Age-Specific and Sex-Specific Variations in Body Composition of Adults Belonging to the Rajbanshi Population of Darjeeling District, West Bengal, India

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Abstract: Human body can be quantified at several levels depending on the clinical concerns. Body composition holds utmost importance in the study of nutritional status and health, especially among adult individuals. The present cross-sectional study was conducted among 450 adult individuals (aged 19–49 years) belonging to the Rajbanshi scheduled caste and residing near Siliguri town, Darjeeling district, West Bengal, India. Height and weight were measured using standard procedures. Percentages of subcutaneous fat and skeletal muscles (of whole body, trunk, arms and legs), body fat percentage and visceral fat percentages were measured using Omron Karada body fat analyzer. All the statistical analyses were performed using Statistical Package for Social Science (SPSS version 23.0, SPSS Inc., Chicago, IL). Sexual dimorphism was observed in all variables denoting body composition. There are pronounced body-segmental differences in body composition variables between males and females. The mean values of all recorded variables were found to change significantly with an increase in age.

Key Words: Bio-impedance, Rajbanshi, West Bengal, Body composition, Adults

Introduction: Body composition is a key component of an individual’s health and physical fitness profile that can be influenced by environmental (social and cultural), genetic, and ethnicities as well as age and sex.[1] The assessment of body composition changes with aging can be of utmost importance in establishing optimal weight for health status and physical performance.[2] Body Mass Index (BMI) acts as a promising measuring index for evaluating body fat and patterns of nutritional status.[3] Nevertheless, BMI appeared to act as an inaccurate measure of fatness and a less reliable indicator to evaluate changes in adiposity in older adults.[4] Apart from this, it is well documented that aging process brings about many changes in body composition, without any concomitant changes in body weight and BMI.[5] There also exist significant sex differences in the body composition variables since women are claimed to have proportionally more fat mass while men with more muscle mass.[6-8]

Why is Bio-electrical Impedance Analysis technique chosen for the present study? Table 1 demonstrates various techniques used to measure human body composition.[9] Compared to other techniques, bio-electrical impedance analysis (BIA) is an inexpensive, quick and non-invasive method to determine body composition. Its basic principle was initially described by Thomasset in 1962 where it was assumed that human body would flow only through ion- and water-containing media.[10] Based on basic assumptions involving human tissue hydration, the measured resistance values allow for estimation of skeletal muscle mass or total lean body mass. The remaining sophisticated imaging techniques mentioned in Table 1 are appropriate and useful for smaller laboratory based studies. However, these techniques are often impractical for routine use in the clinical settings and in large epidemiological studies due to high cost, time considerations, and difficulty in assessing such machines. As a result, BIA is more commonly employed in these types of studies. Moreover, BIA has been validated against other techniques such as dual-energy X-ray absorptiometry,[11] skinfold measurements,[12] 2H dilution technique[13] and air displacement plethysmography.[14]
Focusing on the subjects and area of study
North Bengal is a colloquial term for the northern part of the state of West Bengal. The region comprises of 8 districts presently grouped under two main divisions: Jalpaiguri division (Alipurduar, Cooch Behar, Darjeeling, Jalpaiguri and Kalimpong) and Malda division (North Dinajpur, South Dinajpur and Malda). The area of North Bengal is the homeland to a large number of populations who speak different languages, having diverse ethnic origins and varied cultural traditions (e.g. Rajbansi, Dhima, Lepcha, Toto and Bengali Hindu Caste). Studies have indicated that the populations of this region are affected by high levels of malnutrition among adults.[15-17] A thorough literature search has yielded a scarcity of studies in the field of body composition (in terms of subcutaneous fat, skeletal muscles, body fat and visceral fat) among the different ethnic populations of the above mentioned region. Keeping the above issues in mind, the present study aims to explore the changes in body composition with aging in both male and female individuals belonging to Rajbanshi population of Darjeeling district, West Bengal, India.

Methods:
Source of data: The present cross-sectional study was conducted among 450 adult individuals (aged 19-49 years) belonging to the Rajbanshi scheduled caste and residing near Siliguri town, Darjeeling district, West Bengal, India. More particularly, the subjects are the residents of the localities (namely New Rangia, Batalavita, Salkavita and Bataliguri) under Atharoghai Gram Panchayat of Darjeeling district. The aforementioned localities were chosen owing to easy accessibility by road as they are approximately 12 km from Siliguri town. The nature of Rajbanshi scheduled caste can be found in several studies.[18, 19] The age of the individuals were recorded and verified from the age certificates (e.g., birth certificates) and other age-related proofs (e.g., voter identification cards) issued by the competent authorities. The individuals were identified as Rajbanshis by observing their physical features, cultural features and by recording their surnames. These were subsequently verified from the official records of the Gram Panchayat (local village level governing authority).

