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Association of Indian Diabetes Risk Score with Arterial Stiffness in Asian Indian Nondiabetic Subjects: The Chennai Urban Rural Epidemiology Study (CURES-84)

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Abstract

Objective:

In this study, we aim to determine the association of Indian Diabetes Risk Score (IDRS) with augmentation index (AI), a preclinical marker of early atherosclerotic changes.

Methods:

Subjects without known diabetes (n = 1985) were randomly selected from the Chennai Urban Rural Epidemiology Study, an ongoing population-based study on a representative population (aged ≥20 years) of Chennai, the largest city in Southern India. Augmentation index was measured using the Sphygmocor apparatus (Sphygmocor BPAS-1; PWV Medical, Sydney, Australia). Serum lipids were measured in an overnight fasting sample along with other biochemical parameters. Indian Diabetes Risk Score includes four parameters: age, abdominal obesity, family history of type 2 diabetes, and physical activity.

Results:

Arterial stiffness values increased with an increase in IDRS. Subjects with IDRS ≥60 had significantly higher AI (24.6 ± 7.2; $p < .001$) compared to subjects with an IDRS of 30–60 (16.4 ± 5.5; $p < .001$) and with IDRS <30 (13.3 ± 4.5), and the p for trend was statistically significant (<.001). Pearson correlation analysis in the total population revealed that AI was significantly correlated with age ($p < .001$), systolic and diastolic blood pressure ($p < .001$), IDRS ($p < .001$), glycated hemoglobin A1c (A1C) ($p < .001$), serum cholesterol ($p < .001$), serum triglycerides ($p < .001$), high-density lipoprotein (HDL) cholesterol ($p < .001$), low-density lipoprotein cholesterol ($p < .001$), and non-HDL cholesterol ($p < .001$). In linear regression analysis, IDRS showed a significant association with AI even after adjusting for blood pressure, smoking, insulin resistance, A1C, cholesterol, and triglycerides ($\beta = 6.388$; $p < .001$).

Conclusion:

This study shows that, in addition to identifying unknown diabetes, IDRS also helps to identify those with arterial stiffness.

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Abbreviations: (A1C) glycated hemoglobin A1c, (AI) augmentation index, (BMI) body mass index, (CAD) cardiovascular disease, (CURES) Chennai Urban Rural Epidemiology Study, (HDL) high-density lipoprotein, (HOMAIR) homeostasis assessment model for insulin resistance, (IDRS) Indian Diabetes Risk Score, (LDL) low-density lipoprotein, (ROC) receiver operating characteristic, (WHO) World Health Organization

Keywords: arterial stiffness, Asian Indians, atherosclerosis, augmentation index, Indian Diabetes Risk Score

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Introduction

India currently leads the world in the number of people with diabetes (40 million), and this number is expected to increase to 70 million by 2025, accounting for one-fifth of the world's population of diabetes.[1] This rising trend predicts a significant health burden due to diabetes in India in the future. Unfortunately, more than 50% of the subjects with diabetes in India remain undiagnosed, which could add to the disease burden, as this increases the risk of developing complications of diabetes.[2] The prevalence of impaired glucose tolerance, a known risk factor for cardiovascular mortality,[3] is also high in India.[4,5] As diabetes shares many characteristics and risk factors with cardiovascular disease (CAD),[6,7] the risk for CAD is also indirectly escalating with the increase in prevalence of diabetes. Estimates from the Global Burden of Disease Study project that India will have the greatest burden due to coronary artery disease in the future.[8]

Coronary atherosclerosis has been shown to initiate early in life, many years before clinical manifestations of CAD.[9] Changes in the arterial wall can lead to increased arterial stiffness, which has been shown to influence cardiovascular prognosis adversely.[10] Thus, measuring arterial stiffness has been recommended in the preventative management of CAD.[11] Augmentation index (AI) has been associated with the presence of coronary atherosclerosis and increased level of cardiovascular risk.[12,13] Our earlier study has shown that AI was found to be significantly greater among diabetic subjects compared to age- and sex-matched nondiabetic subjects, confirming diabetic subjects have an increased tendency to develop premature atherosclerosis.[14]

