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Original Article

FUTREX 5000-A OVER-ESTIMATES BODY FAT IN YOUNG INDIANS OF DIFFERENT BODY MASS INDEX

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There is a need for the development of databases and standards of body composition in humans based on actual measurements, particularly the body fat rather than depending on some surrogate measures. This is because, the validity of body mass index as an indicator of body fat in cardiovascular risks and other conditions is recently challenged. Therefore, the present study was designed in an attempt to create a data base for the young Indian subjects. The body composition was assessed in 216 young male and female college students, aged between 18 and 22 years, using Futrex 5000-A, an electronic, computerized body composition and fitness analyzer. The subjects were divided into normal, underweight and overweight subjects based on their body mass index. The results obtained showed that the body fat estimated (13% to 25% in males and 26% to 35% in females) was slightly higher in all groups as compared to 11-16% (males) and 20-26% (females) of some previous reports using other methods from India. Fat distribution was higher in the thigh region than in the abdomen or gluteal areas. A little over 4% of the male and 10% of the female subjects were overweight while 21% of the male and 25% of the females were undernourished despite the students were from well-to-do families. Lean body mass varied inversely with body fat ranging from 75% to 87% in different BMI groups. Total body water was well within the normal limits.

Key words: Body composition, Body Fat, Lean Body Mass, Total Body Water Near Infrared-light Interactance (NIRI)

Body composition studies involve estimating the size of fat, protein (lean body mass or fat free mass) and water component that contributes to the human body weight. Body composition is relatively stable in healthy conditions. However, several factors such as the cumulative effects of food, physical activity and other personal habits are reflected in body weight changes. Body composition estimations have gained much importance, because, body fat and the pattern of its distribution are good predictors of health risks and imbalance in energy metabolism (WHO Tech Rep Series., 1995). This fact is evident from many metabolic, nutritional, energy balance and clinical studies (Fogelholm et al., 1996; Shetty, 1993).

It is important to establish a reference data for different populations to enable comparison of data on body composition from other studies (Grande and Keys, 1980). Although, there are a few reports (Avadhany

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and Shetty, 1986; Banerjee and Sen, 1958; Gupta and Shetty, 1991; Sen and Banerjee, 1958; Shetty, 1984), systematic studies on body composition are rare. Most of these studies have estimated body composition at two compartment levels namely, Body Fat (BF) and Lean Body Mass (LBM). Furthermore, Near Infrared-light Interactance (NIRI) principle is fairly a new method. Few researchers have used this (NIRI) principle and have published their results (Brooke-Wavell et al., 1995; Hortobagyi et al., 1992; Mc Lean and Skinner, 1992; Wilmore et al., 1994). And, particularly no reports are available for the Indian population. This technique has the advantage to assess body composition at a three-compartment level, namely, BF, LBM and Total Body Water (TBW) and also the distribution of fat in different regions of the body. Abnormal distribution of body fat in certain regions of the body is also quite relevant to health risks. Early detection of abnormal reserves of fat and its distribution may help one to re-adjust his/her body weight to desirable levels. Therefore, this study on a large sample of young male and female subjects was undertaken with the objective of assessing the body composition and distribution of body fat in selected regions of the body.

Materials and Methods

The subjects recruited for the study were briefed about the project. Prior consent was obtained before they were enrolled. Ethical committee of the institution for research had approved the study. Two male and two female trained personnel took the measurements required for this study from the male and female subjects respectively.

Two hundred and sixteen young, healthy medical students (male-116; female-100), aged between 18 and 22 years were recruited for this study. They were apparently normal and did not suffer from any illness or health problems such as diabetes or hypertension in the recent past or with any physical disabilities. Data on body weight and height and other measurements for body composition from each participant were collected. Body Mass Index (BMI) (kg/m^2) was derived from such measurements. Waist circumference was taken at the point between umbilicus and xiphoid process. Hip circumference taken at the maximum circumference around the buttocks and pubic symphysis. Average of two values of measurements at each point was taken to calculate Waist-hip ratio (WHR). Fat distribution was also assessed at abdomen, gluteal and thigh regions.

Based on the BMI, subjects from both sexes were classified separately into different groups in accordance with the recommendations of a recent WHO technical report in 1995. However, there were only few subjects in extreme underweight and overweight groups. Therefore, we considered having only three groups, namely, the underweight (UW), Normal (N) and overweight (OW) for the purpose of the present study.

