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ANTHROPOMETRIC CHARACTERISTICS, FASTING PLASMA GLUCOSE AND LIPID PROFILE IN PREMENOPAUSAL AND POSTMENOPAUSAL WOMEN FROM NAXALBARI IN DARJEELING, WEST BENGAL

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Abstract: Glucose and lipid metabolism alterations are associated with menopause. The objectives of the present study were to 1) evaluate the differences in anthropometric characteristics, body fat, and lipid profile between premenopausal and postmenopausal women aged 40 to 44 years; 2) assess the magnitude of the parameters to distinguish between two groups. The study was cross-sectional, and participants were 40 to 44-year-old premenopausal (n = 50) and postmenopausal (n = 50) women. Height, weight, and waist circumference were measured. Body fat (%) was evaluated using a bioelectrical impedance analyzer. Levels of fasting plasma glucose (FPG), triglycerides, low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C) were estimated. Body mass index (BMI), total cholesterol (TC), and non-HDL-C were calculated. Discriminant function analysis was used to distinguish between pre- and postmenopausal groups by FPG and non-HDL-C. Mean values of age (premenopausal 42.34 years, postmenopausal 42.23 years) were not different. Mean age at menopause was 41.30 years. Postmenopausal women had higher mean values of body fat (22.17%), FPG (117.43 mg/dL), triglycerides (153.65 mg/dL), LDL-C (133.77 mg/dL), TC (169.83 mg/dL), non-HDL-C (133.84 mg/dL) in comparison with the corresponding values among premenopausal women (18.28%, 82.82 mg/dL, 96.88 mg/dL, 104.74 mg/dL, 143.98 mg/dL, 104.75 mg/dL respectively) with significant differences ($p<0.05$). Postmenopausal women showed higher prevalence of BMI-based thinness or undernutrition (28.0%), excess weight (overweight and obesity) (24.0%), hypertriglyceridemia (38.0%), high LDL-C (56.0%), and low HDL-C (56.0%) in comparison with the corresponding percentages in premenopausal women (16.0%, 20.0%, 8.0%, 32.0%, and 42.0%, respectively). High prevalence of type 2 diabetes mellitus was observed among postmenopausal women (60.0%). No premenopausal woman was diabetic. Canonical discriminant function of FPG and non-HDL-C was significant to distinguish between pre- and postmenopausal women. In conclusion, postmenopausal women were significantly different from premenopausal peers with respect to body fat (%), FPG, and lipid profile characteristics.

Keywords: Menopause; Body fat; Diabetes, Triglycerides, LDL-C, Total cholesterol, Non-HDL-C.

INTRODUCTION

Menopause is the end of a woman's reproductive years that is characterized by the decline of ovarian follicular estrogen production and consecutive 12 months of amenorrhea (Sherman, 2005; WHO, 1981, 1996). Menopause has significant impacts on physical and psychological health and changes of social status in women's lives (Namazi et al., 2019). Major physiological changes at menopause take place in the endocrine system. Estrogen is the primary female sex hormone that controls female reproductive system and secondary sex characteristics. During menopause, relative decrease of estrogen and increase of androgen cause certain metabolic changes.

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Low-density lipoprotein cholesterol (LDL-C) is used as a substrate in the metabolic pathway to produce estrogen. Therefore, estrogen deficiency at menopause causes elevated levels of lipoproteins and consequently affects cardiovascular health (Ko and Kim, 2020). Estrogen-induced gluteo-femoral fat in the premenopausal age decreases in postmenopausal age. Dysregulation of lipid metabolism in association with the changes in relative levels of estrogen and androgen result in the changes of adiposity and body composition characteristics, development of visceral fat and central obesity in the postmenopausal age. Risks for cardiometabolic diseases and type 2 diabetes mellitus (T2DM) increase at menopause (Ko and Kim, 2020; Spangenberg et al., 2016; Stefanska et al., 2015).

Development of T2DM, overweight and obesity (excess weight) among postmenopausal women are associated with psychosocial stress (Namazi et al., 2019). The biological mechanism directly associated with the development of T2DM and excess weight originates from the hypothalamic–pituitary–adrenal axis (HPA axis) under the conditions of stress, anxiety, and depression. Visceral fat accumulation is induced by the insulin resistance and gluconeogenesis, and lipolytic pathways are stimulated, which activate the receptors causing damage to neurons and inflammation of the hypothalamus that eventually leads to metabolic defects such as obesity, T2DM, and metabolic syndrome (Josephand Golden, 2017; Sears and Perry, 2015).

