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Assessment of Nutritional Status and Body Composition in Tibetan Adolescent girls of Kangra district, Himachal Pradesh

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ABSTRACT: Malnutrition among adolescents is an important public health issue in India. The aim of the present study was to assess nutritional status and body composition characteristics of adolescent girls and their interrelationships with physical activity and socioeconomic status (SES). Nutritional status and body composition characteristics were assessed in terms of body mass index (BMI), upper arm muscle area by height (UAMAH) and percent body fat (PBF) among 276 Tibetan adolescent girls from Kangra district, Himachal Pradesh. Overall, 12.7% of the girls were in the wasting category (using Z-score based classification for UAMAH) and 9.8% were thin. About 16.3% girls were obese. Significant variabilities of PBF have been observed with respect to age and levels of physical activity and wasting. Adolescent girls were observed to have higher lean body mass than body fat.

KEY WORDS: body mass index, percent body fat, upper arm muscle area by height, physical activity, socioeconomic status

Introduction

In developing countries, nutritional status has been considered to indicate living standard (Nube, Aseno-okyere and Van Den Boom 1998). Prevalence of malnutrition of any form is a persistent problem among adolescents in India (Debnath, Mondal and Sen 2019). Global prevalence of thinness among adolescent girls was 8.4% (NCD 2017). The assessment of body composition depicts the muscle mass composition along with the body fat percent in an individual, reflecting the nutritional intake over a time period (Thibault and Pichard 2012). Anthropometry has a long tradition of assessing nutritional status and body composition as it is an inexpensive, non-invasive method that provides detailed information on different components of body composition, especially muscular and fat components (Bharati et al. 2007).

Body fat percentage when assessed using body mass index (BMI) has a limitation as it does not differentiate be-

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tween excess body weight associated with either muscle-mass and/or fat-mass (Thibault, Genton, Pichard 2012). Also, BMI is better represented in terms of fat mass (FM) and fat free mass (FFM) (Wells 2010). Several studies report that percent body fat (PBF), FM and FFM are widely used as indicators of adiposity (VanItallie et al. 1990; Rolland-Cachera 1993; Sharma and Mondal 2018). Excess body fat has been reported to be a significant risk factor for certain non-communicable diseases (e.g., CVDs, insulin resistance, diabetes mellitus and types of cancer) and related mortality and morbidity (Vaan Gaal, Mertens and De Block 2006).

It is suggested that BMI alone is a poor measure of body fat and may fail in detecting the future health risks (Franzosi 2006). In addition, more direct measures like upper arm muscle area (UMA), upper arm fat area (UFA) and arm fat index (AFI) can be more useful for assessing body fat content (Frisancho and Tracer 1987). UMA is a measure of muscularity, reflecting the protein reserve in the body while UFA is a measure of adiposity, reflecting body calorie reserve. AFI indicates fat percentage of the arm area (Deurenberg et al. 1990).

Several studies conducted worldwide reveal that the problem of malnutrition in adolescent girls is quite prevalent (Mishra 2017). Adolescence is a crucial time for girls as the body prepares for various nutritional demands in pregnancy, lactation, and heavy workloads for the future (Venkaiah et al. 2002). Adolescent girls who are under-nourished are at a risk of being stunted mothers. It is essential that adolescent girls are well nourished since the risk of malnutrition spans across generations, termed as intergenerational effects of malnutrition (Martorell and Zongrone 2012). Any nutritional deficiency experienced during this critical period of female ontogeny can have an effect on the future health of the girl and her offspring (Das et al. 2018).

BMI, PBF, UFA and UMA are reliable indicators of adiposity among adolescents (Micozzi et al. 1986; Moreno et al. 2002). Several studies have been conducted among children and adolescents considering UMA and UFA as accurate measures of body composition and nutritional status (Erfan et al. 2003; Chowdhury and Ghosh 2009; Çiçek et al. 2009; Basu et al. 2010; Sen et al. 2011, 2015; Sikdar 2012; Singh and Mondal 2014). As UMA was found to be linearly correlated with total body mass, it may be considered as a fair indicator of protein malnutrition (Cicek et al. 2014). To assess nutritional status in terms of wasting, the Z- scores of upper arm muscle area by height (UAMAH) is considered as a reliable measure (Frisancho and Tracer 1987).

