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ANTHROPOMETRY OF SRI LANKAN SPORTSMEN AND SPORTSWOMEN, WITH SPECIAL REFERENCE TO BODY MASS INDEX

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Summary: Weight, height (TH), sitting height (SH), skinfold thickness and mid upper arm circumference have been measured in 235 sportsmen and 204 sportswomen, drawn from several districts, participating in tournaments held in Colombo between March and August 1988 in order to obtain reliable data on Sri Lankan adults, to look for inter-district and inter-games differences, and to study the suitability of a BMI less than 18.5 for diagnosis of chronic energy inadequacy.

Inter-district differences, reported in studies carried out about 40 years age, no longer exist. Differences between games for the variables weight, TH, SH and total body fat are significant for both genders, and for the variable BMI in the case of males. There has been a positive secular change in heights and weights of adults. When a BMI of 18.5 is used as a cut-off point, only 53% of women and 77.9% of men are categorised as being energy adequate. It is concluded that the BMR of Sri Lankan adults is probably lower than the values used by the FAO/WHO in calculating energy requirements.

Key Words : Anthropometry of adults, secular change, BMI and energy adequacy, total body fat, lean body mass.

INTRODUCTION

There have been no studies on the anthropometry of Sri Lankan adults drawn from different districts since those of Marett (1) in 1937/39. published posthumously by Stoudt in 1962, and of Cullumbine and colleagues in 1947/49 (2,3). Both these studies showed inter-ethnic and inter-district differences. After a study of 133 medical undergraduates in 1974 Balasuriya (4) concluded that difference between two major ethnic groups, the Sinhalese and Tamils, no longer existed. Such a conclusion is supported by recent studies on school children (5,6,7).

This is a report of a study carried out in 1988/89 on sportsmen and sportswomen drawn from several districts in the country. The aims of the study were to obtain values for heights, weights and BMI for adults that could be used by planners, to compare these values with values reported earlier, to look for inter-district and inter-games differences in various anthropometric characteristics, and to study the applicability of a body mass index less than 18.5 as an indicator of chronic energy deficiency in adults.

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STUDY POPULATION AND METHODS

Those included in the study were sportmen and sportswomen participating in inter-district and national tournaments held in Colombo who volunteered to be measured. Stature or total height (TH) and sitting height (SH) were measured using a Holtain stadiometer and weight with a Bauman platform beam blance. Skin-fold thickness at four sites, biceps, triceps, sub-scapular and supra-iliac, on the left side, were measured with Holtain skin-fold calipers. Mid upper arm circumference (MAC) was measured at the middle of the left upper arm with a flexible steel tape. Precautions taken when making these measurements have been described earlier (8, 9). The percentage body fat of each subject was assessed from the sum of the 4 skin-fold thicknesses using ables published by Durnin and Womersley (10). Total body fat was calculated from body weight.

The number of men and women from the different districts who participated in the study are shown in Table 1. Several districts in the north, east and south are not repesented at all, due to political unrest in those areas that prevented participation in tournaments, all of which were held in Colombo. Representation in the differnt games/events is indicated in Table 2. The games are those in which each person said he/she had specialised. Those who participated in at least one game and in one event at the athletic meet have been grouped under "Others"

RESULTS

In Table 3, 5 and 6, those above 18 years of age have been grouped together to enable comparison with previous studies on adults.

Table 3 shows the weight, height (TH), sitting height (SH) and the sitting height index (ratio SH x 100/TH). The mean values for those above 18 years of age are compared with values reported by Cullumbine (2, 3) and by Balasuriya (4) in Table 4. Although there has been an increase in heights of both men and women since 1949 and also since 1979, only differences between 1949 and 1989 are statistically significant. The increase in SH during the 10 year period is also significant. The increase in the sitting height index is significant only in the case of women, indicating that, in women, sitting height increase has been significantly greater than that of the subischial leg length. The change in weight of both men and women between 1949 and 1989 is statistically significant.

