

Short Communication

Cross-sectional reference values of upper arm anthropometry of the Khasi tribal adolescents of Meghalaya, India

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The Khasi tribal people in India with their distinct ethnic identity have relative geographic isolation from the rest of the country. Although chronic energy deficiency has been documented in this population, their nutritional status has not been re-evaluated following a decade of economic growth in India. In this study, the nutritional status of an ethno-homogenous sample of contemporary Khasi tribal adolescent cohort of age 11+ to 17+ years in the state of Meghalaya, India has been assessed by cross sectional analysis. This was achieved through the use of the following derived anthropometric measurements - total upper arm area (TUA), upper arm muscle area (UMA), upper arm fat area (UFA), and arm fat index (AFI). A total of 670 adolescents (335 boys; 335 girls) participated in this study. In comparison with North American NHANES 1999-2002 standards, UMA, a measure of upper arm muscle mass, was lower at all age groups in Khasi girls. Conversely, in Khasi boys, AFI, a marker of upper arm fat mass was lower at all age groups, thereby showing a gender dimorphic difference in upper limb muscle and fat proportions. We conclude that in upper arm indirect anthropometry, contemporary Khasi adolescent children remain nutritionally deficient with gender dimorphic muscle and fat proportions.

Key Words: nutritional status, upper limb indirect anthropometry, Khasi, adolescents, India

INTRODUCTION

It is well known that environmental factors like socio-economic status, dietary patterns, heterosis and religion variably influence nutritional status.¹⁻⁴ It is generally accepted that socio-economic conditions in North East India have improved following a period of recent economic growth which may have influenced the nutritional status of inhabitants in this region. Nutritional surveys in the Khasi population have previously reported variable prevalences of chronic energy deficiency,³⁻⁶ using conventional anthropometric measurements such as weight and body mass index (BMI). Anthropometry of the upper limb is a valuable tool in nutritional assessment, particularly in states of nutritional restriction, where muscle and fat mass estimation of the upper limb may indicate differential utilization of nutritional reserves.⁷⁻¹⁰ The value of indirect anthropometry in the context of emerging economic well-being in relatively isolated populations such as the Khasi tribal population remains to be determined.

The Khasi tribes are a group of people in the North East of India, who are ethnically distinct and are geographically relatively isolated from the rest of the country. The homelands of the Khasis are in the Khasi and Jaintia Hills of Meghalaya, bounded by the state of Assam and by the country of Bangladesh. The Khasis are identified with the Mon-Khmer people of the Far East mainly on the

basis of the language, megalithic culture and iron smelting techniques. The Khasis cultivate paddy, potatoes and maize as the main crops. Rice is their staple food while consumption of animal proteins such as pork and beef is common.⁴⁻⁵ It is not known, although anticipated, that such dietary practices may have changed over the preceding decade.

In this study, we have described the nutritional status in a contemporary adolescent Khasi tribal population by upper limb anthropometry, derived from Mid Upper Arm Circumference (MUAC) and Triceps Skinfold Thickness (TSF).

MATERIALS AND METHODS

We have studied a cohort (N= 670, 335 boys and 335 girls) of Khasi adolescents (age 11+ to 17+ years) from a geographically distinct area in the state of Meghalaya in

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Nongpoh, district capital of Ri-Bhoi district, and Shillong, state capital of Meghalaya, during March-April, 2003 and June, 2008 after obtaining prior permission at the local level and research ethical approval from the Anthropological Survey of India. Upper arm anthropometry was assessed by standard techniques.¹¹⁻¹⁴

Nutritional status was assessed by indirect anthropometric measurements - total upper arm area (TUA), upper arm muscle area (UMA), upper arm fat area (UFA), and arm fat index (AFI). These measurements were derived from mid upper arm circumference (MUAC) and triceps skinfold thickness (TSF) using standard methods.^{13,14} Substituting C for MUAC, and measurements made in centimeters, the following formulae were used: $TUA = C^2 / (4 \times \pi)$; $UMA = [C - (TSF \times \pi)]^2 / (4 \times \pi)$. To adjust the area of the bone and to obtain the bone-free arm muscle area, the values were adjusted by subtracting 10.0 cm² for males and 6.5 cm² for females. $UFA = TUA - UMA$, $AFI = (UFA / TUA) \times 100$.

Among the Khasis, no distinction was made among the sub-groups of Khyntiam-, Pnar-, Bhoi- and War Khasi. Children between 8.00 years and 8.99 years were designated as 8+ years, those between 9.00 years and 9.99 years as 9+ years and so on.¹² The difference in quantitative measures of muscle and fat, i.e. UMA and AFI between males and females was assessed by one way ANOVA tests, using the statistical package SPSS 15.0, Chicago, Illinois.

