

Risk factors, comorbidityEs and Atherogenic dysLipidaemia in Indian YOUNG patients with dyslipidaemia attending hospital/clinic: REAL YOUNG (dyslipidaemia) study

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ABSTRACT

Objective: To evaluate the pattern of dyslipidaemia, risk factors, and comorbidities in young Indian adults with dyslipidaemia. **Methods:** A retrospective, multi-centric real-world study included individuals with dyslipidaemia, aged 18 - 45 years, attending to 623 hospitals/clinics across India. Data were collected retrospectively from medical records to note demographics, risk factors (smoking, alcohol consumption, sedentary lifestyle, family history of dyslipidaemia, diabetes mellitus, and hypertension), and clinical details (height, weight, waist circumference, body mass index (BMI), blood pressure, blood sugar, glycated hemoglobin (HbA1c), triglycerides (TG), total cholesterol (TC), low-density lipoproteins (LDL-C), and high-density lipoprotein (HDL-C)). A descriptive analysis and comparative analysis (Mann-Whitney U test and Chi-square test) were done. **Results:** Of the total 8135 patients, the majority were men (65.0%). Overall, 87.1% of population had one or multiple comorbidities which included the presence of dyslipidaemia alone (12.9%), dyslipidaemia with diabetes and hypertension (39.1%), dyslipidaemia with diabetes (33.6%), and dyslipidaemia with hypertension (14.4%). Sedentary lifestyle was prevalent observation in >50% of the population. Youngest age (18 - 25) group had higher prevalence of hypertriglyceridemia (63.2%), high LDL-C levels (56.8%), and low HDL-C levels (64.6%), while patients from the age group >25 to ≤35 years had the highest incidence of hypercholesterolemia (66.6%). Atherogenic dyslipidaemia was observed in 41.9%, 25.5%, and 23.2% of patients from age groups of ≥18 to ≤25, >25 to ≤35, and >35 to ≤45 years, respectively. Patients with HbA1c ≥6.5% had significantly higher levels of TG, TC, LDL-C, and lower HDL-C compared to those with HbA1c <6.5%. **Conclusion:** Hypertriglyceridemia, high LDL-C, low HDL-C, and atherogenic dyslipidaemia were prevalent in the young Indian cohort and sedentary lifestyle, and HbA1c ≥ 6.5% were the predominant risk factors of dyslipidaemia.

Keywords: Atherogenic, hypertension, hypertriglyceridemia, sedentary lifestyle, young dyslipidaemia

Introduction

The premature coronary artery disease (CAD) has increased at an alarming rate in India with an obvious visible impact on the young Indian population. In recent times, over 50% of mortality due to cardiovascular diseases (CVD) has been

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noticed in individuals aged <50 years. A recently published review discussed the established and emerging risk factors for CAD in very young South Asians and the higher rates of CAD in this population may be partially explained by an increased prevalence of traditional risk factors, including diabetes, hypertension, smoking and metabolic syndrome.^[1] The most common attributable risk factors among young individuals with the premature occurrence of coronary heart disease (CHD) include dyslipidaemia, hypertension, and smoking.^[2,3]

Among the patients with atherosclerosis, dyslipidaemia has been shown as one of the significant risk factors. In addition, reports from recent studies have also confirmed the increasing prevalence of dyslipidaemia in urban as well as rural Indian populations.^[4-6] The burden of dyslipidaemia in Indian urban population is higher (25 - 30%) than in rural population (15 - 20%).^[5] Particularly, the Indian Council of Medical Research–India Diabetes (ICMR-INDIAB) study demonstrated higher rates of dyslipidaemia in the youngest age group (20 - 24 years).^[6] A very few dedicated epidemiological studies have been conducted in the last two decades that analyzed dyslipidaemia prevalence among young Indians. Most of these studies had a smaller sample size, representing a small geographic area or single centre data.^[2,7-9]

Considering the heterogeneous ethnicities of Indian populations and prevalence of atherogenic dyslipidaemia among them, an individualized treatment schedule is a need of the hour, and the young population is not an exception to this approach.^[10] Effective public health education and intervention strategies for better management of dyslipidaemia among young Indians will depend on an accurate assessment and understanding of dyslipidaemia pattern in young Indian cohort. In addition, the primary physicians are the first contact in early stage of diseases like hypertension, dyslipidaemia and diabetes mellitus; hence, early screening and identification of dyslipidaemia pattern would help the primary care physicians in future management and to avoid complications including the long-term risk of developing premature atherogenic CVDs and associated comorbidities. Therefore, the present study aimed to determine patterns of dyslipidaemia, risk factors and comorbidities using data from a carefully conducted cross-sectional study among young individuals with dyslipidaemia attending hospitals and clinics in India.

