



## The association of anthropometric indices and cardiac function in healthy adults

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### Original Article

#### Abstract

**BACKGROUND:** Obesity is a major risk factor for many diseases including cardiovascular diseases (CVDs). Recently, it has been shown that upper body obesity can predict CVDs per se. In this study, we aimed to determine the association between indicators of upper body obesity and echocardiographic indices.

**METHODS:** In this cross-sectional study conducted in Hajar Hospital in Shahrekord, Iran, from March to August 2014, 80 healthy adults were included. Participants' neck circumference (NC), waist circumference (WC), body mass index (BMI), and blood pressure were measured. Echocardiography was performed for all participants, and echocardiographic indices such as early (E') and late (A') diastolic tissue velocity, early (E) and late (A) transmitral flow velocity, E/E' ratio, pulmonary arterial pressure (PAP), and left atrial volume (LAV) were recorded. The association between these indices were investigated using bivariate Pearson correlation coefficient.

**RESULTS:** For men, NC had a significant correlation with LAV, systolic blood pressure (SBP), diastolic blood pressure (DBP), PAP, and A', and a negative correlation with E'. WC had a significant correlation with LAV, SBP, and PAP, and a negative correlation with E', while BMI had a significant correlation with LAV, PAP, SBP, A, and A'. For women, NC had a significant positive correlation with LAV, A, ejection fraction (EF), SBP, PAP, and A', and a negative correlation with E' and E/E'. WC had a significant positive correlation with LAV, DBP, PAP, A, A', and a negative correlation with E', while BMI had a significant correlation with LAV, EF, SBP, PAP, E', A, and A'.

**CONCLUSION:** The positive correlation of NC with SBP, A, and A', as well as NC, WC, and BMI with LAV and PAP in both sexes, and the negative correlation of NC with E' show the importance of these measures in estimation of metabolic and cardiovascular risk factors.

**Keywords:** Obesity, Risk Factors, Cardiovascular Diseases

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#### Introduction

Insight into echocardiographic parameters in the general population may facilitate early recognition of ventricular dysfunction, and reducing the population's morbidity and mortality due to heart failure.<sup>1</sup> Echocardiographic parameters can predict cardiovascular events in several clinical settings.<sup>2</sup> For decades, metabolic syndrome including obesity has been a major risk factor for cardiovascular diseases (CVDs).<sup>3</sup> Recently, the results of observational studies have stated that upper body obesity has a significant association with CVD,

hyperinsulinemia, diabetes mellitus (DM), and hypertriglyceridemia independently.<sup>4,7</sup> It has been shown that upper body obesity is correlated with CVDs and metabolic syndrome more than general obesity and body mass index (BMI).<sup>8</sup>

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There are many different ways to assess upper body obesity. Although imaging techniques such as magnetic resonance imaging (MRI), computed tomography (CT), and double X-ray are known as the best methods for estimation of upper body obesity, the excessive costs and adverse effects of radiation has disabled using them as appropriate screening methods. Thus, anthropometric measurements, such as measuring waist circumference (WC), waist to hip ratio, waist to height ratio, and neck circumference (NC), have been suggested as commonly-used simple and non-invasive methods for estimation of upper body obesity.<sup>9-13</sup> Evidence suggests NC as an independent indicator of upper body obesity, associated with metabolic syndrome factors and CVDs.<sup>14</sup> As some studies have shown the variation of upper body obesity based on the population's ethnicity and race for predicting DM and CVD,<sup>4</sup> and this association has not been studied in Iranian population, in this study, we aimed to determine the association between upper body anthropometric measurements and cardiac diastolic dysfunction in people with normal ejection fraction (EF).

### Materials and Methods

This cross-sectional study was performed in Hajar Hospital, Shahrekord, Iran, from March to August 2014. Eighty participants were selected from those who referred to the cardiovascular clinics, only to accompany a patient. The participants' age ranged from 35 to 50 years, and all were invited to the study after reading and signing the written informed consent form. Any patient with any of the following criteria was excluded from the study: sleep apnea, DM, neck deformity, lymphadenopathy, thyroiditis, thyromegaly, hypertension, left ventricular hypertrophy, EF < 50%, and valvular heart diseases.