Anthropometric assessments for muscle and fat mass were compared to North American normative data specified in the National Health and Nutrition Examination Survey (NHANES 1999-2002), maintained by the National Center for Health Statistics (NCHS).¹⁵

Smoothed centile curves for Upper Arm anthropometric measurements were constructed by the LMS method¹⁶ using LMS ChartMaker Pro software package. Maximum penalized likelihood was used to derive optimized L

(power transformation curve), M (median curve) and S (coefficient of variation curve) parameters for boys and girls.

RESULTS

Table 1 shows the sample size (N), mean (M) and standard deviation (SD) values of MUAC, TSF and the indirect anthropometric measurements TUA, UMA, UFA, AFI and Upper Arm Muscle Area as a percentage of Total Upper Arm Area (UMA%) in Khasi adolescents by age and sex.

In Khasi girls and boys, UMA values increased with age (except for age 16 years in boys) in keeping with North American trends. UMA, representing muscle status, was greater in Khasi boys than in girls after age 11 years ($p < 0.001$ for difference at each age group), indicating proportionately greater muscle mass in boys (Figure 1). UMA% too was greater in Khasi boys than in girls ($p = 0.001$ at age 11 yrs, $p < 0.001$ at all other age groups).

AFI, representing fat status, remained relatively constant over time, similar to that of North American girls. In Khasi boys, there was a downwards trend in AFI in keeping with North American standards (Figure 2). Arm Fat Index (AFI) was greater at age 11 years in Khasi girls than in boys ($p = 0.001$) and also at subsequent ages ($p < 0.001$ for difference at each age). UFA, another reliable measure of fat status was assessed by plotting 5th and 85th centile values in Khasi children against 10th and 90th centile values in North American children (Figure 3). UFA was lower in Khasis with normal ranges (5th to 85th centiles) around the 10th centile values in North American children.

For each of the indirect anthropometric indices, smoothed centiles were derived by using the LMS method. L, M and S values for both sexes in Khasi adolescents have been appended in Table 2.

Table 1. Mean (M) and standard deviation (SD) values of mid upper arm circumference (MUAC), triceps skinfold thickness (TSF), total upper arm area (TUA), upper arm muscle area (UMA), upper arm fat area (UFA), arm fat index (AFI) and upper arm muscle area as a percentage of total upper arm area (UMA%) in Khasi boys and girls in age groups 11-17 years

Age (years)	MUAC (cm)		TSF (mm)		TUA (cm) ²		UMA (cm) ²		UFA (cm) ²		AFI (%)		UMA%		
	N	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD		
Boys															
11+	45	17.6	1.7	7.8	2.6	24.8	5.1	18.3	3.4	6.4	2.6	25.7	6.3	74.2	6.3
12+	47	18.9	2.8	7.4	2.2	28.9	9.8	22.4	9.0	6.5	2.1	23.2	6.6	76.8	6.6
13+	52	20.2	2.4	8.1	3.5	32.3	8.4	25.0	6.2	7.7	4.2	23.6	7.0	76.8	7.0
14+	43	20.7	2.2	6.8	1.5	35.6	7.3	27.9	6.6	6.7	1.6	19.7	4.2	80.3	4.1
15+	51	21.9	2.0	6.9	2.0	38.5	6.8	31.3	6.2	7.2	2.1	18.9	5.1	81.1	5.0
16+	52	23.5	2.3	7.2	2.1	44.2	9.4	36.2	8.4	10.0	2.5	18.3	5.2	81.6	5.1
17+	45	24.4	1.9	7.6	2.6	47.8	7.8	39.0	6.6	8.8	3.2	18.5	5.7	81.5	5.6
Girls															
11+	43	17.9	1.4	9.3	2.1	25.7	4.0	18.0	2.9	7.7	1.9	29.9	5.4	70.0	5.4
12+	50	18.9	2.4	10.6	3.3	28.9	7.4	19.6	4.5	9.3	3.8	31.5	6.9	68.5	6.9
13+	45	19.9	2.0	12.6	4.2	31.8	6.4	20.5	5.3	11.3	3.9	35.5	10.6	64.5	10.5
14+	53	21.4	1.6	13.7	4.4	36.7	5.7	23.5	3.8	13.2	4.6	35.5	9.0	64.5	9.0
15+	52	22.0	1.8	14.4	3.9	38.8	6.1	24.5	4.3	14.3	4.2	36.6	7.6	63.4	7.5
16+	48	22.2	2.0	13.6	4.0	39.5	6.8	25.7	4.4	1.8	4.6	34.4	7.4	65.6	7.4
17+	44	23.0	1.7	15.0	3.9	42.2	6.2	26.6	3.9	15.6	4.5	36.5	7.0	63.4	6.9