Body composition assessment using Futrex 5000-A:

Futrex 5000-A, an electronic body composition and fitness analyzer (Futrex Inc, Gaithersburg, MD 20879, USA) was used for BF, LBM and TBW assessment. The equipment was calibrated to hydrostatic procedures to provide accurate body fat readings.

Futrex 5000-A which is designed on Near Infrared-light Interactance (NIRI) works on the principles of both the reflectance and transmittance principle. It detects interactive light waves and provide body composition readings directly. When light is passed through the fat, it will cause certain wavelengths to be absorbed by the fat and certain wavelengths to be transmitted. The optical measurements were made at NIRI wavelengths of 940-950 nm, which provide a direct measure of TBF and TBW. Lean body mass was calculated as the difference between body weight and body fat. Age, sex, height, body frame, physical activity rating (determined as described in the manual) of each subject was fed into the machine. The light wand (an important component of the equipment) was placed on the right biceps at midpoint between anterior cubital fossa and acromion for measuring fat content. The other part of the procedure is simple to perform and is explained in the user manual. Distribution of fat was also assessed in the thigh, abdomen and gluteal regions by placing the light wand in respective areas. Results were obtained through a printout.

BF, LBM and TBW are presented both in percent (in Table 2) and absolute values (in the text). Results were compared in each sex across groups and between similar groups of male and female subjects for statistically significant differences. All values given are mean ± SEM. Data obtained was analyzed by one-way ANOVA or unpaired t test wherever appropriate for comparison of results. Values were considered statistically significant when $P < 0.05$.

Table 1. Anthropometric data in three subgroups of male and female subjects with different BMI

Variable	Male UW BMI <18.49 (26)	Male N (18.5-25) (85)	Male OW >25 (5)	Female UW <18.49 (25)	Female N (18.5-25) (65)	Female OW >25 (10)
Age (Yrs)	18.62 ± 0.80	18.82 ± 0.80	19.00 ± 1.00	18.52 ±0.71	18.77 ± 0.79	18.70 ± 0.68
Body weight (Kg)	53.46 ± 6.26 *	64.89 ± 6.52*	77.20± 5.72*	45.22 ± 3.79 *#	53.86 ±6.19 * #	66.85 ± 5.96 * #
Height (cm)	176.85 ± 9.87	176.01 ± 6.72	171.80 ± 8.08	161.00 ± 5.62#	159.9 ± 6.81 #	158.8 ± 4.85 #
BMI (kg/m^2)	17.08 ± 0.99*	20.99 ± 1.71*	26.16 ± 0.81*	17.26 ± 0.94 *	20.99 ± 1.73 *	26.48 ± 1.76 *
Waist–hip ratio	0.80 ± 0.14	0.84 ± 0.12	0.88 ± 0.02 *	0.73 ± 0.05 #	0.76 ± 0.08	0.78 ± 0.04

Values are Mean ± SEM; Figures in parenthesis denote number of subjects in each group; UW = Under weight; N = Normal; OW= Over weight; *: P<0.05 across groups; #: P<0.05 across sex

Results

The subjects in different groups from both sexes were age matched. BMI was naturally different across groups in each sex but was comparable between corresponding subgroups of males and females. WHR was within the normal limits for each sex group (0.85 to 1.0), although the OW males (0.88) showed a significant difference (Table 1). A small percent (males 5; females 10) of the 216 subjects were overweight with a BMI of >25. About 25% of the subjects were undernourished (males 26/116; females 25/100) despite the fact that the subjects came from well-to-do families (BMI <18.49). The remaining subjects (males 73%; females 65%) had a BMI ranging from 18.5 to 25 kg/m^2 who were considered as normal or control group.

Body fat expressed either in kg or percent values was significantly different among the three groups in male subjects. The UW subjects had the lowest body fat of 6.8 kg amounting to about 13% as part of their body weight whereas the OW had 19.3 kg (25%). The normal group had 12.7 kg that formed 19% of the body weight. LBM varied inversely with body fat percent values i.e. higher the body fat lesser was the LBM. LBM constituted 46-58 kg (75% - 87%) of body weight (Table 2).