With the increasing prevalence of diabetes and coronary artery disease in India,[1,8] early detection of subjects with high risk for diabetes and CAD using a simple but robust tool would be of great clinical significance and would help make screening programs more cost-effective. In this context, we evolved the Indian Diabetes Risk Score (IDRS), a simplified risk score for identifying undiagnosed diabetic subjects using four simple parameters: age, waist circumference, family history of diabetes, and physical activity.[15] Indian Diabetes Risk Score has been validated using receiver operating characteristic (ROC) curves to identify the optimum value for determining diabetes diagnosed using World Health Organization (WHO) consulting group criteria. Sensitivity, specificity, positive and negative predictive values, and accuracy for predicting undiagnosed diabetes were calculated for different cutoff scores.[15] Indian Diabetes Risk Score is an inexpensive tool for screening undiagnosed diabetes, and it requires minimum time and effort. A score of 60 was found to have optimum sensitivity and specificity for detecting undiagnosed diabetes.

The present study was undertaken to determine the association of IDRS with AI, a preclinical marker of early atherosclerotic changes, in an Asian Indian population using a population-based study.

Research Design and Methods

The study subjects were recruited from the Chennai Urban Rural Epidemiology Study (CURES), an ongoing epidemiological study conducted on a representative population (aged ≥20 years) of Chennai (formerly Madras), the fourth largest city in India. The methodology of the study has been published elsewhere.[16] Briefly, in phase 1 of the urban component of CURES, 26,001 individuals were recruited based on a systematic random sampling technique. Fasting capillary blood glucose was determined using a OneTouch Basic glucose meter (LifeScan, Johnson & Johnson, Milpitas, CA) in all subjects. Subjects were classified as "known diabetic subjects" if they stated that they had diabetes and were on the treatment.

In phase 2 of CURES, all the known diabetic subjects (n = 1529) were invited to our center for detailed studies on vascular complications, and 1382 responded (response rate 90.3%). In addition, 10% of newly detected diabetic subjects, 15% of subjects with impaired fasting glucose, and 10% of subjects with normal fasting glucose in phase 1 were requested to undertake an oral glucose tolerance test. Subjects without known diabetes and those with 2 h post glucose value <11.1 mmol/liter (200 mg/dl)[17] were randomly recruited (using computer-generated random numbers) (n = 1985) for the present study. Institutional ethical committee approval was obtained from the Madras Diabetes Research Foundation Ethical Committee, and written informed consent was obtained from all study subjects.

Anthropometric Measurements

Anthropometric measurements, including weight, height, and waist measurements, were obtained using standardized

techniques as detailed elsewhere.[16] The body mass index (BMI) was calculated using the following formula: weight (kg)/height (m^2). Blood pressure was recorded in the sitting position in the right arm to the nearest 2 mmHg using the mercury sphygmomanometer (Diamond Deluxe BP apparatus, Pune, India). Two readings were taken 5 min apart, and the mean of the two was taken as the blood pressure. If the difference between the first and the second reading was >6 mmHg for systolic and/or >4 mmHg for diastolic pressure, then a third reading was taken.

Biochemical Parameters

Fasting plasma glucose (glucose oxidase-peroxidase method), serum cholesterol (cholesterol oxidase-peroxidase-amidopyrine method), serum triglycerides (glycerol phosphate oxidase-peroxidase-amidopyrine method), and high-density lipoprotein (HDL) cholesterol (direct method-polyethylene glycol-pretreated enzymes) were measured using Hitachi-912 Autoanalyser (Hitachi, Mannheim, Germany). The intra- and inter-assay coefficient of variation for the biochemical assays ranged between 3.1% and 7.6%. Low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula. Glycated hemoglobin A1c (A1C) was estimated by high-pressure liquid chromatography using the Variant machine (Bio-Rad, Hercules, CA). The intra- and inter-assay coefficient of variation of A1C was <10%. Serum insulin was estimated by enzyme-linked immunosorbent assay and insulin resistance calculated using the homeostasis assessment model for insulin resistance (HOMAIR) using the following formula: fasting insulin (μI/ml) fasting glucose (mmol/liter)/22.5.

