

Presence of High Rates of Overweight and Obesity among Adult Marwaris of Howrah, West Bengal, India

Mithun Das¹ and Kaushik Bose²

¹ Indian Statistical Institute, Kolkata, West Bengal, India

² Department of Anthropology, Vidyasagar University, Midnapore, West Bengal, India

ABSTRACT

A cross-sectional study of 220 (110 men and 110 women) adult (> 20 years) Marwaris of Howrah, West Bengal, India, was undertaken to investigate the frequency of overweight and obesity, using different criteria. Results revealed that men had significantly greater mean height, weight, waist circumference (WC), waist-hip ratio (WHR), conicity index (CI) and fat free mass (FFM), compared with women. Women had significantly higher mean body mass index (BMI), biceps (BSF) and triceps (TSF) skinfolds, mid-upper arm (MUAC) and hip (HC) circumferences, percent body fat (PBF), fat mass index (FMI), mid-arm fat area (MAFA) and PBF/BMI ratio compared with men. The frequency of overweight (BMI \geq 25.0) was significantly higher among women (71.8%) compared with men (44.5%). Similarly, significantly more women (41.8%) had high WHR than men (22.7%). Significantly more women also had high PBF (97.3%) compared with men (90.9%). In conclusion, these results demonstrated that the level of overall and central adiposity, as well as body fat, was found to be high among Marwaris, as compared with other ethnic populations of India. Moreover, there existed significant sexual dimorphism in these measures among this ethnic group. This high level of overall and central adiposity and body fat could have severe adverse health implications in this ethnic group.

Key words: Marwaris, sex differences, body mass index, waist-hip ratio, percent body fat

Introduction

The origins of Marwaris are in the western Indian State of Rajasthan. They derive their name from 'Marwar' which is a region in Rajasthan, India. Their diet and social customs are distinctly different from other ethnic groups of western India like the Gujaratis, Marathis, Parsis and Sindhis. Many Marwaris migrated to Kolkata from Rajasthan between 100 to 300 years ago. Predominantly, Marwaris are traders. The major reason for them to migrate was economic, i.e., trading opportunities were better in Kolkata as compared with their native place. A recent study demonstrated that their level of physical activity is less; they are vegetarians and generally consume hydrogenated and saturated fats and oils in large quantities¹.

Recent studies in India have been undertaken to study adiposity, central body fat distribution and body composition among adult Bengalees²⁻⁴, Punjabis⁵ and other ethnic populations⁶. Although blood pressure and lipid levels of Marwaris have been reported earlier¹, in-

formation on their anthropometric and body composition profiles are lacking. The present study was undertaken to study the levels of adiposity, central body fat distribution and body composition among adult Marwaris of Howrah, a suburb of Kolkata. It is the first report dealing with the levels of adiposity, central body fat distribution and body composition of this ethnic group.

Materials and Methods

Study population

The study sample consisted of randomly selected 110 men and 110 women aged more than 20 years, belonging to the Marwari ethnic group residing in Howrah, an urban suburb of Kolkata, West Bengal, India. The age ranges were similar in both sexes (males: 50 years; females: 48 years). Males and females had similar minimum (males: 25 years; females: 22 years) and maxi-

mum (males = 75; females = 70) ages. For women, the mean number of children was 2.0. The majority of women (n=58, 52.7%) had 2 children. The rest had 1 (n=28; 25.5%), 3 (n=21; 19.1%) and 4 (n=3; 2.7%) children, respectively. All individuals belonged to upper socio-economic status.

Written consents were obtained from all subjects prior to the commencement of the study. Information on ethnicity, age, number of children and occupation were obtained by means of a questionnaire. Subjects were requested to make an appointment and measurements were made at their residence on Sundays. There was no missing data.