Table 1. The number of men and women representing each district included in the study

	District	Males	Females
01	Colombo	27	26
02	Gampha	20	14
03	Kalutara	4	22
04	Kandy	10	20
05	Matale	16	23
06	Nuwara Eliya	10	5
07	Galle	9	27
08	Matara	—	—
09	Hambantota	26	26
10	Jaffna	—	—
11	Mannar	—	—
12	Vavuniya	16	—
13	Mulativu	—	—
14	Kilinochchi	—	—
15	Batticoloa	15	—
16	Ampara	—	12
17	Trincomalee	—	25
18	Kurunegala	36	14
19	Puttalam	20	9
20	Anuradhapura	2	10
21	Polonnaruwa	23	19
22	Badulla	19	6
23	Monaragala	9	10
24	Ratnapura	13	20
25	Kegalle	11	30

Table 2. The number of men and women specialising in the different games or events

	Game/Event	Males	Females
01	Soccer	113	—
02	Volley Ball	—	104
03	Net Ball	—	100
04	Elle	44	—
05	Others *	17	7
06	Long distance runs	6	2
07	Mid distance runs	24	37
08	Short distance runs	77	58
09	Jumps	9	5
10	Throws	—	4
11	Cycling	—	1

* See text.

However, such comparison is not without error. The equipment used in the present study are more sensitive than those used in earlier studies.

The mean values for body mass index (BMI) vary between 18.57 and 21.25 for both sexes, males having a slightly greater BMI than females, in most age groups. Values of BMI less than 18.5 are found in 22.1% of males and 47.5% of females (Table 5)

Table 3. Weight (in kg), total height (TH), sitting SH) and subischial leg length (in cm) of sportsmen and sportswomen, in different age groups.

Age Group Yr	N	Weight		Height		Sitting height		Leg length		SH/TH X 100	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male											
15-16	4	53.68	3.53	167.73	5.16	85.30	2.22	82.43	4.46	50.88	1.46
17-	13	51.48	8.49	164.39	8.00	82.90	4.63	81.49	4.52	50.43	1.39
18-	34	54.53	6.37	168.83	6.27	85.64	3.49	83.19	4.14	50.73	1.33
19-	22	54.89	6.29	168.93	6.79	85.30	4.00	83.63	4.22	50.50	1.35
20-	34	51.51	5.43	165.33	6.14	84.60	2.89	80.74	4.03	51.18	1.04
21-25	125	55.71	7.76	167·20	6.41	84.78	3.55	83.11	8.76	50.31	4.90
26 30	44	56.72	6.84	167.25	5.52	84.58	2.98	82,66	3.94	50 59	1.29
31-37	10	59.02	7.17	166.72	5.05	85.26	1.26	81.46	4.30	51.17	1.20
19-37	235	55.36	7.35	167.08	6.23	84.78	3.34	83.33	4.84	50.54	3.69
Female											
13-16	29	43.12	6 02	157.25	5.88	79.34	33.1	77.90	3.78	50.48	1.84
17-	40	44.82	4.08	156.60	3.57	78.90	8.05	77.70	8.45	50.39	5.07
18-	45	47.72	5.36	158.80	5.52	80.72	2.77	78.90	3.98	50.85	1.31
19-	32	46.64	5.54	158.82	7.77	80.77	2.22	78.04	7.11	50.95	2.21
20-	30	48.07	5.55	159.34	5.80	80.78	3.26	78.56	4.73	50.72	1.82
21-25	129	47.10	6.46	157.99	6.22	80.92	3.31	77.07	4.11	51.23	1.30
26-30	10	48.88	7.19	160.54	7.17	81.04	3.62	79,05	4.17	50.49	0:97
31-38	3	49.90	5.45	158.30	5.36	83.63	1.42	74.67	6.45	52.89	3.53
19-38	204	47.30	6.23	158.45	6.49	80.92	3.17	77.53	4.87	51.10	1.59

Table 4. Comparison of results of present study with those of Cullumbine (1949) and Balasuriya (1979) (SD of parameters is given within brackets)