Indian Diabetes Risk Score

The IDRS was developed based on multiple logistic regression model using four simple parameters, namely, age, abdominal obesity, family history of diabetes, and physical activity as described elsewhere.[15] The information for these risk factors was obtained based on four simple questions and one anthropometric measurement, namely, waist circumference, and was coded as shown:

1. Age: <35 years, coded 0; 35–49 years, coded 20; and ≥50 years, coded 30.

2. Abdominal obesity: Male waist circumference <90 cm, coded 0; ≥90–99 cm, coded 10; and ≥100 cm, coded 20. Female waist circumference <80, coded 0; ≥80–89 cm, coded 10; and ≥90 cm, coded 20.

3. Family history of diabetes: two nondiabetic parents, coded 0; one diabetic parent, coded 10; and two diabetic parents, coded 20.

4. Physical activity: vigorous, coded 0; moderate, coded 20; and sedentary, coded 30.

Indian Diabetes Risk Score has been previously validated using ROC curves to identify the optimum value (>60%) for determining diabetes as diagnosed using WHO consulting group criteria. Sensitivity, specificity, positive and negative predictive values, and accuracy for predicting undiagnosed diabetes were calculated for different cutoff scores.[15] Subjects with an IDRS value <30 was categorized as low risk, those between 30 and 60 as medium risk, and those with ≥60 as high risk for diabetes.

Arterial Stiffness (Augmentation Index)

Arterial stiffness was measured using the Sphygmocor apparatus (Sphygmocor BPAS-1; PWV Medical, Sydney, Australia) as previously discussed.[14,18] In brief, a high-fidelity micromanometer (SPC-301; Millar Instruments, Houston, TX) was used to flatten but not occlude the right radial artery using gentle pressure. When the two surfaces are flattened, circumferential pressures are equalized, and an accurate pressure waveform can be recorded. Data were collected directly into a portable microcomputer. The system software allowed online recording of the peripheral waveform, which was assessed visually to ensure that the best possible recording was obtained and that artifacts from movement were minimized. After 20 sequential waveforms had been acquired, the integral software was used to generate an averaged peripheral and corresponding central waveform that was used for the determination of the AI. Augmentation index was defined as the difference between the first and second peaks of the central arterial waveform, expressed as a percentage of the pulse pressure.[19]

Augmentation index is a measure of the contribution that the wave reflection makes to the arterial pressure waveform. The amplitude and timing of the reflected wave ultimately depends on the stiffness of the small vessels and large arteries, and thus AI provides a measure of systemic arterial stiffness.[20] Pulse-wave analysis has been demonstrated as a reproducible, noninvasive method for assessing AI.

Statistical Analysis

Student's *t*-test or one-way analysis of variance (with Turkey's Honestly Significant Difference), as appropriate,

was used to compare groups for continuous variables, and Chi-square test or Fisher's exact test, as appropriate, was used to compare proportions. Pearson's correlation analysis was carried out to determine the correlation of AI with IDRS and cardiovascular risk factors. Regression analysis was done to determine the association of IDRS with AI. All analyses were done using Windows-based SPSS statistical package (Version 10.0, Chicago) and p values <.05 were taken as significant.

Results

Table 1 presents the clinical and biochemical characteristics of the study subjects in relation to the grades of IDRS. With increasing IDRS, there was an increase in BMI (p value for trend <.001), systolic blood pressure (p value for trend <.001), diastolic blood pressure (p value for trend <.01), fasting plasma glucose (p value for trend <.01), A1C (p value for trend <.001), HOMAIR p value for trend <.01), total cholesterol (p value for trend <.01), triglycerides (p value for trend <.01), LDL cholesterol (p value for trend <.01), and non-HDL cholesterol (p value for trend <.01).

Arterial stiffness values increased with an increase in IDRS. Subjects with IDRS ≥60 had significantly higher AI (24.6 ± 7.2; $p < .001$) compared to subjects with IDRS 30–60 (16.4 ± 5.5; $p < .001$) and with IDRS <30 (13.3 ± 4.5), and the p value for trend was statistically significant (<.001) (**Figure 1**).

