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ATHEROGENIC DYSLIPIDAEMIA, BLOOD PRESSURE AND CARDIOMETABOLIC CLUSTERING IN PREDIABETES: A CROSS-SECTIONAL STUDY FROM MUMBAI, INDIA

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ABSTRACT

Background: Prediabetes is associated with increased cardiovascular risk, but clinic-based Indian data on the co-occurrence of lipid and blood pressure (BP) abnormalities in prediabetes, and on their relation to glycaemia, are limited.

Materials and Methods: In this cross-sectional study, we enrolled 180 consecutive adults with prediabetes (fasting plasma glucose [FPG] 100–125 mg/dL and HbA1c 5.7–6.4%) attending general medicine outpatient clinics of a tertiary centre in Mumbai between October 2023 and October 2025. Lipids were classified by NCEP ATP III, BP by ISH 2020 and BMI by Asian Indian cut-offs. We calculated the atherogenic index of plasma (AIP) and lipid ratios. Clustering was defined as ≥3 of: BMI ≥25 kg/m², BP ≥130/85 mmHg, triglycerides ≥150 mg/dL and low HDL-C.

Results: Mean age was 51.7 ± 15.8 years, 51.7% were women and 68.3% were obese. At least one lipid abnormality was present in 90.6% (95% CI 85.4–94.0): hypertriglyceridaemia 65.0%, total cholesterol ≥200 mg/dL 48.9%, low HDL-C 47.8% and LDL-C ≥130 mg/dL 34.4%. AIP exceeded 0.21 in 51.7%. BP was in the hypertensive range in 60.6% and ≥130/85 mmHg in 78.9%. Clustering was present in 56.1%. Women more often had atherogenic dyslipidaemia (50.5% vs 12.6%; adjusted OR 7.70, 95% CI 3.52–16.82) and clustering (67.7% vs 43.7%; adjusted OR 2.77, 1.50–5.11). FPG and HbA1c showed no correlation with any lipid measure or AIP (all |r| <0.08).

Conclusion: Dyslipidaemia and elevated BP were common and unrelated to the degree of hyperglycaemia within the prediabetic range. Lipid and BP assessment should form part of the routine evaluation of every person with prediabetes.

Keywords: prediabetes; dyslipidaemia; atherogenic index of plasma; hypertension; cardiometabolic risk; India

INTRODUCTION

Prediabetes sits between normal glucose regulation and diabetes. By American Diabetes Association criteria, it means a fasting plasma glucose (FPG) of 100–125 mg/dL, a 2-hour plasma glucose of 140–199 mg/dL after a 75-g oral glucose load, or a glycated haemoglobin (HbA1c) of 5.7–6.4%.[1] People who meet these criteria are much more likely than others to develop type 2 diabetes.[2] In India the numbers are large. The ICMR-INDIAB-17 survey put the national prevalence of prediabetes at 15.3%.[3] and in the Chennai Urban Rural Epidemiology Study 58.9% of people with prediabetes had developed diabetes within ten years.[4]

Progression to diabetes is not the only concern. Meta-analyses of prospective cohorts link prediabetes with higher all-cause mortality and with more coronary heart disease and stroke.[5–7] Much of this excess risk probably comes from the abnormalities that travel with impaired glucose regulation: atherogenic dyslipidaemia, raised blood pressure (BP) and excess

weight. Asian Indians seem especially prone to them. In the ICMR-INDIAB study, 79% of adults had at least one lipid abnormality and 72.3% had low high-density lipoprotein cholesterol (HDL-C).[8] and metabolic risk begins at a lower body mass index (BMI) than in Europeans.[9]

Indian studies comparing people with prediabetes and normoglycaemic controls have generally found higher triglyceride and low-density lipoprotein cholesterol levels and worse atherogenic indices in prediabetes.[10,11] We know much less about how often lipid and BP abnormalities occur together in the patients we actually see in outpatient clinics, or whether the glucose level within the prediabetic range tells us anything about their cardiovascular risk. This matters in day-to-day practice. If these abnormalities do not depend on FPG or HbA1c, then a glucose value just above the normal range is no reason for reassurance, and every new diagnosis of prediabetes should lead to the full cardiovascular risk assessment that current standards of care recommend.[12]

We therefore studied adults with prediabetes attending a tertiary care centre in Mumbai. Our aims were to estimate how common individual and combined lipid abnormalities, raised BP and clustering of cardiometabolic risk factors were; to see how these varied with sex, adiposity and age; and to find out whether they were related to FPG or HbA1c. Inflammation, insulin resistance and treatment patterns in the same patients are reported in a separate paper.