Elevated levels of fasting plasma glucose (FPG), triglycerides (TG), LDL-C, total cholesterol (TC), non-HDL-C, and decreased high-density lipoprotein cholesterol (HDL-C) among postmenopausal women were reported from China (Guo et al., 2020; Wang et al., 2016; Wu et al., 2018), Korea (Cho et al., 2011), Nepal (Khakurel et al., 2018), Nigeria (Nwagha et al., 2010), and Brazil (Alvim et al., 2017) in last ten years. Studies also reported association of dysregulation of lipid metabolism with increased risk for cardiovascular diseases (CVDs) in postmenopausal women (Alvim et al., 2017; Cho et al., 2011;Guo et al., 2020; Wu et al., 2018). Similar studies were not available from India in recent years except one (Kilim and Chandala, 2013). A study from West Bengal reported metabolic syndrome in pre- and postmenopausal women (Ghosh, 2008).

In this background, objectives of the present study were to 1) evaluate the differences in anthropometric characteristics, body fat, and lipid profile between premenopausal and postmenopausal women aged 40 to 44 years; 2) assess the magnitude of the parameters to distinguish between two groups.

PARTICIPANTS AND METHODS

A cross-sectional study was carried out in 2012 at Naxalbari *Panchayat* or village council (a statutory body of the government that executes community development programs in rural areas) in Darjeeling district of West Bengal. Villages at Naxalbari

were located approximately 35 to 40 kilometers away from the nearest town Siliguri and 600 kilometers away from Kolkata (previously Calcutta), the capital of the state of West Bengal. Ethical clearance was obtained from the institutional committee in connection with a research project (see Acknowledgements). The informed consent form was signed (or put thumb impression) by the participants and two witnesses from the family or community. Sampling was not probabilistic. People representing Dhimal, Mech, Limbu, Rai, Rajbanshi, and Muslim communities are living at Naxalbari. A household survey registered 172 women (91 postmenopausal) between 40 and 44 years of age. The present sample selected 100 women aged 40 to 44 years (50 premenopausal and 50 postmenopausal) from the list who agreed to participate. The participant women reported an approximate age that matched with the official documents issued by the government. Decimal age of the participants has been estimated based on date of birth [recorded in the voter identity card, issued by the Election Commission of India and *Aadhaar* card, issued by the Unique Identification Authority of India (UIDAI), Government of India] and date of survey.

As reported earlier, menopause between 40 and 44 years was considered as early (Eckhardt and Wellons, 2016). However, mean age at menopause of women from India was 45.59 ± 5.59 years (Ahuja, 2016). In the present study, women were asked their age at menopause and mid-year age at menopause was estimated for analysis. Menopause has been defined as consecutive 12 months of amenorrhea (Sherman, 2005; WHO, 1981, 1996). Aspects of irregular menstruation in perimenopausal stage, caused by the hormonal changes or other unknown physiological and metabolic reasons were not considered for the study. Therefore, women were either pre- or postmenopausal in this cross-sectional study. The participants did not receive any surgical or hormonal treatment that could affect ovarian function.

Anthropometric measurements were recorded following standard protocol (Lohman et al., 1988). Height (cm) was measured to the nearest tenth of a centimeter using a standard stadiometer (Seca, Germany). Body weight was recorded to the nearest 0.05 kg using an electronic scale (Seca, model 881, Hamburg, Germany). Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). Waist circumference (WC) was measured to the nearest 0.1 cm using a standard tape measure (Lufkin). Body fat (%) was estimated using a bioelectrical impedance analyzer (Bodystat: model 1500 MDD), following the manufacturer's manual. Measurements were recorded by a trained researcher. Blood sample (10 ml) has been collected from the participants after 10 to 12-hour fasting; women were asked to avoid taking medicines, smoking and alcohol intake. Levels of fasting plasma glucose (FPG)(mg/dL), triglycerides (TG) (mg/dL), low-density lipoprotein cholesterol (LDL-C) (mg/dL), and high-density lipoprotein cholesterol (HDL-C) (mg/dL) were estimated following laboratory procedures of colourimetric method (Godgar and Godgar, 2003). The diagnosis of type 2 diabetes mellitus (T2DM)

(FPG ≥126.0 mg/dL) (ADA, 2019; WHO, 2006), hypertriglyceridemia (≥150 mg/dL), high LDL-C (≥130 mg/dL), and low HDL-C (<50 mg/dL) followed standard criteria (Alberti et al., 2009).Total Cholesterol (TC) (HDL-C + LDL-C + 20 percent of TG level) and Non-HDL-C (Total cholesterol minus HDL-C) were calculated.