	Cullumbine's Study		Balasuriya's study		Present Study	
	Male (n=414)	Female n=35	Male(n=83)	Female (n=70)	Male (n=235)	Female(n=204)
Stature (cm)	162.5[a] (1.67)	147.1[b] (0.52)	165.78[c] (5.8)	153.69[d] (4.2)	167.08[ac] (6.25)	158.45[bd] (6.49)
SH (cm)	—	—	81.93[e] (4.1)	75.26[f] (3.2)	84 78[e] (3.34)	80.92[f] (3.17)
SH Index	—	—	49.80[g] (4 1)	48.9[h] (2.1)	50.54[g] (3.69)	51.1[h] (1.54)
Weight (kg)	51.9[i] (9.15)	45.0[i] (3.31)	— —	— —	55.36[i] (7.36)	47.3[i] (6.23)

a $p < .001$ c NS e $p < .001$ g NS i $p < .001$
b $p < .001$ d NS f $p < .001$ h $p < .001$ j NS

NS — Not significant at 95% confidence limits

Table 6 shows the mid-upper-arm circumference (MAC), trunk skin-folds, TSF (sum of subscapular and suprailiac skin – folds), arm skin – folds, ASF (sum of biceps and triceps skin - folds), total body fat (TBF) and lean body mass (LBM). LBM equals body weight minus total body fat. In all age groups TSF, ASF, % body fat and total body fat are greater in women than in men. On the other hand, both MAC and LBM are greater in men, which indicate a greater muscle mass in the males.

Figs. 1 and 2 show the relationship of BMI to the percentage of body fat, TBF, MAC and LBM. Both the percentage body fat and the fat mass increase with increase in BMI, the curves for women being at a higher level than those of the men. In men, the increase in both percentage body fat and fat mass is nearly linear at BMIs greater than 18. Among the young adults (19-38 years) studied there was no one with less than 14% body fat. At each BMI level both LBM and MAC are greater for males than for females.

Tables 7, 8, 9 and 10 show the distribution of the parameters measured in men and women participating in the different games/events. The results of ANOVA (summarised in Table II) indicate that

1. The differences between districts for all variables (weight, TH, SH, SH/TH, TBF and BMI) are not statistically significant, for both genders.
2. For both .genders the differences seen between games are significant for the variables TH, weight, SH and TBF.
3. The differences in BMI between games are significant for men, but not for women.
4. The differences in the sitting height index between games are not significant, for both genders.

The differencs in the means of each anthropometric characteristic between individual games / events were subjected to the students 't' test. Among men, soccer players and those taking part in jumps and short distance runners are significantly heavier and have greater BMIs than the rest ($p < 0.01$) while the heights of jumpers and of short distance runners are significantly greater than the heights of other subjects ($p < 0.01$). Neither sitting height nor the sitting height index show significant differences between games / events. Short distance runners and jumpers also have a greater muscle mass (LBM) than the rest ($p < 0.05$). Among women, volley ball and netball players are significantly heavier ($p < 0.05$) than those participating in the runs and jumps. Volley ball players also have a greater percentage of body weight as fat than the rest ($p < 0.01$).

Table 5. BMI (weight x 100/height^2) of sportsmen and sportswomen in different age groups.

Age Group Yr	N	BMI Mean	BMI SD	% with BMI < 17	% with BMI 17 - 18.4	% with BMI < 18.4
Male						
15 — 16	4	19.10	1.47	0.	50.0	50.0
17 —	13	18.93	1.79	15.4	30.8	53.8
18 —	34	19.09	1.54	8.8	26.5	64.7
19 —	22	19.17	1.04	0.	9.1	90.9
20 —	34	18.83	1.58	14.7	23.5	61.8
21 —	125	19.89	2.42	3.2	19.2	77.6
26 —	44	20.27	2.27	2.3	13.6	84.1
31 — 37	10	21.25	2.56	10.0	20.0	80.0
19 — 37	235	19.80	2.26	4.3	17.9	77.9
Female						
13 — 16	29	17.42	2.19	37.9	41.4	20.7
17 —	40	18.28	1.60	27.5	22.5	50.0
18 —	45	18.91	1.75	13.3	31.1	55.6
19 —	32	18.57	2.52	18.8	37.5	43.8
20 —	30	18.92	1.82	20.0	23.3	56.7
21 —	129	18.86	2.27	13.2	32.6	54.3
26 —	10	18.89	1.82	0	60.0	40.0
31 — 38	3	20.06	3.63	0	33.3	66.7
19 — 38	204	18.84	2.25	14.2	33.3	52.5

Table 6. Mid upper arm circumference (MAC), in cm, trunk skin-folds TSF and arm skin-folds, ASF (in mm) and total body fat and lean body mass (in kg) of sportsmen and sportswomen.

