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Relationship between Anthropometric Measures and Body Composition Parameters in Adult Brick Kiln Workers of Murshidabad District, West Bengal*

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ABSTRACT Body composition and body shapes have been topics of interest to scholars over the ages because of health considerations. Present study investigates the correlation between various anthropometrics measure with body composition characteristics. For the present study 501 adult male Bengalee brick-kiln workers were selected from Murshidabad of West Bengal, India. All anthropometric measurements were taken following the standard techniques and body composition was calculated using the standard formulae. Results indicated that most the anthropometric parameters showed highly significant correlation ($p<0.001$) with height, weight, Body Mass Index (BMI), PBF, FM and FFM, without Conicity Index (CI) with FFM. The highest amount of variation of weight (82.6%), PBF (82.5%) and FM (81.4%) was explained by Mid Upper Arm Circumference (MUAC). The study revealed that all anthropometrics measurement are significantly correlated with weight, BMI, PBF, and FM but the relationship of MUAC with weight and WC with BMI, PBF and FM was much stronger than other parameters. All circumferences measurement explained large amount of variation with weight and BMI.

INTRODUCTION

The determination of blood pressure has been based on measure of body composition that allow a breakage of total body mass into lean body mass and total body fat. Consequently, the possible effects of these factors on blood pressure have been not separated. Several anthropometrics indicator such as sub-scapular skinfold thickness (SSKF), waist hip ratio (WHR), waist circumference (WC) (Shear et al. 1987; Freedman et al. 1999; Lurbe et al. 2001) have been shown to be connected with cardiovascular disease risk factors, although debate still exists regarding the best anthropometrics marker for assessing the relationship between body fat distribution and the risk of elevated blood pressure. A positive correlation between blood pressure (BP) and body weight has long been recognized in adults (Boe et al. 1957; Chiang et al. 1969; Stamler et al. 1975; Stamler et al. 1978; Heyden 1978; Tobin 1978; Florey and Acheson 1996). Stature in adults has little or no influence on BP (Boe et al. 1957; Roberts and Maurer1977; Tobin 1978; Bergland and Wilhelmsen 1995).

Developing countries are increasingly facing with the double burden of hypertension; weight reduction is commonly associated with a decrease in BP and other cardiovascular disease, along with infection and malnutrition (Murray et al. 1996). The relationship between BMI and BP has long been the subjects of epidemiological research. From the Asian population a Positive association between BMI and BP has also been reported (Gupta et al. 1995; Tandon 2000; Tandon 2006).

Human body dimensions have been studied substantially and used in physical anthropology, forensic anthropology, medical science and ergonomic, for designing of tools and workplace. In all of these areas, body compositions indicator plays a vital role. The BMI is a measure of overall adiposity, whereas WC, WHR and CI reliable proxy measures of abdominal fat (Bose and Mascie-Taylor 1998; Kopelman 2000). Proxy anthropometric methods have been employed including skinfolds (Durnin and Womersley 1974), BMI (Deurenberg et al. 1991), and skinfolds combined with various body circumferences (Jackson and Pollock 1978; Jackson and Pollock 1980; Lean et al. 1996) to prophesy body fat estimated by under-water weighing. Several

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studies on anthropometry indicate that, anthropometry is a strong tool in estimating body composition (Fosbol and Zerahn 2014) and specific distribution from models that utilize body circumferences and skinfolds (Wang et al. 2004). The most widely used field method for total fat has been the four skinfold method, derived from underwater weighing (Kopelman 2000). Recognizing possible errors of predicting body fat in sub-populations with altered fat distribution, regression equation including waist circumference appear to have advantages in predicting total body fat by taking some account of this variation in fat distribution (Lean et al. 1996). The WC, alone, predicts health (Lean et al. 1998) as well as body composition and is recommended for public health promotion (SIGN 1996; NIH 1998). Human physical variation of body dimension exists among and between population and geographical region (Saha 1985; Gite and Singh 1997; Dewangan et al. 2005). Anthropometric parameters can be divided into three clusters: circumference (transverse breadths), body length and body fat; indicating the length of coronal plane and skinfold thickness (Majumder 2014).The WC has a better association with body fat than other anthropometric measurements (Chakraborty and Bose 2009; Singh et al. 2014).

