Original Article

A Study to derive distribution of carotid intima media thickness and to determine its COrrelation with cardiovascular Risk factors in asymptomatic nationwidE Indian population (SCORE-India)

Ravi R. Kasliwal [a,*], Manish Bansal [a], Nagaraj Desai [b], Bhavesh Kotak [c], Ammar Raza [c], Hardik Vasnawala [c], Amit Kumar [c], On behalf of SCORE-India collaborators[1]

[a] Medanta, The Medicity, Gurgaon, India
[b] Department of Cardiology, JSS Hospital MG Road, Mysuru, India
[c] Medical Affairs, AstraZeneca Pharma India Ltd., Bangalore, India

ABSTRACT

Background: There is presently no data to describe normal distribution of carotid intima-media thickness (CIMT), an established measure of subclinical atherosclerosis, in Indian subjects.
Methods: In this multi-centric study, 1229 subjects with age ≥30 years and no previous cardiovascular disease (CVD) underwent CVD risk factor assessment and CIMT measurement. Mean far wall common carotid artery IMT was measured on both sides and averaged.
Results: Mean age of the subjects was 48.0 ± 12.0 years and 54.2% were men. CIMT measurement was feasible in 1157 subjects. Mean, median and 75th percentile values of CIMT for different age-groups were derived for men and women separately. There was a progressive increase in CIMT with increasing age ($P < 0.001$) and men had higher CIMT values than women (0.608 ± 0.12 mm vs. 0.579 ± 0.11 mm, $P < 0.001$). The CIMT values were also higher in diabetics (0.635 ± 0.10 mm) and hypertensives (0.624 ± 0.10 mm) as compared to non-diabetics (0.589 ± 0.12 mm, $P < 0.001$) and non-hypertensives (0.592 ± 0.12, P 0.02) respectively. Among continuous variables, age, systolic blood pressure and fasting blood glucose had strong to modest correlation with CIMT (Pearson's r 0.524, 0.282 and 0.192 respectively, all P values <0.001), whereas body mass index, diastolic blood pressure and serum triglycerides exhibited weak but still statistically significant relationship (Pearson's r 0.069, P 0.019; Pearson's r 0.065, P 0.026; and Pearson's r 0.094, P 0.001, respectively).
Conclusions: This is the first study to provide age- and gender-specific distribution of CIMT in Indian subjects free from CVD. This information should help facilitate further research and clinical work involving CIMT in India.

1. Introduction

Early detection of atherosclerosis, when still in its preclinical stage, has emerged as a promising approach to facilitate optimum cardiovascular disease (CVD) risk stratification of asymptomatic individuals.[1–4] Although definitive outcome data is lacking, preliminary evidence suggests that addition of atherosclerosis imaging to conventional risk assessment tools may help better

determine the nature and aggressiveness of the required preventive measures and can thus improve clinical outcomes.[5] In addition, limited evidence also suggests that detection of structural evidence of atherosclerosis may improve patient compliance toward therapeutic measures.[6–10]

Numerous tools have been developed for preclinical atherosclerosis assessment, such as carotid intima media thickness (CIMT), coronary calcium score (CCS), brachial artery flow-mediated dilatation, pulse wave velocity, ankle brachial index, etc. Of these, CIMT is one of the most extensively utilized modalities. A large number of clinical trials involving several thousand patients have shown that increased CIMT is associated with increased risk of vascular events, independent of conventional CVD risk factors or

* Corresponding author at: Clinical and Preventive Cardiology, Medanta – The Medicity, Sector 38, Gurgaon 122001, India. Tel.: +91 9971698148.
E-mail address: rrkasliwal@hotmail.com (R.R. Kasliwal).
[1] See Appendix A.

Framingham risk score.[4,11–16] Compared with other modalities for atherosclerosis imaging, CIMT has the advantages of being less expensive, widely available and being free from ionizing radiation.

However, CIMT is significantly influenced by ethnicity and therefore ethnic-specific reference values are needed for interpreting CIMT values in a given individual. Although numerous small scale studies have evaluated associations of CIMT in Indian subjects,[17–22] there is unfortunately no large-scale study to provide normal values of CIMT in Indian subjects. Therefore, this study was sought with the primary objective of defining normal distribution of CIMT in Indian subjects and to also explore the relationship of CIMT values with various demographics characteristics and CVD risk factors in Indians.

2. Methodology

2.1. Study design and procedure details

This was a non-interventional, observational, cross-sectional study, conducted at 15 sites across India. The study was performed in accordance with the ethical guidelines of the Declaration of Helsinki. Institutional review board and the local ethics committee approval was obtained at each site (the core ethics committee: Medanta Independent Ethics Committee, study no. MICR-208/ 2012). A written informed consent was obtained from all the participants.

A total of 1229 asymptomatic subjects with age ≥30 years and no pre-existing CVD were enrolled in the study. The subjects were recruited from participating clinics/hospitals and included healthy volunteers or those undergoing preventive health checks. The absence of significant coronary artery disease (CAD) was confirmed on the basis of history and normal exercise stress test. The subjects were excluded if they (1) had any acute or chronic systemic illness, (including gastro-intestinal, renal, hepatic, central nervous system, respiratory, infectious, or psychiatric diseases), (2) were already taking lipid lowering drug for more than three months, (3) had known hypersensitivity to carotid bulb, (4) were suffering from any medical condition that, in the opinion of the investigator, would have interfered with safe completion of the study, or (5) were already participating in any other clinical study. In addition, pregnant or lactating women were also not allowed to take part in this study. A urine pregnancy test was performed for all female participants with child bearing potential to exclude pregnancy.

