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Relationship Between Body Adiposity and Arterial Stiffness in Young Indian Adults

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ABSTRACT

Background: Obesity is one of the major cardiovascular risk factors and is linked with arterial stiffness. This study was undertaken to establish the relationship between regional adiposity and arterial stiffness using simple noninvasive techniques. **Methods:** In total, 181 young Asian Indian adults aged 18–28 years (mean age 21.9 ± 2.2) were measured for adiposity and arterial stiffness. Total body fat percentage was derived from skinfold thickness of various body sites. Body mass index and waist-hip-ratio were also measured. Arterial stiffness was measured using a SphygmoCor with a carotid-radial pulse wave analysis technique. **Results:** Significant gender differences were observed on anthropometric variables including skinfold thickness ($P < 0.05$) and all the arterial stiffness variables ($P < 0.05$) except pulse wave velocity. Systolic pressure, augmentation pressure, augmentation index (AIx), AIx at 75% heart rate, and aortic systolic pressure had statistically significant correlations with all three adiposity variables ($P < 0.05$). Significant correlations were found in a higher number of variables in the females. Physical activity had negative correlations with arterial stiffness and adiposity variables ($P < 0.05$). **Conclusion:** Arterial stiffness measured by carotid-radial pulse wave analysis is strongly related to adiposity measured from skinfold thickness in females. Females had higher arterial stiffness and adiposity compared with men. These findings could be helpful in future research using noninvasive arterial stiffness measurements.

Key words: Adiposity, arterial stiffness, obesity, pulse wave analysis, skinfold thickness

INTRODUCTION

Obesity is one of the important risk factors for diabetes and other cardiovascular disease. The World Health Organization has declared that ischemic heart disease will be ranked first, and diabetes will move from 11th place to 6th place for the global burden of diseases and mortality by 2030.[1] In 2005, it was estimated that 33% of the world's adult population were overweight or obese. Further, it is projected that there will be up to 57% overweight or obesity levels by 2030.[2] Obesity prevalence is observed in developed as well as developing counties such as India. In India, it is projected that there will be an increase of the prevalence of overweight or obesity from 16.9% (as in 2005) to 32.8% by 2030.[2] In India, obesity was observed even in school aged preadolescents and adolescents in both males and females. There was higher prevalence in high socioeconomic children and females.[3]

Arterial stiffness and obesity

Arterial stiffness is one of the key tools in the measurement of cardiovascular risk. Many studies have confirmed the relationship between arterial stiffness and adiposity in different age groups.[4-7] A strong relationship between adiposity and arterial distensibility using ultrasound

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imaging was found in British adolescents.[4] In addition to adiposity, physical fitness and lifestyle also influence arterial stiffness.[5] Physical activities have a strong correlation with the incidence of obesity in adolescents and young adults.[8] Body mass index (BMI) is a standard method of assessing overall obesity. Skinfold thickness and waist-hip circumferences are used to measure adiposity in specific parts of the human body. Acree *et al.*[6] found that obesity was associated with decrease in large and small artery compliance. In their study, large arterial compliance had significant correlations with the skinfold thickness and small arterial compliance with the waist-hip circumferences and their ratios. Total adiposity and truncal subcutaneous fat accumulation at the age of adolescence had positive correlations with the carotid intima-media thickness at the age of 36 in a longitudinal study.[7] Juonala *et al*.[9] also found that childhood obesity was related to the development of carotid stiffness in adulthood. Interestingly, Zebekakis *et al.*[10] found that carotid distensibility decreased with higher BMI. They state that the arterial stiffness was modulated with age, i.e., the negative effects of obesity on arterial stiffness were higher in younger age groups. They also suggest studying whether obesity in young adults is related to a higher risk of arterial stiffness and cardiovascular disease. It could help find the potential of preventing obesity at younger age.[10] Most of the studies using noninvasive pulse wave analysis have measured carotid-femoral pulse wave velocity (PWV). The current study aims to use and establish the importance of carotid-radial PWV, which is less intrusive.

To the investigators' knowledge, no study has been carried out to find the relationship between adiposity and arterial stiffness in young and healthy Indian adults. The current study aims to study the relationship between adiposity using skinfold thickness and arterial stiffness using pulse wave analysis in young Indian adults. It was hypothesized that in young healthy Indian adults, there would be a significant positive relationship between body fat percentage measured by skinfold thickness and arterial stiffness measured by a noninvasive pulse wave analysis. There would be significant differences between males and females in the above said relationship. Also, there would be a significant relationship between abdominal obesity and arterial stiffness.