Table 2 presents the Pearson correlation analysis in the total population, which reveals that AI was significantly correlated with age ($p < .001$), systolic and diastolic blood pressure ($p < .001$), IDRS ($p < .001$), A1C ($p < .001$),

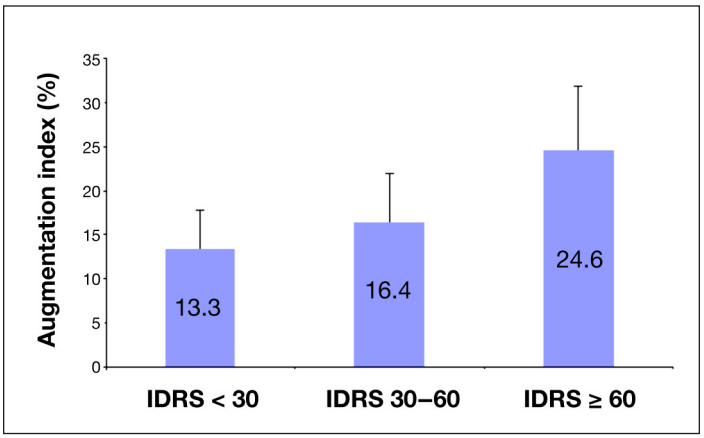

Figure 1. Arterial stiffness measured by augmentation index in relation with grades of IDRS. In the second bar, $p < .01$. In the third bar, $p < .001$ compared to IDRS < 30 and $p < .001$ compared to IDRS 30–60.

Table 1.
Clinical and Biochemical Characteristics of Study Subjects in Relation to Grades of Indian Diabetes Risk Score

Parameters	IDRS <30 (n = 143)	IDRS 30–60 (n = 1057)	IDRS ≥60 (n = 785)
Age (years)	28 ± 6	32 ± 8[a]	48 ±11[a,b,c]
BMI (kg/m^2)	20 ± 3	22 ± 4[a]	24 ± 4[a,b,c]
Systolic blood pressure (mmHg)	109 ± 12	113 ± 15[a]	124 ± 18[a,b,c]
Diastolic blood pressure (mmHg)	69 ± 10	71 ± 11[d]	77 ± 11[a,b,c]
Fasting plasma glucose (mg/dl)	83 ± 8	84 ± 9	88 ± 11[a,b,c]
A1C (%)	5.3 ± 0.43	5.4 ± 0.45[a]	5.7 ± 0.5[a,b,c]
HOMAIR	1.5 ± 1.1	1.8 ± 1.2	2.1 ± 1.4[a,b,c]
Total cholesterol (mg/dl)	160 ± 32	170 ± 37[d]	188 ± 38[a,b,c]
Serum triglycerides (mg/dl)	99 ± 67	107 ± 70	129 ± 72[a,b,c]
LDL cholesterol (mg/dl)	99 ± 24	105 ± 32	118 ± 32[a,b,c]
HDL cholesterol (mg/dl)	41 ± 9	42 ± 10	43 ± 10
Non-HDL cholesterol (mg/dl)	119 ± 31	127 ± 35[d]	144 ± 36[a,b,c]

[a] $p < .001$ compared to IDRS <30.
[b] $p < .001$ compared to IDRS 30–60.
[c] p for trend <.01
[d] $p < .01$.

serum cholesterol ($p < .001$), serum triglycerides ($p < .001$), HDL cholesterol ($p < .001$), LDL cholesterol ($p < .001$), and non-HDL cholesterol ($p < .001$).

Linear regression analysis was performed using AI as the dependent variable and IDRSs as independent variables to determine the association of IDRS with AI (**Table 3**). In model 1, the individual contribution of IDRS to AI was determined; in model 2, blood pressure and smoking were introduced as independent variables; in model 3, insulin resistance and A1C were introduced as an independent variable; and in model 4, cholesterol and triglycerides were introduced as independent variables. Indian Diabetes Risk Score showed a significant association with AI even after adjusting for blood pressure, smoking, insulin resistance, A1C, cholesterol, and triglycerides ($\beta = 6.388$; $p < .001$).