On the other hand, underweight does not have the same meaning between adults and children. In adults, underweight or thinness indicates low BMI, whereas in children underweight is low weight for age and wasting is low weight for height (WHO 1995). Thus, for children and adolescents, the term thinness means low BMI-for-age (Cole et al. 2007). However, more data is needed regarding the assessment of thinness in adolescents as compared to the amount of literature focusing on overweight among them (Bovet et al. 2011).

Material and Methods

Study design A cross-sectional survey was conducted among 276 Tibetan adolescent

girls (13–18 years) of Kangra district, Himachal Pradesh, India during 2018–2019. After obtaining authorized consent from the school management, data was collected using stratified random sampling technique. Ethical clearance was obtained from the Ethical Committee of Department of Anthropology, University of Delhi.

Study population: In 1949, the Government of China unilaterally announced Tibet as an integral part of China. As a result, many Tibetans followed the Dalai Lama and took shelter at Dharamsala, Himachal Pradesh, India in 1959. The Government of India accepted the Tibetans and ensured to safeguard their interest. Approximately, 94,203 Tibetans are reported to live in India (CTA 2010). They are Buddhists by birth and their language belongs to the Tibeto-Burman family. The local markets in Dharamsala consist of Tibetan sellers selling handicrafts and food. The major economic activities of the Tibetans include agriculture, handicrafts, small shop and business owners in the local market, dairy and horticulture.

Anthropometric measurements were taken as per the standards provided by the International Society for the Advancement of Kinanthropometry (Marfell-Jones et al. 2012). Height was measured to the nearest 0.1 cm, using an anthropometric rod while weight was measured to the nearest 100g using a floor type weighing scale. Mid upper arm circumference (MUAC) was taken using a non-stretchable measuring tape to the nearest 0.10 cm. The Skinfolds at triceps (TSF) and skinfold at subscapular (SSSF) were measured using a Harpenden skinfold caliper calibrated to exert a constant pressure of 10gm/mm^2 to the nearest 0.20 mm.

Assessment of body composition: Upper-arm body composition was evaluated from the anthropometric measurements of MUAC and TSF by using the standard equations (Frisancho 1981) given below:

$$\text{UMA (cm}^2\text{)} = \{\text{MUAC} - (\text{TSF} \times \pi)\}^2 / / (4\pi)$$

$$\text{UFA (cm}^2\text{)} = \{(\text{MUAC})^2 / (4\pi)\} - \text{UMA}$$

$$\text{AFI} = \text{UFA} / \{(\text{MUAC})^2 / (4\pi)\} \times 100$$

The anthropometric indices for body composition (VanItallie et al. 1990) were also calculated as follows:

$$\text{FM (kg)} = (\text{PBF}/100) \times \text{Weight}$$

$$\text{FFM (kg)} = \text{Weight} - \text{FM}$$

Percent body fat (PBF) was estimated using given equations (Slaughter 1988) and was categorized as per American Council on Exercise (ACE 2009).

If (SSSF + TSF) = <35 mm, then

$$\text{PBF} = 1.33 \times (\text{SSSF} + \text{TSF}) - 0.013 \times \times (\text{SSSF} + \text{TSF})^2 - 2.5$$

And if (SSSF + TSF) = >35 mm, then

$$\text{PBF} = 0.546 \times (\text{SSSF} + \text{TSF}) + 9.7$$

Assessment of nutritional status Nutritional status was determined in terms of wasting by using the Z-score based classification for UAMAH (Frisancho and Tracer 1987). The age-sex specific BMI was also calculated for the assessment of nutritional status in terms of different grades of thinness (Cole et al. 2007) (low BMI-for-age) as grade-III, grade-II and grade-I (severe, moderate and mild), re-

spectively, corresponding with BMI values of 16.0, 17.0 and 18.5 kg/m^2.

