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Original Research Article

Vascular Studies in Women in Urban Population

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Abstract

Introduction: Urbanization is associated with higher prevalence of cardiovascular disease worldwide. Aortic stiffness, as measured by pulse wave velocity (Pwv) is a validated predictor of cardiovascular disease. However, in India, there are few population-based studies regarding pulse wave velocity and augmentation index (Aix). ***Method:*** Our aim is to determine vascular ageing measured by pulse wave velocity and the arterial augmentation index in urban population. Pulse wave velocity and augmentation index and was measured in 292 urban population subjects without any ECG changes. ***Results:*** Normal PWV and the 95% confidence intervals values were obtained in 20-29 year age group (compared to 30–39, 40–49, and 50–60 age groups. The mean Pwv found was 5.85 m/s ± 1.25 (range: 4.86–8.47). PWV increases linearly with aging with a high degree of correlation; with low dispersion in younger subjects. Pwv progressively increases 6–8% with each decade of life; this tendency is more pronounced after 40 years. A significant increase of Pwv between hypertensive versus nonhypertensive, diabetes vs non-diabetes groups were demonstrated. This is the first population-based study from urban population of Nellore that provides normal values of the Pwv in these region. Augmentation index was also increased significantly in both diabetic and hypertensive groups. ***Conclusion:*** The findings of present study suggest that, although related, peripheral augmentation index AIx and Pwv provide early identification of high risk groups. Implication of life style modification is the first intervention to consider in adults followed by drug therapy to control risk factors. Specifically, AIx might provide a more sensitive marker of arterial aging in younger individuals.
Keywords: Pulse wave velocity, augmentation index, hypertensive, aging.

INTRODUCTION

Over half of the world's population resides in urban areas and this proportion may increase to 66% by 2050. Currently, the world's second largest urban population resides in India with approximately 410 million people and this number is projected to double by 2050 [1-5]. The urbanization process itself, whereby municipalities undergo growth in population density and complexity, leads to shifts in diet, physical activity, and psychosocial demands resulting in an increase in CVD risk factors [6-9], that describes a continuum where an early stage is characterised by hypertensive heart disease and a large proportion of haemorrhagic stroke. Later on, driven by increasing prevalence of vascular risk factors in the population, ischaemic heart disease and ischaemic stroke due to atherosclerosis emerge.

The measurement of carotid to femoral pulse wave velocity (Pwv) is considered the gold standard method for arterial stiffness assessment in daily practice because of its easy use, low cost, and high reproducibility. Measurement of the aortic pressure waveform gives measurement of central arterial pressure and hall mark of systemic arterial stiffness, such as Augmentation Pressure (AP) and Augmentation Index (AIx). These parameters are related to the reflected pressure waves from the peripheral arterial system.

However, several studies have shown significant differences in size, structure, and arterial stiffness of large and small arteries [10–15]. There is a paucity of information on the association between urbanization and aortic stiffness.The elements within the urban environment, such as obesity, psychosocial stress, and other cardiovascular risk factors are known to be associated with both urbanization and with Pwv. At present, there are no reference values of PWV in urban population involving adolescents, young adults, and older people that take into account factors influencing PWV values such aging and risk factors.

Andhrapradesh after bifurfication is at an early stage of economic and health transition, there is currently very little published information on the prevalence of vascular risk factors in these population, although such data will be essential in planning future health services.

The aim of this work is to establish normality values of carotid-femoral Pwv and Augmentation index in urban population with no cardiovascular risk factor according to age.

Materials and Methods

Sample type: 292 urban population with normal ECG

The present analysis is a descriptive, observational, and cross-sectional population-based study carried out in population from the urban population of Nellore city.

Inclusion Criteria

Subjects from 20 to 60 years without history of cardiovascular, pulmonary, and renal disease.

Exclusion Criteria

Subjects were excluded if they had abnormal clinical, biochemical, serological, electrocardiographic with the peripheral vascular disease and chronic illness, as these conditions interfere with the recording of pulse wave velocity.

Procedure

All subjects underwent detailed physical and clinical examination. Height was measured using stature meter. Weight with calibrated weighing machine. Body Mass Index (BMI) was calculated using formula weight (kg)/height (m2) (BMI classification for Indian society was followed). ECG tracings were recorded. Blood pressure and pulse rate were recorded in the sitting position in the right arm with an electronic OMRON BP apparatus and the mean of the three readings was used as the final blood pressure recording. Indian hypertension guidelines-III (2015) was adopted for the present study. The weight was measured with the patients in the orthostatic position, with the arms extended along the body, being barefoot, and wearing light clothes. A stadiometer with a precision of 0.1 cm was used to measure height, with the participants standing barefoot. The body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in square meters (kg/m^2).