Anthropometric measurements

All anthropometric measurements were made by the first author using standard anthropometric techniques⁷. Biceps skinfolds (BSF), triceps skinfolds (TSF) and mid-upper arm circumference (MUAC) were measured on the left side. Body mass index (BMI) was computed following the standard equation:

$$\text{BMI (kg/m}^2\text{)} = \text{weight (kg)} / \text{height (m}^2\text{)}$$

Two indices of central body fat distribution were studied: waist-hip ratio (WHR) and conicity index (CI). WHR was computed following the standard equation:

$$\text{WHR} = \frac{\text{waist circumference (cm)}}{\text{hip circumference (cm)}}$$

Conicity index (CI) was computed following the standard equation⁸:

$$\text{CI} = \frac{\text{waist circumference (m)}}{0.109 \times \sqrt{(\text{weight (kg)} / \text{height (m)})}}$$

World Health Organization⁹ cut-off point of BMI ≥ 5.0 kg/m² was utilized to identify individuals who are overweight. A high WHR was defined as >0.95 in males and >0.80 in females^{5,10}.

Body composition characteristics

Percent body fat (PBF) was computed from biceps (BSF) and triceps (TSF) skinfolds following the equations of Durnin and Womersley¹¹. These equations have been shown to be valid for use among Indians^{5,12} and other South Asian populations¹³. The following equations were used:

$$\begin{aligned} \text{PBF} &= (4.95 / \text{density} - 4.5) \times 100, \text{ where} \\ \text{density for men} &= 1.1356 - 0.070 \times \log(\text{BSF} + \text{TSF}) \\ \text{for women} &= 1.1362 - 0.074 \times \log(\text{BSF} + \text{TSF}) \end{aligned}$$

High PBF was set as $>25\%$ in men and $>30\%$ in women as recommended by several researchers¹⁴⁻¹⁵. These cut-off points have been found to be appropriate for Indian populations⁵.

Fat mass (FM), Fat free mass (FFM), Fat mass index (FMI) and Fat free mass index (FFMI) were computed following the standard equations¹⁶:

$$\begin{aligned} \text{FM (kg)} &= (\text{PBF} / 100) \times \text{weight (kg)} \\ \text{FFM (kg)} &= \text{weight (kg)} - \text{FM (kg)} \end{aligned}$$

$$\text{FMI (kg/m}^2\text{)} = \text{FM} / \text{height}^2 \text{ (m}^2\text{)}$$

$$\text{FFMI (kg/m}^2\text{)} = \text{FFM} / \text{height}^2 \text{ (m}^2\text{)}$$

PBF/BMI ratio was computed following the equation of Dudeja et al.⁵:

$$\text{PBF/BMI} = \text{PBF} / \text{BMI}$$

Mid-arm muscle circumference (MAMC, mm) and mid-arm muscle area (MAMA, mm²) were computed following the standard formulae¹⁷:

$$\text{MAMC} = \text{MUAC} - (\pi \times \text{TSF})$$

$$\text{MAMA} = \text{MAMC}^2 / 4\pi$$

Mid-arm fat area (MAFA, mm²) was calculated using the following equation¹⁸:

$$\text{MAFA} = \{(\text{TSF} \times \text{MUAC}) / 2\} - \{(\pi - \text{TSF}^2) / 4\}$$

Statistical analyses

All continuous variables were checked for normality and it was found that majority of their distributions were not significantly skewed. Statistical analyses were undertaken using Statistical Package for Social Sciences (SPSS/PC+ Version 5). Technical error of measurements (TEM) were found to be within acceptable values^{7,19}. Since the mean ages of males (41.6 \pm 11.4 years) and females (37.4 \pm 11.1 years) were significantly different ($p < 0.01$), sex differences in anthropometric and body composition profiles were evaluated using multiple regression analyses, after controlling for age. Sex differences in the frequency of overweight and obese subjects were determined by using the χ^2 test. Statistical significance was set at $p < 0.05$.

Results

Anthropometric profile

The means and standard deviations of anthropometric and central body fat distribution variables and indices are presented in Table 1. Men were significantly ($p < 0.001$) taller and heavier than women. Women had significantly higher mean BMI ($p < 0.001$), BSF ($p < 0.01$), TSF ($p < 0.001$), MUAC ($p < 0.025$) and HC ($p < 0.005$) than men. Men had significantly greater mean WC ($p < 0.005$) and both indices of central body fat distribution, WHR ($p < 0.001$) and CI ($p < 0.005$), compared with women.

