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Composite Nutritional Burden Model: A proposal to evaluate anthropometric failure in adults

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ABSTRACT

Co-existence of stunting, undernutrition, overweight, obesity, and associated chronic diseases are important public health issues in developing countries. The objective of the present study was to evaluate height and BMI-based nutritional status among adults and to use a new Composite Nutritional Burden Model (CNBM) to estimate a composite index of anthropometric failure. A cross-sectional study was done among adults (1,283 men, 1,184 women) aged 20 to 59 years at Naxalbari in Darjeeling, West Bengal. Height and weight were measured, body mass index (BMI) has been calculated. Short height was estimated as height <165 cm and <150 cm in men and women respectively. BMI-based nutritional status (thinness, normal, overweight, and obesity) has been evaluated. The CNBM was used to classify individual and combined rates of short height, thinness, overweight, and obesity. Composite Index of Nutritional Burden or CINB (100% minus no failure) has been estimated. Significant sex differences have been observed with respect to age (men 41.37 years, women 37.26 years), height (men 162.21 cm, women 151.02 cm), body weight (63.14 kg, women 50.24 kg), and BMI (men 23.96 kg/m^2, women 22.0 kg/m^2). Prevalence of BMI-based thinness (men 22.9%, women 32.18%), overweight (men 14.88%, women 14.78%), and obesity (men 22.66%, women 10.14%) were remarkable in the sample. Estimated CINB was 73.99% (men 74.38%, women 73.56%). CNBM was found to be an effective measure to estimate levels of malnutrition due to short height and its coexistence with BMI-based thinness and excess weight that can be used in adults.

***Keywords*:** Short height, thinness, overweight, obesity.

INTRODUCTION

Height is an important indicator of growth and nutritional status in children and adolescents and stunting (low height-for-age) is used as an indicator of growth failure that might have a long-tern effect leading to short height in adulthood (Bogin, 1999). Social-Economic-Political-Emotional (SEPE) inequalities and insecurities are the responsible factors for stunting among children and adolescents (Bogin and Varea, 2020; Scheffler et al., 2019). Body mass index (BMI) is used to evaluate thinness, overweight and obesity with certain limitations for not being able to distinguish between body fat mass and fat free mass (Bogin and Varela-Silva, 2012). Dual burden of malnutrition or coexistence of short height or stunting and excess weight (BMI-based overweight and obesity) are reported from developing countries (Kapoor and Anand, 2002; Varela-Silva et al., 2012) that are related to nutrition and epidemiological transitions (Popkin, 2001). Dual burden of two extremes of malnutrition (undernutrition and excess weight) has been evaluated at individual (for example, short height and excess weight), household, and societal levels across generations (Varela-Silva et al., 2012).

Short height in adults is an important risk factor for chronic diseases like hypertension, diabetes, dyslipidemia, and metabolic syndrome in developing countries (Chen et al., 2017; Silva et al., 2011). Shorter leg length in adulthood and its association with health risks was reported to be associated with unfavorable environmental conditions, particularly socioeconomic and nutritional status during growth period (Bogin and Varela-Silva, 2010). Therefore, short height in adults may be used as a marker of long-term nutritional deficits since childhood that might enhance health risk in adulthood (De Lucia Rolfe et al., 2018). Co-existence of stunting and excess weight may enhance risk of morbidity and mortality (Wittenbecher et al., 2019).

Svedberg (2000) proposed "Composite Index of Anthropometric Failure" (CIAF) that estimated individual and combined rates of stunting, underweight, and wasting in children. Studies have further modified and validated the use of CIAF (Nandy et al., 2005; Nandy and Miranda, 2008). In a study among adolescent girls from West Bengal, India, a new Composite Nutritional Burden Model (CNBM) has been proposed to estimate a combined rate of undernutrition (stunting and thinness) and excess weight (Datta Banik, 2014b). Another study also proposed an extension of CIAF to evaluate nutritional status in children that included overweight (Kuiti and Bose, 2018).

However, similar model to evaluate combined rates of short height and BMI-based nutritional status in adults are not available.

In this background, the objective of the present study was to evaluate height and BMI-based nutritional status among adults and to use the CNBM (Datta Banik, 2014b) to estimate a composite index of anthropometric failure.

PARTICIPANTS AND METHODS

A cross-sectional study was undertaken during 2010-2012 at Naxalbari in Darjeeling, West Bengal. Altogether eleven villages were selected from Nakshalbari, Maniram, Hatighisa, Lower Bagdogra, and Upper Bagdogra village councils under Naxalbari block (an administrative jurisdiction). Distance of Naxalbari block from the nearest town Siliguri was approximately 25 kilometers. Ethical clearance for the research project (see Acknowledgements) was issued by the institutional committee (Datta Banik and Dash, 2013). Participants (n = 2,467) were adult men (n = 1,283) and women (n = 1,184) aged 20 to 59 years, representing Dhimal (191 men, 162 women), Limbu (487 men, 435 women), and Mech (605 men, 587 women) communities. The present study has been done taking a pooled sample from the three communities. Participants did not report any diseases prior to the study, no one had any physical handicap and women were neither menstruating nor pregnant.

