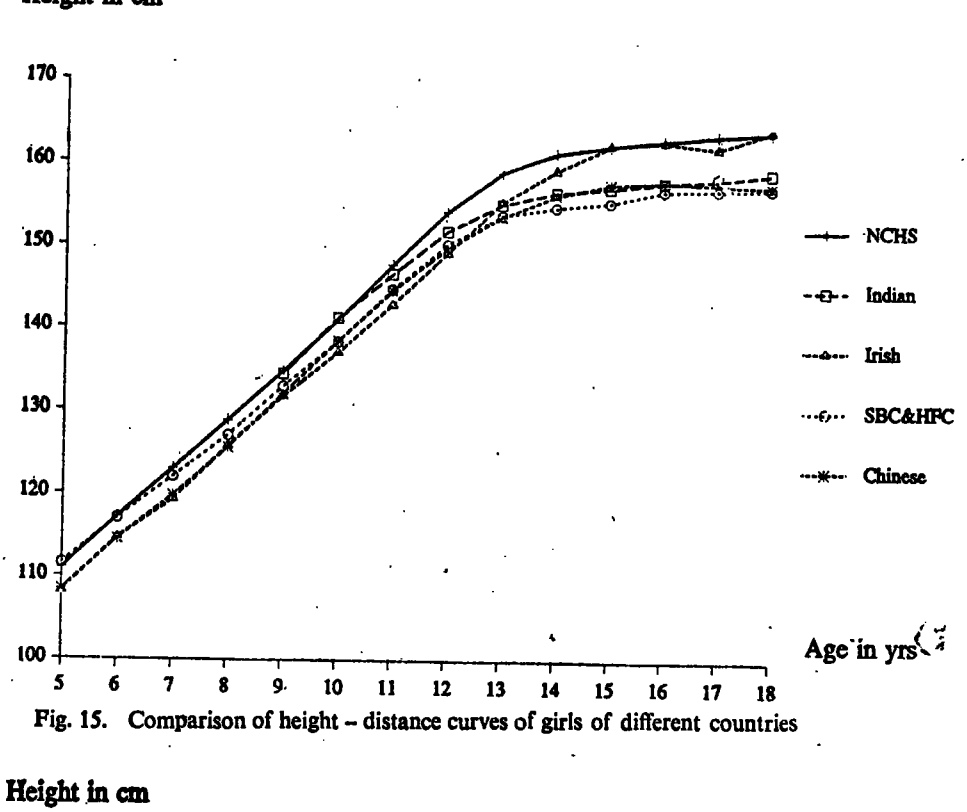

Fig. 15. Comparison of height – distance curves of girls of different countries

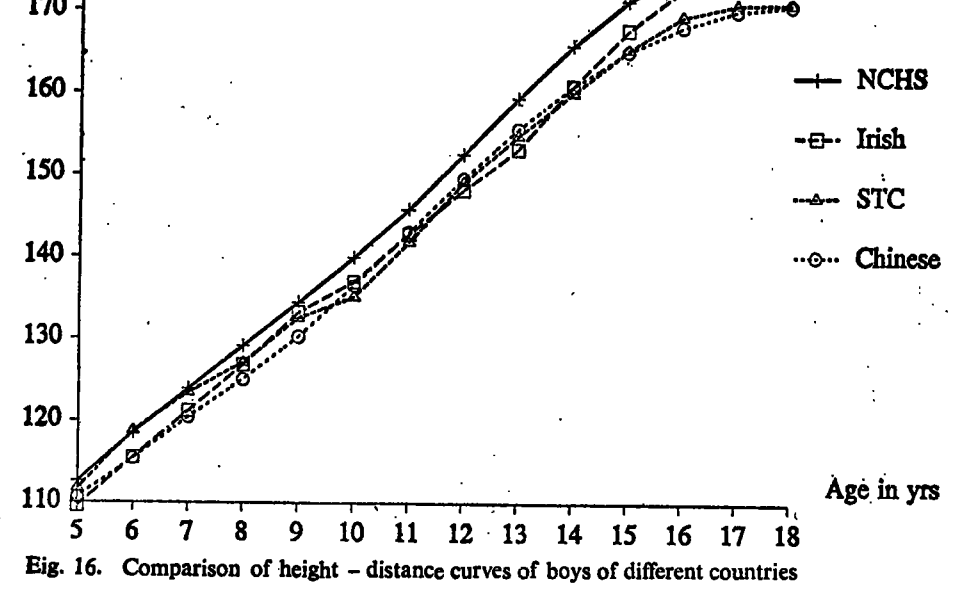

Fig. 16. Comparison of height – distance curves of boys of different countries

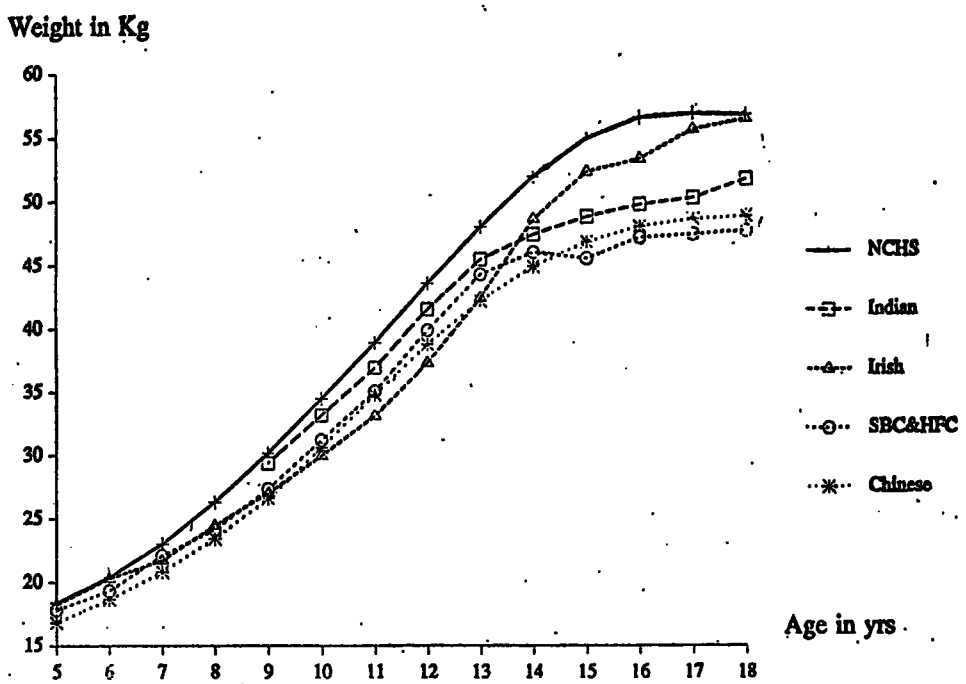

