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# High body fat and low muscle mass are associated with increased arterial stiffness in Asian Indians in North India

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## ABSTRACT

**Aim:** To investigate the association of high body fat and low muscle mass with arterial stiffness in Asian Indians with type 2 diabetes mellitus in North India.

**Methods:** In this cross sectional study, subjects with T2DM (males  $n = 110$ , females  $n = 58$ , mean age:  $53.8 \pm 10.0$  years) were recruited. Anthropometry and body composition analysis were performed and measures of glycemia, lipids and PWV were analyzed.

**Results:** Significant positive correlation was observed between PWV and body fat ( $p < 0.05$ ), left leg fat ( $p < 0.05$ ), and right leg fat ( $p < 0.01$ ) percentages only in females. In males, significant negative correlation was observed between PWV and truncal fat free mass ( $p < 0.05$ ) and fat free mass in right arm ( $p = 0.05$ ) and left arm ( $p < 0.05$ ). In both males and females, significant negative correlation was observed between PWV and fat free mass in left leg ( $p < 0.01$ ) and for right leg fat free mass only in females.

**Conclusion:** Excess adiposity and low fat free mass are associated with arterial stiffening in Asian Indians with T2DM in North India, with significant gender differences.

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## 1. Introduction

The prevalence of type 2 diabetes mellitus (T2DM) is high and continues to increase in India due to changing lifestyle and increasing obesity (Misra & Shrivastava, 2013). Asian Indians, as compared with White Caucasians, tend to have characteristic body composition features; higher body fat, excess truncal fat and lower lean body mass (Misra & Khurana, 2011), which contribute to insulin resistance, dyslipidemia, hyperglycemia, metabolic syndrome and increased risk for the development of atherosclerosis (Dudeja et al., 2001; Misra et al., 2008).

Pulse wave velocity (PWV) is a simple, non-invasive technique of assessing arterial stiffness (Vlachopoulos et al., 2010; Williams et al., 2006). High values on PWV analysis are indicative of increased rigidity and low distensibility of vascular walls, along with poor vascular function (O'Rourke & Hashimoto, 2007). Increased PWV has been shown to be correlated with dyslipidemia (Moritani et al., 1987), hypertension (London, 1995) and atherosclerosis (Shoji et al., 1998). Clinical measures of abdominal

adiposity such as waist circumference, visceral adipose tissue, and truncal fat have been reported to be positively related to arterial stiffness in Dutch adolescents (Ferreira et al., 2004), healthy Chinese adults (Lee et al., 2012) and in Chinese patients with T2DM (Zhang, Li, et al., 2014). Such research has not been conducted in Asian Indians.

We hypothesized that high body fat and low muscle mass in Asian Indians with T2DM is associated with increased arterial stiffness. This study was aimed to analyse the association of measures of adiposity and fat free mass with PWV in Asian Indians with T2DM, residing in North India.

## 2. Methodology

The present study was done at the outpatient department of Fortis Hospital, New Delhi, India. Clinical data from medical records of patients with T2DM ( $n = 375$ ) were collected and reviewed. Case records ( $n = 168$ ) with complete data of anthropometry, lipid profile, body composition and PWV were included in the study. Anthropometry and blood pressure were recorded as mentioned in previous studies from our group (Nigam et al., 2013). Body composition (adiposity and fat free mass) was measured using leg-to-leg bioelectrical impedance method (TANITA BC-418MA, Tanita Corporation, Tokyo, Japan). Subjects were instructed to void urine 30 minutes before the analysis. The age, sex and height of each participant were entered in the digital scale. The subjects stood in bare feet with the heel and toe of each

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**Table 1**  
Cut off values for measures of adiposity in Asian Indians (Joseph et al., 2011).