METHODS

The participants aged 18–28 years (mean age 21.9 ± 2.2) were recruited from a student population in Mangalore, India, and 181 volunteered to participate.

Skinfold thickness

The skinfold thickness was measured using a Harpenden Skinfold Caliper (Quality Measurement Limited, Victoria Road Burgess Hill, RH15 9LB United Kingdom). Measurements were taken according to the manufacturer's guidelines.

Measurement was taken on healthy, undamaged, and uninfected dry skin. The participants were instructed to keep the muscles relaxed during the test. All the measurements were taken on the right side of the body. An exception was made in case of a deformity in the right limb. The skinfold site was marked using a water-soluble ink marker. A tape measure was used to find the accurate mid-points. Each skinfold was firmly grasped by the thumb and index finger, using the pads at the tip of the thumb and finger. Then, the assessor gently pulled the skinfold away from the body, placed the caliper with its dial facing up, perpendicular to the true double fold of skin thickness, and on the site marked, the caliper was applied at approximately 1 cm below the assessor's finger and thumb. While maintaining the grasp of the skinfold, the caliper was allowed to release so that full tension was placed on the skinfold. After the grip was fully released for 1–2 s, the dial was read to the nearest 0.50 mm. Two measurements were taken at each site and averaged. The measurements were repeated if the two measurements varied by more than 1 mm. The skinfold measurement was taken from seven sites as follows. Chest measurements were taken only on male participants.

- Site 1: Biceps - the anterior surface of the biceps midway between the anterior fold and the antecubital fossa
- Site 2: Triceps - a vertical fold on the posterior midline of the upper arm, over the triceps muscle, halfway between the acromion process (bony process on top of the shoulder) and olecranon process (bony process on elbow). The elbow should be extended and the arm relaxed
- Site 3: Subscapular - the fold is taken on the diagonal line coming from the vertebral border to between 1 and 2 cm from the inferior angle of the scapula (a diagonal fold about 1–2 cm below the point of the shoulder blade and 1–2 cm toward the arm)
- Site 4: Suprailiac - a diagonal fold above the crest of the ilium at the spot where an imaginary line would come down from the anterior auxiliary line, just above the hipbone and 2–3 cm forward
- Site 5: Chest (juxta-nipples) - a diagonal fold taken one-half of the distance between the anterior auxiliary line and the nipple (the anterior auxiliary line is the crease where the top of the arm when hanging down, meets the chest)
- Site 6: Abdominal - the vertical fold taken at the lateral distance of approximately 2 cm from the umbilicus (2 cm to the side of the umbilicus)
- Site 7: Thigh - a vertical fold on the anterior aspect of the thigh, midway between the hip and knee joints (on the front of the thigh halfway between the hip joint, where the leg bends when the knee is lifted, and the middle of the knee cap). The leg should be straight and relaxed.

The body fat percentage was calculated using the linear regression equations of Durnin and Wormersley and Siri's equation [Table 1].[11] The four skinfold measurements of biceps, triceps, subscapular, and suprailiac were used in this equation.

The Siri's equation fat percentage = ([4.95/body density] −4.5) × 100.

Arterial stiffness measurement

Participants were asked not to smoke for 3 h before the study. Measurements were performed while subjects were in a quiet environment after at least 10 min of supine rest. Local blood pressures were assessed using a conventional measurement of the ipsilateral brachial artery blood pressure using a validated oscillometric device (BP-300 Kernel Int'l Corp. 1F., No. 96, Lane 31, Sec. 1, Sanmin Rd., Banciao Dist., New Taipei City 22070, Taiwan, R.O.C). The mean of three brachial blood pressure values was used for the autocalibration in the measurement of arterial stiffness. Arterial stiffness was assessed with a SphygmoCor system (SCOR-PVx, Version 8.0, AtCor Medical Inc North America, One Pierce Place, Suite 225W, Itasca, IL, 60143, USA). The SphygmoCor is one of the recently developed computerized portable and simple to use devices to assess pulse waveforms and one of the common systems in use for measuring arterial stiffness. It uses an arterial applanation tonometer for recording pressure waveforms that include PWV, pulse pressure (PP), augmentation pressure (Aug. P), augmentation index (AIx), AIx corrected for heart rate at 75 bpm (AIx@HR75), subendocardial viability ratio, and ejection duration. An electrocardiogram recording during measurements is used for synchronization of carotid and radial pulse wave times and heart rate.