The subjects were selected using a multi-stage stratified sampling technique. In the first stage, the households of the subjects belonging to the Rajbanshi populations were identified based on the surnames, physical and cultural features. In the second stage, adult population of the aforementioned age-group were identified and approached for the study. Initially, 553 individuals were approached to participate in the study. However, 103 subjects were excluded based on the following exclusion criteria:

1. Individuals not belonging to the specified age-group
2. Individuals under medication that are known to affect the musculoskeletal system such as anti-osteoporotic drugs, anti-androgen drugs, corticosteroids, etc.
3. Individuals with body-metal implants such as pacemaker, joint replacement devices, etc.
4. Individuals having physical deformities
5. Female individuals who were unable to state their menstruation state or having non-natural menopause.
6. Individuals not willing to participate.

Hence, the final sample yielded a sample size of 450 adult Rajbanshi individuals (219 males; 231 females). The study was in compliance with the ethical guidelines for human experimental research as laid down in the Helsinki Declaration.[20]

Anthropometric measurements: Anthropometric measurements of height and weight of subjects of the aforementioned age-group and ethnicity were recorded according to standard procedures of Weiner and Lourie.[21] A most commonly used indicator of precision or rather accuracy index called Technical Error of Measurement (TEM) was utilized.[22] For the calculation of intra-observer and inter-observer TEM, height and weight were recorded from 50 subjects, other than those selected for the study. The measurements were taken thrice on each individual by two observers.

The TEM was calculated by the formula of TEM= √(D^2/2N) where D=difference between the measurements and N= number of individuals measured.[23] The coefficient of reliability (R) which estimates the proportion of variance in a measured population that is free from measurement error was subsequently measured by the following equation:

\[ R = \frac{1-(TEM)^2}{S^2} \]

SD=standard deviation of the measurements.

Very high values of R (> 0.975) were obtained for the TEM analysis. All the values of R were appreciably higher than the accepted cut-off value of 0.95 as suggested by Ulijaszek and Kerr.[24] Hence, the anthropometric measurements recorded were considered to be reliable and reproducible and the TEM values were not incorporated for further statistical consideration. The recorded measurements of subjects’ ID, height, weight, sex and age were entered into the Omron Karada Scan HBF-375 Body Fat Analyzer (OMRON

Table 1: Various techniques used to measure body composition

<table>
<thead>
<tr>
<th>Body Fat Derived from Body Density</th>
<th>Hydro-densitometry</th>
<th>Air Displacement Plethysmography</th>
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<tbody>
<tr>
<td>Total Body Water</td>
<td>Intracellular and Extracellular Water</td>
<td></td>
</tr>
<tr>
<td>Total Body Sodium and Potassium</td>
<td>Total Body Water</td>
<td></td>
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</table>

Dilution Technique

<table>
<thead>
<tr>
<th>Whole-Body Counting and Neutron Activation Analysis</th>
<th>In Vivo Neutron Activation Analysis (IVNA)</th>
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<tbody>
<tr>
<td>Total Body Potassium Measurement (TBK)</td>
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</table>

Imaging Techniques

<table>
<thead>
<tr>
<th>Imaging Techniques</th>
<th>Computed Tomography (CT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Resonance Imaging (MRI)</td>
<td></td>
</tr>
<tr>
<td>Magnetic Resonance Spectroscopy (MRS)</td>
<td></td>
</tr>
<tr>
<td>Quantitative Magnetic Resonance</td>
<td></td>
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<tr>
<td>Positron Emission Tomography</td>
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Anthropometry

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<tr>
<th>Anthropometric measurements</th>
<th>Skin-fold thickness measurements</th>
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Tissue Biopsy

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<tr>
<th>Dual energy X-ray absorptiometry (DXA)</th>
<th>Bio-electrical impedance analysis (BIA)</th>
</tr>
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</table>

Healthcare Co., Kyoto, Japan). Our literature search has divulged existence of numerous studies that have utilized the Omron body fat analyzer for estimating body composition.\textsuperscript{[25-28]} It works on the principle of BIA.

The subjects were asked to step on the main unit of the scanner barefooted placing both the feet on the sole electrodes. According to the manufacturer’s guidelines, the subjects were then asked to hold the hand electrodes and lift their arms 90° away from the trunk. The surface of the hand electrode was placed in contact with each of the five fingers (i.e., the thumb was placed lightly on the hand electrode while the other four fingers were placed along the bottom of the hand electrode). With the aid of this analyzer, body composition was measured in terms of segmental readings of subcutaneous fat and skeletal muscles percentages for the whole body, trunk, arms and legs. Additionally, variables such as body fat percentages, BMI and visceral fat percentages were recorded from this analyzer. The measurements were recorded in a data sheet.