Methods

This was a retrospective, non-comparative, multi-centric real-world study which included young individuals with a diagnosis of dyslipidaemia and receiving treatment of dyslipidaemia and/or diabetes and/or hypertension, attending to hospitals and clinics in India.

The study was conducted in accordance with ethical principles that are consistent with the Declaration of Helsinki, International Conference on Harmonisation–Good Clinical Practices, and the applicable legislation on non-interventional studies. The study protocol was approved by an independent review board (31 July 2018).

Data were collected from the medical records of clinics/hospitals across the 623 study sites in India. The inclusion criteria were patients of either sex, aged within the range of 18 - 45 years, with a confirmed diagnosis of dyslipidaemia and receiving treatment for dyslipidaemia and/or diabetes mellitus and/or hypertension. Patients aged >45 years were excluded.

The selection of these retrospective cases was based on the integrity and completeness of the available data sets. Consent from patients for retrospective samples was not obtained, in view of the difficulty in tracking patients. Data were collected through paper-based case record forms at a single visit. These included demographic and clinical details mentioned in the questionnaire. Demographic details included age, sex, smoking habit, alcohol consumption, sedentary lifestyle, family history of dyslipidaemia, diabetes mellitus and hypertension, anthropometric measurements (height, weight, waist circumference, and BMI calculations), blood pressure, fasting and postprandial blood glucose levels, and glycated hemoglobin (HbA1c) in patients with diabetes mellitus. Lipid profile included triglycerides (TG), total cholesterol (TC), low-density lipoproteins cholesterol (LDL-C), and HDL-C.

Definitions:

National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) guidelines were used for definition of dyslipidaemia as follows^[11]:

- Hypercholesterolemia—serum cholesterol levels ≥ 200 mg/dL (≥ 5.2 mmol/L)
- Hypertriglyceridemia—serum triglyceride levels ≥ 150 mg/dL (≥ 1.7 mmol/L)
- Low HDL cholesterol—HDL cholesterol levels, <40 mg/dL (<1.04 mmol/L) for men and <50 mg/dL (<1.3 mmol/L) for women
- High LDL cholesterol—LDL cholesterol levels ≥ 130 mg/dL (≥ 3.4 mmol/L)
- Atherogenic dyslipidaemia—Elevated levels of TG and small-dense low-density lipoprotein and low levels of HDL-C.

Other definitions:

- Diabetes: Individuals diagnosed by a physician and on antidiabetic medications
- Hypertension: Individuals diagnosed by a physician and on antihypertensive medications
- Obesity: Generalized obesity was defined as BMI ≥ 25 kg/m²; overweight as BMI = 23 - 25 kg/m² and abdominal obesity was defined as waist ≥ 90 cm (males), ≥ 80 cm (females) using Asia Pacific guidelines for south Asians^[12,13]

Statistical analyses

Data were analyzed using Statistical Package for The Social Sciences (SPSS) software, version 23.0. Qualitative data were presented as number and percentages, while quantitative data were presented as mean (standard deviation (SD)) or

median (interquartile range (IQR)), depending on the normal or skewed distribution of data. The normal distribution of quantitative data was assessed by the Shapiro-Wilk test. A comparison of qualitative and quantitative variables between the groups was done using the Mann-Whitney U test and Chi-square test, respectively. $P < 0.05$ was considered statistically significant.

Results

A total of 8,135 patients with dyslipidaemia were included in this study, of which, the majority of patients were men (65.0%). The median (IQR) age was 38 (34 - 40) years and BMI was 27.5 (25.0 - 30.4) kg/m². A greater number of patients belonged to the age group of >35 to ≤45 years ($n = 5422$) followed by age group >25 to ≤35 years ($n = 2467$) and age group ≥18 to ≤25 years ($n = 246$). Overall, 1050 (12.9%) patients had only dyslipidaemia, while the 39.1% of patients had both comorbidities (diabetes and hypertension), followed by dyslipidaemia with diabetes (33.6%), and dyslipidaemia with hypertension (14.4%). The majority of the population reported a family history of diabetes mellitus (63.4%) and hypertension (47.6%) [Table 1].