MATERIALS AND METHODS

Study design and setting: This was a descriptive cross-sectional study, reported according to the STROBE statement.[13] It was conducted in the general medicine outpatient department of K.J. Somaiya Medical College and Research Centre, Mumbai, a tertiary teaching hospital, from October 2023 to October 2025.

Participants: Adults aged 18 years or older with newly identified or known prediabetes by American Diabetes Association criteria were recruited consecutively.[1] Eligibility required FPG 100–125 mg/dL, 2-hour plasma glucose 140–199 mg/dL, or HbA1c 5.7–6.4%. We excluded people with diagnosed type 1 or type 2 diabetes, pregnant women and those with severe comorbid illness likely to interfere with assessment. All 180 participants enrolled had both FPG and HbA1c in the prediabetic range.

Sample size: The sample size of 180 was set for the parent study (160 participants plus 10% for non-response). For the prevalence estimates reported here, this gives a 95% confidence interval no wider than ±7.3 percentage points.

Data collection: Trained investigators recorded age, sex and socioeconomic status (SES; low, middle or high, based on family monthly income) using a structured case record form. BP was measured once in the seated position after rest, and height and weight were recorded to calculate BMI. Venous blood was drawn after an overnight fast for FPG, HbA1c, total cholesterol (TC), HDL-C, triglycerides (TG), fasting insulin and high-sensitivity C-reactive protein (hsCRP). All tests were done in the hospital's accredited laboratory. LDL cholesterol (LDL-C) values corresponded to the Friedewald estimate (TC − HDL-C − TG/5),[14] no participant had TG ≥400 mg/dL. Insulin resistance was estimated with HOMA-IR.[15]

Definitions: Lipid categories followed NCEP ATP III,[16] TC ≥200 mg/dL, LDL-C ≥130 mg/dL, TG ≥150 mg/dL, and low HDL-C <40 mg/dL in men and <50 mg/dL in women. Non-HDL-C was TC minus HDL-C, with ≥160 mg/dL considered high. Atherogenic dyslipidaemia was TG ≥150 mg/dL together with low HDL-C. We calculated TC/HDL-C, LDL-C/HDL-C and TG/HDL-C ratios, and the atherogenic index of plasma (AIP) as $\log_{10}$ (TG/HDL-C) in mmol/L.[17] AIP was graded as low (<0.11), intermediate (0.11–0.21) or high (>0.21) risk.[18]

BP was classified by the International Society of Hypertension 2020 guideline,[19] as normal (<130/85 mmHg), high-normal (130–139/85–89 mmHg), grade 1 hypertension (140–159/90–99 mmHg) or grade 2 hypertension (≥160/100 mmHg). BMI was classified with Asian Indian cut-offs as normal (<23 kg/m²), overweight (23–24.9 kg/m²) or obese (≥25 kg/m²).[9,20]

Cardiometabolic clustering was defined as three or more of four components: BMI ≥25 kg/m², BP ≥130/85 mmHg, TG ≥150 mg/dL and sex-specific low HDL-C. Waist circumference was not available, so this is not a formal metabolic syndrome diagnosis.

Statistical analysis: Data from the case record forms were entered into a spreadsheet and checked for entry errors before analysis. Continuous variables are given as mean ± standard deviation and categorical variables as number (%), with Wilson 95% confidence intervals (CIs) for key proportions. Women and men were compared with Welch's t-test and the χ^2 or Fisher's exact test. Groups defined by BMI, age (<45, 45–59, ≥60 years) and SES were compared with one-way ANOVA and the χ^2 test, with the linear-by-linear test for trend across BMI categories. Associations of FPG, HbA1c, BMI and age with lipid measures and BP were assessed with Pearson correlation.

Multivariable logistic regression identified factors independently associated with high AIP, atherogenic dyslipidaemia, clustering and hypertension-range BP. Covariates were age, sex, BMI, SES, FPG and HbA1c, chosen a priori. BMI was left out of the clustering model because obesity is one of its components. Model fit was checked with the Hosmer–Lemeshow test, and discrimination with the area under the ROC curve (AUC). All tests were two-sided with $p < 0.05$ considered significant.