Statistical analysis: The data obtained in the present study was statistically analyzed using statistical constants and relevant statistical tests. The statistical analyses were performed utilizing the software named IBM SPSS (Statistical Package for Social Science) Statistics (version 23.0, SPSS Inc., Chicago, IL). A p value <0.05 and <0.001 were considered as statistically significant. Descriptive statistics (mean± standard deviation) of the recorded variables were obtained and were tabulated on the basis of sex and different age-groups. One-way analysis of variance (ANOVA) was performed to evaluate the sex difference and age-group differences in the recorded anthropometric and body composition variables.

Results
Table 2 portrays baseline characteristics of studied sample stratified by gender. Male subjects tended to be taller and heavier compared to the female counterparts. The mean height (165.45±7.09 cm vs. 151.74±6.27 cm) and weight (59.60±12.14 kg vs. 51.16±10.02 kg) were observed to be significantly higher (p<0.001) among the males compared to females. In comparison to female subjects, male counterparts possess lower subcutaneous fat percentages in whole body (13.22±4.47 % vs. 21.71±3.93 %), trunk (11.96±4.11 % vs. 24.97±2.76 %), subcutaneous fat and visceral fat whole body (11.96±4.11 % vs. 24.97±2.76 %), skeletal muscle whole body (33.22±4.99 % vs. 29.44±6.20 %), BMI (59.60±12.14 kg vs. 51.16±10.02 kg) were observed to be significantly higher (p<0.001) among the males compared to females. In comparison to male subjects, female counterparts have comparatively lower percentages of skeletal muscles than males in whole body (24.97±2.76 % vs. 33.22±4.99 %), trunk (19.86±3.06 % vs. 27.06±4.22 %), legs (21.16±3.80 % kg/m2) compared to males (21.71±3.93 kg/m2). The body fat percentage was observed to be higher among females (29.44±6.20 %) compared to males (18.83±4.11 %). On the other hand, visceral fat was observed to be higher among females (6.66±4.37 %) compared to females (4.81±3.19 %). ANOVA results revealed significant sex-differences in height (F-value=327.507); weight (F-value=38.247); subcutaneous fat percentages in whole body (F-value=353.703); trunk (F-value=219.880); legs (F-value=394.614); and arms (F-value=739.434); skeletal muscle percentages in whole body (F-value=490.283); trunk (F-value=273.018); legs (F-value=1109.963) and arms (F-value=589.024); body fat (F-value=173.626) and visceral fat (F-value=15.204) (p<0.001). However, there is no significant sex-differences in BMI (F-value=1.555; p>0.05).

Table 2: Gender-wise baseline characteristics of the recorded variables

<table>
<thead>
<tr>
<th>Height (cm)</th>
<th>Male</th>
<th>Female</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>165.45±7.09</td>
<td>151.74±6.27</td>
<td>327.507**</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.60±12.14</td>
<td>51.16±10.02</td>
<td>38.247**</td>
</tr>
<tr>
<td>Subcutaneous fat</td>
<td>Whole body (%)</td>
<td>13.22±4.47</td>
<td>21.71±3.93</td>
</tr>
<tr>
<td>Skeletal muscle</td>
<td>Whole body (%)</td>
<td>33.22±4.99</td>
<td>24.97±2.76</td>
</tr>
<tr>
<td>Subcutaneous fat</td>
<td>Trunk (%)</td>
<td>11.96±4.11</td>
<td>24.97±2.76</td>
</tr>
<tr>
<td>Skeletal muscle</td>
<td>Trunk (%)</td>
<td>27.06±4.22</td>
<td>19.86±3.06</td>
</tr>
<tr>
<td>Subcutaneous fat</td>
<td>Legs (%)</td>
<td>18.61±4.05</td>
<td>29.44±6.20</td>
</tr>
<tr>
<td>Skeletal muscle</td>
<td>Legs (%)</td>
<td>50.54±5.46</td>
<td>35.73±6.88</td>
</tr>
<tr>
<td>Subcutaneous fat</td>
<td>Arms (%)</td>
<td>18.86±5.49</td>
<td>20.83±7.21</td>
</tr>
<tr>
<td>Skeletal muscle</td>
<td>Arms (%)</td>
<td>39.36±3.31</td>
<td>28.40±4.31</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>18.83±6.61</td>
<td>29.44±6.20</td>
<td>173.626**</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.71±3.93</td>
<td>22.16±3.80</td>
<td>1.555</td>
</tr>
<tr>
<td>Visceral fat (%)</td>
<td>6.66±4.37</td>
<td>4.81±3.19</td>
<td>15.204**</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.001

Table 3 depicts trends of baseline characteristics of both genders with aging. For an effective apprehension of the collected data, the subjects have been classified into 3 age groups:

1. Age group I (19-29 years): This group contained 150 individuals (males: 75; females: 75).
2. Age Group II (30-39 years): This group contained 150 individuals (males: 74; females: 76).
3. Age group III (40-49 years): This group contained 150 individuals (males: 70; females: 80).