The participants' demographic characteristics were recorded on the study checklist, including positive family history of cardiac disorders and risk factors (like DM, smoking, and hypertension). Participants' height and weight were measured by the researcher with precision of 1 mm and 100 grams, respectively, while the person was wearing light clothing and no shoes; BMI was calculated by dividing weight (in kilograms) by squared height (in meters). The participants were asked to stand straight with their head positioning in Frankfort horizontal level, and a tape measure was placed right under laryngeal prominence around the neck in order to measure the NC. WC was measured while the participants stood up with no clothes, and a tape

measure was placed between the last rib and the iliac crest. Systolic (SBP) and diastolic (DBP) blood pressures were measured using an oscillometric approach, and an appropriate cuff was used based on the participants' right arm circumflex. Before measuring BP, all participants relaxed for at least 10 minutes, and BP was measured only once.

Echocardiography was performed using a Vivid 3 Ultrasound Machine (cardiac ultrasound images). Cardiac function parameters such as EF, early diastolic mitral annular (E'), and late diastolic (A') velocities were measured by Doppler Tissue Imaging (DTI), and the E/E' ratio was computed. Recorded mitral inflow measurements included early mitral filling (E) and late (A) velocities, E/A ratio, deceleration time of E velocity, and duration of A.<sup>15</sup> Left atrial volume (LAV) was also measured using prolate ellipse method ( $D_1 \times D_2 \times D_3 \times 0.523$ ).<sup>16</sup> Systolic pulmonary artery pressure (SPAP) was measured using tricuspid regurgitation and Bernoulli formula.<sup>16</sup> All the measurements were performed by a single investigator and echocardiography assessments were carried out by a fixed individual cardiologist.

All data were analyzed using SPSS software (version 20.0, IBM Corporation, Armonk, NY, USA). Numerical measurements were normally distributed and reported as mean  $\pm$  standard deviation (SD). Two samples t test was used to compare mean differences of cardiac function parameters between men and women participants. Pearson correlation coefficient was calculated to evaluate association between anthropometric measures (NC and WC) and cardiac function parameters. To avoid multiplicity problem, Bonferroni correction was applied. P-values of less than 0.050 were considered statistically significant.

### Results

Eighty subjects (54 women and 26 men) with mean ( $\pm$  SD) age of 40.0 ( $\pm$  8.1) years participated in this study. None of the participants were a known case of CVDs or DM. The mean values of BMI, NC, WC, and BP are presented in table 1. Independent t test showed that the difference between the mean age and BMI of the women and men were not statistically significant ( $P > 0.050$ ). But, there were significant differences between men and women in terms of other variables such as height and weight, NC, and WC ( $P < 0.050$  for all).

The correlation of NC, WC, and BMI with echocardiographic variables and BP was tested for men and women, and the results of which are shown in tables 2 and 3, respectively.

**Table 1.** The demographic characteristics of participants

Variable	Men (n = 26)	Women (n = 54)	Total (n = 80)	P
Age (year)	41.5 ± 7.3	39.2 ± 8.3	40.0 ± 8.1	0.227
Height (cm)	171.8 ± 9.7	160.3 ± 6.1	40.0 ± 8.1	0.003
Weight (kg)	82.3 ± 15.1	71.2 ± 12.7	40.0 ± 8.1	0.001
NC (cm)	40.1 ± 3.4	35.6 ± 3.1	37.1 ± 3.8	0.023
WC (cm)	94.9 ± 12.5	83.5 ± 11.5	87.2 ± 12.9	0.008
SBP (mmHg)	120.9 ± 6.6	114.3 ± 7.5	116.5 ± 7.8	0.040
DBP (mmHg)	80.7 ± 5.9	76.2 ± 5.5	77.7 ± 6.0	0.001
BMI (kg/m <sup>2</sup> )	27.8 ± 4.4	27.7 ± 4.8	27.7 ± 4.6	0.879

Data are reported as mean ± standard deviation (SD).