Fig. 17. Comparison of weight – distance curves of girls of different countries

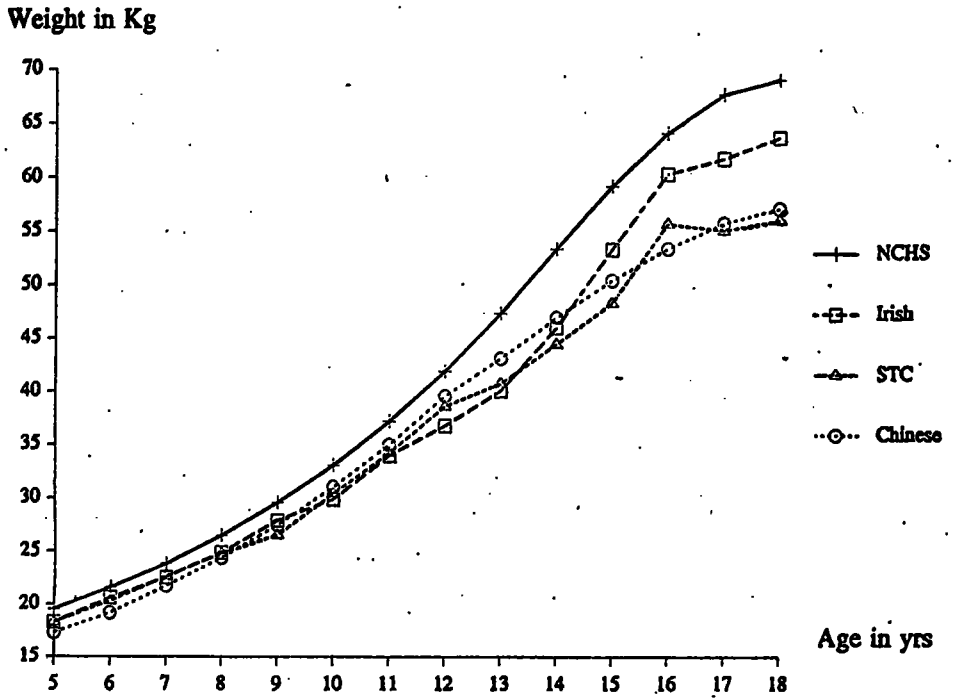

Fig. 18. Comparison of weight – distance curves of boys of different countries

Comparison of adult heights and weights at the age of 18 y indicate the following:

