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Assessment of thinness based on BMI and MUAC among the adult Jaunsari – A tribal community of Uttarakhand, India

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Abstract

Background Researchers worldwide have tried to develop alternative measures to assess the nutritional status, especially among adults in developing countries. Body mass index (BMI) is a commonly used technique but sometimes difficult to obtain in large-scale surveys. Mid-upper arm circumference (MUAC) has been used as an alternative, but data are limited, especially in the Indian context.

Objectives The objective of the present study was to evaluate the BMI and MUAC of the Jaunsari tribal community of Uttarakhand and to assess whether MUAC is an acceptable proxy for BMI.

Sample and Methods A total of 303 (male 134, female 169) healthy adult Jaunsari individuals aged 18–60 years from Lakhamandal village of Dehradun district of Uttarakhand, India have been selected. Anthropometric measurements of height (cm), weight (kg), and MUAC (cm) were taken following the standard protocol. Globally accepted cut-off values for thinness were used (BMI<18.5kg/m^2 and MUAC<24.0cm). Descriptive statistics, Student's *t*-test and Chi-square test were performed. The statistically significant level was set at $p<0.05$.

Results The Jaunsari people of Lakhamandal village of Dehradun district are very thin when following the categories developed by WHO (30.4%). Females are on average thinner than males when assessed by BMI and MUAC. Overweight was found in 12.2% of the village's people. Individuals are two times more likely to be considered thin when classified by MUAC, than if classified by BMI.

Conclusions Healthy Jaunsari people are on average very thin, but there is already some evidence of overnutrition in a few cases. Thinness when assessed by MUAC is twice as prevalent, than if assessed by BMI.

Take-home message for students The Jaunsari people of Lakhamandal village of Dehradun district are very thin. Individuals with low MUAC are two times more likely to be classified as thin, than if classified by BMI.

Abbreviations

BMI Body Mass Index
FANTA Food and Nutrition Technical Assistance III Project
IIPS International Institute for Popultion Science
MUAC Mid-upper Arm Circumference
NNMB National Nutrition Monitoring Bureau
SD Standard Deviation
SPSS Statistical Package for Social Sciences
WHO World Health Organization

Introduction

For the last couple of decades, the Indian population has undergone changes in their social, economic, and cultural conditions, like other developing countries where large-scale developmental activities and urbanization influenced the lifestyle of the individuals (Das et al., 2020; Das and Bose, 2015; Kshatriya and Acharya, 2016a; Popkin et al., 2020; Ruel et al., 2017). As a consequence, changes in dietary practice, dependency on urban processed food, improved economic conditions, changes in occupational activities, etc. and more prevalence of sedentary lifestyle have caused a steady increase in conditions of overweight or obesity and lifestyle-related diseases (Dutta et al., 2019; Kshatriya and Acharya, 2019, 2016a; WHO, 2021). Additionally, undernutrition is a consistent health problem prevailing among Indian people of all ages and both sexes and specifically among the tribal people. They constitute a sizable portion (8.6%) of the total population of India (Agrawal et al., 2013; Das et al., 2020; Das and Bose, 2015; Dutta et al., 2019; Laxmaiah et al., 2007; NNMB, 2009). The presence of undernutrition with the increasing prevalence of overweight/obesity is defined as a double burden of malnutrition and poses major health challenges for not only India but for other neighbouring developing countries like Bangladesh, Nepal, Pakistan, Sri Lanka, etc. (Dutta et al., 2019; Popkin et al., 2020; Selvamani and Singh, 2018; WHO, 2017). Previous studies revealed that both undernutrition and overweight/obesity is associated with several health outcomes like diabetes, hypertension, cardiovascular disease, tuberculosis, infertility, certain types of cancers, osteoarthritis, etc. (Ezeh et al., 2017; Lönnroth et al., 2010; NNMB, 2017; Venkatrao et al., 2020). Latest National and Family Health Survey (IIPS, Mumbai, 2021) data revealed that both the prevalence of undernutrition and overweight was higher among Indian adult females (18.7% and 24%) when compared to males (16.2% and 19.7%) (IIPS, Mumbai, 2021).

In this context, it needs to be stressed that currently used definitions of undernutrition are based on critical BMI cut-off points published by the WHO (WHO, 1995). The BMI expresses a weight for height ratio. Convincing evidence that weight for height ratios can generally be used for evaluating a nutritional state is still lacking. A previous study conducted by the NNMB (2009) revealed a high prevalence of thinness among Indian tribal women (49%) compared to men (40%) that has since been interpreted as evidence of undernutrition. This study also reported a 2–3% prevalence of overweight among the Indian tribes.

