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Differences in body parameters of Pre- and Postmenopausal women and possible association with factors of cardiovascular diseases

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ABSTRACT

Background: Body composition changes become evident in women as they pass through the transition phase of their life where their reproductive phase ends up at menopause. Women at menopause often experience redistribution of body fat particularly around the abdomen. Redistribution of body fat among postmenopausal women leads to various metabolic syndromes which lead to cardiovascular diseases even with controlled BMI.

Material and Method: For the present cross-sectional study, 530 women (300 pre- and 230 postmenopausal) ranging in age from 30-60 years were personally interviewed and their anthropometric and physiological parameters were measured with standardized methods. Their height, weight, waist circumference, biceps, triceps, sub scapular and suprailiac measurements were taken and blood pressure was noted down. From these values, their waist-hip ratio, waist-stature ratio, percent body fat, total body fat, pulse pressure, mean arterial pressure were calculated. Pearson's correlation was computed to find out the association of BP with various anthropometric parameters.

Results and Conclusion: Positive association of waist circumference, waist hip ratio, percent body fat and total body fat was observed with systolic and diastolic blood pressure. Present observations support the notion that hormonally-induced redistribution of adipose tissue at menopause in the intra-abdominal depots in post-menopausal women might be leading to adverse changes in the metabolic profile.

Key words: Menopause, Intra-abdominal fat, Cardiovascular diseases, Metabolic syndromes

INTRODUCTION

The body undergoes many changes as it ages whether it begins as an apple or a pear, the overall body shape probably shifts with time. The rate at which body shape changes occur is closely connected to lifestyle factors like exercise, smoking and diet. Generally, fat increases, and muscle mass or lean tissue, and mineral bone density decrease with age. Among women, menopause appears as a very important factor which brings so many changes along with it. Body composition changes become evident in women as they pass through the transition phase of their life where their reproductive phase ends up at menopause. In females, in our culture, menopause is frequently seen as a negative milestone and is sometimes viewed as a disease or medical condition requiring a cure.

Women at menopause often experience weight gain, particularly around the abdomen. These changes include an increase in overall and central adiposity, especially visceral adipose tissue and a decrease in total and central lean tissue mass (Poehlman and Tchernof, 1998). Obesity or adiposity has been recognized as a potential risk factor for cardiovascular diseases (CVD), diabetes mellitus (DM), and cancer (Berghöfer et al., 2008). Studies indicate that even with a normal body mass index (BMI), those with an elevated waist circumference (WC) can have a two fold increase in CVD risk (Pischon et al., 2008). BMI may not indicate the level of central adiposity. At present, WC has been recommended as a measure of abdominal obesity. Studies have revealed an independent effect of WC on CVD risk factors (Ardern et al., 2003; Zhu et al., 2004). Body fat distribution is an important contributor to the association between obesity and high blood pressure (BP) (Johnson et al., 1992; Okosun et al., 1999).

Studies using dual-energy X-ray absorptiometry showed increased trunk fat in postmenopausal women. Moreover, studies using computed tomography and magnetic resonance imaging show that postmenopausal women have greater amounts of intra-abdominal fat compared to premenopausal women. Collectively, these studies suggest that the menopause transition is associated with an accumulation of central fat and, in particular, intra-abdominal fat (Ley et al., 1992). Whether menopause-related differences in trunk or intra-abdominal fat are independent of age and/or adiposity, however, is unclear. It is evident from different studies that early postmenopausal status is associated with a preferential increase in intra-abdominal fat that is independent of age and total adiposity (Toth et al., 2000; Kanaley et al., 2001).

The physiological changes associated with menopause have a significant impact on total body fat and adipose tissue distribution. Several cross-sectional studies that have used waist-to-hip (WHR) ratio or WC as estimates of relative or absolute accumulation of abdominal fat respectively have failed to link abdominal adipose tissue accumulation and menopause (Razay et al., 1992; Troisi et al., 1995). However, by using DEXA to measure abdominal adipose tissue, several investigators have noted that menopause has an independent effect on adipose tissue distribution even after controlling for age (Tremollieres et al., 1996) and BMI (Ley et al., 1992). Several studies have reported increases in total body fat mass with age. In a six-year longitudinal study, Björkelund et al. (1996) found that abdominal adipose tissue accumulated selectively in women who became post-menopausal when compared to women who remained pre-menopausal over the same period. Changes in adipose tissue distribution were observed using anthropometric measurements such as WHR ratio and WC. In addition, BMI remained similar between post-menopausal and pre-menopausal women.

