Assessment of body composition of Bengalee boys of Binpur, West Bengal, India, using a modified Hattori chart method

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Sri Lanka Journal of Child Health, 2016; **45**(3): 177-183

Abstract

Objective: To investigate the relationship between fat-free mass index (FFMI) and fat mass index (FMI) by applying a body composition chart (BCC) on school boys of Binpur, West Bengal, India.

Method: Data from 214 healthy school children of 10 to 17 years of age were obtained. The FFMI and FMI were plotted on the BCC, and the differences in the relationships between categories of FFMI and FMI were separately evaluated by Chi square test with body mass index (BMI) cut-off value.

Results: The means of FFM and FM were 32.3±7.92 kg and 6.58± 3.2 kg respectively. Means of FFMI and FMI were 14.0±1.78 kg/m^2 and 2.83± 1.20 kg/m^2, respectively. Both FFMI and FMI categories were highly significant with cut-off BMI. Hattori chart indicated a wide variability in PBF that can occur for a given BMI value.

Conclusions: Use of Hattori Charts incorporating BMI, PBF, FMI and FFMI are useful in studying the interrelations between these 4 variables. Both FFMI and FMI categories were highly significant when compared to cut-off BMI in measuring body composition. Modified Hattori Chart indicated a wide variability in percentage body fat (PBF) that can occur for a given BMI value.

DOI: http://dx.doi.org/10.4038/sljch.v45i3.8030

(Key words: Bengalee, adolescent, body composition, Hattori Chart)

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(Received on 14 October 2015: Accepted after revision on 20 November 2015)

The authors declare that there are no conflicts of interest

Personal funding was used for the project.

Introduction

Weight, height and skinfold measurement have become popular usable tools for assessing nutritional status, fat pattern and fat distribution at individual level or in population and epidemiological research. The body mass index (BMI) is widely used as a surrogate marker of childhood weight gain or loss and their body fatness[1,2]. The numerical definition of BMI is that it adjusts body weight for variability in body height[3]. The equation of BMI is weight/height squared. It has been reported that BMI has limitations and should be used with caution when assessing children as the change in BMI does not reflect the change in adiposity during childhood[4-6]. Like the BMI, body composition measures are useful for estimating body fatness or leanness. In humans, body composition varies depending on ethnicity, sex and age[7]. The simplest and numerical equation of body composition divides body weight into fat mass (FM) and lean body mass (LBM) or fat free mass (FFM) components. Many researchers have stated that there exists variability of FFM with height[8-11]. In 1990, Van Itallie et al. proposed the fat free mass index (FFMI) and fat mass index (FMI) by dividing FFM and FM by height squared[12].

Hattori in 1991 for the first time graphically presented body composition based on the FMI (FM/height squared) and FFMI (FFM/height squared)[13]. After a few years, in 1997, Hattori and coauthors revised this chart method and added the lines of percentage body fat (PBF) and the BMI. Thus, they presented four variables/indices (FMI, FFMI, BMI and PBF) simultaneously by this evaluated chart method[14]. It is noteworthy that, hitherto, no study from India has utilized the Hattori Chart to study the interrelationships between FMI, FFMI, BMI and PBF.

Objectives

The aim of our study was to investigate the relationship between fat-free mass index (FFMI) and fat mass index (FMI) by applying a body composition chart (BCC) on school boys of Binpur, West Bengal, India. We also attempted to study the interrelationship of FMI and FFMI with BMI and PBF.

Method

The present investigation was a cross-sectional study carried out in Andharia Raj Ballav High School, a rural high school of Andharia Grampanchayat No-3 under the Binpur-I no. block in the Jhargram subdivision of Paschim Medinipur district, in West Bengal. The sample size consisted of 214 adolescent boys aged 10-17 years. Data were collected during July 2015. Ethical approval was taken from Department of Anthropology of Vidyasagar University, before commencing the study. All anthropometric measurements were collected by one observer (SP) using standard techniques[15]. All measurements were made with the subject wearing no other clothing except underpants. Skinfolds were measured on the subject's right side. Measurements were made to the nearest 0.2 mm. using a Holtain skinfold caliper.

Four measures of body fat composition, namely PBF, FM, FFM, FMI and FFMI were studied. Percentage body fat (%BF) was calculated using the skinfold equation of Slaughter *et al* (16) for predicting body fat in children aged 8 to 18 years. The present study utilized the following equations to predict body fat by using triceps (TSKF) and subscapular (SSKF) skinfolds.