Ethics: The Institutional Ethics Committee (Academic) of K.J. Somaiya Medical College and Hospital approved the protocol at its meeting on 20 December 2023. All participants gave written informed consent. Participants found to have untreated high-risk conditions were referred for further care.

RESULTS

Participant characteristics: Of the 180 participants, 93 (51.7%) were women. Mean age was 51.7 ± 15.8 years (range 25–79), and half (51.1%) belonged to the middle socioeconomic group [Table 1]. Mean BMI was 27.1 ± 3.7 kg/m², and 123 (68.3%) were obese by Asian Indian criteria. Men had higher BMI than women (27.8 vs 26.5 kg/m², p = 0.013). Mean FPG was 113.3 ± 7.0 mg/dL and mean HbA1c 6.05 ± 0.22%, with no difference by sex.

Lipid abnormalities and atherogenic indices: At least one lipid abnormality was present in 163 participants (90.6%; 95% CI 85.4–94.0) [Table 2]. Hypertriglyceridaemia was the most common (65.0%), followed by TC ≥200 mg/dL (48.9%), low HDL-C (47.8%), non-HDL-C ≥160 mg/dL (41.1%) and LDL-C ≥130 mg/dL (34.4%). Atherogenic dyslipidaemia, the combination of high TG and low HDL-C, affected 58 (32.2%). Mean AIP was 0.212 ± 0.131, and 93 (51.7%) were in the high-risk AIP category.

Women had higher TG (177.0 vs 164.1 mg/dL, p = 0.034), TG/HDL-C ratio (4.09 vs 3.70, p = 0.029) and AIP (0.233 vs 0.190, p = 0.028). Mean HDL-C was similar in women and men (44.8 vs 45.6 mg/dL, p = 0.549). The large sex gap in low HDL-C (69.9% vs 24.1%) therefore reflects the higher threshold applied to women. With a common cut-off of <40 mg/dL, low HDL-C was found in 28 women (30.1%) and 21 men (24.1%) (p = 0.369).

Table 1: Characteristics of participants, overall and by sex (n = 180)

Characteristic	All (n = 180)	Women (n = 93)	Men (n = 87)	p
Age, years	51.7 ± 15.8	52.7 ± 15.5	50.5 ± 16.1	0.351
Socioeconomic status				0.867
Low	55 (30.6)	30 (32.3)	25 (28.7)	
Middle	92 (51.1)	46 (49.5)	46 (52.9)	
High	33 (18.3)	17 (18.3)	16 (18.4)	
BMI, kg/m²	27.1 ± 3.7	26.5 ± 3.4	27.8 ± 3.9	0.013
BMI category				0.182
Normal (<23)	21 (11.7)	12 (12.9)	9 (10.3)	
Overweight (23–24.9)	36 (20.0)	23 (24.7)	13 (14.9)	
Obese (≥25)	123 (68.3)	58 (62.4)	65 (74.7)	
Systolic BP, mmHg	134.0 ± 15.1	135.0 ± 15.5	133.0 ± 14.7	0.371
Diastolic BP, mmHg	84.3 ± 9.1	84.5 ± 9.2	84.1 ± 9.0	0.737
Fasting plasma glucose, mg/dL	113.3 ± 7.0	113.6 ± 6.9	113.0 ± 7.1	0.543
HbA1c, %	6.05 ± 0.22	6.05 ± 0.24	6.05 ± 0.20	0.863
HOMA-IR	3.61 ± 0.57	3.59 ± 0.58	3.62 ± 0.57	0.683
Total cholesterol, mg/dL	196.2 ± 27.4	194.9 ± 27.8	197.7 ± 27.0	0.497
LDL-C, mg/dL	116.8 ± 25.8	114.6 ± 26.5	119.2 ± 25.0	0.230
HDL-C, mg/dL	45.2 ± 8.2	44.8 ± 8.2	45.6 ± 8.2	0.549
Non-HDL-C, mg/dL	151.0 ± 26.4	150.0 ± 26.7	152.1 ± 26.2	0.604
Triglycerides, mg/dL	170.8 ± 40.8	177.0 ± 39.2	164.1 ± 41.6	0.034
TC/HDL-C	4.46 ± 0.92	4.47 ± 0.96	4.45 ± 0.88	0.895
LDL-C/HDL-C	2.68 ± 0.81	2.65 ± 0.83	2.71 ± 0.78	0.624
TG/HDL-C	3.90 ± 1.20	4.09 ± 1.23	3.70 ± 1.13	0.029
Atherogenic index of plasma	0.212 ± 0.131	0.233 ± 0.131	0.190 ± 0.128	0.028

Values are mean ± SD or n (%). p from Welch's t-test (continuous) or χ^2 test (categorical). BMI categories use Asian Indian cut-offs.