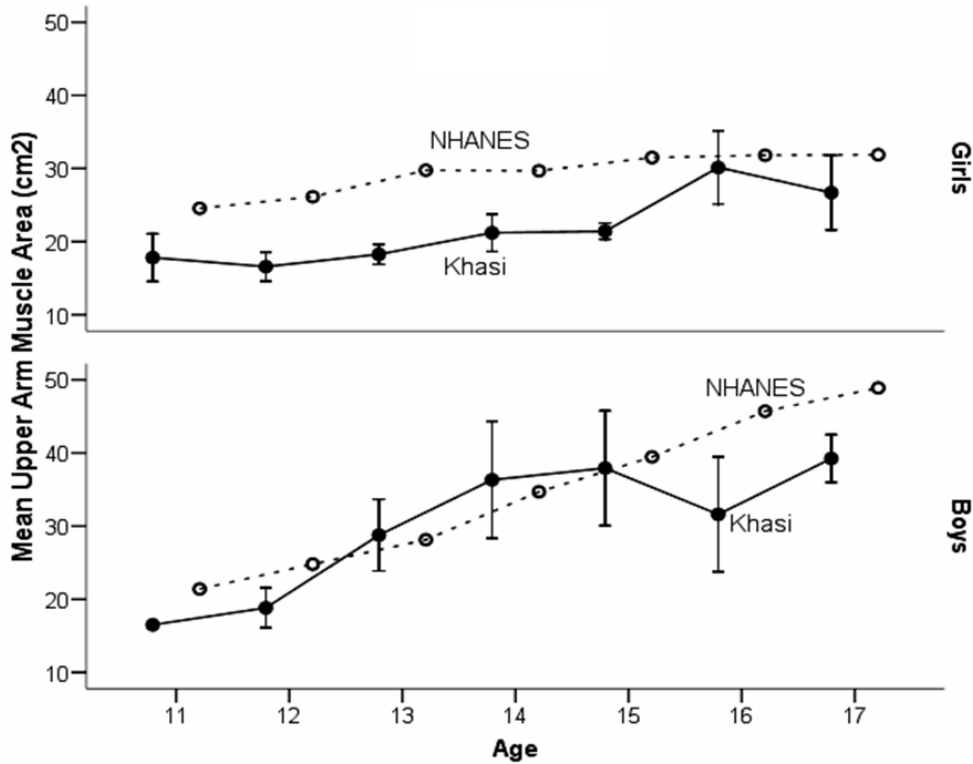


Figure 1. Mean values (± 1 Standard error, SE) of upper arm muscle area (UMA) (cm²) in age groups 11+ to 17+ years in Khasi adolescents compared against mean UMA in NHANES 1999-2002 data.