Body composition characteristics

The means and standard deviations of body composition variables and indices are presented in Table 2. Women had significantly greater ($p < 0.001$) mean PBF (men (M)=31.8%; women (W)=37.6%), FMI (M=8.0 kg/m²; W=10.4 kg/m²), MAFA (M=3026.6 mm²; W=3974.6 mm²) and PBF/BMI ratio (M=1.293; W=1.417) compared with men. However, men had significantly ($p < 0.001$) greater mean FFM (M=47.9 kg; W=40.2 kg) than women.

TABLE 1
MEAN VALUES OF ANTHROPOMETRIC CHARACTERISTICS OF MARWARI MEN AND WOMEN OF HOWRAH, WEST BENGAL

| Variable | Men (n=110) | Women (n=110) |
|------------------------------|------------------|------------------|
| Height (cm)**** | 168.4 (6.7) | 154.7 (5.0) |
| Weight (kg)**** | 70.8 (13.2) | 65.0 (12.3) |
| BMI (kg/m ²)**** | 24.9 (4.0) | 27.2 (5.2) |
| BSF (mm)** | 16.7 (6.2) | 18.8 (5.6) |
| TSF (mm)**** | 20.4 (6.7) | 25.7 (6.3) |
| MUAC (cm)* | 27.8 (3.7) | 29.0 (3.7) |
| WC (cm)*** | 87.1 (12.5) | 82.1 (10.8) |
| HC (cm)*** | 97.9 (8.7) | 103.4 (11.3) |
| WHR**** | 0.887 (0.081) | 0.794 (0.058) |
| CI*** | 1.234 (0.109) | 1.165 (0.075) |

Standard deviations are presented in parenthesis. BMI – body mass index, BSF – biceps skinfold, TSF – triceps skinfold, MUAC – mid upper arm circumference, WC – waist circumference, HC – hip circumference, WHR – waist-hip ratio, CI – conicity index. Sex differences were evaluated using multiple regression analyses after controlling for age. Sex was the independent variable. *p<0.025, **p<0.01, ***p<0.005, ****p<0.001.

Overweight and obesity

Table 3 presents the frequency of overweight and obesity, using BMI, WHR and PBF, in both sexes. The frequency of overweight individuals (BMI ≥ 25.0 kg/m²) was significantly ($\chi^2=9.7$; p<0.001) higher among women (71.8%) compared with men (44.5%). Similarly, significantly ($\chi^2=9.2$; p<0.005) more women (41.8%) also had

TABLE 3
FREQUENCY OF OVERWEIGHT AND OBESITY USING BODY MASS INDEX (BMI), WAIST-HIP RATIO (WHR) AND PERCENT BODY FAT (PBF) AMONG MARWARI MEN AND WOMEN

| | Men (n=110) | Women (n=110) |
|--|-------------|---------------|
| BMI > 25.0*** | 49 (44.5) | 79 (71.8) |
| High WHR** (men > 0.95, women > 0.80) | 25 (22.7) | 46 (41.8) |
| High PBF* (men > 25.0, women > 30.0) | 100 (90.9) | 107 (97.3) |

Percentages are presented in parentheses. Sex differences were evaluated using the χ^2 test. *p<0.05, **p<0.005, ***p<0.001

TABLE 2
MEAN BODY COMPOSITION CHARACTERISTICS OF MARWARI MEN AND WOMEN OF HOWRAH, WEST BENGAL

| Variable | Men (n=110) | Women (n=110) |
|---------------------------|--------------------|--------------------|
| PBF* | 31.8 (4.9) | 37.6 (4.0) |
| FM (kg) | 22.9 (6.9) | 24.8 (6.6) |
| FFM (kg)* | 47.9 (7.6) | 40.2 (6.4) |
| FMI (kg/m ²)* | 8.0 (2.2) | 10.4 (2.8) |
| FFMI (kg/m ²) | 16.9 (2.2) | 16.8 (2.6) |
| MAMC (mm) | 214.1 (30.5) | 208.7 (29.1) |
| MAMA (mm ²) | 3721.0 (1064.0) | 3521.9 (981.3) |
| MAFA (mm ²)* | 3026.6 (1334.4) | 3974.6 (1371.1) |
| PBF/BMI* | 1.293 (0.187) | 1.417 (0.215) |

Standard deviations are presented in parenthesis. PBF – percent body fat, FM – fat mass, FFM – fat free mass, FMI – fat mass index, FFMI – fat free mass index, MAMC – midarm muscle circumference, MAMA – midarm muscle area, MAFA – midarm fat area. Sex differences were evaluated using multiple regression analyses after controlling for age. Sex was the independent variable.