Each site was encouraged to recruit subjects in an age-stratified manner with nearly equal number of subjects in each of the following four age groups:

- 30–39 years,
- 40–49 years,
- 50–59 years, and
- 60 years and above.

Once recruited in the study, all participants underwent clinical assessment, biochemical investigations and CIMT measurement. All the study procedures were completed in a single day. However, due to any reason, if any study variable was not captured on the same day, the subject was asked to come back for a second visit within 7 days of the first visit.

Clinical assessment included a detailed medical history about CVD risk factors, concomitant medications and symptoms suggestive of CVD, if any; height, weight and blood pressure (BP) measurement; and examination of the cardiovascular system. BP was measured in the right arm in supine position, using a standard sphygmomanometer. Laboratory investigations included fasting blood glucose and lipid profile estimation; and estimation

of spot urinary albumin concentration. For the purpose of the present study, hypertension was defined according to Joint National Committee (JNC) 7 guidelines as systolic BP ≥140 mmHg or diastolic BP ≥90 mmHg or previous history of hypertension or self-reported use of anti-hypertensive medications.[23] Diabetes mellitus was defined as fasting blood glucose ≥126 mg/dL or 2-hour postprandial blood glucose ≥200 mg/dL or pharmacological treatment for diabetes or previous history of diabetes mellitus.[24] Family history was considered positive if a coronary event had occurred in a male first degree relative before the age of 55 years or a female first degree relative before the age of 65 years.[25] Smoking or tobacco use in any form during the preceding month was also considered to be a CVD risk factor.

2.2. CIMT measurement

The measurement of CIMT was performed following the recently published guidelines of the American Society of Echocardiography (ASE).[4] The images were obtained at the participating study sites and were then transferred to the core lab for offline CIMT measurement.

2.2.1. Image acquisition

Imaging was performed using a linear-array transducer with minimum fundamental frequency of 7 MHz attached to Sonosite M-turbo 1.5 color Doppler ultrasound system.

The subjects were asked to lie supine with head resting comfortably. The neck was slightly hyperextended and rotated in the direction opposite to the side of measurement. ECG was connected for obtaining R-wave gated images. The default scan depth was kept at 4 cm but could be changed depending on the built of the person. Common carotid artery (CCA) was imaged in longitudinal plane and optimal angle of incidence was identified. The optimal angle of incidence is defined as the plane in which the bifurcation of the carotid bulb into the internal and external carotid arteries can be visualized simultaneously with the bulb and distal CCA (Fig. 1). Once this view was created, finer adjustments in the transducer position were done to ensure that distal CCA was perfectly horizontal on the screen and 'double lines' of intima and adventitia were clearly visualized in the far wall of the CCA (Fig. 1). After optimizing the image, a cine-loop with 3–5 beats was stored. The CCA was then imaged from two additional complimentary angles, approximately 45° anterior and posterior to the first image
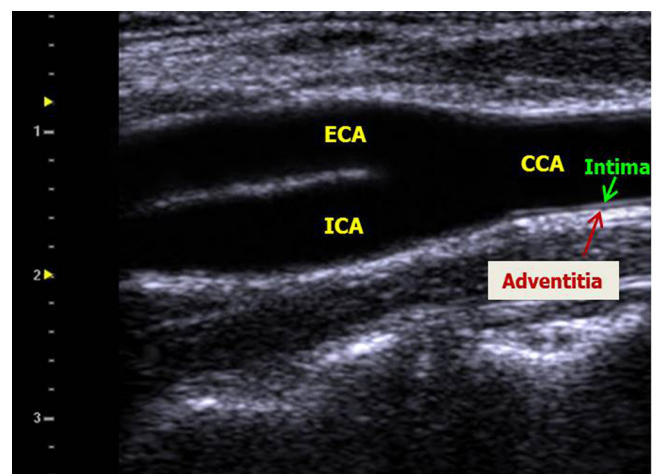