Lipd profile was done. HDL, LDL, VLDL and triglycerides were determined. Augmentation index and pulsewave velocity were calculated by using periscope.

Pulse Wave Velocity Measurement

Two high-fidelity silicon piezoresistive pressure sensors were connected to an amplifier during data acquisition. The sensors were applied in two different sites of the same arterial pathway. The data was acquired in a computer with specific software that allowed obtaining the time delay between the two instantaneous arterial pulse waves obtained. The software works in a Windows environment performing an online digitized pressure wave acquisition that allows several Pwv measurements along a single continuous record, which includes at least 10 cardiac cycles. The same two physicians, one always obtaining the pressure waves and the other operating the computer, performed the data collection in order to avoid operator to operator differences. The quality of the pulse waves was monitored online by the operators and the acquisitions were repeated if necessary. The software was able to calculate the Pwv online, taking into account the distance measured between sensors. In this study, the sensors were positioned in (a) the carotid arteries and (b) the femoral arteries, for carotid-femoral Pwv evaluation.

Measurements were performed in a quiet room with stable room temperature with a patient in a supine position after 10 min of rest. Measurements were obtained by duplicate. The mean and the standard deviation of these measurements were always calculated and considered as the PWV value for each patient. In order to ensure a reliable measurement, special care was taken in monitoring that the standard deviation of measurements was less than 10%.

Table-1: Distribution of pulse wave velocity (m/s) according to the age category in the normal values population (292 subjects)

Age category (years)	Mean (±2 SD)	Median (10–90 pc)
<30	6.2 (4.7–7.6)	6.1 (5.3–7.1)
30–39	6.5 (3.8–9.2)	6.4 (5.2–8.0)
40–49	7.2 (4.6–9.8)	6.9 (5.9–8.6)
50–59	8.3 (4.5–12.1)	8.1 (6.3–10.0)
60–69	10.3 (5.5–15.0)	9.7 (7.9–13.1)
≥70	10.9 (5.5–16.3)	10.6 (8.0–14.6)

SD, standard deviation; 10 pc, the upper limit of the 10th percentile; 90 pc, the lower limit of the 90th percentile

In accordance with international recommendations, the corrected Pwv was calculated by multiplying by 0.8, as suggested by the European recommendations. Reference values of PWV come mostly from multicenter registries [23].

RESULTS

Demographic characteristics of the 292 urban population with normal ECG were included in this work summarized in Table 2. The mean Pwv found was 5.85 m/s ± 1.25 (range: 4.86–8.47). The standard deviation of the <40Y age groups is smaller than that of the >40Y age group indicating an increase in the scatter of the Pwv with the aging process. The Pwv increases linearly with aging with a high degree of correlation with less dispersion in younger subjects. In our population, Pwv progressively increases averaging 6–8% with each decade of life, and this tendency is more pronounced after 50 years in which the average Pwv increased by 18%.

Apart from the dominant effect of aging, other cardiovascular risk factors such as obesity, smoker, lack of physical activity, hypercholesterolaemia, and type 2 diabetes mellitus are associated with increased PWV.

In association with habits 3.51% do smoking, 9 % consume alcohol, 4.1% do tobacco chewing, and 83.3% do not have any unfavorable habits.

Distribution of HTN

High Pwv can lead to increases in systolic blood pressure (SBP) and incidece hypertension (HTN).

Among 292 samples, 31.1% were Optimal, 18.6% were normal, 22.9% were High normal and 6.4% were Stage-1, 1.8% were Stage-2, 2.1% were Stage-3 and 2.9% were Grade-1, 4.3% were Grade-2.

Distribution of Lipid Profile

In association Total Cholesterol out of 292 samples, 63.2% had normal cholesterol and 36.8% had increased cholesterol.

In association to HDL cholesterol out of 292 samples, 36.8% had normal HDL cholesterol, 8.8% had increased HDL cholesterol and 54.4% had decreased HDL cholesterol.

Distribution of Pulse wave velocity

In the distribution of Pulse wave velocity, Out of 292 samples 60.1% had Normal, 7.3% had Border line, 11.75% had Mild, 6.2% had Moderate, 4% had High, 5.1% had Very High Aortic stiffness and 5.5% had Severe.