It is well established that increasing intra-abdominal adipose tissue is one of the most prevalent manifestations of a cluster of abnormalities referred to as the metabolic syndrome, which predicts an increased CVD risk (Despres et al., 2006). Postmenopausal

women have higher total cholesterol (TC), increased low density lipids (LDL) cholesterol and triglyceride (TG) as well as lower high density lipids (HDL) cholesterol levels than pre-menopausal women (Stevenon et al., 1993, Kaur et al., 2014). Substantial changes in LDL concentrations occur early in the transition from pre-menopause to post-menopause (Matthew et al., 2001). On comparison between pre- and postmenopausal women, higher mean values of TC, TG, LDL-C and lower HDL-C were observed in non-obese and obese hypertensive postmenopausal women as compared to premenopausal women (Kaur et al., 2014). The reduction in intra-abdominal adipose tissue deposition observed with hormone replacement therapy in post-menopausal women is associated with a corresponding improvement in fasting lipid levels (Sumino et al., 2003). Several studies have noted a reduction in LDL cholesterol and a rise in HDL cholesterol levels following hormone replacement therapy (Tikkanen et al., 1982; Wilson et al., 1985).

Our own studies and many previous studies have observed higher rate of obesity, hypertension and diabetes among postmenopausal women as compared to their premenopausal counterparts. It is further reported in literature that redistribution of body fat among postmenopausal women leads to various metabolic syndromes which leads to CVD even with controlled BMI. Present study was designed to assess the differences in the anthropometric and physiological variables of premenopausal women and postmenopausal women. If significant differences would exist, these could have been due to the menopausal redistribution of the body fat and might be the culprit for deteriorated status of lipid profile and higher prevalence of CVD among postmenopausal women.

MATERIAL AND METHOD

For the present cross-sectional study, 530 women (300 pre- and 230 postmenopausal) ranging in age from 30-60 years were personally interviewed and their anthropometric body parameters like weight, height, WC, Hip circumference (HC), biceps, triceps, supra iliac, sub scapular were taken with standardized methods (Weiner and Lourie, 1981). The blood pressure (BP) readings were taken as per recommendations of Rose and Blackburn (1968). The data was noted on a predesigned questionnaire proforma. From the anthropometric variables, the derived variables like WHR, waist-stature ratio (WSR), Percent body fat (PBF) total body fat (TBF) and lean body mass (LBM) were derived. From physiological variables like systolic blood pressure (SBP) and diastolic blood pressure (DBP), the mean arterial pressure (MAP) and pulse pressure (PP) were derived. Pre- and postmenopausal women were compared for different parameters and conclusions were drawn.

Statistical Analysis

Data analysis was performed using SPSS 16.0. The results were presented as mean± standard deviation (SD). The statistical significance for intergroup differences was analyzed by the Student's t-test. Pearson's correlation analysis was performed to compute the degree of relationship between the variables. For all statistical tests, a p-value <0.05 was considered statistically significant. Additionally the multiple linear regression was performed to find out the best suitable predictor of SBP and DBP which are the key factors related to CVD.

RESULTS:

Table 1 presents the distribution in mean values of various anthropometric variables of pre- and postmenopausal women. Pre-and postmenopausal women differed from each other with respect to age which is obvious ($p<0.001$). The difference of 0.25 kilogram between the weights of two groups was statistically non-significant. So, pre-and postmenopausal women were matching for weight. Insignificant differences were observed in height of pre- and postmenopausal women. Similarly, the differences between the hip circumference values were also insignificant. The pre- and postmenopausal women were observed as having the same mean values of biceps. Similarly, insignificant difference of 0.42 mm was observed in the mean values of triceps. Statistically insignificant differences were observed in the mean values of suprailiac. Not much difference was observed in the mean values of subscapular in pre- and postmenopausal women.