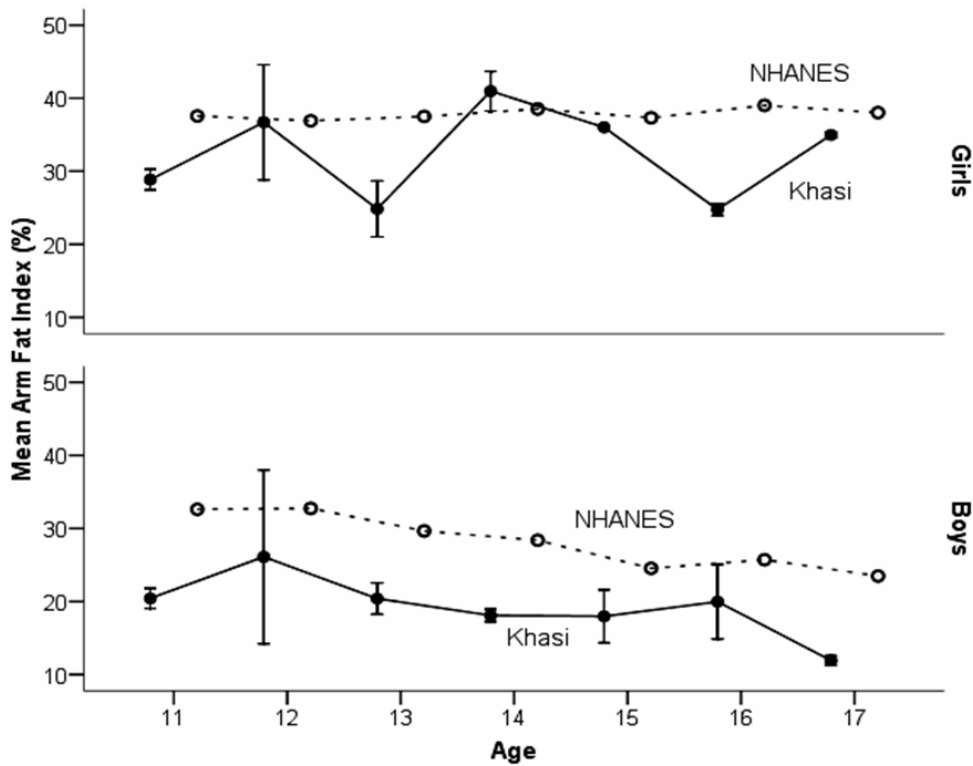


Figure 2. Mean values (± 1 SE) of upper arm fat index (AFI) (%) in age groups 11+ to 17+ years in Khasi adolescents compared against mean UMA in NHANES 1999-2002 data.

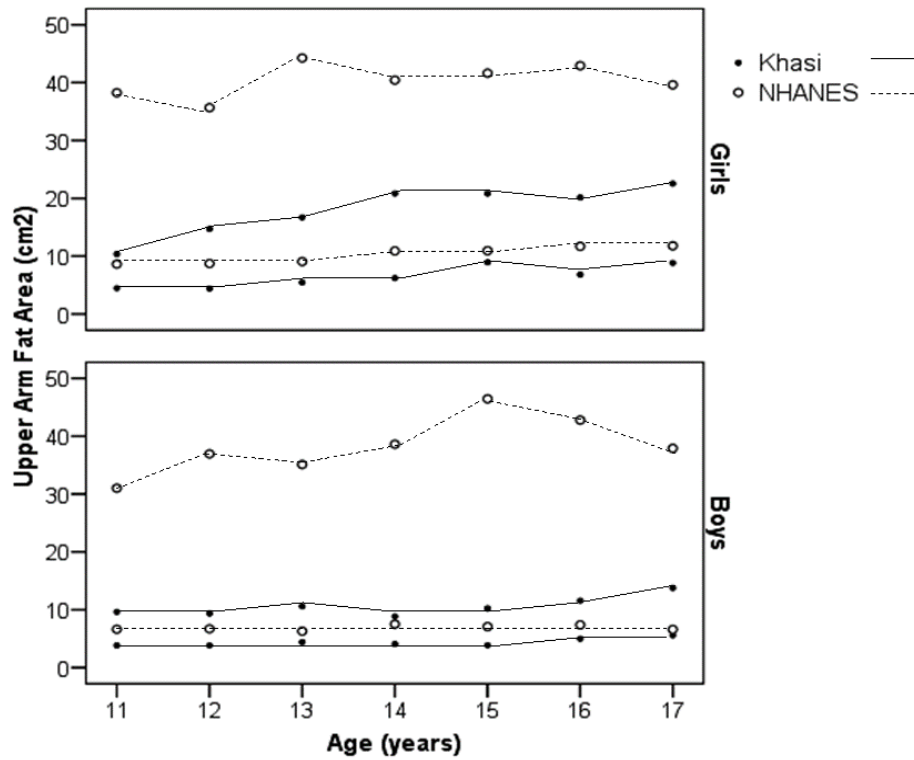


Figure 3. Upper arm fat area (UFA): 85th and 5th centile values (top and bottom dotted lines) of UFA for Khasi boys and girls in comparison with 90th and 10th centile values (top and bottom continuous lines) for NHANES 1999-2002 data for ages 11+ to 17+ years.