Out of 292 samples 37.7% had Normal AO AIX, 13.9% had Border line AO AIX, 12.1% had Mild AO AIX, 6.6% had Moderate AO AIX, 6.6% had High AO AIX, 2.2% had Very High AO AIX and 20.9% had severe increase in AO AIX.

Table-2: Description of clinical and blood parameters of the urban population

Variable	Mean (Range)
Age (years)	39.8 ± 18.5 (range: 10–87)
Weight (kg)	64 ± 14.4
Height (m)	1.66 ± 0.11
BMI (kg/m^2)	24.12 ± 3.84
Waist (cm)	87.7 ± 14.4
SBP (mmHg)	121.03 ± 11.64 (range: 90–139)
DBP (mmHg)	74.84 ± 8.65 (range: 50–89)
PP (mmHg)	46.19 ± 8.48 (range: 20–70)
MAP (mmHg)	90.23 ± 8.89 (range: 66.7–105.7)
Total blood cholesterol (mg/dL)	168.5 ± 22.6 (range: 110–197)
Serum triglycerides (mg/dL)	125 ± 20.5 (range: 78–148)
Glycaemia (mg/dL)	82.4 ± 9.5 (range: 56–189)

Table-3: Carotid-femoral Pwv for each age group in the urban population of Nellore district

Age group (years)	Mean Pwv (m/s)	SD	95% CI Lower-upper limit	Range
20–29	5.86	0.92	5.68–6.03	3.92–8.14
30–39	6.32	0.82	6.16–6.47	4.08–8.26
40–49	6.85	0.91	6.68–7.03	5.0–9.84
50–59	8.15	1.17	7.97–8.33	5.46–12.5
Total	6.84	1.65	6.73–6.96	3.12–13.4

Pwv: pulse wave velocity, CI: confidence intervals

Table-4: Frequency and Percentage Distribution of pulse wave velocity (Periscope) report in urban areas. N=168

SL.NO	Pulse wave velocity	Percentage
1	Normal	61.4%
2	Border line	7%
3	Mild	11.2%
4	Moderate	6.3%
5	High	3.9%
6	Very High Aortic stiffness	4.9%
7	Severe	5.3%
	Total	**100%**

Table-5: Frequency and Percentage Distribution of Periscope report. AOIX (Augmentation index) N=168

Sl No.	Periscope report	Percentage
1	Normal AO AIX	37.5%
2	Border line AO AIX	14.7%
3	Mild AO AIX	12.3%
4	Moderate AO AIX	6.3%
5	High AO AIX	6.3%
6	Very High AO AIX	2.1%
7	Severe increase in AO AIX	20.7%
	Total	**100%**

Table-6: Augmentation index (P2/P1) in the urban population

Age group (years)	Peak1 (Early Systolic)	Peak2 (Late Systolic)	AI	Range
Normal subjects	3.09±0.136	2.79±0.127	0.902±0.006	0.898-0.9008
DM	3.12±0.147	3.12±0.147	0.842±0.008	0.839-0.846
HTN	3.16±0.09	3.16±0.09	0.816±0.011	0.814-0.826
Obese subjects	3.13±0.08	3.13±0.0812	0.822±0.042	0.821-0.824

Discussion

The measurement of Pwv is a well-known method for the quantification noninvasive arterial stiffness and is currently considered the gold standard of arterial stiffness due to its simplicity, accuracy, reproducibility, and predictive value [16, 17]. Previous studies established the reference values of the PWV include data obtained from retrospective analysis of patients evaluated in different specialized centers. The mentioned reports includes several selection bias that difficult comparative studies with other patient populations. Despite the recognized value of Pwv for predicting cardiovascular risk, in South America there is a scarcity of reference values. Moreover, only the Republic of Uruguay has reference values of Pwv based on urban population [18].

The present research clearly shows the normal values of Pwv with the corresponding confidence interval of 95% for each age group providing relevant clinical information in terms of aortic stiffness. Since Pwv is an age dependent parameter, the clinician needs to know the mean value and calculated dispersion for each decade of human life in order to orientate both diagnosis and preventive strategies.

Farro *et al.*, [18] reported the reference values of Pwv in 429 subjects selected from a hospital population from urban Uruguay. They used a methodology considered six age groups and they analyzed subjects older than 60 years as a single group. In addition, the number of individuals in each group is less than our work. On the other hand, the European Registry "Arterial Stiffness Collaboration" reported normal values of Pwv based on 1455 records. These normal values emerged from a retrospective analysis of Pwv obtained with different methodologies in 13 European centers of high complexity. This registry considered subjects less than 30 years as a single group. Moreover, this record included several methods of measurement of Pwv and required validation between different methodologies with international comparative study subjects to verify measurement accuracy. In the research here reported, all data collection was obtained by only one research group, always using the same technology. This methodological aspect allows us to avoid interobserver group differences.