The flat tonometer's end was placed on the arterial site with a small amount of pressure, and the waveforms were displayed on the personal computer screen. A 10 s of stable waveforms with a satisfactory quality were captured and fed into the SphygmoCor system. An averaged pulse waveform was derived from the recording using the integral software. A validated general transfer function was used and aortic pressure waveform was derived. A computer algorithm, comparable to invasive techniques, was used to derive AIx from the ascending aortic waveform. Brachial artery PP was derived from the difference between systolic and diastolic blood pressures. Aortic PP was assessed from radial artery waveforms applying a radial-to-aorta transfer function.

Table 1: Body density constants

	17-19 years	20-29 years	30-39 years	40-49 years	50+years
Male					
C	1.162	11631	1.1422	1.162	1.1715
M	0.063	0.0632	0.0544	0.07	0.0779
Female					
C	1.1549	1.1599	1.1423	1.1333	1.1339
M	0.0678	0.0717	0.0632	0.0612	0.0645

Body density = C (M [$\log_{10}$ sum of all four skinfolds]). C, M = Predicted constant values of various age groups for body density

PWV was measured from sequential recording of ipsilateral carotid and radial waveforms. A foot to foot comparison of these two waveforms was used. PWV was calculated as the "distance:transit time ratio" and is expressed as meter per second. All reported data are mean values of three consecutive high-quality recordings. Care was taken to place the transducers over the same point of the arteries and the same distance was used.

Calculations and statistical analysis

Abdominal obesity was determined using the International Federation of Diabetes's guidelines (waist circumference ≥90 cm in men and ≥80 cm in women).

Data were analyzed using a software package, SPSS 18 (IBM Corporation 1 New Orchard Road, Armonk, New York 10504-1722, USA). A Kolmogorov–Smirnov test was applied to test the normality of the data. A Pearson correlation test was used to analyze the relationship between the adiposity and arterial stiffness variables. The meaningfulness of the correlation coefficient was evaluated by calculating the coefficient of determination (r^2). An independent *t*-test was used to find the difference in the measured values between males and females. Statistical significance was indicated if $P < 0.05$.

RESULTS

Gender differences

In total, 124 females and 57 males participated. The physical characteristics of the participants were (mean ± standard deviation) height (cm) - 162.3 ± 11.0, weight (kg) - 58.8 ± 10.9, and BMI - 22.1 ± 3.0 kg/m^2. More than half of the participants engaged in no physical activity. The duration of their physical activity per day was categorized as follows: >60 min - 15.4%, 30–60 min - 15.4%, <30 min - 9.4%, and none - 59.1%.

The differences in the variables between males and females are listed in Table 2. There were significant differences in height and weight between males and females, but there was no difference in their BMI. There were significant differences in the anthropometric variables between males and females except abdomen skinfold thickness. Abdominal obesity was found in 1.9% males and 15.9% females. There were significant differences in all the arterial stiffness variables except PWV. This was especially the case for females, who had a two-fold higher AIx than in the males.

Table 2: Differences in arterial stiffness variables and skin fold thickness between sexes

Variables	Sex	Mean±SD	Significant	Variables	Sex	Mean±SD	Significant
Height (cm)	Male	169.5±14.9	**	SEVR	Male	158.26±26.1	**
	Female	159.0±6.3			Female	126.36±22.7	
Weight (kg)	Male	66.9±10.4	**	BP (mmHg)	Male	Systolic: 121.1±9.9 Diastolic 80.2±7.7	**
	Female	55.1±9.0			Female	Systolic 110.5±0.9 Diastolic 74.9±9.2	
BMI (kg/m^2)	Male	22.7±2.6	NS	HR (bpm)	Male	69.05±8.9	**
	Female	21.8±3.1			Female	77.85±9.8	
Fat %	Male	20.89±4.5	**	Waist (cm)	Male	80.4±8.1	**
	Female	31.31±3.8			Female	72.1±8.2	
PWV (m/s)	Male	8.00±1.1	NS	Hip (cm)	Male	95.3±7.4	*
	Female	7.96±1.0			Female	92.15±6.4	
Aug. P (mmHg)	Male	1.23±2.4	**	Waist-hip	Male	0.84±0.1	**
	Female	4.36±2.8			Female	0.77±0.1	
AIx	Male	7.34±8.3	**	SFT chest (mm)	Male	13.99±6.2	
	Female	15.88±8.7			Female	Not measured	
AIx at 75	Male	4.54±8.5	**	SFT biceps (mm)	Male	9.77±10.5	**
	Female	17.23±8.3			Female	16.84±8.8	
Aortic PP (mmHg)	Male	26.09±5.3	*	SFT triceps (mm)	Male	14.30±4.8	**
	Female	23.98±6.3			Female	20.73±9.4	
Aortic SP (mmHg)	Male	107.20±8.2	**	SFT thigh (mm)	Male	22.79±8.8	**
	Female	100.17±9.6			Female	34.57±8.0	
Aortic DP (mmHg)	Male	81.13±7.7	**	SFT sub scapular (mm)	Male	17.18±7.2	*
	Female	76.23±8.9			Female	14.77±4.8	
Mean P (mmHg)	Male	93.38±7.7	**	SFT abdomen (mm)	Male	26.34±10.7	NS
	Female	87.80±8.8			Female	26.29±5.9	
Ejection duration (ms)	Male	36.26±3.7	**	SFT iliac crest (mm)	Male	21.47±9.9	*
	Female	41.66±4.2			Female	18.70±5.9	

