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AGE CHANGES IN BODY COMPOSITION AND ITS ASSOCIATION WITH BLOOD PRESSURE AMONG WOMEN OF KALPA VALLEY, DISTRICT KINNAUR (HIMACHAL PRADESH), NORTH INDIA

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The aim of the present cross-sectional study was to estimate age changes in body composition and its association with blood pressure among women of Kalpa Valley, District Kinnaur (Himachal Pradesh). Anthropometric, body composition and physiological parameters were taken on 180 healthy women, aged 30 to 69 years and indices were derived. Percentage body fat and fat mass index of females depicted an age associated increase in their mean values from 30 years to 69 years. Mean values of body mass index and fat free mass index showed a decrement after age group 40-49. The mean values of systolic blood pressure presented an increase with advancing age, whereas diastolic blood pressure exhibited an increment till 50-59 years followed by a sharp decline in their mean values. Weight, waist circumference, percent body fat, body mass index and fat mass index showed a positive and significant association with blood pressure, pulse rate and basal metabolic rate, whereas fat free mass index revealed significant correlation only with diastolic blood pressure and basal metabolic rate.

Keywords: Blood pressure, Body fat, Fat mass index, Fat free mass index, Basal metabolic rate

INTRODUCTION

Body composition is an important determinant of health status (Segal *et al.*, 1987). Ageing process is associated with progressive decline in fat free mass (Forbes, 1987), increase in fat mass and more central distribution of adipose tissue (Carmelli *et al.*,1991; and Prentice and Jebb, 2001). A study of Kyle *et al.* (2002) highlighted that the estimation of fat mass index as well as fat free mass index gives important information about changes in body composition during weight gain or loss, physical activity and ageing. Earlier reports carried out in different countries across globe in the last few decades witnessed substantial body fat gain during childhood and adolescence and it is probable that this trend will continue (WHO, 1998). A range of prior studies (Lovejoy *et al.*, 2001; and Lovejoy *et al.*, 2008) have emphasised that menopause is characterized by changes in gonadal hormones , dietary intake, and energy expenditure thereby causing changes in body composition particularly increase in visceral fat as well as prevalence of obesity. Fat mass is no longer considered just a passive storage unit, but increased body fat content and its distribution are important predictor for potential health related implications including elevated blood pressure ((Williams *et al.*, 1992; Freedman *et al.*, 1999; and Greenberg and Obin, 2006). Heyward and Wagner (2004) described that body composition is applicable to find out the health risk associated with

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excessively low or high levels of total body fat. Currently, according to the reports of WHO (2009) hypertension, tobacco use, high blood glucose and physical activity rank higher as causes of mortality. So the present study has tended to focus on age changes in body composition and its association with blood pressure among women of Kalpa valley, district Kinnaur (Himachal Pradesh).

MATERIAL AND METHODS

The sample comprised of 180 participants, between 30 to 69 years of age (mean age: 46.61 ± 11.72 years) were randomly selected from Kalpa Valley, District Kinnaur (Himachal Pradesh). Kalpa is a small town in the Sutlej river valley, above Recong Peo in the Kinnaur district of Himachal Pradesh, North India. Kalpa is at 31.53°N 78.25°E. It has an average elevation of 2,960 metres (9,711 feet). The data were collected from 23rd September to 1st October, 2013. Only normal healthy individuals, who were not having any history of long term illness or physical deformity, were included in the study. Women who had surgical menopause or taking hormone replacement therapy were not included in the study. Detailed information regarding their caste, education, occupation and diet (vegetarian / non vegetarian) was obtained through personal interview based on schedule. Age in years has been obtained from the date of birth which most of the women could recall, whereas in very few elderly women age had to be ascertained by cross-questioning i.e association with some important event like age at marriage, age of the first child, any important festival etc. With this, it was possible to estimate nearly the correct age of the subject. The age was then converted to decimal age by using the decimal age calendar of Tanner and Whitehouse (1966). All the participants were stratified into four age groups of ten years interval i.e 30-39 years, 40-49 years, 50-59 years, 60-69 years (Table 1). Age group 30-39 includes all the subjects from age 29.500 years to 39.499 years , age group 40-49 includes all the subjects from 39.500 years to 49.499 years and so on. All the measurements were taken by using the standard technique given by Weiner and Lourie (1981). Height (cm) was measured to the nearest 0.1 cm, and weight (kg) was gauged in the upright position to the nearest 0.1 kg with anthropometer and weighing machine respectively. Upper arm circumference (cm), waist circumference (cm) and hip circumferences (cm) of each subject were measured by employing Freeman's steel tape. Systolic and diastolic blood pressure (mm of Hg) of each participant was recorded thrice using manual mercury Sphygmomanometer, the

