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BASAL METABOLIC RATE AND BODY COMPOSITION IN ELDERLY INDIAN MALES

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Abstract : Aging is associated with a decline in basal metabolic rate (BMR) and total energy expenditure. The extent to which changes in fat free mass (FFM) alone, explains the reduction in BMR is still unresolved. In this study, we documented changes in body composition and evaluated its contribution to measured BMR in young and elderly Indian subjects.

We compared 16 healthy elderly male subjects in the age group of 60–75 years with 16 Body Mass Index (kg/m2) matched controls in the age group of 18–25 years. Body composition measurements were determined by using .multiple skinfolds and bioimpedence method. BMR measured by indirect calorimetry.

The % fat and fat free mass was significantly different between two groups. There were significant difference in BMR between elderly and control group (elderly, 5.91 ± 0.54 vs control; 7.08 ± 0.65 MJ/day, P<0.001), which disappeared when corrected for FFM. This suggests that the age related decrease in the BMR is related to the absolute decrease in the FFM in the elderly without any change in the metabolic activity per kg FFM.

Key words : BMR body composition FFM elderly

INTRODUCTION

Normal senescence is associated with a number of changes in the composition and functioning of the human body. A well documented change that occurs with aging in adult humans is with reference to the fat free mass (FFM) (1, 2, 3, 4). Adult males achieve a peak FFM in their mid thirties with a progressive decline in the FFM thereafter (5). A slow and progressive decline in FFM with a concomitant increase in body fat occurs through adulthood (6), which is a risk factor for cardiovascular disease (7).

Different components of the FFM would contribute differently to the overall decrease in the FFM with aging. Skeletal mass at a mean age of 70 years is 60% of its peak weight (8). Reduced myofibrillar protein synthesis may be an important mechanism of the muscle atrophy associated with ageing (9). Total body water (TBW) decreases with aging with values of 54%–60% of body weight being obtained in various studies (10, 11).

The decrease in the FFM would contribute to greater restriction of physical activity and the decreased independence associated with decreased physical mobility and activity. The importance of decrease in the FFM assumes greater significance as the decrease in the basal metabolic rate (BMR) that is observed in the elderly has been ascribed to the decrease in the FFM. The age related decrease in the BMR has been well documented in various groups by both, cross sectional and longitudinal studies (12, 13, 14).

However, a recent longitudinal study shows a very small an age related decline in the BMR or FFM in physically active elderly men (15), implying that the changes in BMR and FFM that have been elicited in previous studies may have been due to possible 'wasting' in the fat free component, secondary to a decrease in the physical activity of the studied population. However, Vaughan et al observed no age related changes in the patterns of spontaneous physical activity in a whole body calorimeter (16).

Most studies that have documented age related changes in body composition and BMR have been carried out in predominantly western populations. Calloway DH et al and Keys A et al have documented decrease in BMR in elderly populations, but when corrected for FFM, there was no change in BMR (17, 18), whereas some author have documented decrease in BMR even after correcting for FFM (19, 20, 21). There is little data to characterize these changes in an Indian population, where life expectancy and levels of physical activity are lower than western populations.

The aims of the study were twofold. Firstly, the study aimed to obtain values of BMR and body composition by two different methods in the elderly Indian population. Secondly, the study aimed to address issues of 'adaptation' in any observed age related changes in the BMR and the FFM.

METHODS

Sixteen healthy elderly male subjects in the age group of 60–75 years were selected for the study. A medical history was obtained and a complete medical examination carried out before including them in the study. Sixteen adult male subjects who were in the age group of 20–25 years were recruited from the student community of St. John's Medical College served as BMI matched controls. The study was approved by the Ethical Committee of the college and all subjects gave informed consent.

Body weights were measured with a digital scale (Soehnle, West Germany) upto the nearest 0.1 kg, and their height was measured to the nearest 0.1 cm using a vertically mobile scale (Holtain, Crymch, UK).