| Cut off values for males |      | Cut off values for females |      |
|--------------------------|------|----------------------------|------|
| Total body fat %         | 25.5 | Total body fat %           | 38.0 |
| Fat mass (kg)            | 15.1 | Fat mass (kg)              | 20.3 |
| Total lean mass %        | 73.7 | Total lean mass %          | 59.0 |
| Lean mass (kg)           | 46.3 | Lean mass (kg)             | 32.6 |
| Fat free mass (kg)       | 48.8 | Fat free mass (kg)         | 34.8 |
| Fat in arms (%)          | 19.8 | Fat in arms (%)            | 43.3 |
| Fat mass in arm (kg)     | 1.4  | Fat mass in arm (kg)       | 3.1  |
| Fat in legs (%)          | 21.9 | Fat in legs (%)            | 38.9 |
| Fat mass in legs (kg)    | 4.1  | Fat mass in legs (kg)      | 6.9  |
| Fat in trunk (%)         | 30.1 | Fat in trunk (%)           | 38.5 |
| Fat mass in trunk (kg)   | 8.8  | Fat mass in trunk (kg)     | 9.5  |

foot in contact with the metal footpads (Kalra, 2013). Fat and lean muscle mass values were measured and expressed in kilograms and percentage values, respectively. Fasting and post prandial blood samples were collected, and biochemical analysis was performed according to methods described previously (Misra et al., 2008).

Carotid-femoral PWV (CfPWV) was measured for all subjects by applanation tonometry using the SphygmoCor System (AtCorMedical Pty Ltd Head Office, West Ryde, Australia). The subjects were instructed to refrain from any vasoactive medication two hours prior to the test and were made to rest in supine position for fifteen minutes to attain hemodynamic stability. Essential data such as age, gender, height, systolic and diastolic blood pressure were entered into system. Distances on the body surface were measured, using a measuring tape, from sternal notch to the femoral location and from sternal notch to the carotid location of the respective pulse wave recording sites. Using a tangent intersection algorithm with an integrated software, the differences in the distance travelled by the pulse wave between the femoral-sternal notch and the carotid-sternal notch were calculated. After acquisition of 15–20 waveforms, a validated generalized transfer function was used to generate the corresponding pressure waveform. Augmentation Index (AIx) was derived from reconstructed central pressure wave form, and it was calculated as the difference between the second and first systolic peaks observed on the central pulse waveform.