While considering the three age-groups, males of age group I were found to be taller (166.81±6.93 cm) compared to other two age-groups (164.53±6.62 cm and 165.38±6.21 cm respectively). In case of female individuals, age group II represents the tallest members with a mean height of 153.05±6.09 cm and the age group I being the least height members’ group has a mean height of 152.19±4.97 cm. ANOVA test revealed no statistically significant differences with respect to age-groups in case of height (p<0.05). The male subjects exhibit an increasing trend of body weight with increasing age-groups, such as age group I (58.42±12.71 kg) < age group II (59.12±10.57 kg) < age-group III (64.84±10.00 kg). However, this kind of linear increase in body weight was not found in case of female individuals. The female individuals exhibited highest mean of weight (54.99±10.11 kg) in age-group II. The mean weight in age-group I and age-group III were 49.55±9.11 kg and 53.26±9.82 kg respectively. ANOVA test revealed statistical significant differences in weight of males (F-value=4.073) and females (F-value=4.338) with respect to age-groups (p<0.05).
In both sexes, percentages of subcutaneous fat in whole body, trunk and arms were found to increase with advancement in age-groups. In males, the lowest percentages of subcutaneous fat were observed in age-group I (whole body = 11.9±4.42 %, trunk = 10.89±4.09 %, arms = 18.16±8.74 %) and then age-group III (whole body = 15.72±4.42 %, trunk = 11.21±3.72 %, arms = 29.79±5.42 %). However, skeletal muscle percentages in whole body (age-group I: 41.36±3.25 % > age-group II: 39.20±2.00 % > age-group III: 37.59±2.60 %). There exist statistical significant differences with respect to age-groups in case of skeletal muscle percentages in whole body (F-value= 28.871), trunk (F-value= 26.318), and arms (F-value= 23.239) (p<0.001). Similar decreasing trend was observed in case of females where percentages of skeletal muscle tended to decrease in whole body (age-group I: 35.80±3.92 % > age-group II: 33.46±3.92 % > age-group III: 31.44±4.73 %), legs (age-group I: 52.88±5.13 % > age-group II: 48.00±2.61 % > age-group III: 44.23±8.93 %) and arms (age-group I: 51.66±5.53 % > age-group II: 48.00±2.61 % > age-group III: 44.23±8.93 %). Visceral fat percentages were observed in age-group I (whole body = 9.09±4.09 % < age-group II: 14.10±4.08 % < age-group III: 26.61±5.46 %). ANOVA test revealed significant statistical differences with respect to age-groups in the above parameters in both the sexes (p<0.001). Male subjects showed statistically significant differences (p<0.001) between the age-groups in subcutaneous fat percentages in whole body (F-value= 10.062), trunk (F-value= 6.847) and arms (F-value= 3.62). Female subjects also showed statistically significant differences (p<0.001) between the age-groups in subcutaneous fat percentages in whole body (F-value= 6.594), trunk (F-value= 7.091) and arms (F-value= 5.519). It was also observed that female subjects exhibited increasing trend of subcutaneous fat percentages in legs with advancement in age-groups (age-group I: 3.62±2.93 % > age-group II: 26.29±6.55 % > age-group III: 22.10±5.52 %). However, the differences in percentages with respect to age-groups is statistically insignificant (p=0.05). Male subjects exhibited lowest mean subcutaneous fat percentages in legs in age group II (17.99±5.54 %) followed by the same in then age-group III (whole body= 23.239 %, trunk= 23.47±4.06 %, arms= 28.871 %). ANOVA test revealed significant statistical differences with respect to age-groups in the above parameters in both the sexes (p<0.001). Male subjects showed statistically significant differences (p<0.001) between the age-groups in subcutaneous fat percentages in legs (F-value= 21.42±3.91 % > age-group II: 24.25±1.84 % > age-group III: 23.03±4.16 %), trunk (F-value= 21.92±2.77 % > age-group II: 18.84±1.92 % > age-group III: 18.47±2.11 %). Visceral fat percentages were observed in age-group I (whole body = 5.29±4.03 % > age-group II: 6.23±3.69 % > age-group III: 9.09±4.13 %). However, in case of females, the trend followed
as age-group I: 3.62±2.93% < age-group III: 5.54±2.92% < age-group II: 5.68±3.63%. Statistical significant differences with age-group I, were observed in case of visceral fat percentages of males (F-value= 12.116) and females (F-value= 6.457) (p<0.001). Mean BMI in males increased with an increase in age-groups (age-group I: 20.94±4.20 kg/m² < age-group II: 21.78±3.30 kg/m² < age-group III: 23.68±4.30 kg/m²). On the other hand, mean BMI in females were observed to be highest in age-group II (23.47±4.06 kg/m²). The other two age-groups showed lower mean BMI than age-group II (age-group I: 21.42±3.91 kg/m² and age-group III: 22.73±2.22 kg/m²). ANOVA test revealed that there exist statistical significant differences with respect to age-groups in mean BMI of males (F-value= 6.620, p<0.001) and females (F-value= 3.866, p<0.05).