Table 2: Prevalence of lipid abnormalities, raised blood pressure and cardiometabolic clustering, overall and by sex

Abnormality	All, n (%) [95% CI]	Women, n (%)	Men, n (%)	p
Total cholesterol ≥200 mg/dL	88 (48.9) [41.7–56.1]	45 (48.4)	43 (49.4)	0.889
LDL-C ≥130 mg/dL	62 (34.4) [27.9–41.6]	30 (32.3)	32 (36.8)	0.523
Non-HDL-C ≥160 mg/dL	74 (41.1) [34.2–48.4]	36 (38.7)	38 (43.7)	0.498
Triglycerides ≥150 mg/dL	117 (65.0) [57.8–71.6]	69 (74.2)	48 (55.2)	0.008
Low HDL-C (<40 men, <50 women)	86 (47.8) [40.6–55.0]	65 (69.9)	21 (24.1)	<0.001
Any lipid abnormality	163 (90.6) [85.4–94.0]	90 (96.8)	73 (83.9)	0.003
Atherogenic dyslipidaemia (high TG + low HDL-C)	58 (32.2) [25.8–39.4]	47 (50.5)	11 (12.6)	<0.001
AIP >0.21 (high risk)	93 (51.7) [44.4–58.9]	54 (58.1)	39 (44.8)	0.076
BMI ≥25 kg/m²	123 (68.3) [61.2–74.7]	58 (62.4)	65 (74.7)	0.075
BP ≥130/85 mmHg	142 (78.9) [72.4–84.2]	73 (78.5)	69 (79.3)	0.893
BP ≥140/90 mmHg	109 (60.6) [53.3–67.4]	60 (64.5)	49 (56.3)	0.261
Clustering (≥3 of 4 components)	101 (56.1) [48.8–63.2]	63 (67.7)	38 (43.7)	0.001
BP category (ISH 2020)				0.357
Normal	38 (21.1)	20 (21.5)	18 (20.7)	
High-normal	33 (18.3)	13 (14.0)	20 (23.0)	

Grade 1 hypertension	97 (53.9)	52 (55.9)	45 (51.7)	
Grade 2 hypertension	12 (6.7)	8 (8.6)	4 (4.6)	
AIP risk category				0.013
Low (<0.11)	39 (21.7)	12 (12.9)	27 (31.0)	
Intermediate (0.11–0.21)	48 (26.7)	27 (29.0)	21 (24.1)	
High (>0.21)	93 (51.7)	54 (58.1)	39 (44.8)	

AIP, atherogenic index of plasma; BP, blood pressure. Clustering components: BMI ≥25 kg/m², BP ≥130/85 mmHg, triglycerides ≥150 mg/dL, low HDL-C. 95% CI by the Wilson method. p from χ^2 test.

Blood pressure: Mean BP was 134.0/84.3 mmHg. BP was in the hypertensive range (≥140/90 mmHg) in 109 participants (60.6%): grade 1 in 97 (53.9%) and grade 2 in 12 (6.7%). A further 33 (18.3%) were high-normal, so only 38 (21.1%) had normal BP. Of those in the hypertensive range, 48 had isolated systolic, 38 isolated diastolic and 23 combined elevation. BP categories did not differ by sex (p = 0.357).

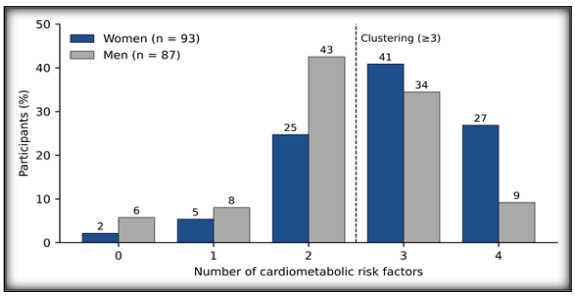


Figure 1. Number of cardiometabolic risk factors (BMI ≥25 kg/m², BP ≥130/85 mmHg, triglycerides ≥150 mg/dL, sex-specific low HDL-C) in women (n = 93) and men (n = 87). Bars show percentages within each sex; the dashed line marks the clustering threshold.