Age Group	N	M A C		T S F		A S F		% Body fat		Total Body Fat		Lean Body Mass	
		Mean	SD	Meaa	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males													
15-16	2	22.95	2.19	12.10	2.97	9.30	1.56	14.65	0.78	7.51	0.15	43 84	3.60
17-	7	24.87	1.89	17.36	8.11	9.71	3.90	17.26	5.08	9.37	2.17	45.79	7.68
18-	22	26.64	3.44	13.77	2.39	7.92	1.61	15.05	1.74	8.27	1.56	46.60	6.07
19-	15	26.15	2.19	14.32	4.27	8.59	1.97	15.59	2.92	8.64	1.83	46.98	5.59
20-	22	25.45	2.29	15.31	6.72	9.65	5.09	16.24	4.36	8.58	2.90	43.75	4.75
21-	75	26.28	2.64	16.02	8.33	9.07	3.72	16.36	4.36	9.19	3.22	46.47	6.63
26-	31	26.52	2.87	17.06	6.16	8.47	3.38	16.93	4.02	9.49	2.98	45.87	4.54
31-	5	27.34	1.74	19.84	9.75	9.46	3.56	20.98	4.90	12.42	4.32	45.52	4.50
19-37	148	26.22	2.59	16.09	7.41	9.00	3.73	16.54	4.24	9.22	3.11	45.96	5.85
Females													
13-16	26	20.66	2.31	23.67	9,27	18.57	8.37	23.18	5 23	10.08	3.12	32.85	4.45
17-	38	22.17	2.07	25.33	10.07	16.28	6.81	23.05	4.96	10.45	2.93	34.44	2.92
18-	44	22.14	1.64	28.15	9.25	17.14	7.56	24.32	4.61	11.68	3.20	35.83	3.29
19-	29	22.47	1.89	24 85	10.07	16.56	7.25	23.02	5.12	10.65	3.10	35.40	4:51
20-	25	22.80	1.82	25.95	10.81	13.52	5.69	22.39	4.70	10.79	2.79	37.19	4.66
21-	125	22.42	3.69	26.48	11.07	17.30	9.03	23.61	5.22	11.24	3.48	35.66	4.20
26-	9	22.53	1.86	26.11	7.96	13.40	4.66	22.86	4.08	11.35	3.33	37.68	5.15
31-38	3	23.37	2.30	22 13	13.08	19.07	9.71	25.27	4.62	12.76	3.66	37.14	1.99
19-38	193	22.50	3.18	26.08	10.72	16.54	8.33	23.35	5.07	11.12	3.32	35.94	4.34