Age-group wise observations

Approximately, more than half of the patients were recently diagnosed (1 - 6 months and 6 - 12 months) with dyslipidaemia across all the age groups (≥18 to ≤25, >25 to ≤35, and >35 to ≤45 years), 52.9%, 56.4%, 50.1%, respectively. A significantly increasing trend was observed in the levels of BMI ($P < 0.001$) from the youngest age group (≥18 to ≤25 years) to the oldest one (>35 to ≤45 years). The most common diagnosis across the three age groups was a triad of dyslipidaemia, diabetes and hypertension (37.0%, 33.2%, and 41.8%); and dyslipidaemia with diabetes mellitus (32.9%, 35.2%, and 32.9%).

Risk factors

Regular smoking and alcohol consumption were more common in patients of age group >35 to ≤45 years ($P < 0.001$); whereas a sedentary lifestyle was the prevalent observation in over 50% of the population across all the groups. More than half of the patients from all the age groups reported a family history of diabetes mellitus (≥18 to ≤25 years, 53.8%; >25 to ≤35 years, 58.6%; and >35 to ≤45 years, 66.1%) [Figure 1a].

Dyslipidaemia patterns

The significantly higher median serum levels of TG, TC, LDL-C, and significantly lower levels of HDL-C were observed in the youngest age group (≥18 to ≤25 years) (218.5, 242.0, 150.0, and 37.5 mg/dL, respectively) compared to other age groups (group B and C) ($P = 0.033, 0.001, 0.003, \text{ and } 0.018$, respectively) [Table 2].

Youngest age group had higher prevalence of hypertriglyceridemia (63.2%), high LDL-C levels (56.8%), and low HDL-C

Table 1: Demographic characteristics of study population

Parameter	Number of patients (N=8135)*
Sex, n (%)	
Female	2848 (35.0)
Male	5287 (65.0)
Age (years)	38.00(34.0-40.0)
Height (cm)	165(158-170)
Weight (kg)	75.0(67.5-83.0)
Waist circumference (cm)	91.0(80.0-98.0)
Body mass index (kg/m ²)	27.5(25.0-30.4)
Diagnosed with, n (%)	
Dyslipidaemia	1050 (12.9)
Dyslipidaemia and DM	2732 (33.6)
Dyslipidaemia and HTN	1175 (14.4)
Dyslipidaemia, DM, and HTN	3178 (39.1)
Family history positive, n (%)	
DM (n=7803)	4950 (63.4)
HTN (n=7698)	3665 (47.6)
Dyslipidaemia (n=7633)	3430 (44.9)
DM and HTN	2865 (35.2)
Dyslipidaemia and DM	2677 (32.9)
Dyslipidaemia and HTN	2390 (29.4)
Dyslipidaemia, DM, and HTN	2005 (24.7)
Smoking habits, n (%) [n=7607]	
Former	422 (5.6)
No	4311 (56.7)
Occasional	1282 (16.9)
Regular	1592 (20.9)
Alcohol consumption, n (%) [n=7729]	2835 (36.7)
Sedentary lifestyle, n (%) [n=7669]	4586 (59.8)

Data shown as median (IQR), unless otherwise specified. *N=8135 unless otherwise specified. DM, diabetes mellitus; HTN, hypertension, IQR, interquartile range

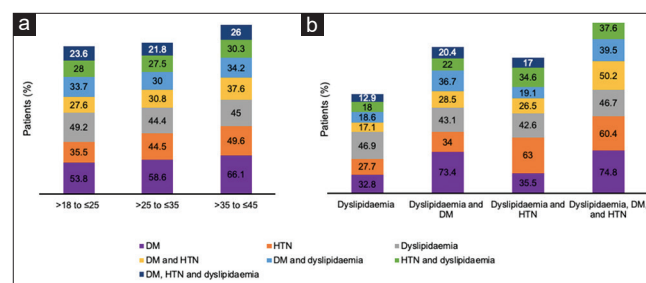


Figure 1: Distribution of patients according to family history (a) age group-wise and (b) diagnosis-wise. DM, diabetes mellitus, HTN, hypertension

levels (64.6%), while patients from the age group >25 to ≤35 years had the highest incidence of hypercholesterolemia (66.7%). High LDL-C with hypertriglyceridemia is the most common mixed dyslipidaemia observed in the 3436 individuals. Among the 1990 individuals with atherogenic dyslipidaemia 103 (41.9%), 630 (25.5%) and 1257 (23.2%) were from age groups of ≥18 to ≤25, >25 to ≤35 and >35 to ≤45 years, respectively.