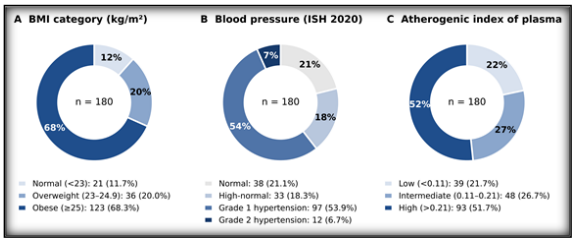


Figure 2: Distribution of the 180 participants by (A) BMI category (Asian Indian cut-offs), (B) blood pressure category (International Society of Hypertension 2020) and (C) atherogenic index of plasma risk category. Percentages are of all participants.

Clustering of cardiometabolic risk factors: Only 7 participants (3.9%) had none of the four components; 101 (56.1%; 95% CI 48.8–63.2) had three or more, and 33 (18.3%) had all four [Figure 1]. Clustering was more frequent in women than men (67.7% vs 43.7%, p = 0.001). [Figure 2] shows how participants were spread across BMI, BP and AIP risk categories: two in three were obese, three in five had hypertension-range BP, and half were in the high-risk AIP group.

Relation to glycaemia, adiposity and age: Neither FPG nor HbA1c correlated with TC, LDL-C, HDL-C, non-HDL-C, TG or AIP (all |r| ≤0.071, all p ≥0.34; Figure 3), or with systolic or diastolic BP (all p ≥0.11). BMI correlated weakly with systolic BP (r = 0.20, p = 0.007) and inversely with diastolic BP (r = −0.16, p = 0.028), but not with any lipid measure (all |r| ≤0.06). Systolic BP rose across BMI categories (127.3, 130.3 and 136.3 mmHg; p for trend 0.003; Figure 4), while lipid levels and lipid abnormalities did not differ [Table 3]. Lipids, AIP, BP and clustering did not differ across age groups or SES groups (all p >0.09).

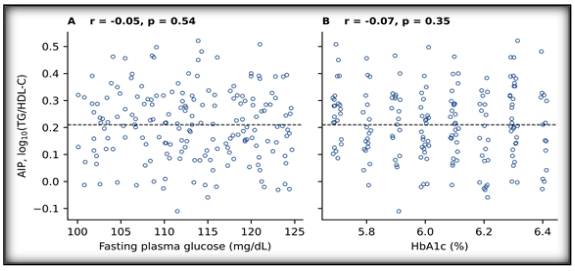


Figure 3: Atherogenic index of plasma (AIP) against (A) fasting plasma glucose and (B) HbA1c in 180 adults with prediabetes. The dashed line marks the high-risk AIP threshold of 0.21. HbA1c is recorded to one decimal place, so small horizontal offsets were added in panel B to separate overlapping points.

Table 3: Blood pressure, lipids and glycaemia by BMI category

Variable	Normal (<23) (n = 21)	Overweight (23–24.9) (n = 36)	Obese (≥25) (n = 123)	p	p for trend
Systolic BP, mmHg	127.3 ± 14.1	130.3 ± 14.4	136.3 ± 15.1	0.010	0.003
Diastolic BP, mmHg	85.2 ± 9.7	87.6 ± 9.7	83.2 ± 8.6	0.036	0.069
FPG, mg/dL	110.5 ± 8.2	115.1 ± 7.0	113.2 ± 6.6	0.058	0.415
HbA1c, %	6.05 ± 0.21	6.02 ± 0.24	6.06 ± 0.22	0.668	0.656
Total cholesterol, mg/dL	189.5 ± 36.1	202.6 ± 24.4	195.5 ± 26.4	0.193	0.833
LDL-C, mg/dL	108.7 ± 29.0	122.1 ± 25.3	116.7 ± 25.2	0.168	0.529
HDL-C, mg/dL	45.4 ± 9.9	46.6 ± 8.4	44.8 ± 7.9	0.504	0.441
Triglycerides, mg/dL	176.6 ± 42.9	169.4 ± 41.4	170.2 ± 40.5	0.786	0.611
AIP	0.228 ± 0.146	0.195 ± 0.119	0.214 ± 0.132	0.626	0.972
BP ≥140/90 mmHg	10 (47.6)	21 (58.3)	78 (63.4)	0.374	0.171
Low HDL-C	9 (42.9)	15 (41.7)	62 (50.4)	0.582	0.359
Triglycerides ≥150 mg/dL	15 (71.4)	23 (63.9)	79 (64.2)	0.805	0.605
Atherogenic dyslipidaemia	8 (38.1)	9 (25.0)	41 (33.3)	0.532	0.976
AIP >0.21	12 (57.1)	19 (52.8)	62 (50.4)	0.840	0.562

Values are mean ± SD or n (%). p from one-way ANOVA or χ^2 test; p for trend from linear regression on category order (continuous) or the linear-by-linear test (categorical).