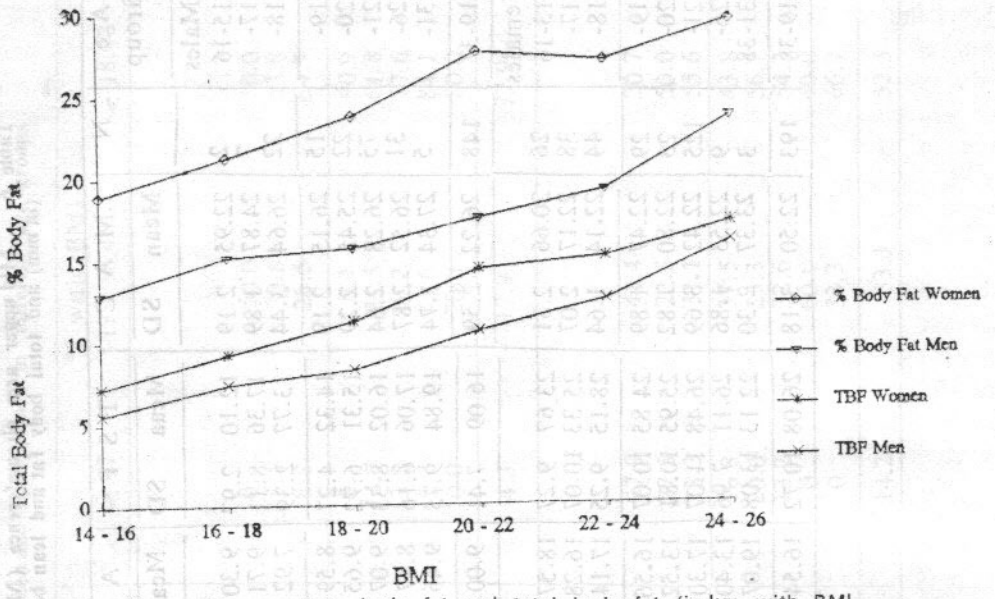

Fig. 1. Change in percentage body fat and total body fat (in kg) with BMI

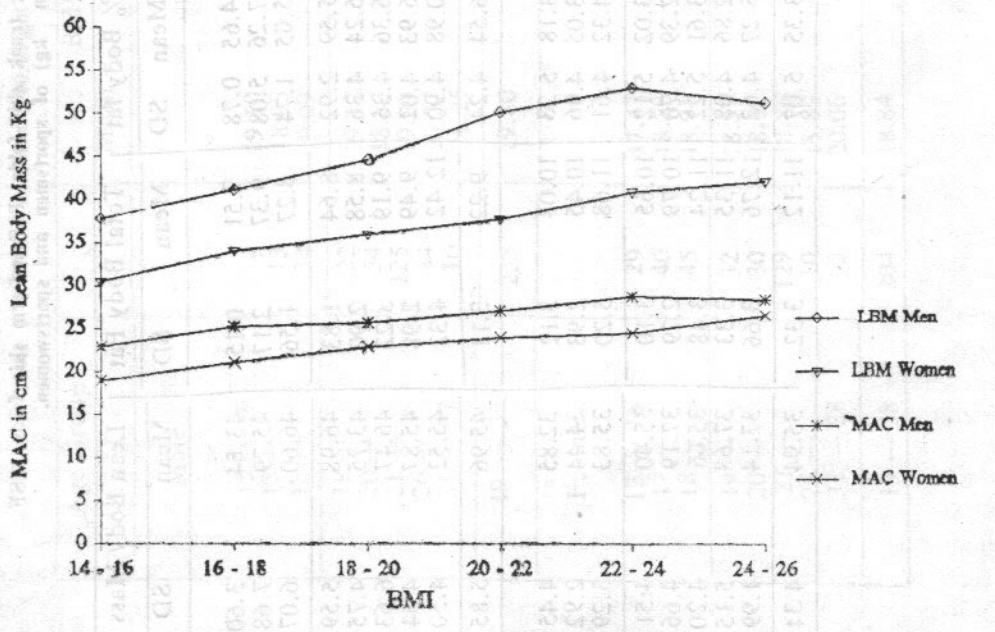

Fig. 2 Change in lean body mass (LBM) and mid-arm circumference (M A C) with BMI

Table 7. Weight (in kg), total height, TH, and sitting height, SH (in cm), BMI and the ratio SH x 100 / TH, of males over 18 years of age, according to games participated in.

Game	N	Weight		Height		Sitting height		SH/THx100		BMI		% with BMI		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	< 17.0	17.0-18.4	> 18.4
01	106	57.05	7.38	166.78	5.72	84.77	3.46	50.85	1.81	20.51	2.36	0.49	12.26	86.79
06	6	47.12	3.30	165.28	2.71	83.72	1.47	50.65	0.72	17.26	1.42	50.00	16.67	33.33
07	19	49.31	8.19	164.84	6.46	82.91	4.01	50.30	1.61	18.12	2.60	21.05	15 79	63.16
08	62	56.46	5.75	169.31	5.12	85.76	2.80	50.67	1.54	19 63	1.34	1.61	16.13	82.26
09	4	56.20	5.92	173.13	4.98	86.68	2.20	50.09	1.67	18.72	1.28	0	75.00	25.00
04	24	51.79	5.36	163.79	6.31	83.83	2.93	51.20	1.13	19.11	1.67	12.50	16.67	70.83
05	16	49.60	-	167.5	-	83.60	-	49.90	-	17.68	-	-	100	-