Individuals in the same population and even members of the same household, with similar life styles may differ with respect to their fatness. Obesity is a chronic condition characterized by an excess amount of body fat (Arterburn and Noel 2001). Both, overweight and obesity result from an intricate interaction between genes and environment characterized by long term energy imbalance due to a sedentary life style, excessive caloric intake, or both (NRC 1989). Anthropometry is the single most portable, universally applicable, inexpensive and noninvasive technique for assessing the size, proportions and composition of the human body (WHO 1998). Study of anthropometric measurement reflects both health and nutritional status and predicts of performance, health and survival (NIH 1998). In higher socio-economic groups, several anthropometric studies have been taken up to investigate the relationship between BMI and adiposity (Wardel et al. 1996; Wellens et al. 1996; Lear et al. 2003). Recently, several studies have indicated that cardiovascular disease (CVD) was a major health problem in the Bengalee ethnic group (Ghosh et al. 2003; Ghoshet al. 2004). The link between body fat and physical performance and determining the level of body fat among athletes is very important (Medeiros et al. 2016; Ashtary-Larky et al. 2017). Recent studies have used the waist-to-height ratio (WHtR) as a screening indicator in those individuals who have a need for assessment of visceral obesity much more than body weight assessment. It can be more useful than other indicators (DeNino et al. 2001; Despres and Lemieux 2006; Hamdy et al. 2006). Appropriate anthropometric indicators can be inûuenced by gender and physical activity (athletes or non-athletes). Waist-to-hip ratio in male athletes and non-athletes had the most correlation with body fat percentage. Body mass index in female athletes and non-athletes had the most correlation with percentage of body fat (Ashtary-Larky et al. 2018).

Objectives

To the best of researcher's knowledge, studies investigating the statistical association of anthropometry, body fat and blood pressure on lower socio-economic groups like brick kiln workers from West Bengal are lacking. The relationship between anthropometric character's, body composition and blood pressure were investigated in the present study. The body weight was divided into fat free mass and fat mass. Such an attempt has been made in this paper.

METHODOLOGY

Study Area and Population

Present cross sectional study was conducted on 501 adults (age 18-60 years) male brick-kiln workers. All the subjects were residents of Beldanga (I and II) blocks, Murishdabad district, West Bengal, India. It is located approximately 195 km from Kolkata, the state capital of West Bengal. All the participants had their origin in the state of West Bengal and spoke Bengali language as their mother tongue. They were Muslims. Their general hygienic condition clearly seemed to be poor. Most, of the subjects were illiterate and earning very low wages. They belonged to the low socio-economic classes.

Ethical considerations were followed by the Helsinki Declaration (Goodyear et al. 2007). Ethical approval and prior permission were obtained from Vidyasagar University and also consulted with Brick Owner Association, respectively, before beginning of the study. Sensible verbal consent was also obtained from each participant. Information on age, occupation status and educational status were obtained from all subjects with the help of a questionnaire.

Anthropometric Measurements

All the anthropometric measurements were taken by the first author following the standard techniques (Loman et al. 1998). Height and weight were measured to the nearest 0.1cm and 0.5 kg, respectively, using Martin's anthropmeter and standard weight scale. Mid upper arm circumference (MUAC), minimum waist circumference (WC) and maximum hip circumference (HC) were measured to the nearest 0.1 cm using measuring tape. Skinfold thickness, triceps (TSF), biceps (BSF), subscapular (SSF) and suprailiac (SISF) were measured to the nearest 0.2 mm using a skin fold caliper (Holtain, UK).

Blood pressure was taken by fully automatic blood pressure monitor (Dr. Morepen, Model No. BP 07). Technical error measurements (TEM) were found to be within acceptable limits (Ulijaszekand Kerr 1999). The body mass index (BMI), waist-hip ratio (WHR) and conicity index (CI) were computed using the following standard equations:

BMI= weight (kg)/Height (m) ^{2}.