**Significant at $P<0.01$, *Significant at $P<0.05$. NS: Not significant, BMI: Body mass index, PWV: Pulse wave velocity, SP: Systolic pressure, DP: Diastolic pressure, SEVR: Subendocardial viability ratio, HR: Heart rate, Aug. P: Augmentation pressure, AIx: Augmentation index, SFT: Skinfold thickness, PP: Pulse pressure, SD: Standard deviation

Table 3: Relationship between arterial stiffness measures and body fat percentage (correlations coefficients)

Variables	Fat percentage	BMI	Waist-hip-ratio
Pulse wave velocity	0.042	0.025	0.021
Aug. P	0.306**	0.224**	0.325**
AIx	0.210*	0.264**	0.274**
AIx at 75	0.413**	0.217**	0.340**
Aortic PP	0.274**	0.046	0.055
Aortic SP	0.256**	0.294**	0.269**
Aortic DP	0.095	0.349**	0.270**
Mean pressure	0.167	0.333**	0.271**
Ejection duration	0.540**	0.058	0.203*
SEVR	−0.514**	−0.031	0.173
SP	0.330**	0.309**	0.309**
DP	0.104	0.345**	0.276**
HR	0.461**	0.048	0.152

**Significant at $P<0.01$, *Significant at $P<0.05$. SP: Systolic pressure, DP: Diastolic pressure, SEVR: Subendocardial viability ratio, Aug. P: Augmentation pressure, AIx: Augmentation index, BMI: Body mass index, PP: Pulse pressure, HR: Heart rate

Relationships

The relationships between the adiposity and arterial stiffness variables are listed in Table 3. Systolic pressure, Aug. P, AIx, AIx@HR75, and aortic systolic pressure had statistically significant correlations with all three adiposity variables. There was no significant relationship found between fat percentage and BMI with gender combined [Table 3], but a significant relationship was established when the data were analyzed separately [Table 4]. AIx had a significant negative correlation with height ($r = -0.329$, $P = 0.0001$).

There were no significant correlations between fat percentage derived from skinfold thickness and any of the arterial stiffness variables in males. Mean pressure and aortic systolic pressure had a significant correlation with waist-hip-ratio (WHR). The females' adiposity variables had significant correlations with a greater number of arterial stiffness variables, including Aug. P, AIx, and mean pressure.

The participants who had higher physical activity scores had significantly less fat percentage. However, BMI had nonsignificant correlations and WHR had a positive correlation with physical activity [Table 5]. Most of the arterial stiffness variables had negative correlations with physical activity [Table 5].

DISCUSSION

Influence of gender and physical characteristics

Any discussion of correlation must take into account the contribution to the total variance. This study showed a

Table 4: Relationship between arterial stiffness variables and fat percentage in both sexes (correlation coefficients)