Fig. 1. Longitudinal image of carotid bifurcation showing distal part of common carotid artery, carotid bifurcation and the proximal segments of external and internal carotid arteries. 'Double lines' of intima and adventitia are also seen at the far wall of the common carotid artery. CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery
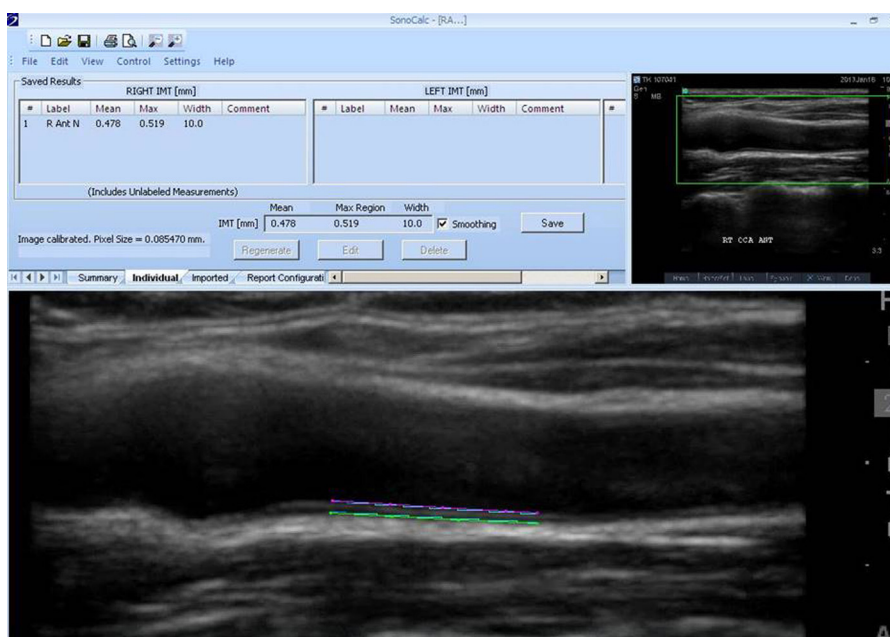
Fig. 2. Carotid intima media thickness measurement using the off-line analysis software.

and a cine-loop was stored for each of these views. All images were transferred to a CD in DICOM format for offline analysis.

2.2.2. Image analysis

The image analysis was performed at the core lab, using the semi-automated software provided by SonoSite Ltd. (Fig. 2). All images were analyzed by a single observer. Only the far wall CIMT of distal 1 cm of CCA was measured, as recommended by the ASE.[4]

For analysis, the images were transferred from the CD to the workstation and were first reviewed for overall image quality. Each loop was then played individually and the R-wave gated still frame showing the best image of distal 1 cm of CCA far wall was selected for CIMT measurement.

A region-of-interest box with 1 cm length was placed at the distal end of the CCA, just before bifurcation. The software then automatically traced lumen-intima and media-adventitia interfaces using leading edge-to-leading edge method. Manual adjustments were done to ensure optimum tracing. If a plaque was present in the segment where CIMT measurement was being performed, it was traced as part of CIMT. The software then provided mean and maximum values of CIMT over 1 cm length of CCA (Fig. 2), which were recorded. The same process was then repeated for all the three angles on both sides. Thus, six (three for each side) values of mean and maximum CIMT were obtained for each subject. The six mean CIMT values were averaged to provide composite 'mean CIMT' which was used for subsequent analysis.

2.3. Statistical methods

The data were managed on Microsoft excel spreadsheet (version 2007, Microsoft Corp., Seattle, Washington) and analyzed using SPSS for Windows (release 15.0, SPSS Inc., Chicago, IL, USA). Standard descriptive analysis was performed to analyze the baseline characteristics of the study population. Continuous values were expressed as mean with standard deviation and the categorical values as actual numbers with percentages. For obtaining CIMT distribution, mean, median and 75th percentile values of mean CIMT were derived for each age-group, for men and women separately.

For assessing the relationship between various CVD risk factors and CIMT, Student's independent samples t-test was used for

dichotomous risk factors and Pearson's correlation coefficient for continuous variables. Spearman's rank correlation was used for assessing the statistical significance of CIMT trend across the age-groups. Multiple regression analysis was used for determining the relative strength of association between various CVD risk factors and CIMT. A P value <0.05 was considered statistically significant for all the analysis performed.

2.3.1. Measurement variability

As mentioned above, all the CIMT measurements in the present study were performed by a single observer. The same observer repeated measurements in 20 randomly selected studies. Coefficient of variation was calculated and Bland–Altman plot constructed to assess the intra-observer variability.

3. Results

Table 1 summarizes the clinical characteristics of the study population. Mean age of the study subjects was 48.0 ± 12.0 years and 54.2% (666 of 1229) were men. Of all the subjects, 11.1% were

Table 1
Clinical characteristics of the study population ($n = 1229$).

Parameter	Value
Age (years)	48.0 ± 12.0
Male gender, n (%)	666 (54.2)
Body mass index (kg/m^{-2})	26.0 ± 4.1
Hypertension, n (%)	96 (7.8)
Diabetes, n (%)	137 (11.1)
Smoking, n (%)	129 (10.5)
Family history of premature CAD, n (%)	121 (9.8)
Systolic BP (mmHg)	125 ± 16
Diastolic BP (mmHg)	78 ± 11
Fasting blood sugar (mg/dL)	104.9 ± 37.8
Total cholesterol (mg/dL)	182.0 ± 39.7
Serum triglycerides (mg/dL)	141.9 ± 80.1
HDL-cholesterol (mg/dL)	43.6 ± 12.1
LDL-cholesterol (mg/dL)	114.4 ± 31.9
Urinary albumin concentration (mg/L) ($n = 664$)	37.3 ± 56.9

All values are mean $\pm$ standard deviation or actual number with percentages in parenthesis.
BP, blood pressure; CAD, coronary artery disease; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Table 2
Age- and gender-wise distribution of mean carotid intima-media thickness[a] in the study population.