The equations are:

If (Triceps + Subscapular) > 35 mm)

Boys: % Body fat = 0.783(TSKF + SSKF) + 1.6

If (Triceps + Subscapular) < 35 mm)

Boys: % Body fat = 1.21 (TSKF + SSKF) – 0.008 (TSKF + SSKF)^2 –1.7

FM (kg) = Body weight (kg) × (PBF/100)
FFM (kg) = Body weight (kg) – FM (kg)

FMI and FFMI (FM and FFM normalised for height) was calculated according to Van Itallie et al. in 1990 (12):

FMI (kg/m^2) = FM in kg/ height in m^2

FFMI (kg/m^2) = FFM in kg/ height in m^2

All statistical analyses were performed using the MedCalc (Version 14.0)

The body composition chart (BCC) was developed to investigate the relationship between FM (FMI) and FFM (FFMI)[14,17]. This simple chart provides four kinds of information at the same time: FMI, FFMI, BMI and PBF, by which those who have a small BMI (slim) without excess fat can be distinguished from the slim who maintain a large FM. The chart is described in detail elsewhere[13,14]. Briefly, the x-axis represents FFMI and the y-axis FMI, with additional diagonal lines indicating BMI and PBF. The categorisation relationship between FFMI and FMI with BMI cut-off values (18) was investigated using X^2 analysis.

Results

Table 1 presents the mean value and standard deviation of age, height, weight, PBF, FM, FFM, BMI, FMI and FFMI among the subjects. The means of FFM and FM were 32.30 kg and 6.58 kg respectively. The mean and standard deviation of FFMI and FMI were 14.0±1.78 kg/m^2 and 2.83± 1.20 kg/m^2, respectively.

Table 1: *Descriptive statistics of the subjects (n=214)*

Descriptive statistics	Age in years	Height (cm)	Weight (kg)	BMI (kg/m^2)	PBF (kg)	FM (kg)	FFM (kg)	FMI (kg/m^2)	FFMI (kg/m^2)
Mean	13.4	150.9	38.9	16.8	16.5	06.6	32.3	02.8	14.0
Std. error of mean	0.14	0.89	0.69	0.16	0.36	0.22	0.54	0.08	0.12
Std. deviation	02.1	13.0	10.1	02.5	05.3	03.2	7.92	01.2	01.8
Minimum	10.0	122.5	23.0	13.0	07.1	02.2	19.5	0.97	10.9
Maximum	17	186.5	70.0	25.7	31.2	16.6	60.2	6.8	21.3

Figure 1 is a BCC displaying the relationship between the two components FMI and FFMI of body composition. Based on the scatter plot (based on mean ± std. deviation), we could classify FFMI into three distinct categories: slender, intermediate and solid. Similarly, FMI was sub-divided into three categories, namely, lean, intermediate and adipose.

