©Human Biology Review
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Human Biology Review (ISSN 2277 4424) 3 (4) 2014
Original scientific paper (Mandal and DasChaudhury, pp 303-314)
Revised and Accepted on September 6, 2014

Influence of body fat distribution by the physiological status in women: a study among the Bengalee population in West Bengal, India

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Citation: Mandal A and DasChaudhury AB. 2014. Influence of body fat distribution by the physiological status in women: a study among the Bengalee population in West Bengal, India. Human Biology Review, 3 (4), 303-314.

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ABSTRACT

Body shape is determined by the nature of body fat distribution that, in turn, is significantly correlated with women's sex hormone profile. It is important to note that women have greater amounts of body fat in lower parts of the body (gynoid–"pear-shaped" body fat) whereas men have greater amounts of fat in the upper body (android–"apple-shaped" body fat) induced by the circulating level of sex hormones. The objectives of the present study was to find out the correlation between the girth and circumferential measurements and the female sex hormonal levels to compare the correlations of hormone for understanding any change in the fat distribution. This cross-sectional study was conducted among the Bengalee of women(n=300) between the ages 20 years to 58 years. They were categorized as fertile, perimenopausal and postmenopausal. The girth and circumferential measurements had varied correlations for the three groups of women. Mid upper arm circumference, chest girth and thigh circumference correlated significantly with E_2 in the fertile group ($p < 0.001$) and the waist girth and hip girth correlated significantly ($p < 0.05$) in the postmenopausal group but showed no significance in the perimenopausal group. Hip girth showed no significant correlation with the fertile or perimenopausal women, but correlated significantly with all the three hormones in the postmenopausal group ($p < 0.05$). Significant differences ($p < 0.05$) were found in the breadth (bi-iliac diameter, chest breadth). Most of the girth measurements (chest and waist girth), circumferential (upper arm, thigh) show highly significant ($p < 0.001$) differences in the three groups. Menopause is associated with an increase in body fat and an increase in the relative proportion of abdominal fat. Thus, compared with fertile, perimenopausal women, fat distribution in postmenopausal women is changing towards that of a man.

Keywords : ***Sex-hormone, fat distribution, Bengalee women, Kolkata*.**

INTRODUCTION :

Background: Body shape is determined by the nature of body fat distribution that, in turn, is significantly correlated with women's sex hormone profile, risk for disease, and reproductive capability (Singh,1994). It is important to note that women have greater amounts of body fat in lower parts of the body (gynoid–"pear-shaped" body fat) whereas men have greater amounts of fat in the upper body (android–"apple-shaped" body fat) induced by the circulating level of sex hormones between the two sexes. To demonstrate that the female body shape is judged attractive due to its reliable link that men would have sought out in ancestral populations, it is essential to establish that this shape has a plausible linkage to physiological mechanisms regulating reproductive capability and good health (Singh,1994). Fat distribution in humans depends both on age and gender, the individuals of both sexes are similar during the periods of infancy, early childhood and old age but differences in fat distribution are greater from the onset of early teens until late middle age (Vague, 1956). There is extensive evidence that sex hormones affect specific regional adiposity and regulate utilization and accumulation of fat in the body (Song et al.,1993; Koskova et al., 2007). Oestrogen inhibits fat deposition in the abdominal region i.e. in the gluteofemoral region while testosterone is responsible for inhibiting fat deposition in the gluteofemoral region (Tonkelaar et al., 1989).

The nature of body fat distribution, is largely determined by the gynoid body shape (Hefferman et al., 2002). The most striking result is the change in direction of correlations between metric traits and oestrogen, gonadotrophin, prolactin and gestagen levels between both fertile and postmenopausal groups, which is probably due to changes in sex-hormone concentrations in women after menopause (Kirchengast, 1993).

Objective

This study aims to compare the correlations of hormone and the girth and circumferential measurements for the fertile, perimenopausal and postmenopausal women, for understanding any change in the pattern of fat distribution.

