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The Association between Malondialdehyde and Body Fat Mass Indices in Postmenopausal Women: An Analysis of Oxidative Stress and Adiposity

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ABSTRACT

Background: The postmenopausal period is characterized by metabolic changes that often lead to increased central adiposity. Concurrently, the decline in estrogen is linked to elevated oxidative stress. Malondialdehyde (MDA), a primary biomarker of lipid peroxidation, serves as a key indicator of oxidative damage.

Aims and Objectives: The aim of the study is to associate oxidative stress with Body Fat Mass Indices in Postmenopausal Women with normal and high BMI.

Materials and Methods: This research was directed on 104 postmenopausal women of age 45–60 years grouped them into two. Group 1 having normal BMI (18.50–24.99) and Group 2 having high BMI >25.00 based on Asian's classification for BMI. Approval from the Institutional Ethical Committee was obtained before beginning the study. Body fat composition was measured using the equipment named Bodystat that uses the technique of bioelectrical impedance analysis. The oxidative stress marker Malondialdehyde was measured from the serum samples using a fully automated clinical ELISA workstation analyser.

Statistical analysis: Unpaired t-test was used to analyse all parameters of the study (control and study group).

Results: Consistent positive correlations were observed between serum MDA levels and various indices of body fat mass. Studies indicate that higher adiposity, particularly visceral fat, is a significant contributor to oxidative stress. In this study it was revealed that this relationship is influenced by dietary patterns, physical activity levels, and duration since menopause.

Conclusion: There is a strong, positive association between MDA concentration and body fat indices in postmenopausal women. This suggests that managing adiposity through lifestyle interventions could be a crucial strategy in relieving oxidative stress and reducing the risk of associated chronic diseases in this population.

Keywords: *Postmenopausal women, Body Fat mass indices, oxidative stress, BMI, Malondialdehyde*

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1. INTRODUCTION

A woman's menstrual cycle permanently stops after the menopause, a natural biological process that signifies the end of her reproductive years. This is caused by a decrease in ovarian follicular activity. Numerous physiological changes are brought on by the substantial drop in estrogen levels that occurs throughout this transition. Among the most noticeable changes is a change in body composition, which includes a rise in body fat and a redistribution of adipose tissue to the abdomen, resulting in a higher android (central) fat pattern.[1]

Increased body fat, especially visceral fat, is not a physiologically inactive condition. Particularly when hypertrophied, adipose tissue functions as an endocrine organ that secretes pro-inflammatory cytokines and encourages oxidative stress and chronic, low-grade inflammation.[2] An imbalance between the body's antioxidant defence systems and the generation of reactive oxygen species (ROS) leads to oxidative stress. Lipid peroxidation, in which ROS attack polyunsaturated fatty acids in cell membranes, produces malondialdehyde (MDA), one of the most common and extensively researched byproducts. Its level in blood or plasma is a sensitive and accurate biomarker for determining an individual's level of oxidative stress.[3] Given that postmenopausal women are at an elevated risk for both obesity-related metabolic disorders (e.g., cardiovascular disease, type 2 diabetes) and conditions linked to oxidative damage (e.g., osteoporosis, certain cancers), understanding the interplay between adiposity and oxidative stress is critical.[4,5] This paper aims to synthesize evidence to elucidate the relationship between malondialdehyde levels and body fat mass indices in postmenopausal women.[2-6]

2. MATERIALS AND METHODS

Participants

The study was carried out on 104 postmenopausal women after receiving approval from the Institutional Ethics Committee for Human Studies and the JIPMER Scientific Advisory Committee (JSAC). The women were divided into two groups, with group 1 having a normal BMI (18.50–24.99) and group 2 having a high BMI >25.00 according to Asian BMI classification. Age and menopausal duration were matched equally among the subjects. Subjects were gathered from the JIPMER Obstetrics and Gynaecology OPD as well as from employees and their families who lived on campus

Inclusion Criteria:

During the study period, postmenopausal women aged 45–60 who were normotensive, free of serious systemic diseases, nonsmokers, and able to avoid caffeine, caffeine-containing beverages, medications, and alcohol were included.