WHR= WC (cm)/ HP (cm).

CI= WC (m)/ (0.109x $\sqrt{}$[weight (kg)/height (m)].

Body Adiposity Index (BAI)

Body Adiposity Index (BAI) is one among the attempts to identify the obesity of the human body by calculating the percentage of body fat using height and hip circumference.

$$\text{BAI} = \frac{\text{Hip Circumference (m)}^{*}100}{\text{Height (m)}^{1.5}} - 18$$

Body Mass Abdominal Index (BMAI)

BMAI = Weight/Height X Waist Circumference/Height

= Weight/ (Height)^2 X Waist Circumference

= BMI X Waist Circumference.

Waist Height Ratio (WHTR)

It is the ratio which indicates central obesity, that is, the amount of fat accumulated in the central or abdominal region of the body.

WHTR = Waist circumference (cm)/ Height (cm).

Percent of Body Fat (PBF)

Percent of body fat (PBF) was calculated using the four skin folds with the help of standard equations.

Fat density = 1.1765-0.0744x$\log_{10}$ (BSF+ TSF+ SSF+SISF).

PBF = (4.95/fat density- 4.50) x100.

Fat mass (FM) was calculated using the following formula.

FM= [PBF/100X body weight (kg)].

Fat free mass (FFM) = [Body weight (Kg) - Fat mass (kg)].

Mean arterial pressure (MAP):

MAP =SBP + (2*DBP)/3

All the statistical analyses were undertaken using the SPSS Statistical package, version 16.0. Statistical significance was set at $p < 0.05$ level.

RESULTS

Table 1 shows the age and anthropometric characteristics of brick kiln workers. It presents the mean (SD) value of age, height, weight, BMI, MUAC, waist circumference, hip circumference, biceps SF, triceps SF, subscapular SF and suprailliac SF were 36.96 (11.60), 163.84 cm (5.91), 54.08 kg (7.20), 20.14 kg/m^2 (2.38), 24.55 cm (2.06), 75.95 cm (7.28), 79.96 cm (5.31), 3.66 mm (1.98),

Table 1: Age and anthropometric characteristics of brick kiln workers (N = 501)

Variables	*Mean*	*SD*
Age (years)	36.96	11.60
Anthropometric		
Height (cm)	163.84	5.91
Weight (kg)	54.08	7.20
BMI (kg/m^2)	20.14	2.38
Circumference (cm)		
MUAC	24.55	2.06
Waist circumference	75.95	7.28
Hip circumference	79.96	5.31
Skinfolds (mm)		
Biceps SF	3.66	1.98
Triceps SF	5.75	2.97
Subscapular SF	10.38	5.46
Suprailiac SF	7.07	4.78

5.75 mm (2.97), 10.38 mm (5.46) and 7.07 mm (4.78) respectively. Table 2 displays the body composition characteristics of brick kiln workers. The mean (SD) values of PBF, FM, FFM, WHR, CI, BAI, BMAI and WHtR were 11.13 percent (6.07), 6.32 kg (4.24), 47.76 kg (4.62), 0.95 (0.05), 1.21 (0.07), 20.21 (2.66), 15.43 (3.28) and 0.46 (0.04), respectively. Table 3 displays the blood pressure of brick kiln workers. The mean (SD) value of SBP, DBP, PR and MAP were 115.25 mmHg (12.36), 73.55 mmHg (7.84), 77.03 p/min (11.26) and 87.45 mmHg (8.68), respectively. Tables 4 and 6 demonstrated that all anthropometric measurements like as WC, HC, MUAC, TSF, BSF, SSF, SISF, WHR, CI, BAI, BMAI, WHtR, SBP, DBP and MAP have significantly positive correlation (p<0.01) with BMI and weight. In case of height, only circumference measurements and CI have positive correlation (p<0.01). However, height is negatively correlated (though not signficantly) with skinfold measurements and blood pressure. Tables 5 and 7 also showed that PBF, FM and FFM were strongly correlated (p<0.01) with all anthropometric parameters, body adiposity indicators and blood pressure, except CI. Pulse rate (PR) was significantly correlated (p<0.05) with weight and fat mass. Table 8 demonstrated that except PR, blood pressure like SBP, DBP and MAP have significantly positive correlation (p<0.001) with BAI, BMAI and WHtR.