MATERIALS AND METHODS :

Study area

All the subjects under study were chosen from the Middle Income Group, Housing Complex of Kalindi Housing Estate, Kolkata-89. All were Bengalee Hindu Women. This was done to maintain an endogenous group for the study

Study population

Table :1 Age ranges, mean age, standard deviations and physiological condition of the studied women

Physiological Condition	N	Age ranges (in years)	Mean age (in years	SD.
Fertile	115	20-44	31.62	5.04
Perimenopausal	85	41-48	45.11	1.69
Post menopausal	100	39-58	50.60	4.09
Total	300	20-58	41.73	9.22

The probands (n=300) comprised of women between the ages 20 years to 58 years. They were divided into three groups (Table 1): group-I : comprised of 115 fertile women between the ages 20years to 44 years (X = 31.63), who were fertile with regular cycles. Group-II comprised of 85 perimenopausal women between the ages of 41 years to 48 years (X = 45.11) where women experienced physiological changes occurring disrupting their regular menstrual cycles that begin the transition to menopause. Women were considered to be perimenopausal if they still menstruated in the past 12 months (Tonkelaar et al., 1989). Group-III comprised of 100 postmenopausal women between the ages of 39 years to 58 years (X = 50.60) whose menopause occurred naturally at a minimum of 1 year before the time of investigation. Women having children of their own were considered for the study. All women participants in this study are Homemakers. All 300 women were healthy, had intact ovaries, uterus and adrenals and a history of normal menstrual cycles. None was under any hormone therapy, hormonal contraception or other medication.

Anthropometric measurements

From each proband 5 circumferential, mid upper arm circumference, chest girth, waist girth, hip girth and thigh circumference measurements were taken according to Knussman ,1988 and Tonkelaar et al., 1989.

Hormone assay

Blood sample was drawn by a pathological laboratory assistant. Each sample was drawn for a volume of 15ml, in sterilized vials containing EDTA dust. The samples were taken to Repromed Diagnostic Centre, Park Circus, Kolkata, for hormone assay. Blood was drawn from

the fertile women between the 8th and 10th day of menstrual cycle of each women i. e. during the follicle phase before ovulation. A reasonable characterization of inter individual differences in premenopausal oestradiol, androgen and progesterone levels may be achieved with single blood samples taken on specific days. Pollard et al., 2000, concludes that this day can well be the 9th day of the cycle for women having regular periods. Blood was drawn in between the 9th and 12th day of the cycle for the perimenopausal women. For the post menopausal group of women no such day was demarcated, it was taken on any convenient day according to them. For all the cases blood was drawn in between 7.30am – 8.30 am.

Statistical analysis: Statistical evaluation of the data was carried out using SPSS program version 7.5. Results of the Kolmogoroff—Smirnov test indicated that no normal distribution could be assumed for several anthropometric and all hormonal variables and so to determine the correlation between sex-hormone levels and each of the body measurements distribution free Spearman rank correlations were computed.

RESULTS:

Table 2. Mean (SD) and ANOVA of the variables among the studied women

Variables	Fertile	Perimenopausal	Postmenopausal	F
MUAC	28.80(2.0)	32.00(2.6)	32.35(2.5)	26.5***
CG	92.82(4.9)	95.42(6.697)	98.51(9.1)	17.4***
WG	84.12(6.9)	90.57(5.7)	90.96(9.1)	21.0***
HG	91.06(9.6)	91.77(7.8)	95.93(10.2)	6.2**
THC	46.98(3.4)	43.88(4.8)	44.37(4.9)	9.5***
BID	30.4(3.9)	31.2(3.6)	29.6(3.4)	4.0*
CB	30.1(3.5)	32.2(4.2)	30.7(4.4)	6.6**
BWT	60.3(6.3)	63.5(3.4)	67.4(7.1)	6.8**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

MUAC = Mid upper arm circumference, CG = Chest girth, WG = Waist girth,
HG = Hip girth, THC = Thigh circumference, BID = Bi-iliac diameter,
CB = Chest breadth, BWT = Body weight.

The table 2 depicts the ANOVA of the mean (sd) values of the circumferential and girth measurements among the three groups of women. All the five circumferential measurements show highly significant ($p < 0.0001$) differences among the three groups of studied women.

Table 3. Correlation of girth and circumference measurements with Estradiol (E_2) among the three groups of women

Variables	Fertile	Perimenopausal	Postmenopausal
MUAC	0.247**	-0.063	0.555
CG	0.452**	0.021	0.251*
WG	0.301*	0.035	0.397**
HG	0.175	0.034	0.322**
THC	0.241**	0.147	0.148

* $p < 0.05$; ** $p < 0.01$

MUAC = Mid upper arm circumference, CG = Chest girth, WG = Waist girth, HG = Hip girth, THC = Thigh circumference

The correlation of the hormone estradiol (E_2) with the circumferential and girth measurements is shown in table 3. Significant correlations are seen in the fertile women with these measurements except the hip girth. The perimenopausal group do not show any significant correlation in any of the measurements. In the postmenopausal group only the girth measurements are seen to correlate with the hormone E_2.