% of NCHS median value at 18 years.

		height in cm	*weight in kg*
Sri Lankan	girls	96.0	83.9
	boys	96.5	81.1
Chinese	girls	96.0	86.0
	boys	96.4	82.7
New Delhi	girls	97.0	91.2
Irish	girls	100.1	99.5
	boys	99.3	92.2

DISCUSSION

In the present study children attending SBC, HFC and STC have been assumed to be of a higher socio-economic status than the others because the fees charged at these schools are very high when compared with state-aided WC and Kadawatha schools. No attempt was made at ascertaining the incomes of the children or their parents. The few children on scholarships and bursaries at SBC, HFC and STC have been included among the "affluent". That the nutritional status of these affluent children is higher than that of children in the other schools is indicated in Table 6 & 7.

The data in Tables 2, 3, 4 and 5 show that when children from similar socio-economic levels, living in like surroundings, are considered, differences in height and weight due to ethnicity are not significant. Previous studies which reported ethnic differences (2, 3, 11) drew the Tamil population mainly from the Northern and Eastern provinces, and differences noticed between Tamils and Sinhalese could have been due to environment, e.g. calcium content of the water. In the present study Tamil children are shorter and lighter than the Sinhalese during the growth period but attain a greater adult height, although these differences are not significant, in agreement with results of Balasuriya and Fernando (4). The educational and economic status of inland areas of the country, in which a majority of the Sinhalese reside, have changed during the past 40 years, and moved towards that of the maritime provinces, which appears to have improved the heights and weights of the Sinhalese. A comparison of Tamils born and bred in Colombo with those living in the Northern Province might indicate any difference due to environment.

At all ages the affluent girls are taller than girls of Kadawatha, except at age 15 yr when there is a transient increase in height velocity (Fig. 11) that makes the Kadawatha girls almost as tall as the city girls (Fig. 5). The weights of Kadawatha girls are well below that of the affluent girls at all ages. The increase in weight-velocity at age 14 y (Fig 13) produces a steep rise in the weight for age curve but is inadequate to catch up with the SBC & HFC curve.

Differences between boys at STC and at WC occur after age 10 y. The Kadawatha curve for boys is well below the other two curves (Figs. 2 and 4). Like the girls at Kadawatha, the boys show a rapid increase in height velocity, well above the NCHS curve (Fig. 12) which helps them to catch up with the STC boys by age 16 y (Table 8). The weight for age curve for STC is always above the curves for WC and Kadawatha schools.

These results are in agreement with views expressed by earlier workers, that the children from higher socio-economic-educational status families (well-fed, medically and socially protected children) are taller and heavier than their less privileged counterparts, (12, 13, 14) and that genetic factors set a ceiling on growth only when nutritional and other factors have reached an optimum level (14, 15, 16).

Comparison with the NCHS median shows that the weights of Sri Lankan school children are below the NCHS values between age 5 and 18y. The height for age curves are different. Affluent Sri Lankan children are alightly taller than the American (NCHS) population, between ages 5 and 7 y for boys and 5 and 6 y for girls. Thereafter the NCHS median moves away from the Sri Lankan curves. In 1936 Nicholls observed that the affluent Ceylonese boys (at Royal College, RC) were lighter than British boys till age 13 y, when they become heavier and remained so till age 16 y. On the other hand the height for age curve for RC was well above the British curve between 5 and 17y. The British curve started well below all the Ceylonese curves at age 5 y, overtook the vernacular school, VS, boys (low-income) between 6 and 7 y, was almost alongside the secondary school, SS, curve till age 15 y. The final height achieved by the British boys and the RC boys was the same (1). Similarly for girls: the British height for age curve was below the Ceylonese curve, caught up with the low income (vernacular school) girls at age 9 y and went above the curve for secondary school (affluent) girls at age 13 y. The weight for age curve for British children was well above the Ceylonese curves at all ages except between ages 13 and 16 y, when the RC boys were heavier (1). Nicholls' data and results of the present study indicate that heights of small children in Sri Lanka are comparable with those of the British and Americans, probably due to a greater height-velocity below the age of 6 y. The height velocity of affluent Sri Lanka children below 5 years is not known.