Table 1: Mean values of anthropometric variables of Premenopausal (Pre-M) and Postmenopausal (Post-M) women

Variables	Pre-M			Post-M			Difference between Pre-M & Post-M	P-value
	Mean	SD	SEM	Mean	SD	SEM		
Age (yrs.)	42.42	5.99	0.34	52.50	4.20	0.29	10.08	<0.001
Weight (kg)	65.16	11.40	0.64	65.41	11.73	0.81	0.25	NS
Height (cm)	156.80	5.60	0.31	154.61	5.94	0.41	2.19	NS
Waist Circumference (cm)	88.63	11.35	0.64	93.15	11.44	0.79	4.52	<0.001
Hip Circumference (cm)	101.01	10.23	0.58	101.58	11.20	0.78	0.57	NS
Biceps (mm)	20.07	7.08	0.40	19.80	6.97	0.48	0.27	NS
Triceps (mm)	24.65	8.36	0.47	25.07	9.18	0.64	0.42	NS
Supra iliac (mm)	24.62	7.83	0.44	22.07	5.60	0.39	2.55	NS
Sub scapular (mm)	23.11	7.77	0.44	24.94	9.14	0.63	1.83	NS

But the mean value of WC was observed much higher in postmenopausal women as compared to premenopausal subjects. Statistically significant difference of 4.52 cm ($p<0.001$) was observed in the mean values of WC in pre- and postmenopausal women.

Table 2: Differences between derived anthropometric variables of pre- (Pre-M) and postmenopausal (Post-M) women

Variables	Pre-M			Post-M			Difference between Pre-M & Post-M	P-value
	Mean	SD	SEM	Mean	SD	SEM		
BMI (kg/m^2)	26.64	4.45	0.25	27.52	4.62	0.32	0.88	NS
Waist-Hip Ratio	0.88	0.07	0.01	0.92	0.07	0.01	0.04	<0.001
Waist-Stature Ratio	0.57	0.08	0.00	0.60	0.07	0.00	0.03	<0.001
Percent Body Fat	38.79	4.64	0.26	40.50	5.66	0.39	1.71	<0.001
Total Body Fat (kg)	25.61	6.74	0.38	27.20	7.19	0.49	1.59	<0.001
Lean Body Mass (kg)	39.54	5.23	0.29	38.20	5.29	0.37	1.34	NS

Table 2 presents the mean values of the derived variables. Insignificant difference of 0.88 kg/m^2 was observed in the mean values of BMI between the groups. Postmenopausal women took the lead over premenopausal women in the mean value of WHR. The difference between the groups was statistically significant ($P<0.001$). The mean value of WSR was observed 0.03 higher in postmenopausal women as compared to premenopausal women and the difference was statistically significant ($p<0.001$). It is visible from Table 2 that the postmenopausal women had more PBF as compared to premenopausal women. There was statistically significant differences of 1.71% ($p<0.001$). Postmenopausal women led the premenopausal women in the mean values of TBF. There was net difference of 1.59 kg. in the mean value of TBF which was statistically significant ($p<0.001$).

It is reflected from Table 3 that pre- and postmenopausal women differed significantly ($p<0.001$) from each other in the mean values of SBP. Higher value of SBP was observed in postmenopausal women as compared to their premenopausal counterparts. The difference of 7.83 mmHg was observed in their mean values. Similarly, higher mean value of DBP was observed in postmenopausal women as compared to premenopausal women although the difference was statistically insignificant.

Postmenopausal women took an edge over premenopausal women in the mean value of PP. The difference of 5.39 mmHg in their mean values was statistically significant ($p<0.001$). Similarly, statistically higher ($P<0.001$) mean value of MAP was observed in postmenopausal women.

Table 3: Status of Physiological variables of pre- (Pre-M) and postmenopausal (Post-M) women

Variables	Pre-M			Post-M			Difference between Pre-M & Post-M	P-value
	Mean	SD	SEM	Mean	SD	SEM		
SBP (mm/Hg)	121.08	17.45	0.98	128.91	19.14	1.33	7.83	<0.001
DBP (mm/Hg)	80.19	11.81	0.66	82.26	13.72	0.95	2.07	NS
Pulse Pressure (mm/Hg)	41.36	9.49	0.56	46.75	12.50	0.87	5.39	<0.001
Mean Arterial Pressure (mm/Hg)	93.43	12.68	0.71	97.40	13.70	0.95	3.97	<0.001

Table 4: Pearson's correlation co-efficient (r) of WC, WHR, TBF and PBF with SBP and DBP among Premenopausal Women

Variable	SBP		DBP	
	R	p	r	P
Age	0.243	<0.001	0.202	<0.001
WC	0.301	<0.001	0.368	<0.001
WHR	0.296	<0.001	0.288	<0.001
PBF	0.203	<0.001	0.286	<0.001
TBF	0.245	<0.001	0.345	<0.001