Exclusion Criteria:

Postmenopausal women of less than 45 and above 60 yrs, Tachycardia, Cardiac arrhythmias, Hypertension, Diabetes, Ischaemic heart disease, Retinopathy, Neuropathy, Any chronic disease or associated factors that may affect the autonomic reflexes, Neurological disease, Psychiatric diseases, Chronic alcoholics, Women receiving hormone replacement therapy and taking any medication that have been reported to affect BRS (like for instance autonomic blockers)

Before beginning the study procedures, all postmenopausal women who were taking part in this study gave their written informed consent after being informed of the study protocol in their mother tongue. After obtaining their history, each participant was asked to complete an individual data sheet. Subjects were instructed to refrain from engaging in any physically demanding activities, drinking alcohol, smoking, or consuming caffeinated beverages for at least 12 hours before to the recording. At least 48 hours before to the recordings, subjects were instructed not to take any tranquilizers or sleeping drugs.

Anthropometric Indices:

A weighted machine and height strands were used to capture the physiological and physical data. A stadiometer was used to measure the subjects' height in centimeters and their weight in kilograms using a digital weighting machine while they were barefoot and wearing very little clothing. The Quetlet index, which uses the person's height and body weight, was used to determine BMI. Non-elastic steel tape (CESCORF, Brazil, South America) was used to measure circumferences. Hip circumference was measured at the level of the buttocks' greatest posterior protuberance, and waist circumference (WC), which is located between the lower costal border and the top of the iliac crest, was also measured. WHR and WHtR were among the other indices that were computed.

Body Fat Analysis:

A device called Bodystat (Model QuadScan 4000, Isle of Man, United Kingdom) that employs the bioelectrical impedence analysis (BIA) method was used to measure the body fat composition [9,10]. Based on the multi-frequency bioelectrical impedence principle analysis evaluates body composition and has been approved by the National Institutes of Health (NIH, U.S.A.) for use in nutritional surveys [11,12]. An electrical impedence plethysmograph with a four electrode configuration that creates a painless alternating current of 500 to 800 micro amperes in the body was used to measure resistive impedence (R). Participants were told not to eat or drink anything for two hours before the test. For at least ten minutes, the subjects were kept in a supine position with no body parts touching one another in a calm environment with a temperature maintained between twenty-four and twenty-six degrees Celsius. The electrodes were positioned proximal to the metatarsal-phalangeal and metacarpal-phalangeal joints on the dorsal surfaces of the hand and foot, respectively. The subjects were instructed not to move any body parts and to keep silent so as not to interfere with the electrodes. 1. Body cell. 2. Water inside cells 3. Water outside of cells 4. Water content of the body 5. Lean body mass 6. Nutritional index and body fat mass mass were the parameters evaluated by Bioelectric Impedence Analysis

BLOOD COLLECTION: Participants were instructed to report to the department of Physiology at 7.30 a.m, after overnight fasting. 5ml of blood sample was collected by venipuncture, from antecubital vein. The blood was allowed to coagulate and then centrifuged at 2300 rpm for 10 minutes. Then the serum was separated by using sterile micropipette tips and stored in the deep freezer until further estimation of biochemical parameters.

The oxidative stress marker Malondialdehyde was measured from the serum samples using fully automated clinical ELISA workstation analyser.

Statistical Analysis of Data:

Data were analyzed using Statistical Product and Service Solutions (SPSS) (IBM SPSS Statistics for Windows, Version 20.0, Armonk, NY). The distribution of continuous data such as age, height, weight, BMI, WC, HC, WHR, WHtR, BF (%), FFM (%), Dry lean (Kg), BCW (Kg), TBW (%), ECW (%), ICW (%), BM (Kcal/day), BM/Wt (Kcal/kg), AM (kcal/day), BFMI, FFMI, MDA values was expressed as mean ± standard deviation. Statistical analysis was done by student unpaired t-test. Correlation between MDA and Body Fat mass indices was done by Pearson's correlation. The p value < 0.05 was considered statistically significant.

3. RESULTS

Table 1: Age and Anthropometric indices in normal and high BMI postmenopausal women

Parameters	Normal BMI (n=50)	High BMI (n=54)	P value
Age	51.68± 4.96	50.46±5.05	0.219
Weight (Kg)	52.44± 7.29	67.17±8.469	<0.000
Height (cm)	153.56± 6.23	151.98±6.00	0.190
BMI	22.16±2.08	29.06±3.18	<0.000
Waist circumference(cm)	81.19±7.91	87.94±9.35	<0.000
Hip circumference (cm)	94.80+ 7.76	100.25±10.20	0.003
Waist : hip	0.85±0.41	0.87±0.04	0.037*
Waist:height	0.52±0.57	0.57±0.06	0.000

The values are expressed as Mean± SD; Statistical analysis was done by student unpaired t-test. The P value <0.05 was considered statistically significant.