Age group	Men (n = 624)				Women (n = 533)			
	N	Mean ± SD	Median	75th percentile	N	Mean ± SD	Median	75th percentile
30–39 years	186	0.528 ± 0.06	0.522	0.561	153	0.510 ± 0.06	0.503	0.543
40–49 years	170	0.583 ± 0.08	0.573	0.623	138	0.577 ± 0.11	0.555	0.605
50–59 years	149	0.642 ± 0.13	0.619	0.686	129	0.609 ± 0.09	0.593	0.651
≥60 years	119	0.725 ± 0.14	0.697	0.771	113	0.641 ± 0.11	0.623	0.682

[a] All values are in mm.
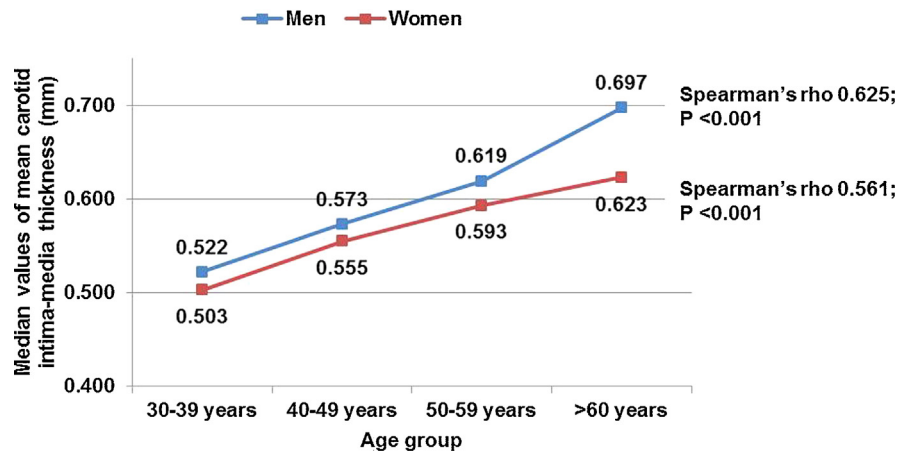
Fig. 3. Age- and gender-wise distribution of mean carotid intima-media thickness in the study population. All values represent median values.

diabetics, 7.8% had hypertension, 10.5% were current smokers and 9.8% had family history of premature CAD. Mean body mass index was $26.0 \pm 4.1 \text{ kg/m}^2$.

3.1. CIMT distribution

Of the 1229 subjects, 1203 (98.0%) completed the study and therefore had carotid scanning done. Of these 1203 subjects, 46 subjects (3.8%) had to be excluded because of the poor image quality. Thus, CIMT measurement was performed in the remaining 1157 subjects (94.1% of total).

The ASE has recommended using age- and gender-specific 75th percentile values of CIMT as the upper limits of normal.[4] Accordingly, mean, median and 75th percentile values of mean

CIMT for men and women in each age-group are provided in Table 2. As is evident, there was progressive increase in CIMT with increasing age ($P < 0.001$, Fig. 3) and men had higher CIMT values than women in each age group (overall mean CIMT 0.608 ± 0.12 mm in men vs. 0.579 ± 0.11 mm in women, $P < 0.001$).

Table 3 summarizes age and gender specific CIMT values in individuals without diabetes, those without diabetes and hypertension and those without diabetes, hypertension, smoking and family history of premature CAD.

3.2. Relationship between various CVD risk factors and CIMT (Table 4)

As already mentioned above, men had higher CIMT values than women. The CIMT values were also higher in diabetics

Table 3
Age- and gender-wise distribution of mean carotid intima-media thickness[a] in the study population in absence of various cardiovascular risk factors.

Age group	Men (n = 624)				Women (n = 533)			
	N	Mean ± SD	Median	75th percentile	N	Mean ± SD	Median	75th percentile
Subjects without diabetes (total 1023; men 542, women 481)								
30–39 years	179	0.526 ± 0.06	0.520	0.556	149	0.510 ± 0.06	0.503	0.543
40–49 years	150	0.582 ± 0.08	0.575	0.621	133	0.579 ± 0.11	0.555	0.609
50–59 years	128	0.640 ± 0.13	0.619	0.682	111	0.607 ± 0.09	0.590	0.654
≥60 years	85	0.732 ± 0.16	0.697	0.771	88	0.647 ± 0.11	0.621	0.680
Subjects without diabetes and hypertension (total 973; men 511, women 462)								
30–39 years	174	0.525 ± 0.06	0.520	0.555	149	0.510 ± 0.06	0.503	0.543
40–49 years	143	0.582 ± 0.08	0.574	0.622	132	0.579 ± 0.11	0.556	0.610
50–59 years	116	0.639 ± 0.13	0.611	0.679	103	0.607 ± 0.09	0.590	0.657
≥60 years	78	0.732 ± 0.16	0.680	0.771	78	0.651 ± 0.17	0.622	0.680
Subjects without diabetes, hypertension, smoking or family history of premature CAD (total 798; men 381, women 417)								
30–39 years	135	0.523 ± 0.06	0.524	0.553	135	0.507 ± 0.06	0.503	0.541
40–49 years	99	0.582 ± 0.08	0.577	0.626	115	0.576 ± 0.11	0.553	0.599
50–59 years	87	0.646 ± 0.14	0.619	0.687	94	0.607 ± 0.10	0.590	0.658
≥60 years	60	0.737 ± 0.15	0.706	0.791	73	0.654 ± 0.12	0.618	0.686

[a] All values are in mm.
CAD, coronary artery disease.