To assess activity patterns, a physical activity questionnaire for adolescents (Kowalski, Crocker and Donen 2004) (PAQ-A) was used. For the present study, a modified BG Prasad scale (Pandey et al. 2019) was used to assess socioeconomic status. This is the most commonly used scale based on per capita monthly income for both urban and rural areas.

Statistical analysis was performed using SPSS Version 20 and MS-Excel. Frequencies and percentages were calculated for categorical variables, while continuous variables were expressed in terms of mean and standard deviation. One-way ANOVA was used to identify the mean differences among the anthropometric variables and indices with respect to age. Chi-square was employed to assess the relation of PBF, wasting and thinness with physical activity and SES.

Results

The descriptive statistics of anthropometric and body-composition variables of the Tibetan adolescent girls are shown in Table 1. Mean values of height, weight, BMI and MUAC increased with age but no age specific trend was observed for mean TSF and SSSF values. Using ANOVA, statistically significant ($p<0.05$) differences were observed in mean height, weight, BMI, MUAC and TSF with respect to age.

Assessment of body composition Age-specific mean UMA, FM and FFM values increased with age, however, no age specific trend was observed in mean UFA, AFI and PBF values. Using ANOVA, statistically significant ($p<0.05$) differences were observed in mean UMA, UFA and FFM values with respect to age.

Distribution of girls in different PBF categories is shown in Table 2. It was observed that 37.3% of girls fell in the

Table 1. Age-specific subject distribution, means and standard deviations of anthropometric and body-composition variables among Tibetan adolescent girls of Kangra district

Age (years)/ Variable	13+	14+	15+	16+	17+	18+	*F*-value
n	45	45	42	52	45	47	
Height (cm)	153.46±5.30	154.32±4.87	156.39±5.21	156.42±5.95	156.84±5.91	156.92±5.94	2.68*
Weight (kg)	46.26±7.14	48.04±9.7	52.01±5.1	52.24±8.07	52.43±7.38	53.25±6.82	6.50*
MUAC (cm)	22.46±2.06	22.81±2.74	23.97±1.74	24.10±2.55	24.51±3.06	24.81±2.17	6.07*
TSF (mm)	12.83±3.1	13.82±3.93	14.9±3.09	14.42±3.88	14.2±3.22	15.35±3.29	2.96*
SSSF (mm)	13.2±3.97	13.24±4.87	15.28±3.88	14.73±3.82	14±3.72	14.69±3.47	2.07
UMA (cm^2)	27.25±4.96	27.41±5.48	29.79±4.53	30.76±5.88	31.13±7.13	32.03±5.16	5.79*
UFA (cm^2)	13.24±4	14.61±6.09	16.19±3.89	15.99±5.38	15.66±4.66	17.36±4.68	3.90*
AFI	32.38±5.64	33.91±5.35	35.03±5.61	33.58±6.42	33.71±6.67	34.82±5.08	1.19
PBF	24.04±6.74	24.89±8.29	27.18±6.88	26.73±7.6	26.05±6.94	27.29±6.82	1.49
FM (kg)	11.43±5.24	12.65±7.91	14.34±4.74	14.41±6.33	14.52±5.64	14.87±5.53	2.18
FFM (kg)	34.82±3.72	35.39±3.67	37.67±3.46	37.83±3.77	38.41±3.68	38.58±3.39	8.55*
BMI (kg/m^2)	19.62±2.71	20.09±3.39	21.29±2.10	21.51±2.76	21.59±2.50	21.76±2.76	4.52*

MUAC – mid-upper arm circumference, TSF – Tricep skinfold, SSSF – subscapular skinfold, UMA – upper arm muscle area, UFA – upper arm fat area, AFI – arm fat index, PBF – percent body fat, FM – fat mass, FFM – fat free mass, BMI – body mass index, Difference statistically significant at *p <0.05.

fit category. One subject was reported in the essential fat category. Furthermore, 27.2% girls were grouped in the average category and 18.8% girls were grouped in the athletic category. On the other hand, 16.3% girls were grouped in the obese category.