Body mass index (BMI) is used as a non-invasive, and inexpensive anthropometric technique for the nutritional screening of adults, especially in developing countries (Das et al., 2020; Das and Bose, 2015; Lee and Nieman, 2003; Lohman et al., 1988; Nuttall, 2015; Sultana et al., 2015; WHO, 1995). However, researchers have identified some drawbacks and encountered problems when measuring height and weight for debilitated or immobile patients or pregnant women (Das et al., 2020; Sultana et al., 2015; Tang et al., 2020).

Even in remote areas during large-scale house-to-house nutritional surveys, carrying an anthropometer rod and a heavy weighing machine causes difficulty (Selvaraj et al., 2017; Sultana et al., 2015; Tang et al., 2020). Another particular problem with BMI is that it could not differentiate between body fat mass and muscle mass, so a person may wrongly be categorised as overweight or obese due to high BMI, but actually has a low amount of fat mass or vice versa (Flegal et al., 2009; Segal et al., 1987; Van Tonder et al., 2019; Wellens et al., 1996). In search for alternative measures for BMI, researchers identified several measurements useful for nutritional screening, preferably in remote areas of rural settings (Benítez Brito et al., 2016; Philpott et al., 2021; Selvaraj et al., 2017; Sultana et al., 2015). Mid-upper arm circumference (MUAC) is a globally acceptable measurement as a proxy for BMI in adults as it is relatively easy to use, less complicated to calculate, inexpensive, transportable and does not require skilled health workers to perform (Philpott et al., 2021; Sultana et al., 2015; Tang et al., 2020; Van Tonder et al., 2019).

Uttarakhand is a state in northern India, largely covered by ranges of the Himalayas and forests. The state is divided into four eco-cultural zones, and one of them is Jaunsar-Bawar (Majumdar, 1955). Jaunsar-Bawar region comprises two areas: the high-altitude snowy region called Bawar and the lower half called Jaunsar. These regions are covered with dense forests and rough mountains, making these places geographically isolated (Pawar et al., 2017). The main inhabitants of these places are known as Jaunsari, a tribal community mythologically claiming themselves as the descendants of the *Pandavas* of the Mahabharata (Majumdar, 1955; Mukherjee and Das, 2014). In Uttarakhand, among several tribal populations, Jaunsari ranked second with 32.5% of the state's total tribal population (Pawar et al., 2017). Traditionally, they were agriculturalists along with animal husbandry (rearing animals like sheep, goats, buffaloes, etc.). Due to a shortage of contemporary conveniences, infrastructure, quality of education and advanced health care services in such a distant place, Jaunsari communities have long struggled to maintain a proper quality of life. Many Jaunsari have low BMI. Subsequently, in search of a better earning opportunity in the wake of urbanization, their traditional way of living was also affected. Many of them were now engaged in wage work as labourers in the big farms of well-to-do cultivators (Majumdar, 1955; Mukherjee and Das, 2014). The overall prevalence of thinness among males and females in this state was 16.2% vs. 13.9%, but there is also a high prevalence of overweight/obesity (27.1% vs. 29.7%) as shown in the report of NFHS-5 (IIPS, Mumbai, 2021). Very few studies are available on the native use of ethnomedicine, communication pattern, the preservation of cultural heritage, marital practices, socio-economic and demographic aspects of the different indigenous people (Majumdar, 1955; Mukherjee and Das, 2014; Pawar et al., 2017; Singh and Ahmed, 2018; Singh, 1997; Tripathi, 2020). One recent study on parameters related to BMI of the Jaunsari people of the Dehradun district of Uttarakhand reported a very high prevalence of thinness (low BMI) (male 32% and female 35%) which was higher than the prevalence at the national level (Ravi et al., 2019). Hence, the objective of the present study was to evaluate BMI and MUAC of the Jaunsari tribal community of Uttarakhand and to assess whether MUAC is an acceptable proxy for BMI.

Sample and Methods

This cross-sectional study was conducted among the Jaunsari community living in the Lakhamandal village of the Dehradun District of Uttarakhand, India. The total study sample was 303 individuals aged 18–60 years (134 male, mean age 32.07±12.84 years, and 169 female, mean age 34.93±13.76 years). Apparently healthy individuals without any physical deformity and known history of chronic diseases were considered. During fieldwork, all the houses within the village were visited, and those who agreed to participate were included in this study. Their participation was completely voluntary. The present study was conducted following the guidelines laid down in the declaration of Helsinki (Touitou et al., 2004). The study protocol was approved by the institutional ethical committee of the Anthropological Survey of India. Before the commencement of the study, necessary permission was obtained from local administration and community leaders. Initially, the study objectives were explained to the participants, and data were collected after getting their written consent.