Variables	Male			Female		
	Fat percentage	BMI	WHR	Fat percentage	BMI	WHR
Fat percentage		0.607**	0.327*		0.556**	0.250*
BMI			0.183			0.382**
Pulse wave velocity	0.160	0.154	0.054	0.106	0.100	0.036
Aug. P	0.001	0.083	0.241	0.279**	0.214*	0.284**
AIx	0.159	0.222	0.001	0.320**	0.231*	0.165
AIx at 75	0.011	0.092	0.239	0.264	0.202	0.254*
Aortic PP	0.088	0.001	0.182	0.183	0.094	0.227*
Aortic SP	0.019	0.153	0.349*	0.168	0.302**	0.014
Aortic DP	0.025	0.147	0.251	0.315**	0.389**	0.135
Mean pressure	0.019	0.158	0.341*	0.254*	0.361**	0.069
Ejection duration	0.216	0.203	0.364*	0.193	0.140	0.090
SEVR	−0.191	−0.208	−0.427**	−0.148	−0.089	0.119
SP	0.002	0.202	0.352*	0.178	0.308**	−0.013
DP	0.023	0.154	0.234	0.320**	0.378**	0.144
HR	0.291*	0.206	0.432**	0.156	0.081	0.114

**Significant at $P<0.01$, *Significant at $P<0.05$. SP: Systolic pressure, DP: Diastolic pressure, SEVR: Subendocardial viability ratio, Aug. P: Augmentation pressure, AIx: Augmentation index, BMI: Body mass index, HR: Heart rate, PP: Pulse pressure

Table 5: Relationship of physical activity with arterial stiffness and adiposity variables

Pulse wave velocity	AIx	Aug. pressure	SEVR	HR	Ejection duration	Aortic PP	AIx at 75	Aortic SP	Aortic DP	Mean pressure	BMI	Fat percentage	WHR
0.123	−0.306**	−0.375**	0.336**	−0.309**	−0.335**	0.126	−0.438**	0.242**	0.183*	0.211	0.093	−0.502**	0.207*

Correlation coefficients **Significant at $P<0.01$, *Significant at $P<0.05$. SEVR: Subendocardial viability ratio, Aug. P: Augmentation pressure, Aug. index: AIx, BMI: Body mass index, WHR: Waist-hip-ratio, SP: Systolic pressure, DP: Diastolic pressure, HR: Heart rate, PP: Pulse pressure

number of significant correlations within the range of 0.3–0.5. It is recognized that the contribution to the total variance is low (9–25%), still leaving a large unaccounted variance. The following discussion recognizes this limitation.

The results show a strong relationship between adiposity derived from skinfold thickness and arterial stiffness derived from a less invasive carotid-radial pulse wave analysis. These results are similar to previous studies, which used similar and alternative methods. de Jongh *et al.*[12] studied the relationship between visceral adiposity using magnetic resonance imaging, skinfold thickness and postocclusive skin capillary recruitment using a vascular microscope. They found that vascular recruitment was inversely related to inflammation score, visceral adiposity, and truncal/extremities skinfold thickness. Whincup *et al.*[4] studied the relationship between adiposity and arterial distensibility in adolescents. They measured the arterial distensibility using ultrasound and body fat using skinfold thickness, similar to the current study. They found a significant relationship between them in both sexes. There was a lower arterial distensibility in females in their study. Similarly, the females in the current study had higher arterial stiffness that includes ejection duration, PP, and AIx. In agreement with these results, Yasmin and Brown[13] also found higher AIx in females using a similar radial pulse wave analysis. These findings clearly show a need to have separate reference values for males and female. Yasmin and Brown[13] also found a similar negative correlation between AIx and height. It confirms that there could be an earlier reflection of pulse waves in shorter people, which results in a lower AIx. It is also important to note that females also had a higher fat percentage as estimated by the measurement of the individual skinfold thickness of the biceps, triceps, and thigh. The current study showed significant relationships between obesity (BMI and WHR) and arterial stiffness similar to the study by Whincup *et al*.[4] However, the relationships were more statistically significant in a number of variables in females [Table 4]. This may be due to the higher number of female participants. Nevertheless, the females had lower BMI compared with males, yet their fat percentage was significantly higher. Several studies have found that Asians have higher fat percentage and, in general, females have higher fat percentage compared with their BMI.[14,15] It was suggested that it might be due to the difference in body type such as trunk/leg length in different ethnics and lifestyle factors.[14-17] Thus, in the current study, the higher fat percentage may be the reason for the significant correlations found between more arterial stiffness variables and fat percentage in females. These findings suggest that fat percentage measured by skinfold thickness has more clinical importance than simple BMI measurements.