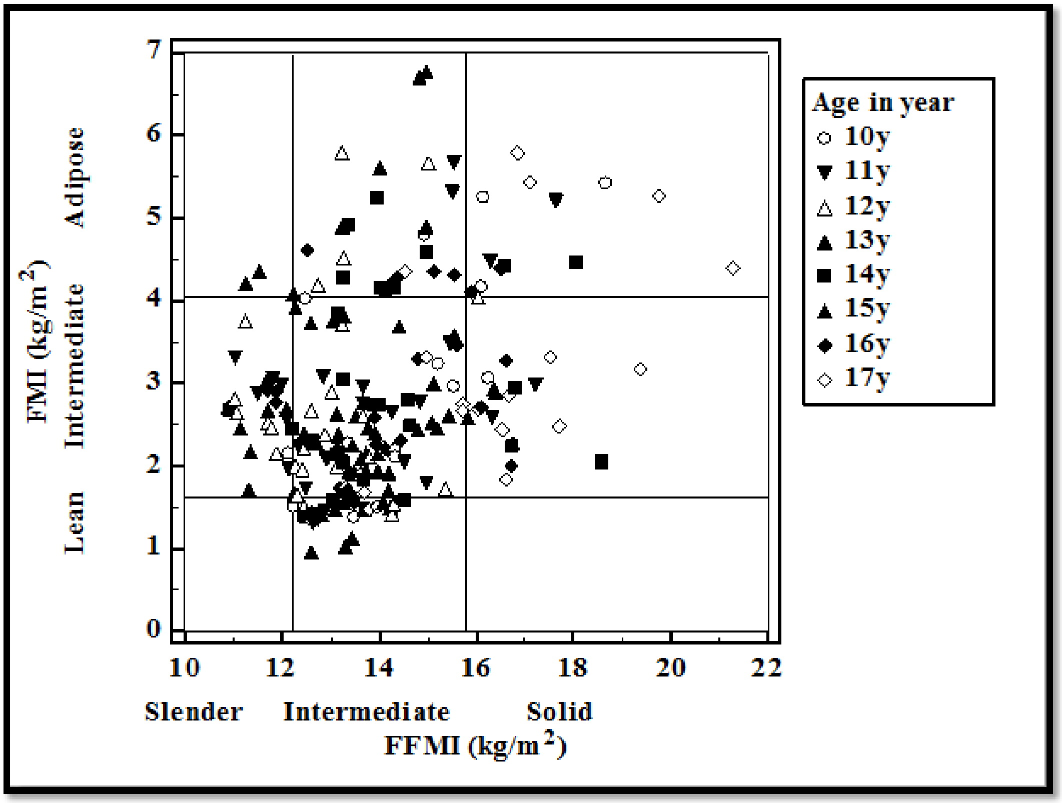

Figure 1: ***Categorisation of levels of FFM and FM based on FFMI and FMI***

Table 2 shows the appropriate cut-off points for these categories. The groups below the mean – SD (FFMI; 12.22 kg/m^2 and FMI; 1.63 kg/m^2), between means ± SDs and larger than mean + SD (FFMI; 15.78 kg/m^2 and FMI; 4.03 kg/m^2) were named slender, intermediate and solid for FFMI, and lean, intermediate and adipose for FMI. In Figure 1, those subjects who are located in upper right part have a little bit amounts of fat and FFMI (adipose-solid). Fourteen subjects of sample fit in to this category. The lower right part refers to a lean-solid physical type. In our observable sample, no one belonged in this category. Upper left and lower left sections were termed as the adipo-slender and lean-slender parts. Only two subjects belonged to adipo-slender part but none in lean-slender part.

Table 2: Categorisation of the subjects based on FMI and FFMI

Categorisation of level of FFM based on FFMI			
Somatotype	Slender	Intermediate	Solid
Measurement	<12.22	12.22-15.78	>15.78
Categorisation of level of FM based on FMI			
Somatotype	Lean	Intermediate	Adipose
Measurement	<1.63	1.63-4.03	>4.03

After categorization of FFMI and FMI, we calculated Chi-square test between cut-off BMI and categorisation level of FFMI and FMI, respectively. As can be seen from Table 3, both FFMI and FMI categories were highly significant (x^2; 75.55, p<0.0001 and x^2; 65.46, p<0.0001) with cut-off BMI.

Table 3: ***Chi-squared test on cut-off BMI with categorisation level of FMI and FFMI***

	Cut-off BMI			**Total**	**Chi-square**
Categorisation level of FMI	**Thinness**	**Normal**	**Overweight**		
Lean	23	08	0	31 (14.5%)	**X^2= 75.55, df=4 p <0.0001**
Intermediate	66	72	02	140 (65.4%)	
Adipose	01	28	14	43 (20.1%)	
Total	90 (42.1%	108 (50.5%)	16 (7.5%)	214	
	Cut-off BMI			**Total**	
Categorisation level of FMI	**Thinness**	**Normal**	**Overweight**		
Slender	23	03	0	26 (12.1%)	**X^2=65.46, df=4, p <0.0001**
Intermediate	67	80	06	153 (71.5%)	
Solid	0	25	10	35 (16.4%)	
	90 (42.1%)	108 (50.5%)	16 (7.5%)	214	

Figure 2 shows the four body composition parameters for the 214 school boys aged 10 to 17 years. The chart indicates the wide variability in PBF that can occur for a given BMI value. In the BCC, the standard deviation of FFMI was 1.62 kg/m^2, and of FMI it was 1.25 kg/m^2, indicating that after adjusting for length, between-subject variability in FFMI is two thirds that in FMI. The two subjects (marked in the graph) belong to BMI 20 kg/m^2, but values for PBF were high. Again, another two subjects (marked in the same BCC graph) belonging to the same below 24kg/m2 BMI category but had different PBF (20 PBF kg and 15 PBF kg).