Table 3 displays cross tabulation of PBF with physical activity and socioeconomic status. Statistically significant differences ($p<0.01$) were found between PBF categories and physical activity. This indicates that the prevalence of obesity in terms of PBF is greater in girls who engage in low levels of physical activity. On the other hand, no statistically significant differences were found between PBF categories and SES.

Assessment of nutritional status: Table 4 represents the prevalence of wasting in the studied population. Overall, 5.07% of girls grouped in the wasting category, 7.62% of girls in the below average category of wasting, and 72.10% of girls were grouped in the average category. Moving to the next category, 11.95% of girls were in the above average category of wasting, while 3.26% of girls were in the high muscle category. It was found that 12.69% of girls were in the overall category of wasting (combining below average and wasted categories).

Table 5 represents the prevalence of thinness in the studied population where severe thinness was reported to be 1.81%. Approximately 2.53% of girls

Table 2. Distribution of Tibetan adolescent girls of Kangra district according to the percent body fat categories

Age (years)/ Body fat category	13+	14+	15+	16+	17+	18+	Total
Essential fat (10–13%)	0	0	0	1 (1.9)	0	0	1 (0.4)
Athletic (14–20%)	12 (27.0)	16 (36.0)	5 (11.9)	7 (13.5)	6 (13.0)	6 (12.8)	52 (18.8)
Fit (21–24%)	23 (51.0)	13 (29.0)	12 (28.6)	19 (36.5)	23 (51.0)	13 (27.6)	103 (37.3)
Average (25–31%)	5 (11.0)	10 (22.0)	18 (42.8)	15 (28.9)	8 (18.0)	19 (40.4)	75 (27.2)
Obese (≥32%)	5 (11.0)	6 (13.0)	7 (16.7)	10 (19.2)	8 (18.0)	9 (19.2)	45 (16.3)
Total	45	45	42	52	45	47	276

Values in parentheses depicts percentages.

Table 3. Crosstabulation of SES and PA with PBF categories among Tibetan adolescent girls of Kangra district

Variables	n	Athletic	Fit	Average	Obese	Chi-square
Physical Activity						
High	125	30 (10.9)	38 (13.8)	51 (18.5)	6 (2.2)	
Moderate	88	19 (6.9)	52 (18.8)	5 (1.8)	12 (4.3)	86.14*
Low	63	4 (1.4)	13 (4.7)	19 (6.9)	27 (9.8)	
Socio-economic status						
Upper	220	39 (14.1)	89 (32.2)	56 (20.3)	36 (13.1)	
Middle	37	7 (2.5)	10 (3.6)	14 (5.1)	6 (2.2)	8.103
Lower	19	7 (2.5)	4 (1.5)	5 (1.8)	3 (1.1)	

Statistically significant at $^*p<0.01$; values in parentheses depicts percentages.
For chi-square analysis, essential fat category was merged with athletic category as expected frequency cannot be less than 1.

were grouped in the moderate thinness category, while 5.43% girls were grouped in the mild thinness category. It was further observed that 9.78% of girls to the category of overall thinness.

Table 6 represents the distribution of wasting and thinness with respect to physical activity and socioeconomic status. Physical activity was found to be statistically significant ($p<0.05$) with

Table 4. Assessment of nutritional status using UAMAH in terms of wasting among Tibetan adolescent girls of Kangra district

Age	n	Wasted	Below average	Average	Above average	High muscle
		<−1.6 Z-score	1.6≤Z-score<−1.0	−1.0≤Z-score<+1.0	+1.0≤Z-score<+1.6	≥+1.6 Z-score
13+	45	1 (2.22)	1 (2.22)	32 (71.12)	9 (20)	2 (4.44)
14+	45	2 (4.44)	2 (4.44)	29 (64.46)	11 (24.44)	1 (2.22)
15+	42	1 (2.38)	1 (2.38)	35 (83.33)	5 (11.91)	0
16+	52	4 (7.69)	2 (3.84)	40 (76.92)	4 (7.71)	2 (3.84)
17+	45	1 (2.22)	8 (17.77)	31 (68.91)	1 (2.22)	4 (8.88)
18+	47	5 (10.63)	7 (14.91)	32 (68.08)	3 (6.38)	0
Total	276	14 (5.07)	21 (7.62)	199 (72.10)	33 (11.95)	9 (3.26)

Values in parentheses depicts percentages.