*p<0.001

high WHR (men: WHR > 0.95; women WHR > 0.80) than men (22.7%). Furthermore, significantly ($\chi^2=4.0$; p<0.05) more women (97.3%) had high PBF (men: PBF >25%; women: PBF >30%) than men (90.9%).

Discussion

Sexual dimorphism in body fatness has important implications for both clinical and epidemiologic research of obesity¹⁸. Higher levels of body fatness in females represent a fundamental aspect of sexual dimorphism in homo sapiens³⁰. The basis of sexual dimorphism in body fatness and body fat distribution lies in evolutionary and reproductive advantages. Furthermore, sexual dimorphism in body fatness underlies the difference in risk of obesity in male and female populations¹⁸. In this paper, we have shown that there exists significant sexual dimorphism in anthropometric measures of body fatness. Moreover, the mean values of WC, BSF and TSF of the Marwaris of the present study were larger than those reported among North Indians in a recent study⁵.

The mean values of BMI reported in some recent studies among various populations of India are presented in Table 4. Mean BMI of the Marwaris was found to be higher in both sexes than all these studies except for those of Gill et al.²⁰ and Bharati²¹ who reported higher means among Mahisyas and Punjabis (urban men only),

TABLE 4
MEAN BODY MASS INDEX (BMI) AMONG MEN AND WOMEN OF VARIOUS POPULATIONS OF INDIA

| Reference | Ethnic group | Region | Mean BMI (kg/m ²) | |
|---------------|---|------------------------------------|-------------------------------|--------------------|
| | | | Men | Women |
| 21 | Mahishya | Howrah District, West Bengal | 28.6 ^a | 25.6 ^a |
| | | | 29.6 ^b | 27.4 ^b |
| | | | 33.7 ^c | 29.3 ^c |
| 20 | Punjabi | North India | 25.3 ^u | 25.7 ^u |
| | | | 20.7 ^r | 23.5 ^r |
| 36 | Reddy caste | Chittor District, Andhra Pradesh | 19.4 | 20.0 |
| 32 | Kannada | South Karnataka | 17.7 | 18.0 |
| 33 | Not mentioned | Nagaur district, Central Rajasthan | 21.3 | 21.2 |
| 35 | Oraon | Northern West Bengal | 18.2 [*] | 17.6 [*] |
| | | | 18.0 ^{**} | 17.7 ^{**} |
| 37 | Yerukalas Mala and Muslims Reddy and Balija Brahmins, Vyshyas Marwadis | Southern Andhra Pradesh | 18.6 | 19.4 |
| | | | 18.8 | 19.3 |
| | | | 20.9 | 19.9 |
| | | | 21.4 | 22.3 |
| 38 | Not mentioned | Kolkata | 20.3 | 19.3 |
| 5 | Northern Indians | New Delhi | 21.4 | 23.3 |
| 39 | Lepchas | Sikkim | 23.0 ^u | 24.6 ^u |
| | | | 23.3 ^r | 23.3 ^r |
| Present Study | Marwaris | Howrah, West Bengal | 24.9 | 27.2 |

^a lower socio-economic group, ^b middle socio-economic group, ^c higher socio-economic group, ^u urban, ^r rural

^{*} high productivity tea pluckers

^{**} low productivity tea pluckers

respectively. Mean BMI of the current study were similar to the ones reported on migrant Indians (men = 25.7 kg/m², women = 27.0 kg/m²) by McKeigue et al.²² These data indicate that Marwaris were more overweight as estimated by BMI, than most populations in India. Their level of generalized adiposity (BMI) were similar to migrant Indians in Britain.