Table 4
Relationship between mean carotid intima-media thickness and various cardio-vascular risk factors.

Categorical variables			
Variable	**Statistics**		
	Mean CIMT (mm)[*]		**P value**[**]
	Risk factor absent	Risk factor present	
Male gender	0.579 ± 0.11	0.608 ± 0.12	<0.001
Hypertension	0.592 ± 0.12	0.624 ± 0.10	0.02
Diabetes	0.589 ± 0.12	0.635 ± 0.10	<0.001
Smoking	0.594 ± 0.12	0.603 ± 0.12	0.38
Family history of premature CAD	0.596 ± 0.12	0.582 ± 0.09	0.282
Continuous variables			
Variable	**Statistics**		
	Correlation coefficient		P value
Age	0.524		<0.001
Body mass index	0.069		0.019
Systolic BP	0.282		<0.001
Diastolic BP	0.065		0.026
Fasting blood sugar	0.192		<0.001
Total cholesterol	0.037		0.21
Serum triglycerides	0.094		0.001
HDL-cholesterol	<0.005		0.992
LDL-cholesterol	−0.002		0.951
Urinary albumin concentration	0.127		<0.001

[*] Values are mean ± standard deviation.
[**] P values derived using Student's independent samples *t*-test.
BP, blood pressure; CAD, coronary artery disease; CIMT, carotid intima-media thickness; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

(0.635 ± 0.10 mm) and hypertensives (0.624 ± 0.10 mm) as compared to non-diabetics (0.589 ± 0.12 mm, $P < 0.001$) and non-hypertensives (0.592 ± 0.12 mm, P 0.02) respectively. However, family history of premature CAD and smoking did not demonstrate any significant relationship with CIMT. Among continuous variables, age, systolic BP and fasting blood glucose had strong to modest correlation with CIMT (Pearson's *r* 0.524, 0.282 and 0.192 respectively, all P values <0.001), whereas body mass index, diastolic BP, serum triglycerides and urinary albumin concentration exhibited weak but still statistically significant relationship (Pearson's *r* 0.069, P 0.019; Pearson's *r* 0.065, P 0.026; Pearson's *r* 0.094, P 0.001; and Pearson's *r* 0.127, $P < 0.001$, respectively) (Table 4). On multivariate analysis, age and gender demonstrated strongest association with CIMT among the risk factors included in the analysis (Table 5).

Table 5
Multivariate regression analysis to assess determinants of carotid intima-media thickness.

|	Unstandardized coefficients		Standardized coefficients	*t*	P value
	B	Std. Error	Beta		
(Constant)	0.259	0.030		8.59	<0.001
Age (years)	0.004	<0.005	0.502	14.57	<0.001
Male gender	0.033	0.007	0.166	5.03	<0.001
Body mass index (kg/m²)	0.002	0.001	0.068	2.044	0.041
Systolic blood pressure (mmHg)	<0.001	<0.001	0.046	1.302	0.194
Fasting blood glucose (mmHg)	<0.005	<0.005	0.135	4.041	<0.001
Urinary albumin concentration (mg/L)	<0.001	<0.001	0.003	0.101	0.920
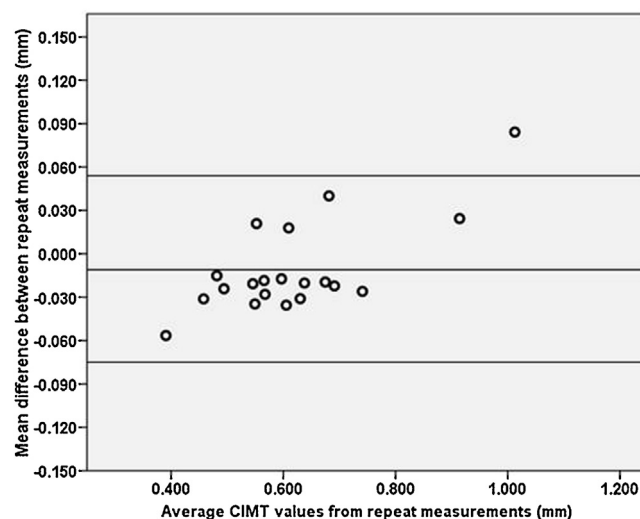
Fig. 4. Bland–Altman limits of agreement for intra-observer reproducibility of carotid intima media thickness measurement in the present study.

3.3. Intra-observer variability

Fig. 4 depicts Bland–Altman limits of agreement for intra-observer reproducibility of mean CIMT. The average difference between repeat measurements was −0.011 mm with standard deviation 0.032 mm and coefficient of variation 5.2%. These values are consistent with those previously reported in the literature.[26–28]

4. Discussion

The rapid increase in the prevalence of CVD world over has necessitated development of aggressive strategies for its prevention. One of the key requirements for any CVD preventive strategy to be effective is the ability to accurately identify the individuals who are at high risk of developing CVD. Focusing on these 'high risk' individuals is expected to result in the most effective utilization of the limited healthcare resources. Additionally, the knowledge of the anticipated CVD risk may also help improve patients' health-related behaviors and improve the compliance to the treatment.