SBP-systolic blood pressure; DBP-diastolic blood pressure ;WC-waist circumference; WHR-waist-hip ratio; PBF- percent body fat; TBF-total body fat

Table 5: Pearson's correlation co-efficient (r) of WC, WHR, TBF and PBF with SBP and DBP among Postmenopausal Women

Variable	SBP		DBP	
	R	p	r	p
Age	0.071	NS	0.047	NS
WC	0.234	<0.001	0.291	<0.001
WHR	0.235	<0.001	0.327	<0.001
PBF	0.111	NS	0.131	<0.05
TBF	0.168	<0.02	0.183	<0.01

SBP-systolic blood pressure; DBP-diastolic blood pressure; WC-waist circumference; WHR-waist-hip ratio; PBF- percent body fat ;TBF-total body fat

Tables 4 and 5 present the Pearson's correlation of BP with age, WC, WHR, PBF and TBF among pre- and postmenopausal women. It is evident from the tables that both SBP and DBP are positively correlated with WC, WHR, PBF and TBF among both pre- and postmenopausal women. Correlation of SBP and DBP with age was observed as significant in premenopausal women, whereas it was non-significant in case of postmenopausal women.

Table:6 Linear Regression Co-efficient (β) and Standard Error (S.E.) with test statistic (t) and probability (*P)* values for different variables in Multiple Regression Model for Systolic and Diastolic Blood Pressure (SBP, DBP) in premenopausal Women

Variable	SBP				DBP			
	β	SE	t	P	β	SE	t	P
Age	0.509	0.180	2.830	0.005	0.154	0.120	1.284	0.202
WC	-0.230	0.291	-0.822	0.412	-0.239	0.291	-0.822	0.412
WHR	77.72	29.72	2.622	0.009	77.72	28.72	2.622	0.009
PBF	-1.05	0.506	-2.07	0.039	-1.054	0.506	-2.07	0.039
TBF	1.040	0.469	2.21	0.027	1.044	0.469	2.211	0.027

Table:7 Linear Regression Co-efficient (β) and Standard Error (S.E.) with test statistic (t) and probability (*P)* values for different variables in Multiple Regression Model for Systolic and Diastolic Blood Pressure (SBP, DBP) in postmenopausal Women

Variable	SBP				DBP			
	β	SE	t	P	β	SE	t	P
Age	0.330	0.313	1.053	0.293	0.136	0.219	0.622	0.536
WC	0.286	0.397	0.720	0.472	0.233	0.278	0.840	0.401
WHR	36.54	35.61	1.026	0.306	44.349	24.87	1.78	0.07
PBF	-0.852	0.649	-1.31	0.191	-0.610	0.453	-1.345	0.18
TBF	0.36	0.64	0.56	0.54	0.186	0.447	0.417	0.677

Additionally, multiple regression was performed to find the best suitable predictor of SBP and DBP. It is evident from Tables 6 and 7 that in case of premenopausal women, age, WHR, PBF as well as TBF came out as best suitable predictor of SBP and WHR, PBF and TBF as best predictors of DBP. But in case of postmenopausal women only WHR came as the best suitable predictor of DBP only.

DISCUSSION

In the present study, both the pre- and postmenopausal groups were almost matching for their mean BMIs (26.64±0.25 kg/m^2 and 27.52 ±0.32 kg/m^2, respectively). In spite of it, there was statistically significant difference in the WC of the two groups. The significant higher values of WHR, WSR, PBF and TBF were observed among the postmenopausal women. Physiological variables like SBP, DBP, PP and MAP also have higher values in postmenopausal women.

WC is an indicator of health risk associated with excess fat around the waist. A waist circumference of 85 cm for men and 80 cm for women is associated with health problems such as type 2 diabetes, heart disease and high blood pressure in Asian population (Snehalatha et al., 2003). WC is a convenient measure of abdominal adipose tissue (Hans et al., 1995) and correlates closely with BMI (Lean et al., 1995) and TBF (Lean et al., 1996) and is associated with CVD risk factors independent of BMI (NIH, 2000). Accordingly, WC may be an effective clinical tool for assessing the risk of CVDs (Lean et al., 1998; Okosun et al., 2000). Women have a greater relative risk of CVD at lower WCs than do men (WHO, 1997). Lack of exercise, smoking, alcohol abuse, low economic and education levels and postmenopausal status were all associated with a significantly increased risk of diabetes and other chronic diseases, even after adjustment for BMI (Han et al., 1998; Toth et al., 2000; Hu et al., 2001). Central obesity and high BP frequently cluster with metabolic complications such as hyperinsulinemia/insulin

resistance and dyslipidemia, popularly considered as "metabolic syndrome" (DeFronzo and Ferrannini, 1991).