Table 4. Correlation of girth and circumference measurements with Follicle Stimulating Hormone (FSH) among the three groups of women

Variables	Fertile	Perimenopausal	Postmenopausal
MUAC	0.006	0.058	-0.267**
CG	0.133	0.106	-0.252*
WG	0.187*	0.196	-0.043
HG	0.171	0.047	-0.211*
THC	-0.027	0.390**	-0.044

* $p < 0.05$; ** $p < 0.01$

MUAC = Mid upper arm circumference, CG = Chest girth, WG = Waist girth, HG = Hip girth, THC = Thigh circumference

Table 4 represents the correlation of the hormone, follicle stimulating hormone (FSH) with the circumferential and girth measurements in all the three groups of women. The waist girth only in case of the fertile women show significant correlation with FSH. In the perimenopausal women only the thigh circumference correlate significantly with FSH. The postmenopausal women show negative significant correlation of mid upper arm circumference, chest and waist girth.

Table 5. Correlation of girth and circumference measurements Luteinizing Hormone (LH)among the three groups of women

Variables	Fertile	Perimenopausal	Postmenopausal
MUAC	-0.094	0.139	0.197*
CG	-0.080	0.131	0.412*
WG	0.052	0.332	0.173
HG	-0.06	0.126	0.225*
THC	-0.165	0.021	0.050

* $p < 0.05$

MUAC = Mid upper arm circumference, CG = Chest girth, WG = Waist girth, HG = Hip girth, THC = Thigh circumference

In table number 5, it is clearly shown that only significant correlation of the mid upper arm circumference, chest girth and hip girth with the luteinizing hormone (LH) exists. In the other two groups, no measurement is found to correlate with LH.

Table : 6. Mean (SD) and ANOVA of the serum hormone concentration among the fertile, perimenopausal and postmenopausal women.

Hormones	**Fertile**	**Perimenopausal**	**Postmenopausal**	**F**
E_2	65.98(10.7)	33.82(6.3)	28.74(7.1)	610.17***
FSH	5.24(1.9)	30.85(5.1)	32.86(5.7)	1317.84***
LH	11.04(2.6)	29.65(5.6)	32.01(6.1)	598.75***

*** = $p < 0.0001$

The Table no. 6 represents that all the three female sex hormones show high significant differences among the fertile, perimenopausal and postmenopausal women.

DISCUSSION

Significant differences were found in case of the bi-iliac diameter (at 0.05 level) and chest breadth (at 0.01 level) in the fertile, premenopausal and postmenopausal women. Most of the girth measurements (chest and waist girth), circumferential measurements (upper arm, thigh) show highly significant ($p < 0.001$) differences in the three groups, where measurements show values increasing from fertile group to premenopausal group and highest among the postmenopausal group. These findings are in well accordance with the findings of (Kirchengast et al., 1998) in a study conducted among the Austrian women. It seems probable that, this is due to the menopause associated weight gain and changes in fat patterning induced by the hormonal changes (Macdonald et al., 2003). The present study shows significant increase in body weight (at 0.05 level) from fertile to premenopausal and then to postmenopausal women. The increase in body weight and waist circumference during the menopausal phase may result not only from reduced physical activity but primarily from metabolic changes dependent on hormonal changes (De Aloysio et al., 1988). Fat distribution is significantly correlated with women's sex hormone profile, risk for disease and reproductive capability (Singh et al., 1998).

Thus, women gain the gynoid body fat pattern having greater amounts of body fat in the lower part of the body, whereas men have greater amounts of fat in the upper body gaining the android body fat. This shape has a plausible linkage to physiological mechanism regulating reproductive capability and good health (Singh et al., 1998). After the menopause a typical increase in trunk fat tissue especially at the abdominal areas, can be observed (Kirchengast et al., 1998). With the menopause the more gynoid type of fat patterning may change towards a more android type (Weiderpass et al., 2004). The postmenopausal women have higher values for the thigh circumference and waist girth. The development of lower body fat depots and the more gynoid fat distribution may be induced by oestrogen (Kirchengast et al., 2001). The serum hormone concentrations revealed significant differences in all the three categories of women in the present study. Significantly higher serum levels of E_2 was manifested in the fertile subjects, with lesser levels in the perimenopausal group and the least values seen in the postmenopausal women. FSH and LH had highest values in the postmenopausal group, as compared to lesser values in the perimenopausal group and the least values in the fertile group. These findings are in accordance to the known hormonal status and physiological condition of the women (West ed.,