Table 2.
Pearson Correlation Analysis of Augmentation Index with Other Risk Variables in Total Subjects

	AI	
	r value	*p* value
Age	0.443	<.001
BMI	0.017	.480
Waist circumference	0.021	.396
Systolic blood pressure	0.148	<.001
Diastolic blood pressure	0.164	<.001
IDRS	0.314	<.001
HOMAIR	0.138	.002
A1C	0.140	<.001
Serum cholesterol	0.168	<.001
Serum triglycerides	0.079	.001
HDL cholesterol	-0.124	.001
LDL cholesterol	0.125	<.001
Non-HDL cholesterol	0.140	<.001

Table 3.
Linear Regression Analysis Using Augmentation Index as a Dependent Variable and Status of Indian Diabetes Risk Scoreas as an Independent Variable

Parameters	β	*p* value
Model 1: IDRS unadjusted	7.309	<.001
Model 2: Model 1 adjusted for blood pressure and smoking	6.778	<.001
Model 3: Model 2 adjusted for HOMAIR and A1C	6.828	<.001
Model 4: Model 3 adjusted for serum cholesterol and triglycerides	6.388	<.001

Discussion

The main findings of the study are as follows: (1) arterial stiffness measured by AI was increased with the increase in IDRS; (2) AI was significantly associated with IDRS and other cardiovascular risk factors; and (3) Indian Diabetes Risk Score is independently associated with AI even after adjusting for blood pressure, smoking, HOMAIR, A1C, cholesterol, and triglycerides.

The rising trend in diabetes and CAD in India necessitates early detection and prevention. Several studies from the West[21,22] and the Indian subcontinent have formulated diabetes risk scores for detecting undiagnosed diabetes.[15] Most of these scores have used multiple questions, inclusive of dietary pattern and use of antihypertensive drugs,[21,22] while others included both waist circumference and BMI in the score.[23] We have reported earlier on the formulation of the IDRS and showed that IDRS was found to be useful in detecting undiagnosed diabetes, metabolic syndrome, and coronary artery disease in the population.[15,24] We also showed that IDRS was one of the strongest predictors of incident diabetes in our population.[25] However, its association with arterial stiffness or atherosclerosis has not been examined. In this study, we found that IDRS was significantly correlated with arterial stiffness as measured by AI.

Because diabetes is a well-known cardiovascular risk equivalent, we restricted our study to subjects without diabetes. The present study suggests that individuals with a "medium" or "high" IDRS had significantly higher AI, indicating that even subjects without diabetes with increased IDRS are at risk for CAD.

Assessment of cardiovascular risk has been carried out using different scores that were developed specifically for populations where CAD is present (SMARTscore, Epidemiological Prevention Study of Zoetermeer risk score) or absent (Equitable Stroke Control score).[26–28] In most studies, AI has been evaluated in patients with diabetes, hypertension, or end-stage renal failure.[18,29] Our study is unique in that we assessed AI in a population without diabetes. Earlier studies have documented that age[30] and diastolic blood pressure[31] are known determinants of AI. Our observation that AI was

correlated with age and diastolic blood pressure in a population that was free from any atherosclerotic disease is consistent with previous reports.[31–33]

It is well established that CAD can be prevented by interventions like lifestyle modification and use of statins, fibrate, or antihypertensive therapy.[34–37] It is essential to identify subjects with cardiovascular risk early. Screening for arterial stiffness as an indicator of increased cardiovascular risk[12,13] is extremely difficult for large epidemiological studies, especially in a developing country like India. In this context, the IDRS appears to be of great significance, as it identifies individuals with higher cardiovascular risk. Subjects with medium- and high-risk scores can be advised to undergo lifestyle intervention by changes in diet, weight reduction, or drug therapy, if required. Indian Diabetes Risk Score includes the conventional cardiovascular risk factors, namely, age, waist circumference, family history of diabetes, and physical inactivity. Studies have shown that changes in the arterial wall can lead to increased arterial stiffness. Therefore, IDRS could be a powerful predictor of atherosclerosis because of its independent association with arterial stiffness.

Given that the various components of arterial stiffness, namely, age, physical inactivity, waist circumference, and family history of diabetes, are all associated with cardiovascular risk, it is hardly surprising that IDRS, which is a composite of these four, is associated with increased arterial stiffness. Although this is not an unexpected finding, given its simplicity, ease of measurement, and low cost, IDRS could help to identify people with arterial stiffness. This is thus an extension of the uses of IDRS not just for a clinician but even for a lay person to identify people at risk for CAD in a public health/prevention setting.

The strengths of the study are that it is a population-based sample and the study numbers are fairly large. However, being a cross-sectional study, it limits its applicability for predicting diabetes and CAD. Prospective studies are thus urgently needed to validate the IDRS in predicting AI.

In summary, this study shows that, in addition to identifying unknown diabetes in the community, IDRS also helps to identify those with arterial stiffness.