When making comparisons with the NCHS reference curves it should be remembered that the NCHS curves represent smoothed data from a very large population, whereas the Sri Lankan curves are obtained from raw data of a much smaller population.

Fig. 5, 6, 7, and 8 indicate that there has been a marked increase in both height and and weight of children between 5 and 18 y, since 1936. The Kadawatha height for age curve for girls in 1988 is higher than the curve for more affluent girls in 1936, and the curve for affluent girls of 1988 is well above the 1936 curve (Fig. 5). Similarly, the low income boys are much taller than they were in 1936. The curves for affluent boys of 1936 (RC) and of 1988 (STC) do not show marked differences at all ages. The STC boys are taller between 5 and 7 y and between 10 and 13 y (Fig. 6), the height at 18 y being the same. Does this mean that the affluent boys have reached their maximum height potential? Or, are the STC boys of 1988 drawn from a more mixed socio-economic background than were the RC boys in 1936 ? A comparison between RC boys of 1936 and of 1988 cannot be made because RC is now non-fee-levying and fully-state-aided, with a population of a more mixed socio-economic status children.

The weights of Kadawatha boys and girls are much higher than that of vernacular school children of 1936, and the affluent girls of 1988, when compard with those of 1936, show marked increases in weight at all age groups (Fig. 7). The STC boys are heavier than the RC boys of 1936 at most ages but the weight at 18 y is the same (Fig. 8).

It may be concluded that the increased availability of health care services and of education have enabled the low-income groups of 1988 to attain heights and weights of the more affiuent children of 1936. There has also been an increase in the heights and weights of the affluent children, although this increase is less marked. The heights and weights of the affluent children of 1988 are attainable by the rest of the population, given a further improvement in their living standards. Therefore, there is no need for centile charts for heights and weights computed from measurements of a heterogeneous population, as has been suggested by Lucas et al (17). In a country like Sri Lanka which is subject to general malnutrition, standards should not be based on a random sample of the entire population. Rather, they should be based on a sample of the population that is environmentally faring the best, since such individuals represent the currently attainable range of desired norms for the entire population of the country. As reference values for Sri Lanka, the values of affluent Sri Lankans or of the NCHS population could be used.

In a study reported earlier (18) it was found that the height for age curve for affluent boys was irregular, being close to the NCHS curve between 5 and 9 y and overtaking the NCHS curve at age 16/17 y. In the present study the number of affluent children have been almost doubled and the curves are more uniform. Except at 5 y and 6 y, the NCHS children are taller and heavier than the Sri Lankans.

TABLE 10 Increments in weights and heights of Sri Lankan children, compared with those of other popluations

	Gain in Height in Cm		Gain in Weight in kg	
	5—10 Years	10—18 Years	5—10 Years	10—18 years
Girls				
SBC & HFC	26.7	18.7	13.3	16.4
Kadawatha	25.8	24.8	10.1	19.0
Chinese	30.0	18.8	13.7	18.2
Indian	29.7	17.6	n.a.	18.5
Irish	28.8	26.9	11.7	26.4
NCHS	29,9	22.8	16.0	22.2
Boys				
STC	23.4	34.0	12.0	25.6
Wesley	24.2	29.3	9.4	25.1
Kadawatha	24.2	39.1	8.1	19.9
Chinese	25.8	35.5	13.7	26.0
Irish	27.4	38.6	11.5	33.7
NCHS	27.3	36.9	13.5	35.9

The absolute gains in height, between ages 5 and 10 y (Table 10) of affluent Sri Lankan girls is less than 29.7 and 29.9 cm seen in well-to-do New Delhi children (19) and in the NCHS population, respectively. Absolute increments in heights and weights of girls during this period appears to be socio-economic dependent. During adolescence, on the other hand, the height-increment of Kadawatha girls is higher than that of the affluent girls in Colombo and of the NCHS population. The weight-increment of Kadawatha girls is also higher than that of SBC and HFC. Because the Kadawatha girls are much lighter than the others, at age 5 y, their final weight is less than that of the affluent Sri Lankans. The increment in linear growth of Kadawatha girls is adequate to enable them to catch up with the affluent girls by age 18 y, in spite of a shorter height at age 5 y.