Liner regression analysis (Tables 4 and 5) indicated that the highest amounts of variation of BMAI (91.1%), MUAC (71.1%), WHtR (69.5%), WC (63.6%) were explained by BMI. The independent variable FM explained the following variation of BMAI, WC, WHtR, HC, MUAC and BAI: 80.4 percent, 70.7 percent, 66.5 percent, 59.2 percent, 56.7 percent and 42.8percent respectively. High amounts of variation of BMAI (68.5%), WHtR (63.7%), WC (62.1%), and WHR (60.3%) were explained by PBF. No variation was found in BSF and SSF, as explained by independent variable height.

Tables 6, 7 and 8 also displayed the results of the liner regression analysis, carried out with blood pressure (SBP, DBP, and MAP, separately) as dependent variables to investigate the amount of variation (R^2) of height, weight, BMI, PBF, FM, FFM, BAI, BMAI and HTR. Results indicated that the highest amount of variation of MAP (16.7%) was explained by WHtR and followed by DBP (16.4%), as explained by BMAI. Lesser amount of variations was found in SBP, DBP, PR and MAP, as explained by height.

Table 2: Body composition characteristics of brick kiln workers (N = 501)

Variables	*Mean*	*SD*
Fat Distribution		
PBF (%)	11.13	6.07
FM (kg)	6.32	4.24
FFM (kg)	47.76	4.62
WHR	0.95	0.05
CI	1.21	0.07
BAI	20.21	2.66
BMAI	15.43	3.28
WHtR	0.46	0.04

Table 3: Blood pressure of brick kiln workers (N = 501)

Variables	*Mean*	*SD*
SBP (mmHg)	115.25	12.36
DBP (mmHg)	73.55	7.84
PR (per min)	77.03	11.26
MAP (mmHg)	87.45	8.68

DISCUSSION

Although the relationship between anthropometric parameters and blood pressure has been frequently studied, to the researchers' knowledge the present study is the first to examine this relationship among the Muslim brick kiln workers of India. The present findings demonstrated that all anthropometric parameters and blood pressure like WC, HC, MUAC, TSF, BSF, SSF, SISF, BAI, BMAI, WHtR, SBP, DBP and MAP were significantly correlated with weight and BMI. WC, HC, MUAC, WHR and CI were also significantly correlated with PBF and FM but the relationship of MUAC with weight and WC with BMI, PBF and FM were much stronger than other parameters. SBP, DBP and MAP were highly positively correlated with BAI, BMAI and WHtR. Like previous study (Al-Sendi et al. 2003), the researchers also found a positive significant (p<0.001) correlation of BMI with SBP and DBP. Another study conducted (Mungreiphy et al. 2001) among adult males of Manipur, also found a positive significant correlation between BMI and blood pressure. Positive association between BMI and BP has also been reported in other Indian Populations (Gupta et al. 1995;Tandon 2000).The close relationship between increased body weight and elevated blood pressure has been described in both adults (Barkely

Table 4: Pearson correlation coefficients and coefficient of determination of variables with anthropometric character

Dependent variables	*Independent variables*								
	Height			*Weight*			*BMI*		
	r	R^2	*p-value*	*r*	R^2	*p-value*	*r*	R^2	*p-value*
WC	0.199**	0.040	0.000	0.816**	0.667	0.000	0.798**	0.636	0.000
HC	0.312**	0.097	0.000	0.816**	0.713	0.000	0.798**	0.569	0.000
MUAC	0.136**	0.019	0.002	0.826**	0.683	0.000	0.727**	0.711	0.000
TSF	0.007	0.000	0.879	0.660**	0.435	0.000	0.843**	0.541	0.000
BSF	-0.042	0.002	0.346	0.593**	0.352	0.000	0.735**	0.481	0.003
SSF	-0.006	0.000	0.895	0.658**	0.433	0.000	0.694**	0.554	0.000
SISF	-0.052	0.003	0.248	0.629**	0.395	0.000	0.744**	0.548	0.000
WHR	-0.026	0.001	0.568	0.407**	0.214	0.000	0.476**	0.291	0.000
CI	0.118**	0.014	0.008	0.361**	0.131	0.000	0.337**	0.113	0.000
BAI	-0.476**	0.225	0.000	0.426**	0.180	0.000	0.766**	0.587	0.000
BMAI	0.040	0.000	0.368	0.872**	0.759	0.000	0.954**	0.911	0.000
WHtR	-0.175**	0.029	0.000	0.647**	0.417	0.000	0.834**	0.695	0.000