It has been reported that WC is a better predictor of cardiovascular risk factors than BMI, although the findings have not been consistent. It has been suggested that WC, WHR, and WSR ratio are better measures of obesity than BMI in predicting cardiovascular risk factors (Ho et al., 2003; Menke et al., 2007; Huxley et al., 2010). In the present study, statistically higher mean values of SBP, DBP, PP and MAP were observed in postmenopausal women as compared to their premenopausal counterparts. Tables 4 and 5 further reflect positive association of WC, WHR, PBF and TBF with SBP and DBP. Higher mean values of WC, WHR, PBF and TBF among postmenopausal women might be responsible for higher mean values of SBP and DBP among postmenopausal women. Higher SBP and DBP along with abdominal obesity lead to metabolic syndromes which include CVD and diabetes.

High BP is a classical feature of the metabolic syndrome, and it has been reported that the metabolic syndrome is present in up to one third of hypertensive patients (Cuspidi et al., 2004; Schillaci et al., 2004). According to World Health Organization (WHO), the National Cholesterol Education Program (NCEP), the International Diabetes Federation, and the American Heart Association/National Heart, Lung, and Blood Institutes, the high BP and dyslipidemia is included in the definition for the metabolic syndrome (WHO, 1999; NCEP, 2001; Guerrero-Romero et al., 2005; Grundy et al., 2004). Higher rate of obesity, hypertension and diabetes among postmenopausal women has been reported in literature (Khokhar et al., 2010 a; Khokhar et al., 2010 b; Khokhar et al., 2013). More than 25% women adult world population is hypertensive. Elevations in BP are related to cardiovascular risks with prevalence high in population $\geq$ 60 years in age (Vasan et al., 2001). In US approximately 75% of postmenopausal women are hypertensive (Ong et al., 2007). During menstruation BP levels are inversely related to estrogen levels (Dubey et al., 2002). Estrogen levels fall in postmenopausal women (Khokhar et al., 2010 b). First decade after menopause is accompanied by increase in BP (Burt et al., 1995).

Fat cells in the hip, thigh and buttock areas have receptors for estrogen. Estrogen, in most women, drives most fat storage to the lower part of the body. As estrogen levels begin to decline, however, estrogen loses its hold on fat storage below the waist and instead, fat starts to show up in the area of the waistline. In conclusion, the above observations support the notion that hormonally-induced redistribution of adipose tissue in the intra-abdominal depots in post-menopausal women might be leading to adverse changes in the metabolic profile. So the postmenopausal phase should be strictly taken care of.

It is also evident from this work that all the variables studied play some significant role in deciding the metabolic profile of a woman. So, Effort should be made to focus of controlled diet coupled with regular exercise. Little negligence in this phase of life may cost a lot.

Further biochemical research with mechanistic approach may enhance understanding of the influence of estrogens and hormone replacement therapy on fat tissue distribution and CVD risk factors.

Limitations

Ours is a cross-sectional study. A longitudinal study in this regards may come up with concrete conclusions.

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REFERENCES

Ardern CI, Katzmarzyk PT, Janssen I, Ross R. 2003. Discrimination of health risk by combined body mass index and waist circumference. *Obesity* 11(1): 135–142.

Berghöfer A, Pischon T, Reinhold T, Apovian CM, Sharma AM, Willich SN. 2008. Obesity prevalence from a European perspective: a systematic review. *BMC Public Health* 8(1):200.

Björkelund C, Lissner L, Andersson S, Lapidus L, Bengtsson C. 1996. Reproductive history in relation to relative weight and fat distribution. *Int J Obes* 20: 213-219.

Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, Horan MJ, Labarthe D. 1995. Prevalence of Hypertension in the US Adult Population Results From the Third National Health and Nutrition Examination Survey, 1988-1991. *Hypertension* 25: 305-313.

Cuspidi C, Meani S, Fusi V, Severgnini B, Valerio C, Catini E, Leonetti G, Magrini F, Zanchetti A. 2004. Metabolic syndrome and target organ damage in untreated essential hypertensives. *J Hypertens* 22:1991-1998.