NC: Neck circumference; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; BMI: Body mass index

According to table 2, for men, NC had a positive correlation with LAV, SBP, pulmonary arterial pressure (PAP), A', and DBP, and a negative correlation with E'. WC had a significantly positive correlation with LAV, SBP, and PAP, but a negative correlation with E'. BMI had a significantly positive correlation with LAV, PAP, SBP, A, and A'.

According to table 3, for women, NC had a positive correlation with LAV, A, EF, SBP, PAP and A' and a negative correlation with E' and E/E'. WC had a significant correlation with LAV, DBP, PAP, A, and A' and a negative correlation with E'. BMI had a significant positive correlation with PAP, E', LAV, EF, SBP, A, and A'.

## Discussion

The results of this study indicated that NC was significantly correlated with LAV, SBP, DBP, and PAP, which shows that all of them can be used as predictors of probable myocardial diastolic dysfunction. WC and BMI were also correlated with parameters, predicting the probability of myocardial dysfunction, but they both had a rather weaker

correlation, compared to NC. Preis et al. showed that NC could be a marker of fat deposit, associated with great potential risk of CVDs.<sup>8</sup> Ben-Noun and Laor also recognized the positive association between NC and some features of metabolic syndrome, predicting the risk of CVDs.<sup>14</sup> The results of both studies are in line with that of ours.

In our study, NC was associated with SBP and DBP. In previous studies, the relationship between NC and BMI or WC has been addressed in order to show the relation between NC and metabolic syndrome.<sup>4-8</sup> Our study is in line with these statements, but adds the correlation of NC, another item of the metabolic syndrome, with SBP and DBP. This indicates that NC can be a potent criterion in metabolic syndrome and probable CVDs, which could be associated with the aforementioned matters. In our study, there was a strong negative correlation between NC and E', and a weak negative correlation between E' with WC and BMI, which shows that E' can be a better predictor for cardiac diastolic dysfunction than BMI and WC.

**Table 2.** The correlation of neck circumference (NC), waist circumference (WC), and body mass index (BMI) with echocardiographic parameters in men

Variable	NC (cm)		WC (cm)		BMI (kg/m <sup>2</sup> )	
	R	P	R	P	R	P
LAV (ml)	0.968	< 0.001	0.668	< 0.001	0.641	< 0.001
EF (%)	0.060	0.298	-0.124	0.137	0.103	0.365
SBP (mmHg)	0.442	< 0.001	0.387	< 0.001	0.291	0.009
DBP (mmHg)	0.239	0.030	0.143	0.200	0.133	0.239
PAP (mmHg)	0.777	< 0.001	0.679	< 0.001	0.500	< 0.001
A (cm/s)	0.469	0.008	0.084	0.342	0.337	0.046
A' (cm/s)	0.612	< 0.001	0.185	0.182	0.379	0.029
E' (cm/s)	-0.410	< 0.001	-0.383	< 0.001	-0.269	0.008
E/E'	-0.015	0.447	-0.024	0.416	0.088	0.437

P-values of less than 0.050 were considered as statistically significant.

NC: Neck circumference; WC: Waist circumference; BMI: Body mass index; LAV: Left atrial volume; EF: Ejection fraction; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PAP: Pulmonary arterial pressure; A: Peak velocity of mitral inflow during atrial contraction, A': Late diastolic mitral annular velocity, E: Peak velocity of mitral inflow during early filling phase; E': Early diastolic mitral annular velocity

**Table 3.** The correlation of neck circumference (NC), waist circumference (WC), and body mass index (BMI) with echocardiographic parameters in women