Table 1: Distribution of Sample by Age

Decimal Age	Age Group	N
29.500-39.499	30-39	64
39.500-49.499	40-49	47
49.500-59.499	50-59	42
59.500-69.499	60-69	27
29.500-69.499	Total	180

lowest value has been included in the study. Pulse rate (beats/minute) was taken from the beats of the radial artery. Body fat analyzer was used to estimate body fat (%) and Basal Metabolic Rate (BMR) (KJ/day). The BMI was calculated following the standard equation: BMI (kg/m^2) = weight (kg)/height^2 (m). Fat Mass Index (FMI) (fat mass/ height^2 (m^2)) and Fat Free Mass Index (FFMI) (fat free mass (kg)/height^2 (m^2)) were also ascertained (Van Itallie *et al.*, 1990; and Wells, 2001).

STATISTICAL ANALYSIS

Statistical Package for Social Sciences (SPSS) version 20.0 computer software was used to statistically analyze the data. Descriptive statistics were calculated for all anthropometric, body composition and physiological variables. One way analysis of variance (ANOVA) was employed to compare mean values of all the variables by age groups. Significance of the differences was set at the level of $p<0.05$. Karl Pearson's correlation was gauged to ascertain the association between various parameters and blood pressure, pulse rate as well as basal metabolic rate. A stepwise regression analysis was performed to gauge the predictive of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Pulse Rate (PR) and Basal Metabolic Rate (BMR).

RESULTS

Table 2 presents the general characteristics of the sample. Out of the total participants, 33.3% were illiterate, 16.11% and 25% studied upto 5th standard and matric respectively. Only 16.11% were graduate and 9.44% were postgraduates. Most of the participants were housewives (60.55%), only 38.33% were working. About 59.44% women had non vegetarian diet, whereas rest of the 40.55% was vegetarian. Age group wise mean, standard deviation and ANOVA of various anthropometric, body composition and physiological variables are summarized in Table 3. All the

Table 2: General Characteristics of the Sample

Parameters	Females N (%)
Education	
Illiterate	60 (33.3%)
Up to 5th	29(16.11%)
Matric	45(25.00%)
Graduate	29(16.11%)
Post graduate	17(9.44%)
Occupation	
Working	69(38.33%)
House wives	109(60.55%)
Pensioner	2(1.11%)
Diet	
Vegetarian	73(40.55%)
Non-vegetarian	107(59.44%)

anthropometric variables (height, weight, upper arm circumference, waist circumference and hip circumference) showed highest mean value at 40-49 years, followed by a decline in their mean values with advancing age till the last age group (60-69 years). Percentage body fat and fat mass index of females demonstrated an age associated increment in their mean values. Mean values of body mass index and fat free mass index displayed a decrement after age group 40-49. The mean values of systolic blood pressure presented an increase with advancing age whereas diastolic blood pressure showed an increment till 50-59 years followed by a sharp decline in their mean values. Pulse rate displayed highest mean value (72.30 beats/minute) at age group 40-49 whereafter a trend of decrement was witnessed till the last age group. Highest mean value (4987.41 KJ/day) for basal metabolic rate was reported at 30-39 years thereafter a regular decrement in the mean values of BMR was observed till 60-69 years (4707.62 KJ/day). Results of one way analysis of variance (ANOVA) displayed highly significant age difference for waist circumference (F = 3.42**), body fat (F = 4.45**), SBP (F = 4.81**), pulse rate (F = 4.24**) and basal metabolic rate (F = 4.49**) as is reflected from their F-

Table 3: Age Group Wise Mean, Standard Deviation and ANOVA of Various Anthropometric, Body Composition and Physiological Variables of the Females of Kalpa Valley

Variables	Age Group (in Years)				
	30-39	40-49	50-59	60-69	ANOVA
	Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D	
Height (cm)	152.23 ± 5.80	152.64±5.38	150.21±5.33	149.89±6.41	2.43
Weight (kg)	56.85 ± 8.20	59.87 ±10.02	57.64 ± 10.24	56.32±7.25	1.14
UAC (cm)	24.92±2.23	25.62±2.63	24.71±2.54	24.37±2.30	1.82
WC (cm)	77.34±11.21	81.89±12.90	81.45±14.12	79.15±13.23	3.42**
HC (cm)	93.43 ± 11.81	96.77 ± 8.67	95.31 ± 12.90	92.44 ± 12.33	1.88
% Body fat (kg)	32.62 ± 4.35	34.64 ± 4.66	35.36 ± 4.24	38.00 ± 3.45	4.45**
SBP (mm of Hg)	124.08 ± 13.25	127.83 ± 11.95	130.95 ± 12.61	134.36 ± 17.28	4.81**
DBP (mm of Hg)	84.88 ± 8.76	86.39 ± 7.09	87.62 ± 7.41	84.96 ± 7.48	1.32
Pulse rate (beats/min.)	67.92 ± 6.59	72.30 ± 5.90	70.81 ± 6.58	69.71 ± 6.70	4.24**
BMR (KJ/day)	4987.41±380.78	4977.07±464	4772.56±450.07	4707.62±475.21	4.49**
BMI (kg/m^2)	24.59 ± 3.75	25.69 ± 4.11	25.56 ±4.56	25.06± 2.71	0.88
FMI (kg/m^2)	8.17±2.15	9.05±2.35	9.14±2.30	9.55±1.57	3.43**
FFMI (kg/m^2)	16.48±1.76	16.63±1.77	16.41±2.35	15.49±3.65	2.27