The female subjects also showed a significant difference in total body fat content between UW, N and OW. The OW group had 44 kg of body fat (35% of body weight), a significantly higher amount than the normal subjects who had 37 kg (30%), while the UN had only 24 kg (26%). LBM was less in UW subjects contributing to 33 kg (73%) while OW students showed a higher value of 43 kg (65%) as compared to 37 kg (69%) in the controls (Table 2).

Regarding the regional distribution of body fat, it was observed to be more in the thigh region than in the abdominal or gluteal regions in both male and female subjects. However, the values were higher in females depicting the characteristic sexual dimorphism. Other details are provided in Table 2.

TBW was different not only across groups in each sex but was also different between similar groups of male and female subjects. TBW ranged from 50 - 56% in females while it was 56-64% in the case of males, the values being low in OW and high in UW groups (Table 2).

Discussion

It is rather remarkable that there is little epidemiological data on body fat content and no normative standards that can be used as clinical or surveillance tools. We hope that the current study and the one that follows this from our group (manuscript in preparation) involving over 1000 subjects of different age groups will contribute as a standard reference for the Indian subjects. In the present study, Futrex 5000-A was employed for the evaluation of body composition, though it has been reported earlier by some authors to perform less well or no better than skin-fold thickness method (Brooke-Wavell et al., 1995; Hortobagyi et al., 1992; Mc Lean and Skinner, 1992) since

Table 2. Body composition (BC) in % and regional body fat (RBF) distribution of male and female subjects of different groups.

	Male			Female		
Group	**UW**	**N**	**OW**	**UW**	**N**	**OW**
BMI	**<18.49**	**18.5-25**	**>25**	**<18.49**	**18.5-25**	**>25**
Variable	**(26)**	**(85)**	**(5)**	**(25)**	**(65)**	**(10)**
BC (%):						
TBF	12.85 ± 4.25*	19.01± 4.24 *	25.18 ± 2.77 *	25.95 ± 2.53 *#	30.56 ±2.31*#	34.75 ± 2.97 *#
LBM	87.15 ± 4.25*	79.57 ± 9.68 *	74.82 ± 2.77 *	73.25 ± 4.80 *#	69.44 ±2.31*#	65.25 ± 2.97 *#
TBW	63.95 ± 2.89*	60.16 ± 2.54 *	56.30 ± 1.53 *	56.13 ± 1.51 *#	52.72 ± 2.93 *#	50.08 ± 1.88 *#
RBF:						
Abdomen	12.11± 3.02	13.60 ± 3.03	12.06 ± 2.82	17.04 ± 2.39 #	17.51 ± 2.41 #	17.61 ± 2.13 #
Thigh	14.91± 2.63**	16.34 ± 3.02**	15.08 ± 3.17**	20.19 ± 2.13**#	19.99 ± 2.04**#	20.03 ±1.46**#
Gluteal	11.95 ± 2.24	12.56 ± 2.92 *	12.06 ± 2.67	16.77 ± 2.51 #	16.93 ± 2.46 #	17.64 ± 1.71 #

Values are Mean ± SEM; BC: Body composition; RBF: Regional body fat; TBF: Total body fat; LBM: Lean body mass; TBW: Total body water; UW = Under weight; N = Normal; OW = Over weight; Figures in parenthesis denote number of subjects in each group; *: P< 0.05 across groups #: P< 0.05 across sex, * *: P<0.001 between regions results obtained from Futrex 5000 A was considered to be reliable by another group (Douphrate et al., 1994). Therefore, we undertook this study since the technique has several advantages such as rapidity, easy operation, acceptability to subjects, non-invasive and the ability to provide a print out of data. Furthermore, the subjects do not need to disrobe and the body composition measurements can be made in any body state i.e. fasting or fed state, before and after exercise etc.

It was interesting to note that among the female subjects 25% were underweight while 10% were overweight as compared to 22% underweight and 4% overweight male subjects on the basis of BMI. Muralidhara (1999) has reported a similar trend in his study where 17% of his female subjects and 9% of the males were overweight which was higher than the present study but less as compared to a another report by Gopalan (1998), who has demonstrated that one-third of the subjects of his study, were overweight or obese.