Table 5. Assessment of nutritional status using BMI-for-age in terms of thinness among Tibetan adolescent girls of Kangra district

Age	n	Grade I (Mild)	Grade II (Moderate)	Grade III (Severe)	Overall Thinness
13+	45	0	2 (4.44)	1 (2.22)	3 (6.66)
14+	45	1 (2.22)	0	4 (8.88)	5 (11.11)
15+	42	1 (2.38)	2 (4.76)	0	3 (7.14)
16+	52	0	0	4 (7.69)	4 (7.69)
17+	45	1 (2.22)	2 (4.44)	2 (4.44)	5 (11.11)
18+	47	2 (4.25)	1 (2.12)	4 (8.51)	7 (14.89)
Total	276	5 (1.81)	7 (2.53)	15 (5.43)	27 (9.78)

Values in parentheses depicts percentages.

Table 6. Cross Tabulation of socioeconomic status and physical activity levels with wasting and thinness among Tibetan adolescent girls of Kangra district

Variable	n	Wasting	Normal	Thinness	Normal
Physical activity					
High	125	5 (1.8)	120 (43.5)	7 (2.5)	118 (42.7)
Moderate	88	8 (2.9)	80 (29.0)	10 (3.6)	78 (28.3)
Low	63	22 (8.0)	41 (14.8)	10 (3.6)	53 (19.2)
Chi-square		37.67*		5.37	
Socio-economic status					
Upper	220	6 (2.2)	214 (77.5)	7 (2.5)	213 (77.2)
Middle	37	15 (5.4)	22 (8.0)	9 (3.3)	28 (10.1)
Lower	19	14 (5.1)	5 (1.8)	11 (4.0)	8 (2.9)
Chi-square		100.74[1]		61.95[1]	

Statistically significant at *$p<0.05$, [1] – yate's correction at $p<0.05$. Values in parentheses depicts percentages.

wasting only. This indicates that the prevalence of wasting was more prevalent in girls engaged in low physical activity. On the other hand, socioeconomic status was seen to be statistically significant with wasting and thinness, indicating that, prevalence of both wasting and thinness are found more in girls from low socioeconomic backgrounds.

Discussion

Body-composition and nutritional status assessment based on anthropometry is an important technique in epidemiological and clinical investigation (Rolland-Cachera 1999). Skinfold testing has been employed in various studies in order to quantify the amount of muscularity and adiposity (Rolland-Cachera 1993; Sen et al. 2011).

The mean values of height, weight, MUAC and UMA were higher among Tibetan adolescent girls than Sonowal Kachari girls, which had more muscle area than fat area that is found in the present study (Singh and Mondal 2014). In another study on Santal tribal children, an increase in mean UMA and UFA was reported. Girls were found to have had more muscle area than fat area, denoting more protein reserves than fat percent (Chowdhury and Ghosh 2009). In contrast, a study on Khasi adolescent girls reported that all body composition variables like UMA, UFA and AFI along with MUAC and TSF were escalated with age increase . Overall, girls had poor muscle status and better fat status (Basu et al. 2010). Female children of West Bengal reported an increase in mean UMA with increasing age. However, the mean values of UFA and AFI reported no particular trend due to fluctuating values, though the girls had more fat area than muscle area (Debnath et al. 2017). The trends from present study show that the current population of Tibetan adolescent girls in the Kangra district, Himachal Pradesh is more muscular than fat with increasing age, and have better protein reserves as compared to fat reserves.