Note: UAC = Upper Arm Circumference, WC = Waist Circumference, HC = Hip Circumference, BMI = Body Mass Index, FMI = Fat Mass Index, FFMI = Fat Free Mass Index, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, BMR = Basal Metabolic Rate.

Table 4: Correlation Coefficient (r) of Blood Pressure (SBP and DBP), Pulse Rate and Basal Metabolic Rate with Various Anthropometric and Body Composition Variables as well as Indices

Variable	Systolic Blood Pressure	Diastolic Blood Pressure	Pulse Rate	BMR
Height	-0.108	-0.015	0.031	0.598**
Weight	0.201*	0.245**	0.208**	0.843**
WC	0.164*	0.228**	0.218**	0.358**
Body fat (%)	0.324**	0.215**	0.254**	0.253**
BMI	0.253**	0.262**	0.205**	0.579**
FMI	0.314**	0.268**	0.254**	0.489**
FFMI	0.143	0.214**	0.114	0.592**

Note: WC = Waist Circumference, BMI = Body Mass Index, FMI = Fat Mass Index, FFMI = Fat Free Mass Index, BMR = Basal Metabolic Rate.

ratio. Table 4 presents correlation coefficient (r) of blood pressure (systolic and diastolic), pulse rate and basal metabolic rate with various anthropometric and body composition parameters as well as derived indices. Weight, waist circumference, percent body fat, body mass index and fat mass index demonstrated positive and significant association with blood pressure (both systolic and diastolic), pulse rate and basal metabolic rate. Fat free mass index displayed significant correlation with diastolic blood pressure only. A stepwise regression analysis identified percentage body fat a significant predictor of systolic blood pressure (β = 1.066, S.E 0.219, $p<0.000$) and pulse rate (β = 0.391, S.E 0.106, $p<0.000$). Fat mass index (β = 0.930, S.E 0.251, $p<0.000$) was presented as a significant predictor of diastolic blood pressure whereas weight (β = 6.682, S.E 0.863, $p<0.000$), height (β = 8.671, S.E 0.764, $p<0.000$) and fat free mass index (β = 9.737, S.E 3.863, $p<0.000$) were the significant predictors of Basal Metabolic Rate (BMR).

DISCUSSION

In the current cross sectional study all the anthropometric variables (height, weight, upper arm circumference, waist circumference and hip circumference) displayed maximum mean value at 40-49 years, followed by a trend of decrement in their mean values till the last age group (60-69 years). Several researchers (Gambacciani *et al.*, 1995; Riggs *et al.*, 1998; Ertungealp *et al.*, 1999; and Wilsgaard *et al.*, 2009) in different populations revealed that in general an escalation of involutionary changes occurs in the fourth decade of life associated with decreased levels of sex hormones. A perceptible decrement in height after maturity was depicted by a range of prior studies (Rahman *et al.*, 1998; Perissinotto *et al.*, 2002; Sanchez-Garcia *et al.*, 2007; Kaur, 2008; and Kaur and Talwar, 2011). Akien (1995) reported that a loss of collagen between spinal veterbrae causes the spine to bow and the height to shrink. A decreasing trend in weight as well as circumferential measurements after middle age has been reported in a number of previous studies (Rahman *et al.*, 1998; Perissinotto *et al.*, 2002; Sanchez-Garcia *et al.*, 2007; Kaur, 2008; and Kaur and Talwar, 2011). This decrement may be attributed to decline in total body water, fat free mass, and bone mineral contents and density after menopause among healthy women (Chumlea *et al.*, 1997; Guo *et al.*, 1997; and Zeller *et al.*, 1997). Findings of Kyle *et al.* (2002) illustrated that evaluation of fat free mass index as well as fat mass index gives significant information about changes in body composition in weight gain or loss, physical activity and during ageing. Rao *et al.* (2012) also witnessed that older subjects have higher Fat Mass Index (FMI) and lower Fat free mass index. Findings of Ranasinghe *et al.* (2013) also showed an increase in percentage body fat with increasing age with a positive linear correlation (r = 0.64; $p<0.000$). Consistent with those findings, in the present study females demonstrated an age related increase in the mean values of percentage body fat and fat mass index. Whereas, mean values of body mass index and fat free mass index demonstrated a decrement after age group 40-49. Many previous studies (Baumgartner *et al.*, 1995; and Zamboni *et al.*, 2003) also attributable a progressive reduction in fat free mass and an increase in fat mass to aging. A study conducted by Roth *et al.* (2000) observed that elderly subjects have reduced BMI and increased percentage body fat (BF %) at the same time. This may be due to sarcopenia, which is explained by progressive loss of muscle mass with age and accumulation of body fat. Age related decline in the level of physical activity, hormone levels, protein synthesis and motor-unit remodelling are attributed to these changes (Roth *et al.*, 2000; and Roubenoff and Hughes, 2000).