Anthropometric measurements of height (cm) and weight (kg) were recorded in the morning (between 8 and 11 AM) by a trained researcher (see Acknowledgements) using a standard anthropometer and weighing scale, following protocol (Lohman et al., 1988). Short height in men (<165 cm) and women (<150 cm) has been defined based on a previous report from India (Mamidi et al., 2011). Nutritional status of the participants has been evaluated based on body mass index (BMI) cut-off values for the adults: undernutrition or thinness (<18.45 kg/m^2), normal (18.50 - 24.99 kg/m^2), overweight (≥ 25.00 Kg/m^2), and obesity (≥ 30.00 Kg/m^2) (WHO, 1995, 1998). BMI cut-off values for Asian populations showed almost similar distributions in the present study (WHO, 2004).

Table 1. Nutritional status based on Composite Nutritional Burden Model (Datta Banik, 2014b)

Group	Anthropometric indices	Stunting	Thinness	Overweight	Obesity
A	No nutritional burden	No	No	No	No
B	Stunting	Yes	No	No	No
C	Thinness	No	Yes	No	No
D	Overweight	No	No	Yes	No
E	Obesity	No	No	No	Yes
F	Stunting + thinness	Yes	Yes	No	No
G	Stunting + overweight	Yes	No	Yes	No
H	Stunting + obesity	Yes	No	No	Yes

Estimation of anthropometric failure (malnutrition) in adults was based on Composite Nutritional Burden Model that has been used for the evaluation of nutritional status in adolescents (Datta Banik, 2014b). Separate and combined prevalence (%) of stunting, thinness, overweight, and obesity have been estimated, followed by a calculation of the prevalence of Composite Index of Nutritional Burden or CINB (100% minus no failure or no nutritional burden) (Table 1). In the present study among adults, the term short height is used in place of stunting. Statistical Package for the Social Sciences (SPSS, version 15.0) was used for data analysis. Student's *t*-test was used to observe significant sex differences for height, weight, and BMI. Chi-square test was used to estimate association between the differential rates of stunting, thinness, overweight, obesity, and CINB in men and women. Statistical significance was set *a priori* at $p < 0.05$.

RESULTS

Significant sex differences have been observed with respect to age (men 41.37 years, women 37.26 years), height (men 162.21 cm, women 151.02 cm), body weight (63.14 kg, women 50.24 kg), and BMI (men 23.96 kg/m^2, women 22.0 kg/m^2) (Table 2).

Table 2. Descriptive statistics of age and anthropometric characteristics in adult men (n = 1,283) and women (n = 1,184)

Variables	Men Mean (SD)	Women Mean (SD)	t	p-value
Age (years)	41.37 (13.53)	37.26 (17.81)	6.48	<0.001
Height (cm)	162.21 (7.26)	151.02 (6.65)	39.81	<0.001
Body weight (kg)	63.14 (17.53)	50.24 (13.22)	20.50	<0.001
Body mass index (kg/m^2)	23.96 (6.40)	22.00 (5.60)	8.07	<0.001

SD: Standard deviation

Frequency of short height (men < 165 cm, women < 150 cm) was very high in the sample (men 36.92%, women 42.82%) (Table 3). In general, prevalence of BMI-based thinness (men 22.9%, women 32.18%), overweight (men 14.88%, women 14.78%), and obesity (men 22.66%, women 10.14%) were remarkable. Using CNBM, the individual rates of stunting, thinness, overweight, obesity, and combined prevalence of anthropometric failures have been estimated. Finally, an estimated CINB was 73.99% (men 74.38%, women 73.56%) (Table 3). Association of differential estimates of the percentages of short height (Chi-square = 8.97) and BMI-based nutritional status (Chi-square = 79.14) in men and women were significant ($p < 0.001$).

Table 3. Nutritional status of adult men (n = 1283) and women (n = 1184)

Parameters	Classification	Total %	Men %	Women %
Height	Short height	39.75	36.92	42.82
BMI-based nutritional status	Thinness	27.35	22.90	32.18
	Overweight	14.83	14.88	14.78
	Obesity	16.65	22.66	10.14
CNBM	No burden (A)	26.01	25.62	26.44
	Stunting (B)	15.15	13.94	16.47
	Thinness (C)	14.71	12.85	16.72
	Overweight (D)	9.85	10.83	8.78
	Obesity (E)	9.68	13.79	5.24
	Stunting + thinness (F)	12.64	10.05	15.46
	Stunting + overweight (G)	4.98	4.05	6.00
	Stunting + obesity (H)	6.97	8.88	4.90
	CINB	73.99	74.38	73.56

CNBM: Composite Nutritional Burden Model; CINB: Composite Index of Nutritional Burden

DISCUSSION

The present study has shown high prevalence of malnutrition among adults at Naxalbari, Darjeeling, a sample represented by three neighboring communities (Dhimal, Limbu, and Mech).