Traditionally, assessment of the CVD risk is performed by taking in to consideration the presence or absence of various CVD risk factors and subsequently using one of the several risk algorithms currently available.[25] A major limitation with these risk algorithms is that they only provide probabilities of developing a CVD event but cannot identify the individuals who are actually going to develop the disease. Thus, while these algorithms work well at the population level, their accuracy at the individual level is suboptimal. To overcome this limitation, detection of subclinical atherosclerosis has been proposed as an alternate strategy with the premise that the presence of an early evidence of atherosclerosis in a given individual will confirm his/her susceptibility to develop atherosclerosis regardless of the presence or absence of various CVD risk factors.

A number of tools for detection of subclinical atherosclerosis are now available, such as carotid ultrasound imaging for CIMT and carotid plaque assessment, CCS, brachial artery flow-mediated dilatation, pulse wave velocity, ankle brachial index, etc. Of these, CCS and CIMT are the most extensively utilized modalities and a large number of studies have documented their incremental value in predicting CVD risk over conventional risk factors.[1,4,11–16,29–34] Although CIMT has relatively less robust evidence base as compared to CCS, it has the advantages of being less expensive, widely available, simpler to perform, and the most

importantly, being free from radiation exposure. These attributes make CIMT an attractive option for incorporation in to routine clinical practice. Although various authorities have provided different recommendations for clinical use of CIMT,[1,35,36] it is already being increasingly adopted for CVD risk stratification in clinical practice.

However, a major challenge with CIMT, just as with all other atherosclerosis imaging modalities, is that it varies with age, gender and ethnicity. Accordingly, ethnic-specific normative data needs to be used for interpreting CIMT results in a given population. Unfortunately, while a number of studies have evaluated the association of CIMT with CVD risk factors and prevalent CVD in Indian subjects,[17–22] no large-scale study has so far provided normal distribution of CIMT in this population. This has remained a major factor limiting wider use of CIMT in clinical practice in India. The present study was conducted as an attempt to fill this knowledge gap. Using a fairly large study sample of men and women free from existing CVD, we derived age- and gender-specific normative data for CIMT in Indians.

While deriving normative data, most of the previous large studies had included all subjects, regardless of the presence or absence of CVD risk factors,[11,12,15,34] and therefore we have also followed the same approach. The reason for not excluding individuals with CVD factors is that the actual incremental value of CIMT is only when it is added to conventional CVD risk factors. As is well established, and was observed in our study too, CIMT values are much lower in individuals who are completely free from all major CVD risk factors. Using these values as reference will result in most of the subjects with one or more CVD risk factors being considered to have increased CIMT, thus defeating the very purpose of risk stratification. Nevertheless, for the benefit of the readers, we have also provided CIMT values in individuals who were free from various specific CVD risk factors.

It is noteworthy that in our study we found significant relationship of CIMT with various CVD risk factors such as age, gender, diabetes, hypertension, urine albumin concentration etc. These findings are consistent with the existing literature on CIMT and provide an indirect validation of our data.

4.1. Limitations

Our study had certain limitations that merit attention. Although this is the largest study to describe normal distribution of CIMT in Indians, it is still small given the overall size and the diversity of our population. For this reason, the present study findings cannot be described as true normative values of CIMT in India. Nevertheless, our study still is an important step toward filling this huge knowledge gap and should be of help in future research and clinical work in India, until larger data is generated.

Second, due to logistic reasons, we did not specifically look for carotid plaques in this study. Previous studies have shown that carotid plaques have stronger association with the presence of obstructive CAD and the future CVD risk as compared to CIMT[37–40] and therefore, detection of carotid plaques (along with CIMT measurement) forms a part of carotid ultrasound examination for CVD risk stratification. However, it should be noted that in apparently healthy young individuals carotid plaques are seen in only <10% subjects.[38] Thus, while the presence of a carotid plaque signifies high CVD risk, absence of a plaque does not help clinicians in assessing CVD risk. For this reason, we believe, lack of information about carotid plaques is unlikely to have appreciably affected the significance of our findings. Moreover, the primary purpose of the present study was to describe distribution of CIMT and not to evaluate the comparative predictive accuracy of CIMT and carotid plaques. This was also the reason (coupled with logistic challenges) why we did not look for other novel CVD risk factors and other measures of subclinical atherosclerosis in this study.

5. Conclusions

To the best of our knowledge, this is the first large-scale study to provide age- and gender-specific distribution of CIMT in Indian subjects free from pre-existing CVD. This information should help facilitate further research and clinical work involving CIMT in India.

Conflicts of interest

The authors have none to declare.