The BMR measurements were carried out in the metabolic ward in the fasted state at 6 A.M. No food or beverages except water were provided for 12 hours prior to the start of the study. The subjects reported to the laboratory at 6 A.M. and were rested for a period of one hour in a quiet room before the measurement. The measurement was carried out in the supine position with the subjects awake and lying still, for a period of 30 minutes by indirect calorimetry (22). A paramagnetic oxygen analyzer (Servomex 540 A, Sybron Taylor Instruments, UK) and an infrared carbon dioxide analyzer (Type SSI, Analytical Development Co, UK) were used to measure the oxygen and carbon dioxide content of sample air. The data from the analyzers was acquired every minute and fed into a computer for online minute to minute recording of oxygen consumption and carbon dioxide production after standard temperature and pressure (STPD) correction. The RQ was then estimated as the ratio of CO_2 (L/min) production to O_2 (L/min) consumption, while energy expenditure was calculated using Weir's equation, and expressed as megajoules per day (MJ/day) (23).

The anthropometric and skinfold measurements were carried out on the subjects at 8 A.M. The skinfolds were measured thrice in the following areas; biceps, triceps, subscapular, suprailliac and the mean expressed to the nearest decimal, which were used in age and gender specific equations (24) to obtain the body density, from which estimates of percentage body fat were made.

Bioelectrical Impedance measurements were carried out at 8.15 A.M. using a Bioelectrical Impedance meter (model BIA-101 RJL Systems, Detroit) and quadripolar electrodes. The subjects had an empty bladder and were in the fasted state with no physical activity permitted for 12 hours preceding the experiment. The procedure was carried out according to the recommendations in the NIH Technological Assessment Statement (25). The source electrodes were applied at the first metacarpophalangeal joint and first tarsophalangeal joint, on the dorsal surface of the hand and foot respectively by the means of 6 cm^2 adhesive electrodes (3 M Corporation, USA). A 800 μA alternating current at a frequency of 50 KHz was applied between the electrodes to provide a measure of resistance and reactance. The Resistance (R) and Reactance (Xc) were used to obtain Impedance (Z) using the formula (26) $Z^2 = R^2 + Xc^2$.

These values were used to obtain the body fat and FFM from software incorporation in the Impedancemeter.

RESULTS

Table I presents a summary of the physical characteristics of the elderly and control group. There were no significant differences between the two groups for body weight and BMI. There were significant differences between the groups for age with the mean age of the elderly and control groups being 69.1 ± 5.1 and 21.0 ± 4.1 years respectively.

TABLE I: Anthropometric characteristics of subjects.

	Elderly (n=16)	*Controls (n=16)*
Age (years)	69.1±5.1	21.0±4.1**
Weight (kg)	68.5±9.8	71.3±9.2
Height (cms)	167.9±7.5	174.8±6.7*
BMI (kg/m2)	24.2±2.1	23.1±2.1

**P=<0.01; *P<0.05

Results are Mean ± SD; BMI: Body Mass Index (kg/M^2)

The % fat as determined by skinfolds was significantly different between the groups, with values of 28.3 ± 3.1 and 20.3 ± 3.5 being obtained for the elderly and control groups respectively. Similar results were obtained when % fat was determined by the bioelectrical impedance method, with the mean value being 29.9 ± 3.9 and 17.8 ± 3.4 for the elderly and control groups.

The FFM as determined by skinfolds was significantly different between the groups, with values of 48.9 ± 6.1 and 56.7 ± 7.8 kg being obtained for the elderly and control groups respectively. Similar results were obtained when FFM was determined by the bioelectrical impedance method, with the mean value being 47.1 ± 7.1 and 58.4 ± 7.0 for the elderly and control groups.

The TBW obtained by the bioelectrical impedance method was 37.1 ± 3.8 and 39.5 ± 5.1 for the elderly and control groups respectively.

There were no significant differences between the skinfold and bioelectrical methods to measure body fat and FFM. The results of the body composition measurements by both methods are presented in Table II.

Oxygen consumption in the elderly and control groups was 0.20 ± 0.02 and 0.24 ± 0.02 L/min respectively. The results between the groups were significant. The BMR was 4.1 ± 0.4 and 4.9 ± 0.4 kj/min in the elderly and control groups. There were significant differences between the groups. There were no significant differences in the measured RQ between the groups, with values of 0.85 ± 0.05 and 0.83 ± 0.04 being obtained for the elderly and controls.