Anthropometric measurements of height (cm), weight (kg), and MUAC (cm) were taken following the standard protocol of Lohman et al. (1988). Height and MUAC were measured by Martin's anthropometer rod and a calibrated non-elastic tape (Gulick Anthropometric tape) to the nearest 0.1cm. Weight was recorded by a digital weighing machine (OMRON HBF-212) to the nearest 0.5kg. Technical errors in measurements were found to be within the acceptable limit (Ulijaszek and Kerr, 1999). BMI was calculated following the standard formula: BMI=Weight (kg)/Height $(m)^2$ (James et al., 1988). To assess the nutritional status in the absence of information on nutrition, and based solely on BMI, the cut-off used by the WHO for the world population was used here (WHO, 1995). For the assessment of MUAC-based nutritional status, the MUAC cut-off point (undernutrition: MUAC<24cm; proposed by the Food and Nutrition Technical Assistance III Project (FANTA), funded by USAID) was used (Tang et al., 2020).

Statistical analysis was performed using the Statistical Package for Social Sciences software (SPSS, IBM; version 26). Descriptive statistics of the mean and standard deviation (SD) of all the anthropometric variables were calculated. Sex differences in mean (±SD) values for the variables were calculated using Student's *t*-test. Chi-square tests were used to evaluate the relation between thinness and sex (male and female), separately for BMI and MUAC. A Chi-square test was used to determine the relationship between/within the categories determined by BMI (thinness<18.5kg/m^2 and overweight25.0kg/m^2) and MUAC (thinness<24cm). The statistically significant level was set at $p<0.05$.

Results

Descriptive characteristics (mean±SD) of studied variables were presented in Table 1. Mean (±SD) height, weight and MUAC were higher in males than in females. A statistically significant difference was observed for all the anthropometric variables except for BMI between males and females. Table 2 showes an overall prevalence of thinness based on a BMI of 30.4% and of overweight based on a BMI of 12.2%. Chi-square (χ^2) test did not reveal any statistically significant association between BMI-based categories and sex ($\chi^2=2.024$, $p=0.363$).

The overall prevalence of thinness based on MUAC was found to be very high (63.8%) (Table 3). Results revealed a statistically significant association between MUAC-based categories and sex in this population (χ^2=15.555, p=0.001).

The discrepancy between thinness defined by BMI and by MUAC was found to be statistically significant (p<0.001) (Table 4). Individuals are two times more likely to be considered thin when classified by MUAC than if classified by BMI.

Discussion

The present study provides information about the body proportions of the Jaunsari community living in far-flung areas of the district of Dehradun, Uttarakhand. Jaunsari people are very thin. Their thinness appears even more pronounced when assessed by MUAC (64%) than when assessed by BMI (30.4%) (χ2=57.381; p<0.001). The overall prevalence of thinness depicts a serious situation when following the categories developed by WHO (WHO, 1995) and according to current perception, suggests nutritional problems relevant for public health. Females were thinner than males (BMI 33.1% vs. 26.8%; MUAC 73.3% vs. 49.2%). A similar result was found in

Table 1 Anthropometric characteristics of the studied population

Variables	Male (n=134)	Female (n=169)	T
	Mean±SD	Mean±SD	
Height (cm)	162.53±5.646	150.86±5.328	18.922***
Weight (kg)	54.66±9.629	47.32±10.246	6.360***
MUAC (cm)	23.85±3.153	22.14±3.237	4.178***
BMI (kg/m^2)	20.72±3.068	20.74±4.067	-0.416NS

*** p <0.001; NS=non-significant

Table 2 Nutritional status of the studied population based on BMI

Categories (BMI)	Sex Categories		Sex combined (n=303)	2
	Male (n=134)	Female (n=169)		
Thinness	36 (26.8%)	56 (33.1%)	92 (30.4%)	
Normal	83 (61.9%)	91 (53.8%)	174 (57.4%)	2.024^{NS}
Overweight	15 (11.2%)	22 (13.0%)	37 (12.2%)	

NS=non-significant

Table 3 Nutritional status of the studied population based on MUAC

Categories (MUAC)	Sex Categories		Sex combined (n=303)	2
	Male (n=134)	Female (n=169)		
Thinness	66 (49.2%)	124 (73.3%)	190 (63.8%)	15.555***
Normal	68 (50.7%)	45 (26.6%)	113 (36.1%)	