Table 8. Mid - arm circumsferance, MAC (ln cm), trunk skin–folds, TSF and arm skin-folds, ASF (in mm), percentage body fat, BF, and total body fat, TBF and lean body mass LBM (in kg) of males over 18 years of age, according to games participated in

Game	N	MAC		TSF		ASF		% BF		TBF		LBM	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
01	41	26.14	2.08	22.28	8.60	13.00	4.40	21.15	4.29	12.29	3.54	45.12	4.60
06	6	24.72	1.31	12.95	3.12	5.48	2.28	13.50	2.10	6.38	1.24	40.73	2.65
07	18	25.69	3.22	13.13	3.19	7.59	1.87	14.69	1.92	7.22	1.41	42.10	7.15
08	61	26.98	2.70	14.38	6.23	7.30	1.52	15.03	2.88	8.51	2.01	47.88	4.75
09	4	26.55	2.56	11.35	1.69	8.75	0.60	14.10	0.90	7.91	0.84	48.29	5.29
04	2	22.00	0.14	14.25	0 21	9.30	1.27	16.25	0.78	7.03	8.1	36.22	0.55

Table 9. Weight (in kg), total height, TH, and sitting height, SH, (in cm), BMI and the sitting height index (SH x 100/TH) of females over 18 years of age, according to games participated in,

Game	N	Weight		Height		Sitting height		BMI		SH/TH x 100		% with BIM		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	<17.0	17.0-18.4	<18.4
02	68	47.32	5.44	157.05	6.15	80.94	2.59	19.23	2.37	51.58	1.61	13.23	20 59	68.18
03	71	49.62	6.63	160.87	6.59	81.75	3.44	19.19	2.44	50.85	1.78	14.08	22.54	63.38
07	24	42.64	5.28	155.53	7.10	78.57	2.81	17.59	1.49	50.55	1.32	29.17	54.17	16.67
08	29	45.18	4.35	157.64	4.55	80.43	2.51	18.16	1.28	51·03	1.01	6.90	65,52	27.59
10	2	60.41	2.27	161.90	0.57	84.15	3.18	23.05	1 03	51.97	1.78	–	0	100
05	7	48.00	1.46	160.76	3.06	83.62	2.16	17 62	0.88	51.38	0.99	–	80.0	20.0

Table 10. Mid - arm circumferance, MAC (in cm), trunk skin-folds TSF amd ar m skin-folds, ASF (in mm), percentage body fat, total body fat TBF and lean body mass LBM (in kg) of females over 18 years of age according to games participated in

Game	N	MAC		TSF		ASF		% BF		TBF		LBM	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
02	68	22.67	2.41	31.24	12.05	22.06	8.13	26.56	4.85	12.66	3.21	34.66	3.99
03	67	23.15	4.02	26.07	7.90	14.21	3.76	23.09	3.56	11.48	2.83	37.81	4.59
07	24	21.04	2.17	20.88	10.58	10.17	2.98	19.28	4.30	8.33	2.70	34.31	3.67
08	25	22.45	2.97	20.00	7.31	15.85	4.61	20.94	4.74	9.49	2.85	35.41	2.85
05	3	21.33	1.15	16.60	2.51	11.60	2 31	18.47	2 54	8.89	1.50	39 08	0.26

Table 11. Analysis of Variance

	Sex		Between games		Between districts		Interaction games/ districts	
Height	F	M	Y^{xx}	Y^{xx}	N	N	N	N
Weight	F	M	Y^{xx}	Y^{xx}	N	N	N	N
Sitting height	F	M	Y^{xx}	Y^{x}	N	N	N	N
SH / TH	F	M	N	N	N	N	N	N
BMI	F	M	N	Y^{x}	N	N	N	N
Total body fat	F	M	Y^{xx}	Y^{xx}	N	N	N	N

N = not significant

Y = significant
^{x}at 5% level
^{xx}at 1% level

DISCUSSION

The population studied is a select group, being physically fit and subjected to discipline during periods of training and participation in tournaments. They may be assumed to be adequately nourished. Their anthropometric characteristis cannot therefore be taken as being representative of the general adult population of Sri Lanka. Their heights and weights, however, may be assumed to be attainable by the entire population.