For boys, the increment in height between 5 and 10 y is about the same in the 3 schools (Table 10), being lower than the NCHS value. During adolescence the height increment of Kadawatha boys is much higher than that for STC and WC boys, as well as NCHS boys. The weight-increment of Kadawatha boys is the lowest among the 3 schools.

The lower height increment of affluent Sri Lankan girls during adolescence may be due to the sharp reduction in height velocity that occurs after 11 y and a persistent low velocity thereafter (Fig. 11 and 13). The fall in height-velocity of affluent boys (Fig. 12) is more gradual so that the absolute gain during adolescence remains high, though lower than the values for Kadawatha and NCHS boys.

These findings suggest that pre-adolescent malnutrition does not affect linear growth during adolescence. The malnourished girls seem to grow at a faster rate during adolescence (Table 10 and Fig. 11), which helps them to narrow the gap in height that existed during the pre-adolescent period. This is in agreement with the results Gopalan and Kaur (19), and

also of Satyanarayana et al(20) who followed up rural Indian girls till age 20 y. Increments in height between 5 and 18 y were inversely related to the degree of deficit at age 5 y. Those who were most stunted at age 5 y had the largest increments, which exceeded the NCHS values. Normal children had increments less than the NCHS values. However, weight gains were similar in all groups, irrespective of the weight at age 5 y.

Affluent children in the present study have heights that equal or exceed the NCHS values till age 7 y. Indian children in Hyderabad have similar linear growth to Americans till age 10 y, after which they fall short of the NCHS values(21). After age 7 y, Sri Lankan children show a fall in height velocity. In Table 11 the peak height velocities (PHV) of Sri Lankan children are compared with the PHV of NCHS and other populations. Although the PHV are similar in these populations, the age at which the PHV is reached differs. Sri Lankan and Chinese boys have PHVs earlier than the Irish and NCHS populations. Among girls the age at which PHV is attained is similar in the different groups.

The data in Table 11 indicate that children who reach spermarche or menarche at an earlier age have lower adult heights than the others. Bourguignon (22) found that very early onset of puberty results in short stature, the marked reduction in prepubertal height gain being only partly compensated for by an increase in pubertal height gain.

TABLE 11. Peak Height velocity (PHV) in cm/y, of affluent Sri Lankan children, compared with those of other populations

Population		Age at PHV y	PHV cm/y
Sri Lankan	Boys	11+	7.3
	Girls	10+	6.4
Chinese	Boys	10+	6.6
	Girls	10+	6.1
Indian	Girls	10+	6.8
Irish	Boys	13+	7.7
	Girls	12+	6.3
NCHS	Boys	12+	6.8
	Girls	11+	6.7

Tanaka et al (23) compared children with early, average and late pubertal maturation. There was a significant difference in height at 6 y in the three groups. The later pubertal maturation occurs, the taller was the final height achieved. The age at PHV (11.2 cm/y at 13.0 y for boys, 8.7 cm/y at 10.3 y for girls) influenced the final height. In the present

study the heights of affluent Sri Lankans at 6 y was similar to that of the NCHS population. Their heights after 7 y as well as the height increments between 7 and 10 y are lower than the NCHS values. They mature earlier and reach a lower adult height than the NCHS population. Is this solely due to earlier spermarche and menarche? Could it have a genetic basis?

Affluent Indian girls in New Delhi are taller than those in Coimbatore and Bombay(19) and in Hyderabad (21). All of them are taller than the affluent Sri Lankans. Does this mean that populations nearer the equator are shorter than those further north? Such a conclusion would be admissible if all Sri Lankans originally migrated from India. However, although there has been migrations from North-West and North-East as well as from South India during the past 2500 years, these migrants would have mixed with different groups that migrated in pre-historic times, from Arabia, East Africa, Malaysia and Indonesia and with those indigenous to the island (24). The gene pool in Sri Lanka could therefore be assumed to be unique to the island and somewhat distinct from either North or South India. Differences in anthropometry are therefore to be expected.

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