**Table 2(a)**  
Body composition profile of T2DM patients.

| Clinical variables                   | Females (n = 58) mean & S.D | Males (n = 110) mean & S.D | p value   |
|--------------------------------------|-----------------------------|----------------------------|-----------|
| Age (Years)                          | 56.1 ± 8.8                  | 52.7 ± 10.4                | 0.02      |
| Body Mass Index (Kg/m <sup>2</sup> ) | 30.3 ± 4.0                  | 29.0 ± 4.8                 | 0.01      |
| Waist circumference (cms)            | 99.1 ± 10.9                 | 102.6 ± 12.2               | 0.19 (NS) |
| Hip circumference (cms)              | 107.5 ± 13.8                | 102.4 ± 10.5               | 0.00      |
| Waist to hip ratio                   | 0.91 ± 0.1                  | 0.98 ± 0.0                 | 0.00      |
| Body fat percentage (%)              | 42.2 ± 6.0                  | 30.2 ± 5.5                 | 0.00      |
| Body fat mass (kg)                   | 32.5 ± 9.4                  | 25.5 ± 8.1                 | 0.00      |
| Right leg fat percentage (%)         | 42.3 ± 7.9                  | 24.3 ± 6.3                 | 0.00      |
| Right leg fat mass (kg)              | 5.8 ± 1.4                   | 3.4 ± 1.4                  | 0.00      |
| Right leg fat free mass (kg)         | 7.5 ± 1.2                   | 10.2 ± 2.0                 | 0.00      |
| Right leg predicted muscle mass(kg)  | 7.1 ± 1.1                   | 9.7 ± 1.7                  | 0.00      |
| Left leg fat percentage (%)          | 42.5 ± 8.1                  | 23.8 ± 6.0                 | 0.00      |
| Left leg fat mass (kg)               | 5.7 ± 1.5                   | 3.3 ± 1.3                  | 0.00      |
| Left leg fat free mass (kg)          | 7.3 ± 1.4                   | 10.1 ± 1.8                 | 0.00      |
| Left leg predicted muscle mass (kg)  | 6.8 ± 1.4                   | 9.6 ± 1.7                  | 0.00      |
| Right arm fat percentage (%)         | 41.0 ± 8.7                  | 25.9 ± 6.7                 | 0.00      |
| Right arm fat mass (kg)              | 1.6 ± 0.5                   | 1.2 ± 0.6                  | 0.00      |
| Right arm fat free mass (kg)         | 2.2 ± 0.4                   | 3.3 ± 0.6                  | 0.00      |
| Left arm fat percentage (%)          | 41.5 ± 8.7                  | 26.5 ± 6.8                 | 0.00      |
| Left arm fat mass (kg)               | 1.7 ± 0.5                   | 1.2 ± 0.6                  | 0.00      |
| Left arm fat free mass (kg)          | 2.3 ± 0.4                   | 3.3 ± 0.6                  | 0.00      |
| Left arm predicted muscle mass (kg)  | 2.1 ± 0.4                   | 3.1 ± 0.5                  | 0.00      |
| Truncal fat percentage (%)           | 41.0 ± 7.8                  | 34.6 ± 6.3                 | 0.00      |
| Truncal fat mass (kg)                | 17.0 ± 4.8                  | 16.5 ± 5.1                 | 0.42 (NS) |
| Truncal fat free mass (kg)           | 23.2 ± 3.2                  | 30.4 ± 4.4                 | 0.00      |
| Predicted truncal muscle mass (kg)   | 22.2 ± 3.1                  | 29.2 ± 4.2                 | 0.00      |

p value ≤0.05: Statistically significant. NS: non-significant.

Finally, cf PWV values were expressed in meters per second (m/s) with standard deviation (Bechlioulis et al., 2013; Laurent et al., 2006). PWV value above 12 m/s was considered to be indicative of subclinical organ damage (Mancia et al., 2007).

## 2.1. Definitions

Abdominal obesity was defined as waist circumference ≥ 90 cms in males and ≥ 80 cms in females (Misra et al., 2006). Overweight and obesity were defined according to the consensus guidelines for Asian Indians wherein a BMI ≥ 23.0–24.9 kg/m<sup>2</sup> was considered overweight and BMI ≥ 25 kg/m<sup>2</sup> was defined as obesity. The metabolic syndrome was defined based on the consensus statement for diagnosis of obesity, abdominal obesity and metabolic syndrome for Asian Indians (Misra et al., 2009). The cutoff values for body fat and lean mass were adopted as defined in a previous study from our group (Joseph et al., 2011, Table 1).

PWV was defined as the speed with which the cardiac pulse wave travels the distance between the carotid and the femoral artery. Augmentation pressure of the pulse waveform was defined as the difference between the second systolic peak (caused by wave reflection) and the first systolic peak (caused by left ventricular rejection) observed on the pulse wave form. Augmentation Index (AIx) is a composite measure of aortic wave reflection and systemic arterial stiffness (Oliver & Webb, 2003) and is defined as difference expressed as a percentage of the central pulse pressure (Miranda et al., 2004) and finally corrected for heart rate at 75% (Bechlioulis et al., 2013).

## 3. Statistical analysis

Data were entered in an Excel spreadsheet (Microsoft Corp, Washington, USA) and analyzed using STATA 11.0 (College Station, Texas, USA). The distribution of clinical, biochemical, anthropometry and body composition parameters was confirmed for approximate normality. Data were summarized as mean values with standard deviation (SD) and median (range) values as appropriate. The differences in mean values of the variables between males and females were tested using student t-test. The association between PWV, fat mass and fat percentage was

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