The BMR when corrected for body weight was 0.091 ± 0.012 and 0.099 ± 0.008 MJ/kg/day for the elderly and control groups respectively. There were no significant differences between the groups. The BMR when corrected for the FFM was 0.131 ± 0.012 and 0.126 ± 0.009 MJ/kg/day respectively. There were no significant

TABLE II: Body composition measurements by the skinfold and bioelectrical impedance method.

	Elderly (n=16)	*Controls (n=16)*
% Fat (BIA)	29.9±3.9	17.8±3.4*
Kg FFM (BIA)	47.1±7.1	58.4±7.0*
% Fat (SF)	28.3±3.1	20.3±3.5*
Kg FFM (SF)	48.9±6.1	56.6±7.8*
TBW (L)	37.1±3.8	38.5±5.1*

*P=∠0.01
% Fat (SF): Fat mass obtained by skinfold measurements
FFM (SF): Fat Free Mass obtained by skinfold measurements
% Fat (BIA): Fat mass obtained by the bioelectrical impedance method
FFM (BIA): Fat Free Mass obtained by bioelectrical impedance method
TBW: Total Body Water

TABLE III: Calorimetric values in elderly and control subjects.

	Elderly (n=16)	*Controls (n=16)*
VO2 (L/min)	0.20±0.02	0.24±0.02*
RQ	0.85±0.05	0.83±0.04
BMR (KJ/min)	4.1±0.4	4.9±0.45*
BMR/kg BW (MJ/day)	0.091±0.012	0.099±0.008
BMR/kg FFM (MJ/day)	0.131±0.012	0.126±0.009

*P=∠0.01
Results are Mean ± SD; BMR: Basal Metablic Rate; RQ: Respiratory Quotient
BMR/kg BW: BMR corrected per kg body weight
BMR/kg FFM: BMR corrected per unit active tissue

differences between the groups. The results are presented in Table III.

Results were expressed as Mean ± SD. Statistical analysis for differences between groups was carried out by the Students independent 't' test. Results were considered significant if $P<0.05$.

DISCUSSION

The ability of the human body to adapt to lower energy intakes is an ongoing matter of speculation. As energy intakes diminish, which is known to occur in the elderly (27, 28), one mechanism by which the body adapts is by reducing body weight and altering body composition, resulting in a decreased BMR. The cause of the age related decrease in the BMR has been largely, but not completely (29) ascribed to a decrease in the FFM.

This study demonstrates an age related decrement in the BMR (4.1 ± 0.4 KJ/day in the elderly and 4.9 ± 0.4 KJ.day in controls) and in the FFM (47.1 ± 7.1 kg in the elderly and 58.4 ± 7.0 kg in controls) in healthy elderly Indian male subjects. However, the differences in the BMR between the elderly and control subjects disappeared when corrected for body weight and FFM, which precludes any mechanism of adaptation that may be postulated.

Shinkai et al (29) have demonstrated that despite an age related decline in the BMR and the FFM, mid-level aerobic exercise could partially reverse the decrease, suggesting that the decrease in the FFM, and therefore the BMR in the elderly is secondary to a decrease in physical activity.

Although a number of studies have demonstrated an association between BMR and the FFM in the elderly, it is probable that the age related decrease in the BMR is not exclusively due to changes in the FFM. Poehlman et al (12) have observed alteration in Na^{+} K^{+} pump may be the important cause for age related decrease in BMR. BMR is directly related to the whole body protein turnover. It constitutes about 15% to 20% of the BMR. It is well documented in elderly adults a reduced turnover of protein (30). There are well documented studies from western countries supporting our data (17, 18). It is also likely that a decrease in physical activity would lead to decreased energy intakes, secondary to decreased expenditure, which would result in changes in the FFM and BMR.

This study also demonstrates that skinfold measurements and bioelectrical impedance, the two methods used to measure body composition in the elderly provide similar values and may be used interchangeably to arrive at estimates of FFM and % Fat.

In conclusion, the decrease in the BMR in an elderly Indian male population is due to a decrease in the FFM, although there may be other contributory factors. Whether the decrease in the FFM in the Indian sub-population is a consequence of aging or it is secondary to a decrease in physical activity remains to be determined. Further studies involving energy intakes, total energy expenditure and physical activity are required to elucidate the changes associated with senescence in this population.

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