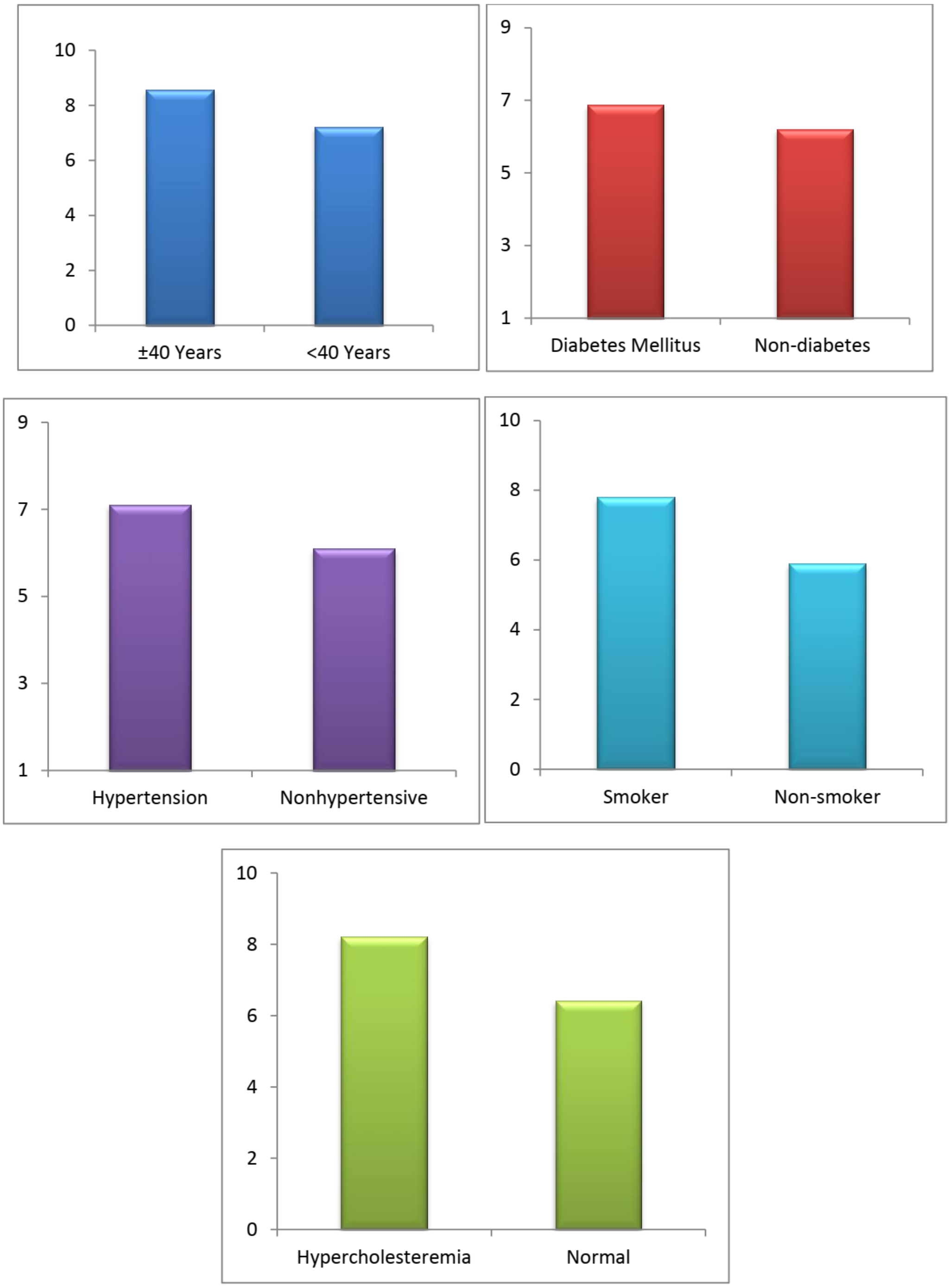

Fig-1: Mean values of pulse wave velocity (Pwv: in meters per second) showing significant differences between young subjects (≤40 years) and subjects with > 40 years, Diabetes mellitus vs non-diabetes, Hypertension vs non-hypertensive, smoking vs non-smokers, and Hypercholsetermiavs normal cholesteremia risk factors

Augmentation index (P2/P1)

Out of 292 samples 59.93% had Normal AO AIX, 6.84% had Borderline AO AIX, 10.95% had Mild AO AIX, 6.16% had Moderate AO AIX, 3.76% had High AO AIX, 4.79% had Very High AO AIX and 5.13% had Severe increase in AO AIX.