DeFronzo RA, Ferrannini E. 1991. Insulin resistance. A multifaceted syndrome responsible for NIDDM, obesity, hypertension, dyslipidemia, and atherosclerotic cardiovascular disease. *Diabetes Care* 14(3):173-194.

Després JP, Lemieux I. 2006. Abdominal obesity and metabolic syndrome. *Nature* 444: 881-887.

Dubey RK, Oparil S, Imthurn B, Jackson EK. 2002. Sex hormones and hypertension. *Cardiovasc Res* 53(3):688-708.

Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults: Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). 2001. *JAMA* 285:2486-2497.

Grundy SM, Brewer HB, Cleeman JI, Smith SC, Lenfant C. 2004. American Heart Association; National Heart, Lung, and Blood Institute: Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation* 109:433-438.

Guerrero-Romero F, Rodriguez-Moran M. 2005. Concordance between the 2005 International Diabetes Federation definition for diagnosing metabolic syndrome with the National Cholesterol Education Program Adult Treatment Panel III and the World Health Organization definitions. *Diabetes Care* 28:2588-2589.

Han TS, Bijnen FCH, Lean MEJ, Seidell JC. 1998. Separate associations of waist and hip circumference with lifestyle factors. *Int J Epidemiol* 27:422–430

Han TS, Leer EM, Seidell JC, Lean MEJ. 1995. Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. *BMJ* 311:1401–5

Ho SY, Lam TH, Janus ED 2003. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. *Ann Epidemiol* 13(10):683-691.

Hu FB, Manson JE, Stampfer MJ, Colditz G, Liu S, Solomon CG, M.D., Willett WC. 2001. Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. *N Engl J Med* 345:790–797.

Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. 2010. Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk–a review of the literature. *Eur J Clin Nutr* 64(1):16-22

Johnson D, Prud'homme D, Despres JP, Nadeau A, Tremblay A, Bouchard C 1992. Relation of abdominal obesity to hyperinsulinemia and high blood pressure in men. Int J *Obes Relat Metab Disord* 16:881–890.

Kanaley JA, Sames C, Swisher L, Swick AG, Ploutz-Snyder LL, Steppan CM, Sagendorf KS, Feiglin D, Jaynes EB, Meyer RA, Weinstock RS. 2001. Abdominal fat distribution in pre- and postmenopausal women: The impact of physical activity, age, and menopausal status. *Metabolism* 50(8); 976–982.

Kaur K, Sidhu S, Kaur G. 2014.Association between Leptin and Lipid Profile among Women. *Annual Research and Review in Biology* 4(5):728-735.

Khokhar KK, Kaur G and Sidhu S. 2010(a). Prevalence of Obesity in Working Premenopausal and Postmenopausal Women of Jalandhar District, Punjab. *Journal of Human Ecology* 29 (1); 57-62.

Khokhar KK, Sidhu S and Kaur G. 2010 (b). Correlation between Leptin level and Hypertension in Normal and Obese Pre- and Postmenopausal Women. *European Journal of Endocrinology* 163; 873-878.

Khokhar KK, Sidhu S and Kaur G. 2013. Relationship between serum leptin and type 2 diabetes and their association with obesity and menopausal status in women subjects. *Archieves of Applied Science Research* 5(5): 38-44.

Lean ME, Han TS, Seidell JC. 1998. Impairment of health and quality of life in people with large waist circumference. *Lancet* 351:853–856.

Lean ME, Han TS, Deurenberg P. 1996. Predicting body composition by densitometry from simple anthropometric measurements. *Am J Clin Nutr* 63:4–14.

Lean ME, Han TS, Morrison CE. 1995. Waist circumference as a measure for indicating need for weight management. *BMJ* 311:158–161.

Ley CJ, Lees B and Stevenson JC. 1992. Sex- and menopause-associated changes in body-fat distribution. *American Journal of Clinical Nutrition* 55: 950-954.

Matthews KA, Kuller LH, Sutton-Tyrrell K, Chang YF. 2001. Changes in cardiovascular risk factors during the perimenopause and postmenopause and carotid artery atherosclerosis in healthy women. *Stroke* 32: 1104-1111.

Menke A, Muntner P, Wildman RP, Reynolds K, He J. 2007. Measures of adiposity and cardiovascular disease risk factors. Obesity (Silver Spring) 15(3):785-795.