Statistical Package for the Social Sciences (Version 15.00, Chicago IL, USA) was used for data analysis. Descriptive statistics (mean values and standard deviation) of age, anthropometric characteristics (height, weight, BMI, WC, body fat %) and lipid profile parameters (TG, LDL-C, HDL-C, TC, and non-HDL-C) were computed. Normality test of data was done following assumption of Shapiro-Wilk test ($p>0.05$). Accordingly, parametric (Student's t-test) and non-parametric (Mann-Whitney U) tests were used to find significant differences of mean and Z values, respectively between two independent variables. Discriminant function analysis was run to understand how far anthropometric characteristics, FPG, and lipid profile could distinguish between pre- and postmenopausal women. For all statistical tests, $p<0.05$ was taken as the significance level.

RESULTS

Mean age of premenopausal women (42.34 ± 2.02 years) was not different from that of postmenopausal women (42.23± 2.05 years). Mean age at menopause was 41.30 (±2.19) years. Mean values of height, weight, BMI, and waist circumference were not significantly different in pre- and postmenopausal women (Table 1). Postmenopausal women had higher mean values of body fat (%) FPG, triglycerides, LDL-C, total cholesterol, non-HDL-C, and lower HDL-C in comparison with the corresponding values estimated among premenopausal women with significant differences ($p<0.05$), except for HDL-C (Table 1).

TABLE 1: DESCRIPTIVE STATISTICS OF AGE, ANTHROPOMETRIC CHARACTERISTICS, BODY FAT PERCENT, FASTING PLASMA GLUCOSE, AND LIPID PROFILE OF PREMENOPAUSAL (N = 50) AND POSTMENOPAUSAL WOMEN (N = 50)

Variables	Premenopausal women (n = 50)	Postmenopausal women (n = 50)	t/Z	p-value
	Mean (SD)	Mean		
Age (years)	42.34 (2.02)	42.23 (2.05)	0.28	0.78
Height (cm)	152.70 (7.79)	152.78 (9.41)	0.05	0.96
BW (kg)	51.22 (9.33)	52.19 (13.50)	0.42*	0.67
BMI (kg/m^2)	22.03 (4.21)	22.55 (6.64)	0.65*	0.52
Body fat (%)	18.28 (5.72)	22.17 (6.89)	-2.70*	**<0.05**
WC (cm)	72.94 (8.55)	77.15 (13.26)	1.88	0.06
FPG (mg/dL)	82.82 (8.30)	**117.43 (38.93)**	-6.78*	**<0.0001**

TG (mg/dL)	96.88 (34.10)	**153.65 (111.14)**	-4.19*	**<0.0001**
HDL-C (mg/dL)	39.23 (8.23)	35.99 (12.33)	-1.56	0.12
LDL-C (mg/dL)	104.74 (36.07)	**133.77 (26.31)**	-4.44	**<0.0001**
TC (mg/dL)	143.98 (37.73)	**169.83 (26.94)**	-3.95	**<0.0001**
Non-HDL-C	104.75 (36.06)	**133.84 (26.30)**	-4.47	**<0.0001**

SD: Standard deviation; BW: Body weight; BMI: Body mass index; WC: Waist circumference; FPG: Fasting plasma glucose; TG: Triglycerides; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; TC: Total cholesterol; Non-HDL-C: Non- high-density lipoprotein cholesterol; * Z-value of Mann-Whitney U.

Prevalence of BMI-based thinness (22.0%), overweight (13.0%), obesity (9.0%), T2DM (30.0%), hypertriglyceridemia (23.0%), high LDL-C (44.0%), and low HDL-C (49.0%) were remarkablein the sample (n=100). Association of BMI-based nutritional status (thinness, overweight, and obesity) with menopause status (pre- and postmenopause) was not significant (Chi-square = 3.85, p = 0.28).

TABLE 2. PREVALENCE OF BMI-BASED NUTRITIONAL STATUS, T2DM, AND ABNORMAL LIPID PROFILE INPREMENOPAUSAL (N = 50) AND POSTMENOPAUSAL WOMEN (N = 50)

Variables	All (n = 100)	Premenopausal women (n = 50)	Postmenopausal women (n = 50)
	(%)	(%)	(%)
BMI-based thinness	22.0	16.0	28.0
Overweight	13.0	14.0	12.0
Obesity	9.0	6.0	12.0
T2DM	30.0	0.0	60.0
Hypertriglyceridemia	23.0	8.0	38.0
High LDL-C	44.0	32.0	56.0
Low HDL-C	49.0	42.0	56.0

T2DM: Type 2 Diabetes Mellitus

Postmenopausal women showed higher prevalence of thinness, overweight, obesity, hypertriglyceridemia, high LDL-C, and low HDL-C than corresponding percentages inpremenopausal women (Table 2). High prevalence of T2DM was observed among postmenopausal women T2DM (60.0%). However, no premenopausal woman was diabetic. Significant association ($p<0.05$) of the percentages between two groups were observed with respect to hypertriglyceridemia (Chi-square = 12.01) and high LDL-C (Chi-square = 5.84) levels. However, associationof low HDL-C with menopause status was not significant (Chi-square = 1.96, p = 0.16).