Our findings in mean FM and FFM are similar to Karbi Anglong adolescent girls of Assam (Sharma and Mondal 2018) as they had more muscle mass than fat mass. In another study conducted among adolescents of Dibrugarh, Assam, 16.6% girls were overweight and 11.1% were obese (Saikia et al. 2018) which is less than what was observed in this study.

Additionally, our study revealed overall wasting to be 12.7% and overall thinness to be 9.8%. National data by ICMR-NNMB (2009) on tribal populations of India noted that the prevalence of overall thinness among adolescents girls was approximately 17.7%. Moreover, severe thinness was identified in 4.4% of cases and moderate thinness in 13.3% of cases based on WHO reference values (Rao et al. 2006). Compared to our study, thinness was found to be much higher among tribal populations of other Indian states.

When comparing the results of our analysis with the Sonowar Kachari adolescent girls (Singh and Mondal 2014), it was found that that 14.84% girls were in the wasting category and 22.33% were below the average category. Overall, 60% of girls fell in the average category while 0.90% and 1.94% of girls fell in above average and high muscle category respectively. This finding concurs with our results. Our results are also similar to those reported among tribal children of Assam (Singh and Mondal 2014). However, the prevalence of thin-

ness among them is two times higher than that observed in our study. Studies among Santal girls belonging to West Bengal (Chowdhury and Ghosh 2009), Darjeeling girls (Debnath et al. 2017) and Bengalee Muslim girls of Darjeeling (Sen et al. 2011) reported wasting to be 45.33%, 41.69% and 88.55% respectively, which is much higher than the results of our study. The classification of malnutrition among adolescents in Xizang (Tibet) indicated that the prevalence of wasting in Tibet has witnessed a gradual decline over the period time from 12.5% in 1995 to 2.3% in 2005 (Jian and Cheng 2014).

Using international standards (Cole et al. 2007) among tribal children and adolescents of Assam (Singh and Mondal 2014), 23.92% of overall thinness was reported. Previous studies using this cut-off values in Salboni children and adolescent girls of West Bengal (De et al. 2013), Santal children and adolescent girls of Purulia, West Bengal (Das and Bose 2011), Muslim adolescent girls of Deganga, North 24 Pargana (Khatun et al. 2017), Birhor adolescent girls of Purulia (Das et al. 2012), and in adolescent girls of North 24 Pargana (Ghosh et al. 2011), reported high prevalence of overall thinness as 48.3%, 44.6%, 51.7%, 44.4%, 64% respectively, which are again much higher than that recorded in the present study of 9.8%.

These differences maybe due to various associated factors like genotype, dietary habits, physical activity, SES and environmental conditions during childhood (Wells 2010, 2007). In the studied group, significant changes in body composition were observed. The statistically significant ($p<0.05$) relationship between physical activity with nutritional status (wasting) and PBF in the present study shows that girls doing more physical activity had better nutritional status and were more muscular. The statistically significant ($p<0.05$) relationship of socioeconomic status with wasting, thinness and PBF in our analysis supports that girls in upper and middle classes had better nutritional status and were more muscular. Another plausible explanation for this recent trend could be birthweight, catch-up growth and breastfeeding pattern of their mothers.

Conclusion

Our study identified evident cases of wasting, thinness and overweight/obese among the female participants. High PBF and wasting was found to be significantly higher in physically inactive participants. Also, our analysis sheds light on the nutritional status and body composition of Tibetan adolescent girls living in Kangra district that were hitherto unavailable. There is a need to extend such investigations among the adolescents across various regions of India. With this, researchers can ascertain ethnic and regional differences concerning nutritional status and body composition among adolescent girls and to what degree they are associated with infectious and communicable diseases.

The Authors' contribution

Concept and design was developed by SS, NS and GKK. Literature search, data acquisition, data and statistical analysis was done by SS and NS. The preparation of manuscript was carried out by SS and NS. Manuscript editing and manuscript review was done by GKK, SS, NS.

Conflict of interest

The authors declare that there is no conflict of interest.

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