Appendix A

K. Agarwal Pankaj[d], Arora Parneesh[e], Bansal Manish[f], Basarge Mahesh[g], Desai Nagaraj[h], K. Jain Vidyut[i], R. Kasliwal Ravi[f], Kotak Bhavesh[j], Kumar Amit[j], Kumar Prathap[k], Kumar Surender[l], P.P. Mohannan[m], Rao Srinivas[n], Raza Ammar[j], Sethi Sudhir[o], Shah Mahesh[p], Shetty Meena[q], U.P. Singh[r], Thanvi Sunil[s], Vasnawala Hardik[j]
[d]Hormone Care & Research Centre, Ghaziabad, India
[e]Fortis Hospital, Noida, India
[f]Medanta – The Medicity, Gurgaon, India
[g]Baroda Heart Institute, Gujarat, India
[h]Namana Medical Centre, Bangalore, India
[i]Choithram Hospital & Research Center, Indore, India
[j]AstraZeneca Pharma India Ltd., Bangalore, India
[k]Meditrina Hospital, Trivandrum, India
[l]Nobel Medicare, Delhi, India
[m]Westford Hi-tech Hospital, Thrissur, India
[n]CARE Hospital, Hyderabad, India
[o]Sethi's Heart Centre, Jalandhar, India
[p]MK's Heart Care, Mumbai, India
[q]Meena Shetty Clinic, Hubli, India
[r]Prime Diagnostics Centre, Chandigarh, India
[s]Pramukh Swami Medical College, Gujarat, India

References

1. Greenland P, Alpert JS, Beller GA, et al. 2010 ACCF/AHA guideline for assessment of cardiovascular risk in asymptomatic adults: a report of the American college of cardiology foundation/American heart association task force on practice guidelines. J Am Coll Cardiol. 2010;56:e50–e103.
2. Mancia G, De Backer G, Dominiczak A, et al. 2007 guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European society of hypertension (ESH) and of the European society of cardiology (ESC). Eur Heart J. 2007;28:1462–1536.
3. Taylor AJ, Merz CN, Udelson JE. 34th bethesda conference: executive summary – can atherosclerosis imaging techniques improve the detection of patients at risk for ischemic heart disease?. J Am Coll Cardiol. 2003;41:1860–1862.
4. Stein JH, Korcarz CE, Hurst RT, et al. Use of carotid ultrasound to identify subclinical vascular disease and evaluate cardiovascular disease risk: a consensus statement from the American society of echocardiography carotid intima-media thickness task force endorsed by the society for vascular medicine. J Am Soc Echocardiogr. 2008;21:93–111.