TABLE 3: DISCRIMINANT FUNCTION ANALYSIS FOR PRE- AND POSTMENOPAUSAL STATUS

Discriminant function analysis model	Status: premenopause = 0; postmenopause= 1
Canonical discriminant function =	-4.74 + 0.03 FPG+ 0.02 Non-HDL-C
Classification functions:	
Fisher's linear discriminant function 1* =	-9.23 + 0.09 FPG + 0.09 Non-HDL-C
Fisher's linear discriminant function 2** =	-16.03 + 0.13 FPG + 0.12 Non-HDL-C
Eigen value	1.53
Canonical correlation coefficient	0.59
Box's M	2.52
Wilks' Lambda	0.66
Chi square (p-value)	40.98 (<0.001)
Correlation coefficient between predictors	0.15
FPG: Fasting plasma glucose * Classification function coefficient for premenopausal women ** Classification function coefficient for postmenopausal women	

A discriminant function analysis (DA) model was used to distinguish between pre- and postmenopausal women, based on FPG and non-HDL-C (Table 3). BMI, body fat (%), and waist circumference had <0.30 loading in the discriminant function and thereby, have been removed from the analysis. The DA model for menopause status (pre and post), taking FPG and non-HDL-C as independent variables was significant ($p<0.001$) as tested by ANOVA. There was no missing data (50 premenopausal and 50 postmenopausal women) and correct classification rate was 75.0% in the model. In the test of equality of group means, it was evident that FPG was more important independent variable to the discriminant function with smaller Wilks' lambda value (0.72) than non-HDL-C (0.82). The Wilks' lambda values were significant by the F test for the independent variables. Within-groups correlation matrix showed that correlations between the predictors was not significant (coefficient = 0.15, $p>0.05$). Box's M (value = 2.52) test did not violate the assumption ($p>0.05$); predicted groups did not differ in their covariance matrices. Association between DA model and the menopause status (pre and post) as tested by canonical correlation coefficient was high (0.59). Eigen value (1.53) showed remarkable variance in the dependent variable as explained by the function.Wilks' Lambda value was low (0.66) that indicated greater discriminatory ability of the function and Chi-squared test result (value = 40.98) was significant ($p<0.001$) in the model (Table 3). The structure matrix showed higher correlations of FPG (0.86) than non-HDL-C (0.64) with the discriminant function. Separate-group plots for pre- and postmenopausal women did not overlap so much (image is available from

the author on request).

DISCUSSION

It was evident that postmenopausal women were significantly different from premenopausal peers with respect to body fat (%), fasting plasma glucose (FPG), and lipid profile characteristics. According to a previous report, transition age at menopause is crucial for such metabolic changes (Eckhardt and Wellons, 2016). Estimated mean age at menopause in the present study was within the age range as reported earlier from India (Ahuja, 2016). In general, HDL-C level was remarkably low in the sample with no significant difference in pre- and postmenopausal women. High degree coexistence of BMI-based undernutrition and excess weight in the sample was another issue that was also not very different in pre- and postmenopausal women. Dual burden of malnutrition is reported from different populations in India (Bharati et al., 2007; Kapoor and Krishnan, 2002; Rengma et al., 2015).This is an important issue that calls for research among pre- and postmenopausal women with bigger sample size from different populations. No premenopausal woman was diabetic in the present study. On the other hand, high prevalence of T2DM (60.0%), hypertriglyceridemia (38.0%), and high LDL-C (56.0%) among postmenopausal women were matters of serious concern that indicate consequences of metabolic changes due to menopause. There was no similar study available from the region and therefore, the results of the present study could not be compared with others.

Studies from India (Kilim and Chandala, 2013) and Nepal (Khakurel et al., 2018) reported postmenopausal women had higher TG, LDL-C, and lower HDL-C levels than premenopausal women. A study carried out in West Bengal, selected 100 premenopausal (mean age 40.2 ± 6.5 years) and 100 postmenopausal (mean age 55.4 ± 5.2 years) Bengalee women in Kolkata and suburbs (Ghosh, 2008). Significant group differences with respect to higher mean values of anthropometric characteristics (BMI, waist circumference) and lipid parameters (triglycerides, TC, HDL-C, FPG and blood pressure) were observed. Age-group difference between the pre- and postmenopausal women was very wide. Higher mean values of body fat (%), LDL-C, TC, triglycerides, and lower HDL-C were also observed in the present study among pre- and postmenopausal women.