Table 4: Multivariable logistic regression: factors associated with cardiometabolic clustering, atherogenic dyslipidaemia and high AIP

Variable	Clustering (≥3 of 4), aOR (95% CI)	Atherogenic dyslipidaemia, aOR (95% CI)	AIP >0.21, aOR (95% CI)
Age (per year)	1.00 (0.98–1.02); p = 0.948	1.00 (0.98–1.03); p = 0.703	1.00 (0.98–1.02); p = 0.888
Female sex	2.77 (1.50–5.11); p = 0.001	7.70 (3.52–16.82); p <0.001	1.74 (0.94–3.20); p = 0.078
BMI (per kg/m²)	Not included	1.06 (0.96–1.17); p = 0.252	0.99 (0.91–1.07); p = 0.788
Middle vs low SES	1.07 (0.53–2.15); p = 0.853	1.01 (0.46–2.23); p = 0.979	0.91 (0.46–1.82); p = 0.799
High vs low SES	1.32 (0.53–3.27); p = 0.549	1.06 (0.38–2.93); p = 0.912	1.49 (0.61–3.64); p = 0.381
FPG (per mg/dL)	0.99 (0.94–1.03); p = 0.534	1.02 (0.97–1.07); p = 0.438	0.97 (0.93–1.01); p = 0.138
HbA1c (per 1%)	0.67 (0.16–2.70); p = 0.569	0.69 (0.15–3.22); p = 0.641	0.44 (0.11–1.72); p = 0.236
Events / n	101 / 180	58 / 180	93 / 180
Model χ^2 (p)	11.8 (0.067)	33.6 (<0.001)	8.3 (0.308)
Hosmer–Lemeshow p	0.412	0.152	0.147
AUC	0.64	0.75	0.62

aOR, adjusted odds ratio. BMI was not entered in the clustering model because obesity is a component of the outcome.

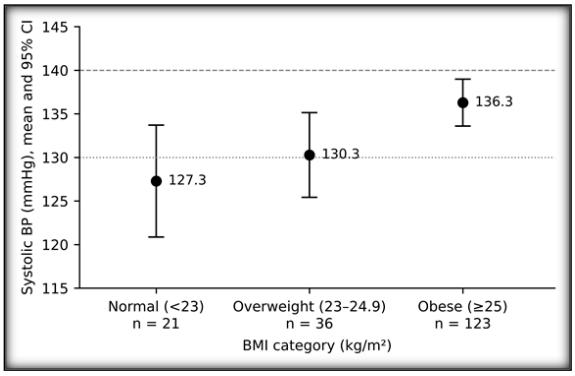


Figure 4: Mean systolic blood pressure with 95% confidence intervals by Asian Indian BMI category. The dashed line marks 140 mmHg and the dotted line 130 mmHg.

Multivariable analysis: After adjustment for age, SES, FPG and HbA1c, female sex was the only factor independently associated with clustering (adjusted OR 2.77, 95% CI 1.50–5.11) [Table 4]. Female sex was also strongly associated with atherogenic dyslipidaemia (adjusted OR 7.70, 3.52–16.82), with BMI, FPG and HbA1c contributing nothing. No variable was independently associated with high AIP, and the model as a whole was not significant (p = 0.308). In a separate model for hypertension-range BP, no covariate reached significance (FPG adjusted OR 1.04 per mg/dL, p = 0.066).

DISCUSSION

Cardiometabolic abnormalities were very common in our patients with prediabetes. Nine in ten had at least one lipid abnormality, three in five had BP in the hypertensive range, and more than half had three or more cardiometabolic risk factors. None of these was related to FPG or HbA1c. BMI was related only to systolic BP. Female sex was the main factor associated with atherogenic dyslipidaemia and with risk factor clustering.