Body composition variables and indices also revealed significant sex differences. Women had significantly greater mean PBF, FMI, MAFA and PBF/BMI ratio compared with men. However, men had significantly greater mean FFM. Dudeja et al.⁵ had also reported similar findings among North Indians. Mean PBF of the Marwaris in the present study was higher in both sexes than those of Northern Indians⁵, the difference being greater among men. Mean PBF/BMI ratio of the Marwari men was higher, while that of women lower, those reported by Dudeja et al.⁵

Using three separate conventional measures of overweight and obesity (BMI, WHR and PBF) it was found that the frequency of overweight was significantly higher among Marwari women. When a BMI \geq 25.0 kg/m² cut-off point was applied, 44.5% of men and 71.8% of women were overweight. This was significantly higher ($p < 0.001$) in both sexes than the frequencies of 15.1% (men) and 27.0% (women) reported by Dudeja et al.⁵. This significant sex difference was consistent for all three differ-

ent criteria used to define overweight and obesity, i.e., BMI, WHR or PBF. In each case, the frequency of overweight and obesity was significantly higher among women, the sex difference being greatest when overweight was defined using BMI ($p < 0.001$) followed by WHR ($p < 0.005$) and PBF ($p < 0.05$). The prevalence of obesity according to PBF estimation in both sexes was highest as compared with those estimated from BMI or WHR. Similar sex differences in obesity were reported by Dudeja et al.⁵ However, the frequency of overweight and obesity observed among Marwaris was higher using these criteria, in both sexes, than those reported by Dudeja et al.⁵ An important finding was that 90.9% men and 97.3% women had excess PBF. These figures are much higher than those reported among other ethnic groups in previous studies^{23–25}. A study on migrant Asian males in USA²⁶ had also reported high mean PBF. Another recent study from Singapore²⁷ had also reported that Indians had higher PBF for the same BMI compared with Chinese and Malays. The authors concluded that there are ethnic differences in the relationship between PBF and BMI. Similar ethnic differences in the relationship of PBF with BMI between Indonesians, Dutch Caucasians and subgroups of Indonesians have been reported in recent studies^{28–29}.

In conclusion, data from the current study suggested that among urban Marwaris of Howrah, the prevalence

of overweight and obesity is high. More importantly, it also indicated that they have very high PBF. Further studies are needed among other ethnic groups resident in urban India to investigate whether this phenomenon is found among them. Since obesity is associated with urbanization³¹, future investigations should specifically target urban populations. There is a paucity of data on the prevalence of obesity using different criteria among different urban populations of India⁴⁰. Lastly, the adverse health implications of excess adiposity are now well established^{41–43}. Thus, future studies should investigate morbidity and mortality associated with excess adiposity among Marwaris. Appropriate health promotion prog-

rammes can be formulated based on the findings of these studies so as to reduce excess adiposity-associated mortality and morbidity in this ethnic group.

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K. Bose

Department of Anthropology, Vidyasagar University, Midnapore – 721 102, West Bengal, India
e-mail: banda@vsnl.net

VISOKA UČESTALOST PEKOMJERNE TEŽINE I PRETILOSTI MEĐU ODRASLIM MARWARIJIMA IZ HOWRAHA, ZAPADNI BENGAL, INDIJA

S A Ž E T A K

Presječna studija 220 (110 muškaraca i 110 žena) odraslih Marwarija iz Howraha, Zapadni Bengal, Indija, provedena je kako bi se istražila učestalost prekomjerne težine i pretilosti uz uporabu različitih kriterija. Rezultati su pokazali kako muškarci imaju značajno veću visinu, težinu, opseg struka, omjer opsega kukova i struka (WHR), indeks koničnosti i bezmasnu masu tijela u usporedbi sa ženama. Žene su imale značajno veći indeks tjelesne mase (BMI), kožne nabore bicepsa i tricepsa, opsege nadlaktice i kukova, postotak tjelesne masti (PBF), indeks tjelesne masti, indeks masti na nadlaktici te omjer PBF/BMI. Učestalost prekomjerne težine ($BMI \geq 25,0$) bila je značajno viša među ženama (71,8%) nego među muškarcima (44,5%). Isto tako, žene su imale značajno (41,8%) veći WHR nego muškarci (22,7%). Žene su također imale i značajno veći postotak tjelesne masti (97,3%) u usporedbi s muškarcima (90,9%). Rezultati pokazuju kako je stupanj debljine i centralne depozicije masti visok među Marwarijima u usporedbi s ostalim populacijama Indije. Štoviše, ustanovljen je i značajni spolni dimorfizam u navedenim mjerama u ovoj skupini. Ovako visok stupanj debljine i centralne depozicije masti mogao bi imati ozbiljne zdravstvene implikacije.