Situation of women was worse compared to men. Higher proportion of women had short height than men; prevalence of thinness was also much higher among women. Frequency of overweight was similar in either sex. However, higher rate of obesity has been observed in men than women. Prevalence of CINB was similar in men and women; marginally higher mean value was observed in men, A study reported secular trend of height, its regional variation across the levels of socioeconomic status in India (Mamidi et al., 2011). Overall, mean values of height in adult men and women from India were 165 cm and 152 cm respectively. The mean values of height in the present study were like that previous report.

Indigenous communities ("Schedules Tribe") in India accounts for more than 8.0% of the total population of the country (Census of India, 2011) High degree malnutrition including stunting and thinness are reported from the indigenous communities in India (Das and Bose, 2015). BMI-based thinness had been reported from adults of several communities in the eastern regional states of India, namely, Bathudi (52.70%) (Bose and Chakraborty, 2005) and Savar (38.0%) (Bose et al., 2006b) in Orissa, Oraon (53.10%) and Sarak (27.85%) in Jharkhand (Datta Banik et al., 2009a), Kora Mudi (48.0%) (Bose et al., 2006c) and Santal (31.5%) (Bose et al., 2006a) from West Bengal.

Previous studies from Naxalbari, Darjeeling also reported remarkable prevalence of BMI-based thinness among adults from Dhimal, Mech, Limbu, and Rajbanshi communities (Datta Banik and Dash, 2013; Datta Banik et al., 2007, 2009b, 2013; Datta Banik, 2014a). Rates of thinness among adults were high among Dhimal (men 27%, women 47%), Rajbanshi (men 17%, women 29%), and Mech (men 10%, women 17%) (Datta Banik et al., 2009b). High rates of thinness have been reported also from 20 to 59-year-old adult Dhimal (n = 88), Mech (n = 71), and Rajbanshi (n = 83) men (Datta Banik, 2014a). Prevalence of overweight among men (n = 242) was relatively low (Mech 20%, Rajbanshi 7%, Dhimal 2%). Another study from the region reported Mech men had relatively high low-density lipoprotein cholesterol (227.5 mg/dL) and fasting plasma glucose level was marginally high (127 mg/dL) among overweight men (Datta Banik et al., 2013). Prevalence of thinness and excess weight recorded in the present study was much higher.

None of the previous studies reported the use of composite index of malnutrition (anthropometric failure) among adults. The CIAF has been used in policy research in developing countries like India where undernutrition in children was used as an indicator to measure poor

socioeconomic status (Nandy et al., 2005; Nandy and Miranda, 2008; Svedberg, 2000). An extension of CIAF has been proposed to include prevalence of overweight and its coexistence with stunting in children (Kuiti and Bose, 2018). That addition was important in the background of increasing rates of dual burden of malnutrition or coexistence of short height and excess weight at individual, household, and societal levels in the developing countries (Kapoor and Anand, 2002; Varela-Silva et al., 2012). In that perspective, Composite Nutritional Burden Model (CNBM) was the first one that proposed a single measure to estimate composite index of anthropometric failure among adolescents (Datta Banik, 2014b). The CNBM seems to be very useful in epidemiological research, particularly in developing countries where co-existence of extreme levels of malnutrition is remarkable. This index can be useful to observe association of hypertension, diabetes mellitus, and dyslipidemia with levels anthropometric failure. The present study throws some light in the new proposal for further research in this line.

Studies proposed that chronic and toxic stress from Social-Economic-Political-Emotional (SEPE) inequalities and insecurities are the causes for malnutrition (Bogin and Varea, 2020). Another study among Indonesian boys and girls reported no relevant correlation between nutritional status (evaluated by skinfold thickness) and height-for-age. The authors raised doubts about the use of global growth standards to conclude that stunting is a *prima facia* evidence of malnutrition and chronic infection. Therefore, stunting cannot be a proxy indicator of malnutrition (Scheffler et al., 2019). In this background, the use of CIAF, CNBM, and CINB will be in a dilemma. However, these indices still offer useful estimates of malnutrition in the large-scale surveys that may help in the development of public health strategies. It may be mentioned that the concept of dual burden of malnutrition does not explain anthropometric failure at population level in a similar way that the composite index evaluates.

In conclusion, Composite Nutritional Burden Model (CNBM) was found to be an effective measure to estimate levels of malnutrition due to short height and its coexistence with BMI-based thinness and excess weight that can be used among adolescents and adults.

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Disclosure

The author declares no competing interest.

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