5. Shah PK. Screening asymptomatic subjects for subclinical atherosclerosis: can we, does it matter, and should we? *J Am Coll Cardiol.* 2010;56:98–105.
6. Bovet P, Perret F, Cornuz J, Quilindo J, Paccaud F. Improved smoking cessation in smokers given ultrasound photographs of their own atherosclerotic plaques. *Prev Med.* 2002;34:215–220.
7. Wyman RA, Gimelli G, McBride PE, Korcarz CE, Stein JH. Does detection of carotid plaque affect physician behavior or motivate patients? *Am Heart J.* 2007;154:1072–1077.
8. Barth JD. Which tools are in your cardiac workshop? Carotid ultrasound, endothelial function, and magnetic resonance imaging. *Am J Cardiol.* 2001;87:8A–14A.
9. Kalia NK, Miller LG, Nasir K, Blumenthal RS, Agrawal N, Budoff MJ. Visualizing coronary calcium is associated with improvements in adherence to statin therapy. *Atherosclerosis.* 2006;185:394–399.
10. Taylor AJ, Bindeman J, Feuerstein I, et al. Community-based provision of statin and aspirin after the detection of coronary artery calcium within a community-based screening cohort. *J Am Coll Cardiol.* 2008;51:1337–1341.
11. Chambless LE, Heiss G, Folsom AR, et al. Association of coronary heart disease incidence with carotid arterial wall thickness and major risk factors: the atherosclerosis risk in communities (ARIC) study, 1987–1993. *Am J Epidemiol.* 1997;146:483–494.
12. O'Leary DH, Polak JF, Kronmal RA, Manolio TA, Burke GL, Wolfson Jr SK. Carotid-artery intima and media thickness as a risk factor for myocardial infarction and stroke in older adults. Cardiovascular health study collaborative research group. *N Engl J Med.* 1999;340:14–22.
13. Chambless LE, Folsom AR, Clegg LX, et al. Carotid wall thickness is predictive of incident clinical stroke: the atherosclerosis risk in communities (ARIC) study. *Am J Epidemiol.* 2000;151:478–487.
14. Lorenz MW, von Kegler S, Steinmetz H, Markus HS, Sitzer M. Carotid intima-media thickening indicates a higher vascular risk across a wide age range: prospective data from the carotid atherosclerosis progression study (CAPS). *Stroke.* 2006;37:87–92.
15. van der Meer IM, Bots ML, Hofman A, del Sol AI, van der Kuip DA, Witteman JC. Predictive value of noninvasive measures of atherosclerosis for incident myocardial infarction: the Rotterdam study. *Circulation.* 2004;109:1089–1094.
16. Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. *Circulation.* 2007;115:459–467.
17. Hansa G, Bhargava K, Bansal M, Tandon S, Kasliwal RR. Carotid intima-media thickness and coronary artery disease: an Indian perspective. *Asian Cardiovasc Thorac Ann.* 2003;11:217–221.
18. Kasliwal RR, Bansal M, Gupta H, Agrawal S. Association of carotid intima-media thickness with left main coronary artery disease. *Indian Heart J.* 2007;59:50–55.
19. Kasliwal RR, Bansal M, Bhargava K, Gupta H, Tandon S, Agrawal V. Carotid intima-media thickness and brachial-ankle pulse wave velocity in patients with and without coronary artery disease. *Indian Heart J.* 2004;56:117–122.
20. Jadhav UM, Kadam NN. Association of microalbuminuria with carotid intima-media thickness and coronary artery disease – a cross-sectional study in western India. *J Assoc Physicians India.* 2002;50:1124–1129.
21. Rema M, Mohan V, Deepa R, Ravikumar R. Association of carotid intima-media thickness and arterial stiffness with diabetic retinopathy: the Chennai urban rural epidemiology study (CURES-2). *Diabetes Care.* 2004;27:1962–1967.
22. Chow CK, McQuillan B, Raju PK, et al. Greater adverse effects of cholesterol and diabetes on carotid intima-media thickness in South Asian Indians: comparison of risk factor-IMT associations in two population-based surveys. *Atherosclerosis.* 2008;199:116–122.
23. Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the jnc 7 report. *JAMA.* 2003;289:2560–2572.
24. Standards of medical care in diabetes – 2014. *Diabetes Care.* 2014;37(suppl 1):S14–S80.
25. National cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). Third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report. *Circulation.* 2002;106:3143–3421.
26. Tzou WS, Douglas PS, Srinivasan SR, et al. Distribution and predictors of carotid intima-media thickness in young adults. *Prev Cardiol.* 2007;10:181–189.
27. Riley WA, Barnes RW, Applegate WB, et al. Reproducibility of noninvasive ultrasonic measurement of carotid atherosclerosis. The asymptomatic carotid artery plaque study. *Stroke.* 1992;23:1062–1068.
28. Davis PH, Dawson JD, Mahoney LT, Lauer RM. Increased carotid intimal-medial thickness and coronary calcification are related in young and middle-aged adults. The muscatine study. *Circulation.* 1999;100:838–842.
29. Greenland P, Bonow RO, Brundage BH, et al. ACCF/AHA 2007 clinical expert consensus document on coronary artery calcium scoring by computed tomography in global cardiovascular risk assessment and in evaluation of patients with chest pain: a report of the American college of cardiology foundation clinical expert consensus task force (ACCF/AHA writing committee to update the 2000 expert consensus document on electron beam computed tomography) developed in collaboration with the society of atherosclerosis imaging and prevention and the society of cardiovascular computed tomography. *J Am Coll Cardiol.* 2007;49:378–402.
30. Greenland P, LaBree L, Azen SP, Doherty TM, Detrano RC. Coronary artery calcium score combined with Framingham score for risk prediction in asymptomatic individuals. *JAMA.* 2004;291:210–215.
31. Taylor AJ, Bindeman J, Feuerstein I, Cao F, Brazaitis M, O'Malley PG. Coronary calcium independently predicts incident premature coronary heart disease over measured cardiovascular risk factors: mean three-year outcomes in the prospective army coronary calcium (PACC) project. *J Am Coll Cardiol.* 2005;46:807–814.
32. Arad Y, Goodman KJ, Roth M, Newstein D, Guerci AD. Coronary calcification, coronary disease risk factors, c-reactive protein, and atherosclerotic cardiovascular disease events: the St. Francis heart study. *J Am Coll Cardiol.* 2005;46:158–165.
33. Kondos GT, Hoff JA, Sevrukov A, et al. Electron-beam tomography coronary artery calcium and cardiac events: a 37-month follow-up of 5635 initially asymptomatic low- to intermediate-risk adults. *Circulation.* 2003;107:2571–2576.
34. Folsom AR, Kronmal RA, Detrano RC, et al. Coronary artery calcification compared with carotid intima-media thickness in the prediction of cardiovascular disease incidence: the multi-ethnic study of atherosclerosis (MESA). *Arch Intern Med.* 2008;168:1333–1339.
35. Perk J, De Backer G, Gohlke H, et al. European guidelines on cardiovascular disease prevention in clinical practice (version 2012). The fifth joint task force of the European society of cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of nine societies and by invited experts). *Eur Heart J.* 2012;33:1635–1701.
36. Goff Jr DC, Lloyd-Jones DM, Bennett G, et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American college of cardiology/American heart association task force on practice guidelines. *Circulation.* 2014;129:S49–S73.
37. Salonen JT, Salonen R. Ultrasonographically assessed carotid morphology and the risk of coronary heart disease. *Arterioscler Thromb.* 1991;11:1245–1249.
38. Belcaro G, Nicolaides AN, Ramaswami G, et al. Carotid and femoral ultrasound morphology screening and cardiovascular events in low risk subjects: a 10-year follow-up study (the cafes-cave study(1)). *Atherosclerosis.* 2001;156:379–387.
39. Jeevarethinam A, Venuraju S, Weymouth M, Atwal S, Lahiri A. Carotid intimal thickness and plaque predict prevalence and severity of coronary atherosclerosis: a pilot study. *Angiology.* 2015;66:65–69.
40. Inaba Y, Chen JA, Bergmann SR. Carotid plaque, compared with carotid intima-media thickness, more accurately predicts coronary artery disease events: a meta-analysis. *Atherosclerosis.* 2012;220:128–133.