Ai and DM and HTN

Augmentation index (P2/P1) was also increased significantly in both diabetic and hypertensive groups than normal subjects without DM and HTN.

In DM subjects, 18.5% DM+HTN are Normal Ao Aix, the adults with 4.6% DM, 4.6% DM+HTN are having Borderline Ao Aix, the adults with 12.3% DM, 10.8% DM+HTN are having Mild Ao Aix, the adults with 4.6% DM, 6.2% DM+HTN are having Moderate Ao Aix, the adults with 1.5% DM, 4.6% DM+HTN are having High Ao Aix, the adults with 3.1% DM+HTN are having Very high Ao Aix and the adults with 7.7%

DM, 9.2% DM+HTN are having Severe increase in Ao Aix.

BMI & Pwv & AI

The underweight Category the subjects falls under Normal Pwv are 51.8%, Very High Pwv are 0.4% and in Normal Category the adults falls under Normal Pwv are 11.4%, Border line Pwv are 1.5%, Mild Pwv are 2.6% Moderate Pwv are 1.1%, High Pwv are 1.8%, Very High Pwv are 0.4% and Severe increase in Pwv are 1.1%,

In overweight, the subjects falls under Normal Pwv are 8.8%, Border line Pwv are 0.7%, Mild Pwv are 1.8% Moderate Pwv are 0.7%, High Pwv are 0.4%, Very high Pwv are 1.1% and Severe increase in Pwv are 0.7%.

And in Obese Category, the subjects falls under Normal Pwv are 38.1%, Border line Pwv are 5.1% Mild Pwv are 7.3% Moderate Pwv are 4.4% High Pwv are 1.8%, Very High Pwv are 3.3% and severe increases in Pwv are 3.7%.

Smoker & Pwv

58.3% smokers had Normal, 8.3% smokers had Borderline, 8.3% smokers had Mild, 8.3% smokers had Moderate and 16.7% smokers had High.

33.3% smokers had Normal AOAIX, 16.7% smokers had Borderline AOAIX, 25% smokers had Mild AOAIX, 8.3% smokers had Moderate AOAIX and 16.7% smokers had Sever AOAIX.

Hypercholesteremia and Pwv

The subjects with Normal Lipid Profile shows that 1.8% TC, 1.8% LDL, 1.8% VLDL are having High Pwv, Increased Lipid Profile shows that 1.8% TGL are having High Pwv and Decreased Lipid Profile shows that 1.8% HDL are having High Pwv.

Hypertension and Pwv

The subjects with Optimal blood pressure shows that 16.8% are having Normal Ao Aix, 3.7% are having borderline Ao Aix, 2.2% are having Mild Ao Aix, 1.5% are having Moderate Ao Aix, 0.4% are having high Ao Aix, 0.4% are having Very high Ao Aix and 6.2% are having Severe increase in Ao Aix.

The subjects with Optimal blood pressure shows that 22.7% are having Normal Pwv, 0.7% are having borderline Pwv, 4% are having Mild Pwv, 1.1% are having Moderate Pwv, 1.1% are having high Pwv, 0.7% are having very high Pwv and 0.7%are having Severe increase in Pwv.

Diabtes and Pwv

The subjects with 21.5% DM, 29.2% DM+HTN are Normal Pwv, the adults with 3.1% DM, 6.2% DM+HTN are having Borderline Pwv, the adults with 12.3% DM, 3.1% are having Mild Pwv, the adults with 4.6% DM+HTN are having Moderate Pwv, the adults with 4.6% DM, 7.7% DM+HTN are having High Pwv, the adults with 1.5% DM+HTN are having Very high Pwv and the adults with 1.5% DM, 4.6% DM+HTN are having severe increase in Pwv.

Our unadjusted results are also consistent with previous studies that have shown that PWV tends to be higher in older women, overweight/obese individuals, and individuals with DM [19-22].

Conclusion

Aortic Pwv and AIx can be assessed by different non-invasive techniques. These interventions should start in acute phase in life to prevent further risk of cardiovascular problem, maintain good quality of life and increase the life expectancy of young adult of known type 2 DM and hypertension. Our findings suggest that, although related, AIx and PWV provide different information. Specifically, AIx might provide a more sensitive marker of arterial aging in younger individual.

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