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References:

1. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27(5):1047–53.
2. Joshi SR. Indian Diabetes Risk Score. J Assoc Physicians India. 2005;53:755–7.
3. DECODE Study Group, The European Diabetes Epidemiology Group. Glucose tolerance and cardiovascular mortality: comparison of fasting and 2-hour diagnostic criteria. Arch Intern Med. 2001;161(3):397–405.
4. Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK, Rao PV, Yajnik CS, Prasanna Kumar KM, Nair JD, Diabetes Epidemiology Study Group in India (DESI). High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. Diabetologia. 2001;44(9):1094–101.
5. Mohan V, Shanthirani CS, Deepa R. Glucose intolerance (diabetes and IGT) in a selected South Indian population with special reference to family history, obesity and lifestyle factors—the Chennai Urban Population Study (CUPS 14). J Assoc Physicians India. 2003;51:771–7.
6. Haffner SM, Lehto S, Rönnemaa T, Pyörälä K, Laakso M. Mortality from coronary heart disease in subjects with type 2 diabetes and in nondiabetic subjects with and without prior myocardial infarction. N Engl J Med. 1998;339(4):229–34.
7. Kannel WB. Metabolic risk factors for coronary heart disease in women: perspective from the Framingham Study. Am Heart J. 1987;114(2):413–9.
8. Murray CJ, Lopez AD. Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. Lancet. 1997;349(9064):1498–504.
9. Stary HC. Evolution and progression of atherosclerotic lesions in coronary arteries of children and young adults. Arteriosclerosis. 1989;9(1 Suppl):119–32.
10. O'Rourke MF, Mancia G. Arterial stiffness. J Hypertens. 1999;17(1):1–4.
11. Guidelines Subcommittee. 1999 World Health Organization—International Society of Hypertension Guidelines for the Management of Hypertension. J Hypertens. 1999;17(2):151–83.
12. Nürnberger J, Keflioglu-Scheiber A, Opazo Saez AM, Wenzel RR, Philipp T, Schäfers RF. Augmentation index is associated with cardiovascular risk. J Hypertens. 2002;20(12):2407–14.
13. Weber T, Auer J, O'Rourke MF, Kvas E, Lassnig E, Berent R, Eber B. Arterial stiffness, wave reflections, and the risk of coronary artery disease. Circulation. 2004;109(2):184–9.
14. Ravikumar R, Deepa R, Shanthirani C, Mohan V. Comparision of carotid intima-media thickness, arterial stiffness and brachial artery flow mediated dilatation in diabetic and nondiabetic subjects (The Chennai Urban Population Study [CUPS-9]). Am J Cardiol. 2002;90(7):702–7.
15. Mohan V, Deepa R, Deepa M, Somannavar S, Datta M. A simplified Indian Diabetes Risk Score for screening for undiagnosed diabetic subjects. J Assoc Physicians India. 2005;53:759–63.

16. Deepa M, Pradeepa R, Rema M, Mohan A, Deepa R, Shanthirani S, Mohan V. The Chennai Urban Rural Epidemiology Study (CURES)—study design and methodology (urban component) (CURES-I). J Assoc Physicians India. 2003;51:863–70.

17. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO Consultation. Diabet Med. 1998;15(7):539–53.

18. Mohan V, Ravikumar R, Shanthi Rani S, Deepa R. Intimal medial thickness of the carotid artery in South Indian diabetic and non-diabetic subjects: the Chennai Urban Population Study (CUPS). Diabetologia. 2000;43(4):494–9.

19. Wilkinson IB, Fuchs SA, Jansen IM, Spratt JC, Murray GD, Cockcroft JR, Webb DJ. Reproducibility of pulse wave velocity and augmentation index measured by pulse wave analysis. J Hypertens. 1998;16(12 Pt 2):2079–84.

20. Wilkinson IB, Prasad K, Hall IR, Thomas A, MacCallum H, Webb DJ, Frenneaux MP, Cockcroft JR. Increased central pulse pressure and augmentation index in subjects with hypercholesterolemia. J Am Coll Cardiol. 2002;39(6):1005–11.

21. Griffin SJ, Little PS, Hales CN, Kinmonth AL, Wareham NJ. Diabetes risk score: towards earlier detection of type 2 diabetes in general practice. Diabetes Metab Res Rev. 2000;16(3):164–71.