In the present study both systolic and diastolic blood pressure exhibited an increment in their mean values with advancing age except for a sharp decline in the mean values of diastolic blood pressure after 50-59 years. Pulse rate revealed an increment in the mean values till 40-49 years thereafter a gradual decrement in the mean values sets in. While explaining role of inflammation in the pathogenesis of arterial stiffness Park and Lakatta (2012) identified arterial stiffening as potential underlying reason for age-related increment in systolic blood pressure, whereas the loss of arterial elasticity enhances pulse wave velocity and is responsible for forward pressure wave from the heart to the periphery is reflected back early toward the heart, returning in late systole rather than early diastole (Izzo and Shykoff, 2001) thereby causing increased systolic blood pressure, reduced diastolic blood pressure and widened pulse pressure. Basal metabolic rate of the studied sample demonstrated a gradual decline with the increasing age. A number of cross sectional studies (Henry, 2000; and Sathyaprabha, 2000) also observed that basal metabolic rate falls with increasing age. Forbes and Reina (43) also observed age associated decrement in BMR is due to lowering of Fat-Free Mass (FFM) with ageing. Findings of Sathyaprabha (2000) suggested that the age related decrease in the Basal Metabolic Rate (BMR) is related to the absolute decrease in the fat free mass (FFM) in the elderly without any change in the metabolic activity per kg fat free mass. The results of stepwise regression analysis of present study identified weight ($\beta = 6.682$, S.E 0.863, $p<0.000$), height ($\beta = 8.671$, S.E 0.764, $p<0.000$) and fat free mass index ($\beta = 9.737$, S.E 3.863, $p<0.000$) as the significant predictors of basal metabolic rate. Contrasting evidence were recognised by other researchers (Fukagawa *et al.*, 1990; Poehlman *et al.*, 1991; and Vaughan *et al.*, 1991) that declining basal metabolic rate with aging is not fully due to loss of fat free mass but other physiological factors probably also play an important role in the decreased BMR.

Body composition is an important determinant of health (Segal *et al.*, 1987). Zamboni *et al.* (2005) observed age-related changes in body composition, namely decrease in skeletal tissue (lean body mass) and relative gain in adipose tissue (percentage body fat mass) particularly in the abdominal region are believed to be potential predictors for functional decline, disability, morbidity, and early mortality. Correlation coefficient (r) exhibited a positive and significant association of weight, waist circumference, percent body fat, body mass index and fat mass index with blood pressure (both systolic and diastolic), pulse rate and basal metabolic rate. Fat free mass index displayed significant correlation only with diastolic blood pressure and basal metabolic rate. In the current cross sectional study stepwise regression analysis identified percentage body fat a significant predictor of systolic blood pressure ($\beta = 1.066$, S.E 0.219, $p<0.000$) and pulse rate ($\beta = 0.391$, S.E 0.106, $p<0.000$). Fat mass index ($\beta = 0.930$, S.E 0.251, $p<0.000$) was presented as a significant predictor of diastolic blood pressure. Rao *et al.* (2012) observed risk estimation for hypertension with Fat Mass Index (FMI) indicated 5 times higher risk in women (OR: 5.3, CI: 2.3-12.4). Previous results (Heitmann *et al.*, 2000; and Allison *et al.*, 2002) confirmed that Body Fat (BF) has a adverse effect and Fat-Free Mass (FFM) has a positive effect on health and physical performance. In agreement with a number of studies (Janssen *et al.*, 2002; and Sternfeld *et al.*, 2002) age-related body composition changes seem to be independently associated with an increased risk of functional limitation. In conclusion, the females of present study showed an age associated increase in percent body fat, fat mass index as well as decrease in fat free mass index and a positive and significant association of blood pressure (both systolic and diastolic), pulse rate and basal metabolic rate with weight, waist circumference, percent body fat, body mass index and fat mass index.

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