Relationship between adiposity, insulin resistance/hyperinsulinemia, and arterial stiffness

A possible mechanism for the positive relationship between adiposity and arterial stiffness is the increase in insulin resistance due to adiposity.[18,19] Banerji *et al.*[20] found a strong correlation between insulin resistance and total body fat as well as regional and subcutaneous fat in Asian Indians. They state that visceral fat increases with total body fat and this results in increased insulin resistance. Urakawa *et al.*[21] observed a direct correlation between adiposity and oxidative stress. They state that adiposity increases the release of reactive oxygen species from leukocytes and thus increases the oxidative stress and leads to an increase in insulin resistance. Insulin resistance resulting in hyperinsulinemia leads to many of the following physiological reactions: (1) Sodium retention due to increased sodium absorption in the renal circulation and[22,23] (2) increased body fat and its associations with over activity of autonomic nervous system especially sympathetic system at rest.[24,25] Hyperinsulinemia is the main mechanism that triggers sympathetic activity.[26] This results in an increase in resting heart rate and blood pressure.[27] The positive relationship between heart rate, systolic blood pressure, and fat percentage in the current results [Table 4] confirms these findings. (3) Hyperinsulinemia increases the mitogenic activities that lead to vascular smooth muscle proliferation, increased collagen synthesis in the vascular wall and vascular hypertrophy.[28-30] In addition, adiponectin, a protein derived from adipocytes, acts as a modulator for vascular smooth muscle proliferation.[31] An increase in other inflammatory adipocytokines such as tumor necrosis factor-α, interlekin-6, leptin, plasminogen activator inhibitor-1, angiotensinogen, resistin, and C-reactive protein (CRP) also have negative impacts on vascular structure.[32] All these mechanisms ultimately affect the endothelium-dependent vasodilatation and increase vascular stiffness.[29,33]

Leptin was not measured in this study. Leptin is a protein, which regulates adiposity and increases in concentration when body fat percentage increases.[34] Leptin is also found to be an important factor that increases sympathetic activity.[35] Singhal *et al.*[36] studied the relationship between leptin, body fat mass, and arterial distensibility. They found the arterial distensibility had a negative relationship with leptin concentration in blood and body fat mass derived from skinfold thickness. This negative relationship was irrespective of other inflammatory markers such as CRP, insulin, and lipids.

PWV had significant positive relationship with body adiposity variables in many previous studies. Sutton-Tyrrell *et al.*[37] found a strong relationship between visceral adiposity measured by computed tomography and PWV measure using Doppler flow signals on 2488 older adults with a mean age of 74 years. However, they found a weak correlation between PWV and the subcutaneous fat ($P = 0.026$). Wildman *et al.*[38] also found a strong positive relationship between Doppler measures carotid-femoral PWV and BMI. Previous studies on Indian obese children[39] and diabetic adults[40] also found strong relationship between PWV and body fat. However, the current study results did not show any significant relationship of PWV with any adiposity variables. Carotid-radial PWV may therefore not be an early indicator of arterial stiffness in young Indian adults. This needs to be studied more to be confirmed.

Physical activity

The negative correlations between physical activity and fat percentage have been demonstrated in previous studies. Sakuragi *et al.*[5] found a negative relationship between cardiac fitness and arterial stiffness (using carotid-femoral pulse wave analysis) as well as adiposity. However, there was no correlation between physical activity and BMI in the current study. Controversially, there was positive correlation between physical activity and WHR. This may be due to the differences in the other lifestyle factors among the participants. Thus, skinfold thickness may be a more valid method to measure body fat. However, it is also important to consider the factors other than physical activity that influence obesity such as ethnicity, parental obesity, dietary pattern, and sedentary behaviors such as watching television.[41-43]

To the best of our knowledge, this is the first study in India to establish the relationship between adiposity and noninvasive brachial-radial arterial stiffness. The agreement between the current findings and previous studies confirms that the noninvasive arterial stiffness could be a marker for cardiovascular risks in young adults. The increase in the prevalence of obesity is seen in all the age groups and continuously developing globally. The current findings could be helpful for future studies and for developing diagnostic and preventive measures for cardiovascular risk at younger age groups.

Limitations

A larger number of participants could improve the significance of the results. It was not possible to control the dietary pattern and physical activities in the participants, and there was a wide range of these values. Measurement of blood lipids and inflammatory biomarkers such as leptin and CRP would have improved the strength this study. It was not possible in this study due to limited availability of funds.

CONCLUSIONS

Arterial stiffness measured by carotid-radial pulse wave analysis is strongly related to adiposity measured from skinfold thickness in young South Asian females. There are gender differences in arterial stiffness variables derived from pulse wave analysis. More controlled studies are necessary to improve the quality of the results using this less intrusive technique, the carotid-radial pulse wave analysis.

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Conflicts of interest

There are no conflicts of interest.

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