The burden of dyslipidaemia we found is well above that reported for Indian adults in general. ICMR-INDIAB reported hypertriglyceridaemia in 29.5%, high LDL-C in 11.8% and any lipid abnormality in 79%.[8] and national hypertension prevalence was 35.5%.[3] In our cohort the corresponding figures were 65.0%, 34.4%, 90.6% and 60.6%. These are in line with other hospital-based Indian studies, which have also reported higher total cholesterol, triglyceride and LDL-C levels and worse atherogenic indices in prediabetes.[10,11,21] Low HDL-C was the exception: it was less common in our patients than in the general population (47.8% vs 72.3%).[8] The dominant pattern was high triglycerides with a raised TG/HDL-C ratio, a profile linked to insulin resistance in prediabetes.[22]

We did not find the graded rise in cardiometabolic risk with glycaemia that other studies have described. In the PREDAPS cohort, risk factors became steadily more common from normoglycaemia to impaired fasting glucose or raised HbA1c alone, and were most common when both criteria were met.[23] HbA1c in the prediabetic range has also been related to arterial stiffness and carotid intima–media thickness.[24] Those studies, however, compared people across a wide glycaemic range. Every one of our participants met both the FPG and the HbA1c criteria, so glucose values fell within narrow limits, and this alone makes correlations harder to detect. The practical point still stands. Within the prediabetic range, a lower FPG or HbA1c did not mark out a group at lower cardiovascular risk. Current guidance already advises screening for and treating modifiable cardiovascular risk factors in prediabetes.[12] our data suggest this should apply to everyone with the diagnosis, not only to those with higher glucose values.

BMI was associated with systolic BP but with none of the lipid measures, and atherogenic dyslipidaemia was at least as common in participants of normal weight (38.1%) as in those who were obese (33.3%). This fits the well-known tendency of Asian Indians to develop metabolic abnormalities at a relatively low BMI, because of visceral and ectopic fat that BMI does not capture.[9] A normal BMI is therefore not a reason to skip lipid testing in a patient with

prediabetes. Waist circumference would have been a better measure of central fat, but we did not have it.

Women had higher TG levels, TG/HDL-C ratios and AIP values than men, and after adjustment they were almost three times as likely to show clustering. Some of the sex gap in low HDL-C, and therefore in atherogenic dyslipidaemia, comes from the higher HDL-C cut-off used for women; mean HDL-C was similar in both sexes. The differences in TG and AIP do not depend on any cut-off, however. This matters because diabetes removes much of the protection against coronary heart disease that women otherwise have.[25,26] and sex differences in cardiometabolic risk appear even before diabetes develops.[27] The women in our study had a mean age of 52.7 years, so many were probably peri- or postmenopausal, and this may have played a part.

More than half the cohort had an AIP above 0.21. AIP combines TG and HDL-C, correlates with LDL particle size.[17] and has been associated with carotid intima–media thickness in Indian adults with prediabetes.[28] It can be calculated from a routine lipid profile at no extra cost, so it may help identify patients who need closer follow-up. Overall, our findings suggest that in Indian outpatient practice a diagnosis of prediabetes should prompt a full lipid profile and a careful BP check, however close the glucose values are to normal. Structured lifestyle intervention reduces progression to diabetes in both American and Asian Indian populations.[29,30] and decisions about lipid-lowering treatment should be based on overall cardiovascular risk.[31]

Strengths and limitations: The study has several strengths: consecutive recruitment, prediabetes confirmed by both FPG and HbA1c in every participant, standard definitions set in advance, and analysis of individual patient data with multivariable adjustment. It also has limitations. Because it was cross-sectional and done at one centre, it cannot show cause and effect, and our urban tertiary-hospital outpatients may not represent community or rural populations. We had no normoglycaemic comparison group, so we could not measure excess risk directly against people without prediabetes. BP was measured at a single visit, which tends to overestimate hypertension, and we did not have information on antihypertensive or lipid-lowering treatment. Waist circumference, smoking, physical activity and family history were not part of the dataset, and LDL-C was calculated rather than measured. Finally, the modest sample size limited the precision of subgroup estimates.

CONCLUSION

Among adults with prediabetes attending a tertiary care centre in Mumbai, dyslipidaemia (90.6%), hypertension-range BP (60.6%) and clustering of three or more cardiometabolic risk factors (56.1%) were common, and none was related to FPG or HbA1c within the prediabetic range. Women had a more atherogenic lipid profile than men. Every patient diagnosed with prediabetes should have a lipid profile and BP assessment, whatever their glucose level or BMI. Prospective studies are needed to find out whether these abnormalities predict cardiovascular events independently of progression to diabetes.

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