1990). It is well established that the hormonal changes occur with the onset of menopause, bringing down drastically the level of estradiol and resulting in the cessation of reproductivity. On the other hand, reduced oestrogen secretion seem to be responsible for the typical changes in female fat patterning during and after menopause (Panotopoulos et al., 1996). The cause for weight gain during this phase of life can be ascribed to reduced physical activity, increased food intake and the metabolic changes dependent on hormonal changes. It seems probable that, this is due to the menopause associated weight gain and changes in fat patterning induced by the hormonal changes.

With regard to the correlations between anthropometric variables and estradiol, the fertile women showed positive correlations with the waist girth, thigh and upper arm circumferences. The follicle stimulating hormone, shows significant positive correlations with thigh circumference in the perimenopausal group and upper arm circumference in the postmenopausal women. The postmenopausal group show negative correlations with chest girth measurements. The luteinizing hormone, give a very distinct picture correlating highly positively with most of the breadth and girth measurements only in the postmenopausal group.

It can thus be said that, it becomes difficult to interpret the individual results of this study, as the mode of action of hormones on the expression of morphologic traits is still not clear in many cases (Barber et al., 2008). This can be explained further as decisive morphogenetic changes have already taken place during adolescence and that women are subject to hormonal changes in the different phases, as life progresses (Kirchengast, 1993). This is well manifested in this study, in not only significant differences of hormone levels between both groups of women, but probably also with respect to changes of direction of correlations with body dimensions. The present study reveals that all the three hormones correlated differently with the body measurements in all the three groups of women. Estradiol correlates highly with the mid-upper arm circumference, chest girth, waist girth, and thigh circumference in the fertile group. Whereas estradiol show no correlation with any of the measurements in the premenopausal women but again positive correlations are shown in the postmenopausal group in chest girth, waist girth and thigh circumference. After the menopause a typical increase in trunk fat tissue especially at the abdominal areas, can be observed (Kirchengast et al., 1998). With the menopause the more gynoid type of fat

patterning may change towards a more android type (Weiderpass et al., 2004). . This can be explained from Tonkelaar et al., (1989), that fat depots in these regions are energy stores for somatic stress phases such as lactation. During fertile life, characteristic differences between the morphology and metabolism of adipocytes in the femoral and abdominal region exist (Welborn et al., 2000). The development of lower body fat depots and the more gynoid fat distribution may be induced by oestrogen (Kirchengast, 1998).

In this study, although there was high significant difference in the concentration of oestradiol between the postmenopausal and fertile women, the breadth and circumferential measurements correlated positively and significantly with level of oestradiol. This can be further explained, as importance of fat tissue for oestrogen production during the menopause. Women with higher circumference and breadth measures produce more oestrogen during the menopause as compared to slender women (Genazzani et al., 2006).

Further work with large sample size including more number of hormonal variables is necessary to understand accurately, the anthropometric-hormonal correlation in women. In this regard, the ethnic heterogeneity of the Indian people offers a unique opportunity for the anthropologists to undertake similar line of research.

CONCLUSION :

These results permit to state the following conclusions: the greatest weight gain in the menopause group suggest weight gain acceleration around menopause. Menopause is associated with an increase in body fat and an increase in the relative proportion of abdominal fat. Women with abdominal fat distribution may have more endogenous available estrogens. Abdominal adiposity in postmenopausal women is associated with a more androgenous hormonal profile. There is an increase in the ‘android’ kind fat but a relative reduction in the ‘gynoid’ fat in postmenopausal women. Thus, compared with fertile, perimenopausal women, fat distribution in postmenopausal women is changing towards that of a man.

ACKNOWLEDGEMENT : The authors are grateful to the participant women for sparing their valuable time. Without them this study could not have been completed.

CONFLICT OF INTEREST: The authors declare no conflict of interest

ETHICAL APPROVAL : As it was a part of the Ph. D. thesis work, the proposal was approved by the appropriate Ph. D committee of the Dept. Anthropology, University of Calcutta, Kolkata.

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