Table 2. LMS values of TUA, UMA, UFA & AFI among the Khasi Adolescents

Age(yrs)	Boys			Girls		
	l	m	s	l	m	s
TUA						
11+	-1.15	24.18	0.20	-0.32	25.07	0.21
12+	-1.15	27.16	0.20	-0.09	28.60	0.20
13+	-1.15	30.23	0.19	0.16	32.00	0.19
14+	-1.15	33.60	0.18	0.39	35.23	0.18
15+	-1.15	37.51	0.18	0.62	37.91	0.17
16+	-1.15	42.08	0.17	0.84	40.20	0.16
17+	-1.15	46.77	0.16	1.03	42.27	0.15
UMA						
11+	-0.82	17.91	0.23	1.24	18.14	0.23
12+	-0.82	20.69	0.22	1.24	19.74	0.22
13+	-0.82	23.61	0.21	1.24	21.35	0.20
14+	-0.82	26.81	0.21	1.24	23.01	0.19
15+	-0.82	30.37	0.20	1.24	24.47	0.18
16+	-0.82	34.31	0.19	1.24	25.77	0.16
17+	-0.82	38.26	0.19	1.24	26.94	0.15
UFA						
11+	-0.65	5.90	0.29	0.23	7.39	0.34
12+	-0.65	6.16	0.29	0.23	9.15	0.34
13+	-0.65	6.41	0.29	0.23	10.80	0.34
14+	-0.65	6.64	0.29	0.23	12.18	0.33
15+	-0.65	6.95	0.29	0.23	13.26	0.32
16+	-0.65	7.43	0.29	0.23	14.14	0.32
17+	-0.65	7.98	0.29	0.23	14.94	0.31
AFI						
11+	-0.30	24.46	0.26	0.74	29.48	0.24
12+	-0.30	22.68	0.26	0.64	31.94	0.23
13+	-0.30	21.13	0.26	0.54	33.98	0.23
14+	-0.30	19.60	0.26	0.47	34.96	0.23
15+	-0.30	18.39	0.26	0.40	35.31	0.23
16+	-0.30	17.64	0.26	0.35	35.43	0.23
17+	-0.30	17.13	0.26	0.30	35.56	0.22

LMS indicates that L (values for power transformation curve), M (values for median curve) and S (values for coefficient of variation curve)

DISCUSSION

In this study, the nutritional anthropometric status among the Khasi tribal adolescent children has been investigated using indirect anthropometric measurements of the upper arm, namely TUA, UMA, UFA and AFI. In Khasi children, UMA a measure of muscle status, was lower than North American standards, more so in girls than in boys. UFA and AFI, indicating fat status, was lower in Khasi children than North American standards, more so in boys than in girls. Thus, we observed a gender dimorphic pattern of suboptimal fat and muscle status in Khasi adolescent children.

Our findings are consistent with that of previous studies in Khasi populations suggesting persistent chronic energy deficiency, assessed by body weight and BMI.^{3,6} Our findings are also similar to that of other tribal populations in India, such as the Santals,¹⁷ with upper arm fat status at the lower end of reference standards. However, unlike the Santals, we observed gender dimorphic fat and muscle proportions, indicating that Khasi boys had greater energy deficiency while Khasi girls had greater protein deficiency. The significance of this gender dimorphic differential undernutrition is unclear. It remains to be examined if the quality and quantity of dietary protein and energy is different between Khasi boys and girls in the context of a greater availability in energy dense foods associated with economic improvement in the region. In our study, detailed food diaries were not obtained to investigate the protein and energy intake to quantify a possible shift from traditional food habits. One possibility to account for the gender difference may be a difference in activity levels between the sexes. However, physical activity was not quantified in our study.

It is possible that the relatively greater fat status in Khasi girls may be a sign of impending insulin resistance in the female population.¹⁸ To explore this possibility, further investigations of glucose tolerance and cardiovascular risk factors may need to be undertaken, particularly in the adult Khasi population.

We conclude that contemporary Khasi tribal adolescent boys and girls continue to suffer from chronic energy deficiency with a gender dimorphic difference in fat and muscle mass proportions, as measured by indirect upper limb anthropometry.

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AUTHOR DISCLOSURES

Authors declare no conflict of interest.

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印度梅加拉亞邦的卡西部族青少年的上臂測量之橫斷性參考值

位於印度的卡西部族有獨特的種族身分，其地理位置亦較印度的其他地區孤立。雖然這個族群已被證實有長期熱量缺乏現象，但是他們的營養狀況並沒有隨著印度近十年經濟的成長而再次被評估。因此，本研究是藉由橫斷性分析來評估梅加拉亞邦 11 至 17 歲卡西部族青少年世代之同一種族樣本的營養狀況。透過下列人體測量來評估：總上臂面積、上臂肌肉面積、上臂脂肪面積以及手臂脂肪指數。本研究總共有 670 位青少年參與(包括 335 位男生，335 位女生)。與美國的 1999-2002 年 NHANES 的標準來比較，所有年齡層的卡西族女性青少年的上臂肌肉面積皆較低，而上臂肌肉面積是用以測量上臂肌肉的質量。相反地，所有年齡層的卡西族男性青少年的手臂脂肪指數則是較 NHANES 的標準低，而手臂脂肪指數是上臂脂肪質量的指標，這顯示上臂肌肉以及脂肪組成有性別上的差異。因此，我們根據上臂間接體組成測量的結果推斷，當代的卡西族青少年仍然有營養缺乏現象，而其肌肉及脂肪比例則兩性互異。

關鍵字：營養狀況、上臂間接人體測量、卡西族、青少年、印度