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level

Table 5: Pearson correlation coefficients and coefficient of determination of variables with fat distribution

Dependent variables	*Independent variables*								
	PBF			*FM*			*FFM*		
	r	R^2	*p-value*	*R*	R^2	*p-value*	*r*	R^2	*p-value*
WC	0.788**	0.621	0.000	0.841**	0.707	0.000	0.499**	0.249	0.000
HC	0.653**	0.478	0.000	0.732**	0.592	0.000	0.599**	0.370	0.000
MUAC	0.685**	0.470	0.000	0.753**	0.567	0.000	0.596**	0.355	0.000
WHR	0.552**	0.603	0.000	0.542**	0.356	0.000	0.137**	0.030	0.002
CI	0.530**	0.281	0.000	0.526**	0.277	0.000	0.080	0.006	0.074
BAI	0.645**	0.427	0.000	0.655**	0.428	0.000	0.063	0.002	0.160
BMAI	0.828**	0.685	0.000	0.897**	0.804	0.000	0.534**	0.284	0.000
WHtR	0.798**	0.637	0.000	0.816**	0.665	0.000	0.258**	0.065	0.000

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level

Table 6: Pearson correlation coefficients and coefficient of determination of anthropometric variables with blood pressure

Dependent variables	*Independent variables*								
	Height			*Weight*			*BMI*		
	r	R^2	*p*	*r*	R^2	*P*	*r*	R^2	*p*
SBP	-0.011	-0.002	0.810	0.329**	0.106	0.000	0.369**	0.134	0.000
DBP	-0.025	-0.001	0.570	0.339**	0.115	0.000	0.388**	0.149	0.000
PR	0.070	0.003	0.116	0.090*	0.008	0.045	0.059	0.001	0.189
MAP	-0.020	-0.002	0.648	0.361**	0.130	0.000	0.410**	0.116	0.000

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05level

et al. 1998) and children and adolescents (Wilson et al. 1985). These results may have implications for human health. Relying of skinfold thickness to distinguish central from peripheral adiposity (Shear et al. 1987) showed that centrally located body fat was strongly and directly related to SBP in children and young adults and that such a relationship was independent of periph-

Table 7: Pearson correlation coefficients and coefficient of determination of body composition variables with blood pressure

Dependent variables	*Independent variables*								
	PBF			*FM*			*FEM*		
	r	R^2	*p*	*r*	R^2	*P*	*r*	R^2	*p*
SBP	0.381**	0.143	0.000	0.392**	0.152	0.000	0.152**	0.021	0.001
DBP	0.385**	0.147	0.000	0.401**	0.159	0.000	0.159**	0.023	0.000
PR	0.076	0.004	0.008	0.095*	0.007	0.033	0.052	0.001	0.242
MAP	0.414**	0.169	0.000	0.429**	0.182	0.000	0.169**	0.027	0.000

** Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05level

Table 8: Pearson correlation coefficients and coefficient of determination of variables with fat distribution

Dependent variables	*Independent variables*								
	BAI			*BMAI*			*WHTR*		
	r	R^2	*p*	*r*	R^2	*P*	*r*	R^2	*p*
SBP	0.381**	0.143	0.000	0.392**	0.152	0.000	0.152**	0.021	0.001
SBP	0.337**	0.112	0.000	0.389**	0.150	0.000	0.373**	0.137	0.000
DBP	0.348**	0.119	0.000	0.407**	0.164	0.000	0.387**	0.148	0.000
PR	0.008	-0.002	0.863	0.077	0.004	0.086	0.049	0.000	0.274
MAP	0.370**	0.135	0.000	0.431**	0.184	0.000	0.411**	0.167	0.000

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level

eral fat. Similar studies are required among other occupational group to investigate whether there exits occupational variation.

