

BODY FAT AND LEAN BODY MASS ASSESSMENT IN HUMAN SUBJECTS - A COMPARISON OF TWO DIFFERENT TECHNIQUES

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Abstract : Body fat and lean body mass was assessed in young college students by two different techniques involving NIR method and body circumference measurements. NIR technique significantly over-estimated the body fat as compared to the results obtained by the other method. The difference between the methods was 23-30% high for fat and the variation was 5-9% low for lean body mass for the whole group. Results obtained by the body girth size measurements agreed well with fat and lean body mass values from other studies on Indian subjects which had employed different methods.

Key words : body composition
lean body mass

body fat body circumference
near infra-red reflectance

INTRODUCTION

Evaluation of body composition in humans is of great value in metabolic, nutritional and energy balance studies (1). It is also important to establish reference data on body composition in different ethnic groups and in different age groups of both sexes so that it would enable comparison of inter-laboratory data on studies of similar nature (2). The earliest attempt to record body composition in humans using the Archimedes principle was made during 1940s by Dr. A. R. Behnke, a navy physician while recruiting men for deep sea diving (3). Though, the underwater weighing (densitometry) method is identified as the 'Gold Standard' technique, many newer methods from the very simpler to sophisticated have been developed for the

estimation of body composition in humans (4). Lukaski has reviewed the merits and demerits of these methods (5). Despite certain limitations in each of these methods, it has been mentioned that body circumference (girth) measurements and Near Infra-red light Reflectance (NIR) methods for body composition estimations in humans have gained wide-spread use because of their low cost, quick procedure, easy operation, acceptability by the subjects, reliability and reproducibility. Being non-invasive procedures, they also have wide range of applications (4, 6).

Body fat (BF) and Lean Body Mass (LBM) which are the main structural components of the body was assessed in young adults in this study using the two methods mentioned above, namely, NIR and

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body girth measurements, and the results are discussed.

METHODS

One hundred and sixteen entry level medical college students of both sexes of the Manipal Academy of Higher Education Unit at Mangalore, aged between 18–22 years were recruited for the study. Prior consent was obtained from each subject for participation in the programme and were briefed about the procedure to achieve full co-operation. Data on physical characteristics such as the body mass (weight), stature (height), body mass index (BMI), waist-hip ratio (WHR) was collected along with the other measurements for body composition from each participant. All measurements were taken between 11.00 and 12.00 hr or 16.00 and 17.00 hr.

Body composition assessment by NIR technique using Futurex 5000-A

Future 5000-A, an electronic body composition and fitness analyser (Futurex Inc, Galthtersberg, MD 20879, USA) was used for total body fat, LBM, body water and physical fitness assessment. However, the data obtained on body water and physical fitness is not presented here since we could not have the same parameters from the other method for comparison of results.

Designed on the Near Infra-red light Reflectance principle, Futurex 5000-A, a simple computerised, commercial equipment works on the features of both reflectance and transmittance which can be summarised as follows. When light is passed through fat it will cause certain wave lengths to be absorbed by the material and certain wave

lengths to transmitted. The optical measurements were made at NIR wave lengths approximately 940 nm to 950 nm that provide a direct measure of the fat content. Futurex 5000-A has been carefully calibrated generally to acceptable hydrostatic procedures to provide body fat readings.

Age, sex, height, body frame, weight, physical activity ratings (determined by frequency, intensity and the time and duration of activity - self reported by the students) of each subject was fed into the computerised machine. The light wand (important component of the equipment) was placed on the right biceps at the mid point between the anterior cubital fossa and acromion for measuring fat content. The other part of the procedure was faithfully carried out by pressing the keys on the instrument as explained in the users' manual. The data on body fat and LBM was obtained through a print out.

Body fat and lean body mass assessment by body circumference measurements

Using a soft plastic measuring tape, measurements of body circumference (girth size) at Right Upper Arm, Abdomen and Right Forearm for male subjects and at Abdomen, Right thigh and Right Forearm for females were taken. Average of duplicate measurement values were used for calculating total body fat and LBM. Fat content values were derived from these girth measurements using age, sex and gender specific equations and conversion constants from the tables. LBM was calculated as the difference between body mass and fat mass. Further details of the procedure are available elsewhere (4). Results of body fat

and LBM are expressed both in kg and percent units.

RESULTS

Statistics

Data obtained from the two methods was analysed by Students 't' test for comparison. Values were considered statistically significant when the $P < 0.05$.

Male subjects weighed significantly more and by stature (height) they were taller than their female counterpart. However, age and body mass index was comparable between the two groups. Waist-hip ratio was within normal limits for the respective category of males and females (Table I).