Variable	NC (cm)		WC (cm)		BMI (kg/m <sup>2</sup> )	
	R	P	R	P	R	P
LAV (ml)	0.935	< 0.001	0.541	0.008	0.722	0.030
EF (%)	0.270	0.024	-0.120	0.465	0.277	0.021
SBP (mmHg)	0.290	0.017	0.182	0.094	0.354	0.004
DBP (mmHg)	0.134	0.167	0.143	0.024	0.136	0.164
PAP (mmHg)	0.289	0.017	0.693	0.003	0.596	< 0.001
A (cm/s)	0.555	< 0.001	0.446	0.002	0.472	0.002
A' (cm/s)	0.589	0.030	0.489	0.003	0.372	0.003
E' (cm/s)	-0.382	< 0.001	-0.234	0.038	0.399	< 0.001
E/E'	-0.123	0.002	-0.075	0.294	0.207	0.067

P-values of less than 0.050 were considered as statistically significant.

NC: Neck circumference; WC: Waist circumference; BMI: Body mass index; LAV: Left atrial volume; EF: Ejection fraction; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PAP: Pulmonary arterial pressure; A: Peak velocity of mitral inflow during atrial contraction, A': Late diastolic mitral annular velocity, E: Peak velocity of mitral inflow during early filling phase; E': Early diastolic mitral annular velocity

For many years, BMI has been used to evaluate obesity, as a risk factor of CVDs. Also many studies have considered central obesity and WC as important markers for predicting CVDs.<sup>17-20</sup> Similarly, the results of our study confirmed the association between WC with different echocardiographic parameters and SBP.

Looking to the whole picture reveals a stronger association between NC and echocardiographic parameters, compared to general obesity and WC. This is in line with studies that present upper body fat deposit as a better predictor of CVDs.<sup>6-22</sup>

In our study, there was no significant correlation between NC and EF in neither sexes. This finding may be due to including only participants with EF of more than 50%. Thus, further studies are needed to evaluate the relation between NC and EF in participants with a wide range of EFs. Similarly, there was no significant correlation between NC and E/E' in men. The inclusion of participants with EF of more than 50% could be the reason for this finding; as E/E' is mainly impaired in advanced diastolic dysfunction, whereas in this study all cases were healthy, and no abnormality in E/E' ratio was expected.

The cross-sectional study design is main drawback of our findings, as it is not possible to discuss the causal relationship between anthropometric indices and cardiac function. Furthermore, the fact that the studied participants came from a healthy population, could be either considered as a positive point or a limitation. Many patients with CVDs suffer from obesity and metabolic syndrome concurrently, and we excluded patients with CVD or DM to decrease the risk of bias in our study. On the other hand, such an inclusion criteria could be a limitation for studying the association between NC and some pathological

features such as EF and E/E'.

### Conclusion

In this study, it was observed that NC, WC, and BMI had a significant correlation with LAV and PAP, both in men and women. NC had a significant correlation with SBP in men and women, and also BMI had significant correlation with A in both sexes. These findings imply that these measures may help refine evaluations of metabolic and cardiovascular risk factors. Accordingly, regular NC, WC, and BMI screening is recommended as an easy and effective way of assessing body weight for prevention of weight-related diseases in men and women.

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### Conflict of Interests

Authors have no conflict of interests.

### References

1. Kardys I, Deckers JW, Stricker BH, Vletter WB, Hofman A, Witteman J. Distribution of echocardiographic parameters and their associations with cardiovascular risk factors in the Rotterdam Study. *Eur J Epidemiol* 2010; 25(7): 481-90.
2. Han SS, Cho GY, Park YS, Baek SH, Ahn SY, Kim S, et al. Predictive value of echocardiographic parameters for clinical events in patients starting hemodialysis. *J Korean Med Sci* 2015; 30(1): 44-53.
3. Clearfield M, Pearce M, Nibbe Y, Crotty D,