BMI: body mass index. *Mann-Whitney test was performed.

Table 2: Comparison of body composition indices in normal BMI and high BMI postmenopausal women

Parameters	Normal BMI (n=50)	High BMI (n=54)	P value
BF (%)	20.28±3.58	29.31±4.47	<0.000
FFM (%)	79.72±3.58	70.68±4.47	<0.000
Dry lean (Kg)	11.58±1.75	19.50±4.32	<0.000
BCW (Kg)	24.00±2.46	30.83±3.58	<0.000
TBW (%)	56.09±12.13	51.37±3.04	<0.010
ECW (%)	24.34±1.99	23.79± 2.77	0.252
ICW (%)	31.62±2.86	29.92±3.26	0.006
BM (Kcal/day)	1347.64±172.37	1791.42±160.05	<0.000
BM/Wt (Kcal/kg)	26.78±1.11	23.92±1.52	<0.000
AM (kcal/day)	1989.78±192.89	2645.24±149.27	<0.000
BFMI	4.54±0.81	6.42±1.31	<0.000

The values are expressed as Mean±SD; Statistical analysis was done by student unpaired t-test. The P value <0.05 is considered statistically significant BF: body fat; FFM: free fat mass; BCM: body cell mass; TBW: total body water; ECW: extracellular water: ICW: intracellular water; BM: basal metabolism; BM/WT: basal metabolism to body weight ratio; AM: activity metabolism; BFMI: body fat mass index; FFMI: free fat mass index.

Table 3: Comparing Malondialdehyde with normal and high BMI postmenopausal women

Parameters	Normal BMI n= 50	High BMI n= 54	P Value
Malondialdehyde (μM/L)	9.65 ± 1.85	14.21 ± 1.93	< 0.000

Table 4: Effect of correlation (r) for Body Fat mass indices with MDA between Normal BMI and High BMI postmenopausal women

Parameter	Normal BMI (Mean ± SD)	High BMI (Mean ± SD)	r value	P value
BF%	20.28 ± 3.58	29.31 ± 4.47	0.74	<0.000
MDA (μM/L)	9.65 ± 1.85	14.21 ± 1.93	0.77	< 0.000

Both BF% and MDA show highly significant differences ($p < 0.000$), and strong positive associations ($r > 0.70$). These findings indicate that higher adiposity in postmenopausal women is closely linked with increased oxidative stress (MDA levels)

4. DISCUSSION

Body fat mass indices in postmenopausal women

Numerous studies have found a substantial correlation between cardiovascular morbidity and death and anthropometric measures such as BMI, WC, WHR, and WHtR.[13–16] It has been demonstrated that measures of abdominal obesity, such as WC and WHR, are better predictors of CV health risk than overall obesity. [17,18] Postmenopausal women with high BMI and those with normal BMI differed significantly in body composition measures such as BFMI, TBW, ECW, and ICW. The percentage of body fat rises and the percentage of body lean (as determined by FFM) falls when these variables alter. Postmenopausal women with high BMI had higher BF (%) and lower FFM (%), according to the findings. When evaluating the clinical results and mortality risk related to obesity, BF and FFM are crucial.[19] The BFMI of postmenopausal women with high BMI was substantially higher than that of the group with normal BMI. Because each person's absolute BF readings vary greatly, evidence indicates that BFMI is the most accurate indication of obesity and the associated metabolic dysfunctions.[20] According to reports, although basal metabolism (BM) is essential for the use of BF, it also contributes to the energy imbalance linked to obesity since it is crucial for maintaining energy homeostasis [21,22]. Furthermore, it has been shown that higher BM is linked to increased sympathetic nervous system activity (23). BM and activity metabolism (AM) levels are considerably higher in postmenopausal women with high BMIs than in those with normal BMIs. The significant rise in body cell mass (BCM) and basal metabolism (BM) in postmenopausal women with high BMI served as more evidence of this. Since an increase in basal metabolic rate is a risk factor for death, these women are more likely to experience health issues [24].