TABLE I : Physical characteristics of the subjects.
(Values are mean \pm SEM)

Sex	Age (yrs)	Body weight (kg)	Height (cm)	BMI (kg/m ²)	WHR
Male (n=61)	18.67 \pm 0.12	62.98 \pm 1.02	173.50 \pm 0.88	20.10 \pm 0.34	0.82 \pm 0.01
Female (n=55)	18.64 \pm 0.12	51.46 \pm 1.05*	157.20 \pm 0.69*	20.61 \pm 0.38	0.74 \pm 0.01*

* $P < 0.001$; n=number of subjects.

TABLE II : Body fat and lean body mass of male subjects as assessed by Near infra-red reflectance (NIR) and body circumference (BC) measurement techniques.
(Values are mean \pm SEM)

Method	Body fat		Lean body mass	
	kg	%	kg	%
NIR	11.70 \pm 0.51	18.06 \pm 0.62	52.22 \pm 0.81	81.94 \pm 0.62
BC	8.11 \pm 0.47**	12.43 \pm 0.57**	54.64 \pm 0.62*	87.77 \pm 0.58**
Bias				
Kg	3.45 \pm 0.37	5.23 \pm 0.54	-2.27 \pm 0.37	-5.62 \pm 0.62
%	31.0	31.0	7.0	5.0

* $P < 0.01$; ** $P < 0.001$; n=61

TABLE III : Body fat lean body mass of female subjects as assessed by Near infra-red reflectance (NIR) and body circumference (BC) measurements techniques.
(Values are mean \pm SEM)

Method	Body fat		Lean body mass	
	kg	%	kg	%
NIR	14.99 \pm 0.46	28.74 \pm 0.44	36.61 \pm 0.62	71.26 \pm 0.44
BC	11.52 \pm 0.57*	22.05 \pm 0.74*	39.50 \pm 0.57*	77.95 \pm 0.74*
Bias				
Kg	3.47 \pm 0.37	6.69 \pm 0.66	-2.81 \pm 0.35	-6.69 \pm 0.66
%	23.0	23.0	9.0	7.0

* $P < 0.001$; n=55

Body fat content (expressed as kg or %) in either sex was significantly higher ($P < 0.001$) as measured by Futurex 5000-A than by body girth measurements (Table II, III). LBM showed just the reverse trend. Body fat as assessed by girth measurements was well within the normal limit of 15% for males and 25% for females (4). On the other hand, fat content obtained by Futurex 5000-A exceeded the normal limits. A difference of approximately 23-30% in fat content was noted between the methods while LBM showed a variation of 5-9%. Other details of the results are given separately in Tables I, II and III.

DISCUSSION

Several techniques have been designed for the assessment of body composition in humans. However, there is no single method available that meet the stringent criteria set for an ideal method (7). Some degree of error in accuracy and precision is inherent in each of the method (6). The 'Gold Standard' technique of underwater weighing also has an error of 3-4% and 2-3% in accuracy and precision respectively (5). The difference in body fat of the subjects estimated by two different methods employed in this study was about 23-30% while the difference in LBM was 5-9%. This is important to note as it was claimed that there was a good correlation of results obtained by NIR method with that of the other method employed in several other studies (6). However, our study using the NIR method showed a variation of 17-20% in fat and LBM values as compared to the results of another study by the same technique on Japanese subjects (6). Though, this could be explained on the basis of the

subjects belonging to entirely different ethnic background, our finding do not agree with such earlier observations made by Rosenthal (6). Results of body fat and LBM using girth measurements from this work are comparable at least, with some findings of the other studies on Indian subjects which have used different techniques such as whole body volumetry, skin-fold thickness measurements for body composition estimations (8-11).

It appears that the higher values obtained in this study on fat and LBM using Futurex 5000-A may be due to calibration of the equipment for physical characteristics was based on the data from Metropolitan Life Insurance Company and that would not agree with our subjects. Secondly, it also should be noted that the activity rating was self-reported by the students themselves which form an important consideration in assessing the body composition using this method.

Though, the same line of argument can be extended to body circumference measurement method for body fat and LBM estimations, as they are derived from the sex, age and gender specific tables for a particular population, the results of the present study agree well with the results of some studies on Indian subjects (8-11). It is mentioned that under the circumstances of non-availability of any other technique either in the laboratory or in the field, body girth measurement technique could be employed since the error in the method is 2-4%. It is also encouraging that these equations developed for the purpose is cross-validated on different samples with good results (13) and is also of value in

determining the pattern of body fat distribution following weight loss (14, 15).

We thus conclude that a very simple technique such as the body girth measurements used in this study which we like to name as the 'Tailor's technique' is inexpensive, easy and rapid the assessment of body composition in young

human subjects.

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