- Wagner A. The "New Deadly Quartet" for cardiovascular disease in the 21<sup>st</sup> century: Obesity, metabolic syndrome, inflammation and climate change: How does statin therapy fit into this equation? *Curr Atheroscler Rep* 2014; 16(1): 380.
4. Kuznetsova T, Herbots L, Lopez B, Jin Y, Richart T, Thijs L, et al. Prevalence of left ventricular diastolic dysfunction in a general population. *Circ Heart Fail* 2009; 2(2): 105-12.
  5. Kissebah AH, Vydelingum N, Murray R, Evans DJ, Hartz AJ, Kalkhoff RK, et al. Relation of body fat distribution to metabolic complications of obesity. *J Clin Endocrinol Metab* 1982; 54(2): 254-60.
  6. Stevens J. Obesity, fat patterning and cardiovascular risk. *Adv Exp Med Biol* 1995; 369: 21-7.
  7. Goodpaster BH, Krishnaswami S, Harris TB, Katsiaras A, Kritchevsky SB, Simonsick EM, et al. Obesity, regional body fat distribution, and the metabolic syndrome in older men and women. *Arch Intern Med* 2005; 165(7): 777-83.
  8. Preis SR, Massaro JM, Hoffmann U, D'Agostino RB Sr, Levy D, Robins SJ, et al. Neck circumference as a novel measure of cardiometabolic risk: The Framingham Heart study. *J Clin Endocrinol Metab* 2010; 95(8): 3701-10.
  9. Ben-Noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obese patients. *Obes Res* 2001; 9(8): 470-7.
  10. Ashwell M, Cole TJ, Dixon AK. Obesity: New insight into the anthropometric classification of fat distribution shown by computed tomography. *Br Med J (Clin Res Ed)* 1985; 290(6483): 1692-4.
  11. Wing RR, Jeffery RW, Burton LR, Thorson C, Kuller LH, Folsom AR. Change in waist-hip ratio with weight loss and its association with change in cardiovascular risk factors. *Am J Clin Nutr* 1992; 55(6): 1086-92.
  12. Haffner SM, Stern MP, Hazuda HP, Pugh J, Patterson JK. Do upper-body and centralized adiposity measure different aspects of regional body-fat distribution? Relationship to non-insulin-dependent diabetes mellitus, lipids, and lipoproteins. *Diabetes* 1987; 36(1): 43-51.
  13. Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, Tremblay A, et al. Waist circumference and abdominal sagittal diameter: Best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *Am J Cardiol* 1994; 73(7): 460-8.
  14. Ben-Noun LL, Laor A. Relationship between changes in neck circumference and cardiovascular risk factors. *Exp Clin Cardiol* 2006; 11(1): 14-20.
  15. Nishimura RA, Tajik AJ. Evaluation of diastolic filling of left ventricle in health and disease: Doppler echocardiography is the clinician's Rosetta Stone. *J Am Coll Cardiol* 1997; 30(1): 8-18.
  16. Jiamsripong P, Honda T, Reuss CS, Hurst RT, Chaliki HP, Grill DE, et al. Three methods for evaluation of left atrial volume. *Eur J Echocardiogr* 2008; 9(3): 351-5.
  17. Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist: Hp ratio as predictors of cardiovascular risk- a review of the literature. *Eur J Clin Nutr* 2010; 64(1): 16-22.
  18. de Koning L, Merchant AT, Pogue J, Anand SS. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: Meta-regression analysis of prospective studies. *Eur Heart J* 2007; 28(7): 850-6.
  19. Nyamdorj R, Qiao Q, Lam TH, Tuomilehto J, Ho SY, Pitkaniemi J, et al. BMI compared with central obesity indicators in relation to diabetes and hypertension in Asians. *Obesity (Silver Spring)* 2008; 16(7): 1622-35.
  20. Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, Commerford P, et al. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: A case-control study. *Lancet* 2005; 366(9497): 1640-9.
  21. Van Gaal LF, Vansant GA, De Leeuw IH. Upper body adiposity and the risk for atherosclerosis. *J Am Coll Nutr* 1989; 8(6): 504-14.
  22. Kaplan NM. The deadly quartet. Upper-body obesity, glucose intolerance, hypertriglyceridemia, and hypertension. *Arch Intern Med* 1989; 149(7): 1514-20.