Oxidative stress in postmenopausal women

Because of its natural estrogen deficit, the postmenopausal condition exacerbates oxidative stress. Losing estrogen eliminates a vital defense against ROS because estrogen itself has antioxidant qualities [25] Research on Indian populations has repeatedly shown that oxidative stress after menopause is strongly linked to obesity [29]. Increased ROS Production [26], Chronic Inflammation, and Dysregulated Cytokines [27] are some of the ways that the growth of adipose tissue, especially visceral adiposity, leads to oxidative stress. ROS are produced by adipocytes themselves via processes that include NADPH oxidase and the mitochondrial electron transport chain [26]. TNF-α and IL-6, two pro-inflammatory cytokines secreted by hypertrophied adipocytes, can cause other cells to produce ROS [27]. Adipokine secretion is altered by estrogen deprivation, which increases pro-inflammatory leptin and decreases anti-inflammatory adiponectin, thus intensifying oxidative stress [28]

Link between Body fay mass indices and oxidative stress:

A recent cross-sectional study in North India that assessed 120 postmenopausal women found a significantly significant correlation between serum MDA levels and BMI ($r = 0.72$, $p<0.001$) and WHR ($r = 0.68$, $p<0.001$). The results of the study showed that higher abdominal obesity was a more reliable predictor of higher oxidative stress than BMI alone (30). In another study, MDA levels and antioxidant vitamins A, E, and C were measured in postmenopausal women with varying BMIs. The study found that compared to women of normal weight, those with a BMI greater than 25 kg/m² had significantly higher levels of MDA and lower levels of antioxidant vitamins. The explanation offered was the pro-oxidant environment created by high obesity and insufficient antioxidant consumption in the diet.[31]

More than 300 postmenopausal women participated in a sizable community-based study in Shanghai has examined the connection between metabolic syndrome components and oxidative stress indicators. The study discovered a substantial correlation between MDA levels and waist circumference, a crucial measure of visceral fat. According to the authors, evaluating the cardiovascular risk profile of postmenopausal women may benefit from monitoring oxidative stress indicators such as MDA [32].

This was further supported by a study that looked at the effects of exercise. It showed that compared to postmenopausal women who regularly participated in moderate exercise (such as brisk walking), inactive women had considerably higher MDA levels and body fat percentages. In the active group, the positive relationship between body fat percentage and MDA was less pronounced, underscoring the function of exercise in separating oxidative stress from adiposity [33] Serum MDA levels in postmenopausal women are significantly positively correlated with body fat mass indices (BMI, WHR, and body fat percentage). The pro-inflammatory and pro-oxidant characteristics of increased adipose tissue, which are made worse by the loss of estrogen's protective effects, make this link biologically tenable.

The implications of this finding are substantial for public health, particularly in countries undergoing rapid epidemiological transitions. Diets increasingly high in processed foods and sedentary lifestyles are contributing to rising obesity rates among women. The identified link suggests that this growing adiposity is directly increasing oxidative damage, thereby elevating the risk for a cascade of chronic diseases, including atherosclerosis, diabetes, and neurodegenerative disorders.

5. CONCLUSION

Anthropometric indices: In our study we concluded that all the anthropometric indices such as weight, BMI, waist circumference, hip circumference, waist hip ratio and waist height ratio were significantly high (Table-1) in high BMI postmenopausal women when compared to normal BMI postmenopausal women

Body composition indices: Among the body composition indices, BF, dry lean, BCM, BM, AM, BFMI and FFMI were significantly high and FFM, TBW, ICW and BM/ Wt. were reduced significantly in high BMI postmenopausal women when compared to normal BMI postmenopausal women (Table- 2)

Antioxidant marker: In the present study, the oxidative stress has been elevated in the high BMI postmenopausal women as indicated by the significant rise in MDA compared to the control group, suggesting that the chance of acquiring CV disease is more in this group (Table -3).

Correlating MDA with body fat mass indice:

In our study, indicators of body fat mass in postmenopausal women are highly correlated with malondialdehyde, a biomarker of lipid peroxidation. Higher adiposity, especially abdominal obesity, is a significant contributor to oxidative stress in this susceptible group, according to evidence from this study. These results highlight the significance of implementing weight-management plans that incorporate regular exercise, balanced dietary changes, and calorie restriction. While regular exercise strengthens endogenous antioxidant defences and promotes fat loss, diets high in fruits, vegetables, and nuts offer natural antioxidants that can combat reactive oxygen species (ROS). Postmenopausal women may benefit from lifestyle changes that lower oxidative stress and help them maintain a healthy weight. These changes may also improve metabolic and general health outcomes.

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