The suggested high normal limit of TBF for young males is 15% and for females is 25% of their body weight (McCardle et al., 1991). Some authors have recommended that a range of 10-20% and 20-30% of body fat be adopted as normal for males and females respectively (Bray, 1993; Pierson et al., 1997; Singh et al., 1999). Several other studies have reported a value of 11-16% TBF for males and 20-26% for females (Avadhany and Shetty, 1986; Banerjee and Sen, 1958; Borgonha et al., 1997; Borgonha et al., 1997a; Gupta and Shetty, 1991; Kurian et al., 1998; Kurpad et al., 1999; Muralidhara, 1999; Sen and Banerjee, 1958; Shetty, 1984). As compared to these studies, evaluation of body fat in the current study by using Futrex 5000-A has yielded higher TBF in both males (19%) and females (30%). This is almost similar to another report by the same authors (Muralidhara and Ramesh Bhat, 1998). A recent study by Muralidhara (1999) reports TBF of 12.5% in normal young males and 23% in females as assessed by anthropometric measurements. These values agree well with the recommended values for TBF for Indians from other studies. Singh et al., (1999) have classified male subjects with less than 10% fat as ‘under fat’ persons. In the present study, the UW male subjects had 13% fat and UW females had 26% fat that appears to be an over-estimation even for these groups as compared to 7-11% reported in other studies cited earlier. Probably, less physical activity due to academic workload and stress induced over-eating habits may have contributed to a slight excess of fat in these subjects. Furthermore, Kurpad et al. (1999) have recently reported that their mild undernourished subjects had 15% TBF as estimated by a three compartment method as opposed to 12% by hydro-densitometry or skin-fold methods. This suggests that mild under-nutrition may not be associated with striking changes in body composition and the subjects were merely constitutionally smaller than the control group. Therefore, caution has to be exercised at times when BMI is used to gauge the nutritional status or body fat content of an individual.

A range of 80-95% of body weight as LBM is accepted as normal for young humans. The LBM may be considered to be present within the normal limits in the control subjects of the present study taking into account the maximal range of body fat for males as 20% and for females as 30% of body weight. However, percentage values of LBM were less as body fat accumulation was in greater proportion with increasing body weight. As already mentioned, food, personal habits, living conditions, physical activity levels might have contributed to small variations in LBM.

Measurement of TBW is important in body composition studies as it permits calculation of LBM or fat free mass (FFM). FFM contains all the water and is hydrated to the extent of 71-72%. TBW is measured by the tracer dilution technique which is an ideal method, but cannot be applied to population studies. In that way, Futrex 5000-A is quite useful and could be applied in studies involving large samples or where suitable facilities are not available.

The normal range of TBW is 45-70% of body weight. An average of 60% for males and 50% for females is accepted as normal. The results of this study agree well with some previous studies from India who have reported 59-61% TBW for men (Avadhany and Shetty, 1986; Borgonha et al., 1997; Borgonha et al., 1997a). This fraction of body composition tends to be on the higher side in leaner than in OW subjects, because, the adipose tissue will have less water content. Based on a similar principle, females had lesser body water content than the males in each group. However, considering the variation from method to method and from population to population, the results on TBW seem to be within the acceptable range.

WHR is another often used index to relate body fat distribution to the type of obesity and its relevance to cardiovascular diseases. There are enhanced health risks at higher levels of BMI and increased WHR. A cut-off value of 0.95 and 0.80 for WHR is suggested for men and women respectively (Lean et al., 1995), above which health risks increases appreciably. In such cases, body weight reductions would become essential. In the present study, although the OW male showed a significant difference, it was well within the normal limits in both males and females. It appears that WHR would be a more important clue for the type of obesity, only at later stages of life than in young age groups. This may be, because accumulation and redistribution of fat would occur only then due to many metabolic and other influences.

In summary, Futrex 5000-A, though little expensive, it is simple to use in the laboratory, clinics and community health studies as it is a non-invasive tool for measuring total body fat and water. The body fat content values obtained using Futrex 5000-A was slightly higher in this study, but it was within the limits of normal range quoted in the literature. We have reported such results as compared with anthropometric method in our previous study (Muralidhara and Ramesh Bhat, 1998). The higher values may be due to differences in the density of fat and fat free tissues and the hydration factors in our subjects; despite the Futrex 5000 A is calibrated to hydrostatic procedures. Since, NIRI based equipments are available for the last 10-15 years, and very few studies are reported one should be aware and cautious of the inherent variations in the body composition and its measurements from method to method and population to population in interpreting the data.

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