22. Lindström J, Tuomilehto J. The diabetes risk score: a practical tool to predict type 2 diabetes risk. Diabetes Care. 2003;26(3):725–31.

23. Ramachandran A, Snehalatha C, Vijay V, Wareham NJ, Colagiuri S. Derivation and validation of diabetes risk score for urban Asian Indians. Diabetes Res Clin Pract. 2005;70(1):63–70.

24. Mohan V, Sandeep S, Deepa M, Gokulakrishnan K, Datta M, Deepa R. A diabetes risk score helps identify metabolic syndrome and cardiovascular risk in Indians—the Chennai Urban Rural Epidemiology Study (CURES-38). Diabetes Obes Metab. 2007;9(3):337–43.

25. Mohan V, Deepa M, Anjana RM, Lanthorn H, Deepa R. Incidence of diabetes and pre-diabetes in a selected urban south Indian population (CUPS-19). J Assoc Physicians India. 2008;56:152–7.

26. Prevention of coronary heart disease in clinical practice. Recommendations of the Second Joint Task Force of European and other Societies on coronary prevention. Eur Heart J. 1998;19(10):1434–503.

27. Simons PC, Algra A, Bots ML, Grobbee DE, van der Graaf Y. Common carotid intima-media thickness and arterial stiffness: indicators of cardiovascular risk in high-risk patients. The SMART Study (Second Manifestations of Arterial disease). Circulation. 1999;100(9):951–7.

28. Hoes AW, Grobbee DE, Valkenburg HA, Lubsen J, Hofman A. Cardiovascular risk and all-cause mortality; a 12 year follow-up study in The Netherlands. Eur J Epidemiol. 1993;9(3):285–92.

29. London GM, Blacher J, Pannier B, Guérin AP, Marchais SJ, Safar ME. Arterial wave reflections and survival in end-stage renal failure. Hypertension. 2001;38(3):434–8.

30. Cameron JD, McGrath BP, Dart AM. Use of radial artery applanation tonometry and a generalized transfer function to determine aortic pressure augmentation in subjects with treated hypertension. J Am Coll Cardiol. 1998;32(5):1214–20.

31. Yasmin, Brown MJ. Similarities and differences between augmentation index and pulse wave velocity in the assessment of arterial stiffness. QJM. 1999;92(10):595–600.

32. Smulyan H, Marchais SJ, Pannier B, Guerin AP, Safar ME, London GM. Influence of body height on pulsatile arterial hemodynamic data. J Am Coll Cardiol. 1998;31(5):1103–9.

33. Gatzka CD, Cameron JD, Dart AM, Berry KL, Kingwell BA, Dewar EM, Reid CM, Jennings GL. Correction of carotid augmentation index for heart rate in elderly essential hypertensives. ANBP2 Investigators. Australian Comparative Outcome Trial of Angiotensin-Converting Enzyme Inhibitor- and Diuretic-Based Treatment of Hypertension in the Elderly. Am J Hypertens. 2001;14(6 Pt 1):573–7.

34. Tonstad S, Sundfør T, Seljeflot I. Effect of lifestyle changes on atherogenic lipids and endothelial cell adhesion molecules in young adults with familial premature coronary heart disease. Am J Cardiol. 2005;95(10):1187–91.

35. Tenenbaum A, Motro M, Fisman EZ, Tanne D, Boyko V, Behar S. Bezafibrate for the secondary prevention of myocardial infarction in patients with metabolic syndrome. Arch Intern Med. 2005;165(10):1154–60.

36. Kjekshus J, Pedersen TR. Reducing the risk of coronary events: evidence from the Scandinavian Simvastatin Survival Study (4S). Am J Cardiol. 1995;76(9):64C–68C.

37. Dahlöf B, Devereux RB, Kjeldsen SE, Julius S, Beevers G, de Faire U, Fyhrquist F, Ibsen H, Kristiansson K, Lederballe-Pedersen O, Lindholm LH, Nieminen MS, Omvik P, Oparil S, Wedel H, LIFE Study Group. Cardiovascular morbidity and mortality in the Losartan Intervention for Endpoint Reduction in Hypertension Study (LIFE): a randomised trial against atenolol. Lancet. 2002;359(9311):995–1003.