In a retrospective cohort-based study from Korea, over a span of 2-4 years (3 visits), women were 47.9 year-old premenopausal (n = 34), some women (n = 34) were in the transitional age (50.6 year-old perimenopausal), and 55.6 year-old women (n= 36) were postmenopausal (Cho et al., 2011). The results showed highest mean values of FPG, TG, LDL-C, and TC among perimenopausal women when compared with the values recorded among pre- and postmenopausal women. It was evident that metabolic changes were greatest among women at the transitional

phase from pre- to postmenopausal age. In the present cross-sectional study, participants were considered as either pre- or postmenopausal. Metabolic changes were profound among postmenopausal women and thereby, mean values of FPG and lipid profile characteristics were significantly different from premenopausal peers of same age-group. No significant differences were observed with respect to BMI and waist circumference between pre- and postmenopausal women. However, postmenopausal women had significantly higher body fat (%). The results indicate that certain changes took place in the body composition characteristics (fat free mass to fat mass) due to menopause and body weight status (BMI) was not different in two groups.

A study among Chinese women aged 40 to 59 years, reported higher prevalence of dyslipidemia (69.7%) among postmenopausal women than premenopausal group (24.3%). Mean values of TG, LDL-C, and non-HDL-C were significantly higher among postmenopausal women (Wang et al., 2016). Association of lipid metabolism alternation due to menopause with CVD has been reported by previous studies. A cohort-based study among postmenopausal women aged 50 years and above from Beijing, China reported significant association of lipid profile (elevated TG, LDL-C, non-HDL-C and lower HDL-C) with coronary artery disease (CAD) (Guo et al., 2020). Another study from China also reported that postmenopausal CAD patients had significantly higher levels of TG, LDL-C, and TC in comparison with non-CAD peers (Wu et al., 2018).

A descriptive study from Nigeria reported higher mean values of lipid parameters and lower HDL-C among postmenopausal women (n = 50) aged 50 to 70 years with significant inter-group difference from premenopausal women (n = 30) aged 25 to 49 years (Nwagha et al., 2010). However, age range of pre- and postmenopausal women were different and impacts of age-related factors on health and metabolism were not considered in the study. Postmenopausal women from urban regions of Vitoria, Brazil had higher FPG (114.1 mg/dL), TG (145.0 mg/dL) LDL-C (161.6 mg/dL), non-HDL-C (191.2 mg/dL) in comparison with the corresponding values of FPG (99.4 mg/dL), TG (106.6 mg/dL), LDL-C (135.2 mg/dL), and non-HDL-C (156.5 mg/dL) estimated among premenopausal women (Alvim et al., 2017). In the present study from Darjeeling, postmenopausal women had higher TG, LDL-C, non-HDL-C, and lower HDL-C values. The women from Naxalbari had similar FPG value that was reported from Brazilian women. Results from the both studies showed similar tendency of higher mean values of characteristics among postmenopausal women than premenopausal peers. However, age of Brazilian premenopausal women (40.2 years) was significantly different from the estimated value among postmenopausal women (54.8 years) that might have association with metabolic changes. In the study from Brazil, non-HDL-C was reported to be a significant risk factor for CVD.

There were several limitations in the present study. Differential lipid profile

parameters in pre- and postmenopausal women were not further analyzed to find the association with blood pressure and hypertension. Previous studies had reported significant association of CVD with lipid metabolism alternations in postmenopausal women. In addition, previous studies also found association of lifestyle habits (diet, exercise, smoking, alcoholism) with hypertension and elevated lipid profile characteristics among postmenopausal women (Alvim et al., 2017; Cho et al. 2011; Guo et al., 2020). These details will be explored in future studies.

CONCLUSION

The present study contributes some important data on the association of body fatness, FPG, and lipid profile characteristics with menopause among women from Naxalbari in West Bengal. Postmenopausal women had higher body fat, elevated FPG, TG, LDL-C, TC, non-HDL-C, and lower HDL-C levels in comparison with premenopausal peers. Discriminant function analysis determined FPG and non-HDL-C as independent variables to classify pre- and postmenopausal status that needs further verification in future research from other populations.

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Abbreviations: BMI: Body mass index; CVD: Cardiovascular disease; FPG: Fasting plasma glucose; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; TC: Total cholesterol; T2DM: Type 2 diabetes mellitus; TG: Triglycerides.

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