Diagnosis-wise observations

Male preponderance was observed across all the diagnosis groups with median age ranging between 36 and 38 years. Among patients diagnosed with dyslipidaemia along with diabetes and hypertension, the majority belonged to the age group >35

Table 2: Age group-wise analysis

Parameter	Group A (≥18 to ≤25 years) (n=246)*	Group B (>25 to ≤35 years) (n=2467)**	Group C (>35 to ≤45 years) (n=5422)#	P
Sex, n (%)				<0.001
Female	115 (46.7)	873 (35.4)	1860 (34.4)	
Male	131 (53.3)	1587 (64.6)	3543 (65.6)	
Age (years)	24.0(22.0-25.0)	32.0(30.0-34.0)	39.0(38.0-40.0)	<0.001, <0.001 ^{abc}
Height (cm)	162(157-170)	165(158-170)	165(158-170)	0.044, 0.012 ^a , 0.016 ^b , 0.719 ^c
Weight (kg)	72.0(64.0-82.0)	74.0(66.2-82.0)	75.0(68.0-84.0)	<0.001, 0.022 ^a , <0.001 ^{b,c}
Waist circumference (cm)	88.0(81.8-95.3)	90.0(81.0-98.0)	91.4(80.0-98.0)	0.008, 0.033 ^a , 0.005 ^b , 0.108 ^c
Body mass index (kg/m ²)	27.1(23.9-30.3)	27.3(24.8-30.1)	27.6(25.3-30.5)	<0.001, 0.178 ^a , 0.009 ^b , <0.001 ^c
Diagnosed with, n (%)				<0.001
Dyslipidaemia	54 (22.0)	431 (17.5)	565 (10.4)	
Dyslipidaemia and DM	81 (32.9)	869 (35.2)	1782 (32.9)	
Dyslipidaemia and HTN	20 (8.1)	347 (14.1)	808 (14.9)	
Dyslipidaemia, DM, and HTN	91 (37.0)	820 (33.2)	2267 (41.8)	
Smoking habits, n (%)	(n=232)	(n=2282)	(n=5093)	<0.001
Former	17 (7.3)	137 (6.0)	268 (5.3)	
No	168 (72.4)	1327 (58.2)	2816 (55.3)	
Occasional	14 (6.0)	376 (16.5)	892 (17.5)	
Regular	33 (14.2)	442 (19.4)	1117 (21.9)	
Alcohol consumption, n (%)	(n=237)	(n=2329)	(n=5163)	<0.001
No	47 (19.8)	868 (37.3)	1920 (37.2)	
Occasional	14 (6.0)	376 (16.5)	892 (17.5)	
Regular	33 (14.2)	442 (19.4)	1117 (21.9)	
Sedentary lifestyle, n (%)	(n=233)	(n=2321)	(n=5115)	0.999
No	139 (59.7)	1388 (59.8)	3059 (59.8)	
Duration of dyslipidaemia (days)	360(180-1080)	360(180-720)	360(240-900)	<0.001, 0.172 ^a , 0.466 ^b , <0.001 ^c
Duration, n (%)				<0.001
1-6 months	66 (32.0)	611 (29.3)	1106 (23.8)	
6-12 months	43 (20.9)	565 (27.1)	1225 (26.3)	
>1 year	97 (47.1)	907 (43.5)	2318 (49.9)	
Triglyceride (mg/dL)	218.5 (165.3-257.0)	201.0 (150.0-259.0)	199.0 (155.00-252.0)	0.033, 0.017 ^a , 0.008 ^b , 0.792 ^c
Total cholesterol (mg/dL)	226.0 (191.0-254.0)	211.0 (184.0-246.0)	210.0 (180.0-242.0)	0.001, 0.004 ^a , <0.001 ^b , 0.083 ^c
Low density lipoprotein cholesterol (mg/dL)	137.0 (110.0-172.0)	134.5 (106.0-164.0)	130.0 (104.0-160.0)	0.003, 0.063 ^a , 0.005 ^b , 0.022 ^c
High density lipoprotein cholesterol (mg/dL)	39.0 (33.5-44.0)	40.0 (35.0-45.0)	40.0 (35.0-45.0)	0.018, 0.006 ^{a,b} , 0.862 ^c

Data shown as median (IQR), unless otherwise specified. *n=246; **n=2467; #n=5422 unless otherwise specified. ^agroup A vs B; ^bgroup A vs C; ^cgroup B vs C. DM, diabetes mellitus; HTN, hypertension; IQR, interquartile range

to ≤45 years (71.3%) compared to only 3% in the youngest individuals. Similar trends were seen in other groups based on the diagnosis.