Okosun IS, Prewitt TE, Cooper RS. 1999. Abdominal obesity in the United States: prevalence and attributable risk of hypertension. *J Hum Hypertens* 13(7): 425-430.

Okosun IS, Tedders SH, Choi S, Dever GEA. 2000. Abdominal adiposity values associated with established body mass indexes in white, black and Hispanic Americans. A study from the Third National Health and Nutrition Examination Survey. *Int J Obes Relat Metab Disord* 24:1279–1285.

Ong KL, Cheung BM, Man YB, Lau CP, Lam KS. 2007. Prevalence, awareness, treatment, and control of hypertension among United States adults 1999-2004. *Hypertension* 49(1):69-75.

Pischon T, Boeing H, Hoffmann K, et al., 2008. General and abdominal adiposity and risk of death in Europe. *N Engl J Med* 359(20): 2105-2120.

Poehlman ET, Tchernof A. 1998. Traversing the menopause: Changes in energy expenditure and body composition. *Coron Art Dis* 9(12): 799-803.

Razay G, Heaton KW, Bolton CH. 1992. Coronary heart disease risk factors in relation to the menopause. *Q J Med* 85: 889-896.

Rose GA, Blackburn H. 1968. Cardiovascular survey methods. Monograph Series. World Health Organization 56; 90–95.

Schillaci G, Pirro M, Vaudo G, Gemelli F, Marchesi S, Porcellati C, Mannarino E. 2004. Prognostic value of the metabolic syndrome in essential hypertension. *J Am Coll Cardiol* 43:1817-1822.

Snehalatha C, Viswanathan V, Ramachandran A. 2003. Cutoff values for normal anthropometric variables in asian Indian adults. *Diabetes Care* 26(5):1380-1384.

Stevenson JC, Crook D, Godsland IF. 1993. Influence of age and menopause on serum lipids and lipoproteins in healthy women. *Atherosclerosis* 98: 83-90.

Sumino H, Ichikawa S, Yoshida A, Murakami M, Kanda T, Mizunuma H, Sakamaki T, Kurabayashi M. 2003. Effects of hormone replacement therapy on weight, abdominal fat distribution, and lipid levels in Japanese postmenopausal women. *Int J Obes Relat Metab Disord* 27: 1044-1051.

Tikkanen MJ, Nikkila EA, Kuusi T, Sipinen SU. 1982. High density lipoprotein-2 and hepatic lipase: reciprocal changes produced by estrogen and norgestrel. *J Clin Endocrinol Metab* 54: 1113-1117.

Toth MJ, Tchernof A, Sites CK, Poehlman ET. 2000. Menopausal-related changes in body fat distribution. *Ann N Y Acad Sci* 904:502–506.

Tremollieres FA, Pouilles JM and Ribot CA. 1996. Relative influence of age and menopause on total and regional body composition changes in postmenopausal women. *Am J Obstet Gynecol* 175: 1594-1600.

Troisi RJ, Wolf AM, Manson JE, Klingler KM, Colditz GA. 1995. Relation of body fat distribution to reproductive factors in pre- and postmenopausal women. *Obes Res* 3: 143-51.

US Department of Health and Human Service. The practical guide—identification, evaluation, and treatment of overweight and obesity in adults. Bethesda, MD: National Institutes of Health, 2000. (NIH publication no. 00-4084).

Vasan RS, Larson MG, Leip EP, Evans JC, O'Donnell CJ, Kannel WB, Levy D. 2001. Impact of high-normal blood pressure on the risk of cardiovascular disease. *N Engl J Med* 345(18):1291-1297.

Weiner JS, Lourie JA 1981: *Practical Human Biology.*New York: Academic Press, Inc.

Wilson PW, Garrison RJ, Castelli WP. 1985. Postmenopausal estrogen use, cigarette smoking, and cardiovascular morbidity in women over 50. The Framingham Study. *N Engl J Med* 313: 1038-1043.

World Health Organization. 1997. Obesity, preventing and managing the global epidemic—report of a WHO consultation on obesity. Geneva: WHO.

World Health Organization. 1999. *Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complication. Part 1: Diagnosis and Classification of Diabetes Mellitus.* World Health Organization, Geneva.

Zhu S, Heshka S, Wang Z, Shen W, Allison DB, Ross R, Heymsfield SB. 2004. Combination of BMI and waist circumference for identifying cardiovascular risk factors in whites. *Obesity* 12(4):633–645.