Table 4 shows that there has been a positive secular change in heights and weights during the period 1948 - 1988. A similar change has been reported in school children of both high and low socio – economic status (6). Balasuriya (4) has concluded that the increase in stature seen between 1937 and 1974 was due to an increase in subischial leg length (LL). Between 1974 and 1988 the increase in stature has been accompanied by an increase in sitting height (SH) and in the sitting height index (Table 4). A study of school children has indicated that, between 5 years and puberty, the LL velocity is greater than the SH velocity and LL catches up with SH just before puberty (7). The acceleration of LL growth during preadolescence is greater among the affluent (and, presumably, better nourished) children. Nutrition seems to influence LL velocity more than SH velocity, during pre-adolescence, when growth in stature is due to the combined influence of the growth hormone and the thyroid hormone (ll). After puberty SH velocity is greater than LL velocity, the increase in SH between puberty and adulthood being greater than of LL (7). Whether the SH index of the adult is greater than 50% or not will depend on the age at spermarche and menarche. As the majority of subjects in the present study were in the same age group as those studied by Balasuriya, the former appear to have attained age earlier than the medical undergraduates of 1974.

Table II indicates that the inter - district differences in heights and weights reported earlier (1,3) no longer exist. Differences in climate and habitat by themselves are apparently not great enough to influence the heights and weights of adults, provided they are physically fit and adequately nourished. However, the poor representation of some distrcts and the absence of participants from many others make this conclusion less valid. Effects of socio - economic factors on heights and weights are more apparent in the pre-school and pre-adolescent (6) children than in older age groups.

In the absence of data for the South Asia region, equations used by Durnin and Womersley (10) for computing the percentage body fat have been applied to the subjects in this study (Table 6). The percentage body fat varies between 15 and 20 in men and 22 and 25 in women. An assessment of body fat of young adult males working on a tea estate in the Nuwara

Eliya district gave values in the range 18 to 22% (unpublished data). Therefore, among physically active young Sri Lankan adults fat accounts for 15–22% of body weight in men and 22–25% in women. At BMI levels 24 to 26, body fat in Sri Lankans is less than 15 kg and 17 kg for males and females respectively, values that are lower than 23 kg and 35 kg for Italian males and females quoted by Ferro Luzzi et al (13), and closer to those for Ethiopia and Somalia. The same is true at other levels of BMI. In Sri Lankans, in contrast to Italians, lean body mass contributes more to BMI, at each level of BMI.

The BMI of males lie between 19.0 and 21.25 and of females between 18.5 and 20.1. A BMI of 20 has been established as being compatible with health and a BMI less than 17 is considered as constituting a risk to health (13). A figure of 18.5 for BMI has been suggested as a cut-off point for defining chronic energy deficiency in adults (13). When this value is applied to the present study, there will be a large number of false positives, only 53% of women and 77.9% of men being considered to be in dietary energy adequacy. 4.3% of the men and 14 2% of women will be at risk, with a BMI less than 17. In the present study, 17.9% of the men and 33.3% of the women would fall into the category of the classification of chronic energy deficiency suggested by Ferro–Luzzi et al, with a BMI of between 17.0 and 18.4 and a physical activity index (PAI) less than 1.4 (13).

In estimating energy adequacy, allowances recommended by the FAO/WHO (14) have been used and these allowances are based on values of resting metabolic rate (RMR) of adults in temperate regions.

The results of the present study indicate that the RMR of Sri Lankans is less than the values used by the FAO/WHO. Values for BMR of Sri Lankans obtained by Cullumbine in 1950 (15) are lower than the FAO values and more in agreement with values for Indians (16). A fresh assessment of RMR of Sri Lankans is needed in order to arrive at cut-off points of BMI that will indicate chronic dietary energy deficiency.

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