All anthropometric parameters and blood pressure like WC, HC. MUAC, TSF, BSF, SSF, SISF, WHR, CI, BAI, BMAI, HTR, SBP, DBP and MAP were highly correlated with height, weight, BMI, PBF, FM and FFM ($p < 0.001$), rest of the anthropometric parameters like all skinfold measurements and WHR with height and FFM with CI were weakly correlated. Three skinfold measurements (BSF, SSF and SISF), WHR, SBP, DBP and MAP were negatively correlated with height, though it is not statistically significant. The finding of the present study is similar to the observations of Khatoon et al. (2008) and Singh et al. (2014). In comparison, WC and WHR explained the highest amount of variation in BPF and FM. On the other hand in case of all anthropometric variables, lesser amount of variation was explained by FFM. For all circumference measurements, large amount of variations were explained by weight and BMI. However, lesser amount of variation of skinfold thickness was explained by height. Waist-to-hip ratio in male athletes and non-athletes had the most correlation with body fat percentage (r = 0.821 and r =0.889, respectively). Body mass index in female athletes and non-athletes had the most correlation with percentage of body fat (r =0.780 and r = 0.863, respectively) (Ashtary-Larky et al. 2018).

Another earlier study had found that the correlations of CI with body composition measures were intermediate between those of WC and WHR (Chatterjee et al. 2006), but in the researchers' study the correlation of CI with anthropometric and body composition measures were lesser than those of WHR. CI had also weaker correlation compared to WC and HC. Most of the recent studies agree that WC is probably a better indicator of abdominal fatness and cardiovascular disease than either BMI or WHR (Ledoux et al. 1997). A recent study (Ghosh and Bandypadhyay 2007) among adult females in the Bengalee population found that WC had the highest correlation with total body fat and explained the large amount of variation in the same measure. Another study among the Bengalee Hindu male adult population found that WC had the highest correlation with PBF and explained the largest amount of variation in the same measure. According to the World Health Organization (WHO 1997) standard for BMI, it was found that the BMI of brick kiln workers working was found to be in the normal range in the researchers' study.

Body roundness index (BRI) and body adiposity index (BAI) and the anthropometric indices destine the metabolic syndrome in Chinese postmenopausal women. In addition, neither BAI nor BRI was superior to consecutive obesity indices for predicting metabolic syndrome (Mets). BAI showed the poorest predictive ability, while BRI showed effective for use as an alternative obesity measure in the assessment of MetS (Liu et al. 2016). Anthropometric indices in relation to blood pressure in China. The results showed that in genders, visceral fat index (VFI) and body fat percentage (PBF) tended to rise with age. In younger men and women, VFI had the highest crude and adjusted odds ratio for hypertension. The area under curve (AUCs) for PBF, VFI and WHtR were significantly larger than those for BMI and WC whereas no statistically significant difference was found in AUCs among PBF, VFI and WHtR, additionally, VFI and PBF yielded the greatest Youden index in identifying hypertension in men and women, respectively (Jiang et al. 2016). Flegal et al. (2009) expressed that, percentage body fat tended to be significantly more correlated with WC than with BMI in men and also, significantly more correlated with BMI than with WC in women. Also, WSR (waist-stature ratio) tended to be slightly more correlated with percentage body fat than was WC.

CONCLUSION

Present study suggested that body fat distribution in brick-kiln workers belonging to this environment can be easily explained by WC and HC in comparison to WHR and CI. The amount of variations of MAP was explained by WHtR than other anthropometric parameters.

RECOMMENDATIONS

One of the limitations of the present study was the fact that the data was collected from a particular geographical area. Further studies should be undertaken not only among other occupational groups who belong to various socio-economic strata but also in different ethnic groups. It would also be interesting to investigate whether similar associations are found among females.

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