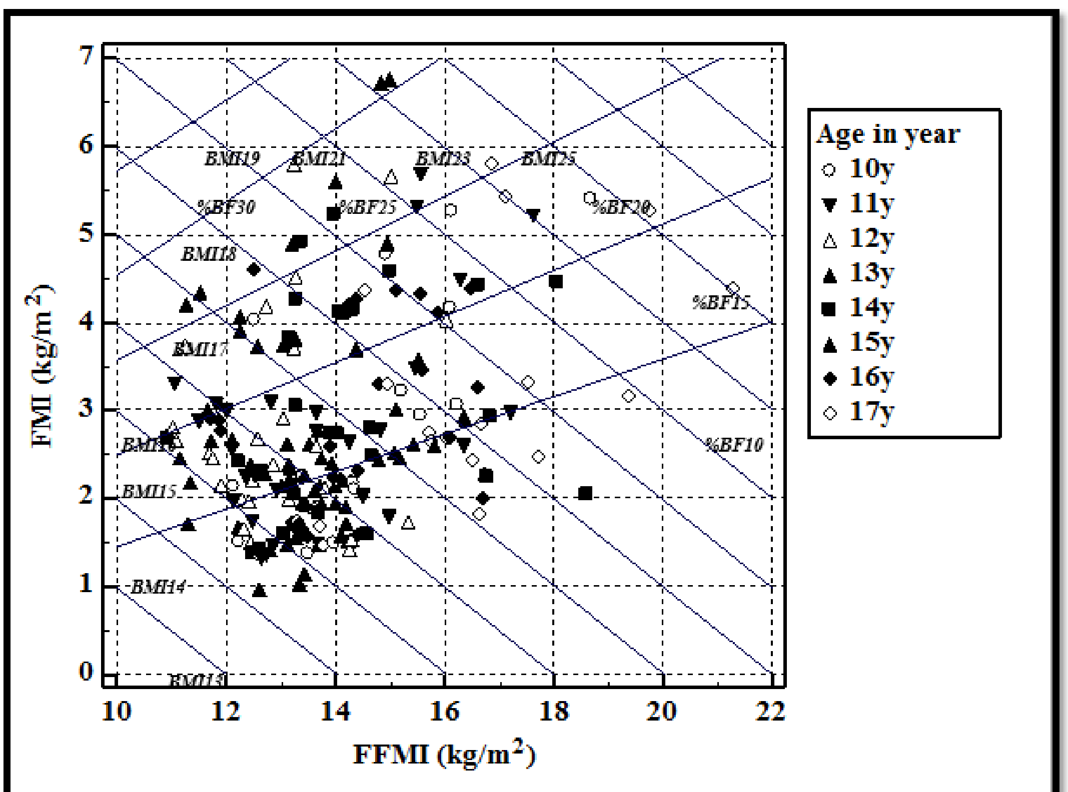

Figure 2: ***The body composition chart of the children***

Discussion

Our study revealed the inadequacy of using only BMI to correctly determine the body composition status in children. This has been earlier reported[4-6] and for the correct estimation of body composition both FMI and FFMI are needed as has been shown by the Hattori Charts. The importance of body composition measurement in studying nutritional status has increasingly been documented recently, mainly in the paediatric age group[19]. Estimating body composition in children is not only to detect excessive fatness but also concerns the related variables of FFM, FFMI and FMI. The BMI value can result from various combinations of FMI and FFMI, and the range of variability in the levels of both FM and FFM is wide in growing children[20,21].

The uniqueness of our study is that, to the best of our knowledge, this is the first investigation from India to study simultaneously the relationship between PBF, BMI, FMI and FFMI using Hattori Charts. These charts graphically present the status in body composition of Indian school boys aged 10-17 years in our study. Although changes with age cannot be accurately determined from our cross-sectional study due to lack of longitudinal data as well as the small sample size, the current study clearly indicates that the pattern of body composition in Indian adolescents are somewhat different from Caucasian, Japanese and Chinese samples at the same age period.

Body composition has been extensively reported in various population groups[22,23] which have indicated ethnic differences. White Caucasians have a high BMI value but low FM compared to Asians[24]. In another study, Indian children had 4.3% more %FM while Pacific Island children averaged 1.7% less %FM[25]. Taking FMI and FFMI together, our results revealed that the difference in body composition between school boys of Binpur and their Caucasian and Japanese counterparts largely lies in the higher fat mass component found in the school boy subjects. Compared with Sri Lankan children[26] the Binpur school children had high FFMI but low FMI. Such ethnicity dependent differences may be attributed to a number of factors, including genetic and many other obesogenic environmental factors[27].

The BMI assesses the entire body mass of an individual rather than a component, FM or FFM, of the body composition. Therefore individuals with same BMI could have different amounts of FM and FFM. The relationship between BMI and fatness among individuals has not been extensively studied in India. Considering India is a land of vast ethnic heterogeneity, future studies should investigate the interrelationships between BMI, PBF, FMI and FFMI using Hattori Charts. Such studies would generate valuable information not only regarding ethnic differences, but would also provide a useful database. These results could be utilized to compare with other ethnic populations worldwide. More importantly, varied age groups should be considered since it is well known that the relationship between BMI and body composition varies with age. Gaining deeper insight into the interrelationship between these four variables is of paramount importance in the light of increasing prevalence of adolescent overweight and obesity associated with many metabolic derangements.

Conclusions

- The use of Hattori Charts incorporating BMI, PBF, FMI and FFMI are useful in studying the interrelations between these four variables.
- Both FFMI and FMI categories were highly significant when compared to cut-off BMI in measuring body composition.
- Modified Hattori Chart indicated a wide variability in PBF that can occur for a given BMI value.

Acknowledgements

Department of Anthropology, Vidyasagar University, is acknowledged for support extended for the present research. We acknowledge the help and cooperation of the Head Master, Anup Kumar Ghosh and school students of Andharia Raj Ballav High School.

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