Discussion
It is generally avowed that women have a higher percentage of body fat than men.[29] Women store more fat in the gluteal-femoral region, whereas men store more fat in the visceral/abdominal depot. This eventually engenders gynoid body shape (pear-shaped) and android body shape (apple-shaped) in females and males respectively. The present study has ventured into addressing age and sex variations of body composition variables. The sex-specific differences in body composition are associated with sex-based differences in energy substrate-utilization patterns i.e., females store more lipids and have higher whole-body insulin sensitivity than males, while males tend to oxidize more lipids than females. It is also documented that these patterns are influenced by the unique actions of sex hormones and adipokines in each sex as well as by nutritional status and physical fitness in both sexes.[30]

The present study found female individuals possess higher percentages of subcutaneous fat compared to the male counterparts. This is in accordance with the studies of Davies et al.[31] and Hattori et al.[32] There exist several factors that contribute to higher subcutaneous fat deposits in women, such as high lipoprotein lipase (LPL) activities in subcutaneous fat depots and high hepatic-derived lipoprotein catabolic rate.[33,34] Additionally, women have the ability to secrete triglyceride-rich very low density lipoproteins (VLDL) during high hepatic-lipid metabolism.[35] This eventually results in redirecting fat storage from liver to subcutaneous fat depots in women.[36] On the other hand, it was found that testosterone in males plays a stimulant role in restraining fatty acid storage in femoral adipose tissue via suppression of LPL and acyl coenzyme A synthetase (ACS) activities which contributes to lesser subcutaneous fat percentages in the male body.[37] Percentages of skeletal muscles were found to be significantly more among males compared to females. The findings are consistent with that of Abe et al.[6] This generally occurs due to huge differences in energy metabolism, types and composition of fibre and contractile speed between both the sexes.[38] Males convert more of their calorific intake into muscle and expendable circulating energy reserves, while females tend to convert more into fat deposits.[39] Additionally, males are reported to possess greater skeletal muscle due to greater capacity for muscular hypertrophy which further occurs as a result of higher levels of circulating testosterone in males.[40] There has been a considerable reduction in percentages of skeletal muscles in both males and females with advancing age. This occurs due to age-related loss of muscle mass. Visceral fat is observed to be higher in males compared to females. This is supported by the findings of Hunter et al.[41] Studies have revealed that about 21% and about 6% of the ingested/dietary fat is accumulated in the intraperitoneal fat and retroperitoneal fat respectively by males.[42] On the contrary, only about 5% of the dietary fat gets accumulated in the intraperitoneal fat by females.[43] Due to higher dietary fat intake, males tend to produce huge number of bigger chylomicrons compared to females.[44] These chylomicrons partially aid in the accumulation of abdominal visceral fats which consequently results in higher visceral fats in males compared to females. Unlike visceral fat, body fat percentages were observed to be higher in females compared to males. According to a mechanism, oestrogen reduces postprandial fatty acid oxidation leading to an increase in body fat which may account for the greater fat mass observed in female individuals compared to male counterparts.[45]

In addition, visceral fat and body fat were also found to increase with increase in age. Hunter et al.[41] encapsulated several factors that occur with increase in age in both males and females such as weight gain, loss of muscle, gradual shift in hormonal environment and sedentary lifestyle that could be the general causes of increase in visceral fat.

Conclusion
Aging involves metabolic, physiologic, and functional impairments which occur, in part, through age-related changes in body composition. The present study confirms that there exists sexual dimorphism among the variables explaining body composition. Moreover, it was found that the mean values of body composition variables increase or decrease significantly with increasing age.

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Conflict of Interest: None

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