*** p <0.001

the work of Pant (Pant, 2016), where 43.5% of women were thin in a survey conducted in the rural areas of Uttarakhand. Another study conducted among the Tharu community of Uttarakhand revealed an opposite trend: Males were thinner than females (male 26.4% and female 18%) (Mukherjee et al., 2015). When comparing the findings of the present study with the earlier work done in the same community by Ravi et al. (Ravi et al., 2019), the prevalence of thinness (BMI) was lower for both males (26.8% vs. 32%) and females (33.1% vs. 35%). The mean value of BMI in the present study was found to be lower than that study. In nine major tribes from three states (Gujarat, Odisha, and West Bengal), thinness was more prevalent in females (47.4%) than in males (32.1%) (Kshatriya and Acharya, 2016b). Tribal females are more susceptible to thinness. This may be due to lack of adequate food and diet, low level of literacy, marginalisation in accessing health care facilities, low social status, and poverty in comparison to their male counterpart (Agrawal et al., 2013; Bhutta et al., 2004; Kshatriya and Acharya, 2016b; NNMB, 2009).

Evidence suggested that the overweight and obesity problem gradually increases among the Indian population, and particularly in a study based on a large sample from different parts of the country revealed an overall prevalence of 40.3% obesity, where females were found more obese than males (41.9% vs. 38.75%) (Mukherjee et al., 2015; Venkatrao et al., 2020), in their study on the Tharu Population of Uttarakhand, revealed a higher prevalence of overweight among males and females compared to the present study. In a study from northeast India, Bharali et al. (2017) reported that the prevalence of overweight was around 20% among the Nyishi tribal women of Arunachal Pradesh. Tangkhul Naga women of Manipur had a considerably high prevalence of overweight (25.1%) (Mungreiphy and Kapoor, 2010). The rapid economic development in India has given rise to transition not only in economic conditions, lifestyle, dietary practices, and decrease in physical activity but also led to an increase in the prevalence of obesity (Bharali et al., 2017; Gouda and Prusty, 2014; Venkatrao et al., 2020).

The use of MUAC as a proxy for BMI, particularly in remote areas, has been shown to be beneficial for children, especially in developing countries (Chakraborty et al., 2011; Das et al., 2020; Sultana et al., 2015). But Indian studies for assessing underweight using this newly proposed cut-off by Tang et al. (2020) are very few. One such study using this cut-off from West Bengal revealed a high prevalence of thinness among adult Sabar males (54.4%) compared to the present study population (males 49.2%) (Das et al., 2020). More studies are required for a better understanding and applicability of MUAC for malnutrition screening, particularly for tribal people living in remote areas with

Table 4 Association between BMI and MUAC

Categories (BMI)	Categories (MUAC)		Total	χ^2
	Thinness	Normal		
Thinness	92 (30.4%)	0 (0.0)	92 (30.4%)	
Normal	102 (33.6%)	109 (36.0%)	211 (69.6%)	57.381***
Total	194 (64.0%)	109 (36.0%)	303 (100%)	

***$p<0.001$; Odds Ratio=2.001

limited resources and an absence of skilled manpower. Yet, the fact that thinness when defined by MUAC, was twofold more prevalent in the healthy Jaunsari population than if defined by BMI, strongly suggests a necessity to develop local Indian references for MUAC.

This study has some limitations. We measured height, weight and MUAC and thereby assessed body proportions and thinness. But the present study does not include data on nutrition. Even though globally accepted for the screening of the nutritional status, the BMI indicates a weight for height ratio, and thus, does not provide information on the nutritional state. Due to the cross-sectional design of the study, only the association between studied variables was presented. The causal relationship between the associations cannot be explored. The sample size was small and restricted to a particular geographical area, limiting the scope of the study. As the study was conducted only on a single community, selection bias should be considered. The result may not be generalised to the whole population. Despite such limitations, as the study population is homogeneous, the result may provide scope to formulate further confirmatory studies.

Conclusion

The present cross-sectional study on the Jaunsari community of Lakhamandal village of Uttarakhand depicted a noticeable state of thinness. Females were thinner than males when assessed by BMI and MUAC. Yet, while BMI revealed a moderate frequency of thinness in both sexes (30.4%), MUAC showed a significantly higher number of thin persons. Almost half of the study participants who appeared normal in BMI, were thin in MUAC. The present study suggests that Indian people need local Indian references for MUAC.

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