Risk factors

In patients with smoking habits across all the groups, regular smoking (20.3%, 15.9%, 27.9%, and 23.0%) was predominant observation than former (7.3%, 4.6%, 5.3%, and 5.9%) or occasional (15.4%, 15.7%, 17.9%, and 18.0%) smoking. Alcohol consumption was the highest (42.6%) in patients diagnosed with dyslipidaemia along with hypertension, however, a sedentary lifestyle was reported in the majority of patients across all groups (range: 56.6-63.1%). Family history of diabetes mellitus was reported to be significantly associated with the risk of developing diabetes mellitus in patients with dyslipidaemia and

both the comorbidities, diabetes and hypertension, in patients with dyslipidaemia (*P* < 0.001) [Figure 1b]. Similarly, family history of hypertension showed significant association with the risk of developing hypertension and hypertension along with diabetes mellitus in patients with dyslipidaemia (*P* < 0.001).

Dyslipidaemia patterns

Overall, significantly higher median levels of lipid parameters (TG, TC, and LDL-C) were observed in patients diagnosed with only dyslipidaemia as compared to other groups (*P* < 0.001) [Table 3].

Dyslipidaemia patterns according to HbA1c levels

Patients with HbA1c ≥6.5% had significantly higher median levels of TG (200 mg/dL), TC (210 mg/dL), LDL-C (127 mg/dL), and low HDL (40 mg/dL) compared to those

Table 3: Diagnosis-wise analysis

Parameter	Group A Dyslipidaemia only (n=1050)*	Group B Dyslipidaemia and DM (n=2732)**	Group C Dyslipidaemia and HTN (n=1175)#	Group D Dyslipidaemia, DM, and HTN (n=3178)##	P
Sex, n (%)					
Female	368 (35.0)	1015 (37.2)	372 (31.7)	1093 (34.4)	0.008
Male	682 (65.0)	1717 (62.8)	803 (68.3)	2085 (65.6)	
Age (years)	36.0(31.0-39.0)	38.0(34.0-40.0)	38.0(34.0-40.0)	38.00(35.0-40.0)	<0.001, <0.001 ^{a,b,c,e} , 0.116 ^d , 0.004 ^f
Age group (years)					
≥18 to≤25	54 (5.1)	81 (3.0)	20 (1.7)	91 (2.9)	<0.001
>25 to ≤35	431 (41.0)	869 (31.8)	347 (29.5)	820 (25.8)	
>35 to≤45	565 (53.8)	1782 (65.2)	808 (68.8)	2267 (71.3)	
Height (cm)	165 (159-171)	164 (158-170)	166 (159-171)	165 (158-171)	<0.001, <0.001 ^{a,d,e} , 0.329 ^b , 0.320 ^c , 0.030 ^f
Weight (kg)	74.0 (67.0-82.0)	73.0(66.0-81.0)	75.0 (68.0-84.0)	76.0 (68.0-85.0)	<0.001, 0.126 ^a , 0.011 ^b , <0.001 ^{c,d,e} , 0.182 ^f
Waist circumference (cm)	90.0 (78.0-97.0)	92.0 (83.0-98.0)	90.0 (83.0-97.0)	91.0 (79.0-99.1)	0.019, 0.002 ^a , 0.329 ^b , 0.097 ^c , 0.031 ^d , 0.192 ^e , 0.406 ^f
Body mass index (kg/m ²)	27.0(24.7-29.7)	27.4(25.0-30.0)	27.6 (25.3-30.4)	27.8 (25.3-30.8)	<0.001, 0.015 ^a , <0.001 ^{b,c,e} , 0.081 ^d , 0.061 ^f
Smoking habits, n (%)	(n=994)	(n=2596)	(n=1107)	(n=2910)	
Former	73 (7.3)	119 (4.6)	59 (5.3)	171 (5.9)	<0.001
No	565 (56.8)	1658 (63.9)	541 (48.9)	1547 (53.2)	
Occasional	154 (15.5)	407 (15.7)	198 (17.9)	523 (18.0)	
Regular	202 (20.3)	412 (15.9)	309 (27.9)	669 (23.0)	
Alcohol consumption, n (%)	(n=1004)	(n=2649)	(n=1121)	(n=2955)	<0.001
	335 (33.4)	874 (33.0)	478 (42.6)	1148 (38.8)	
Sedentary lifestyle, n (%)	(n=989)	(n=2630)	(n=1112)	(n=2938)	<0.001
	585 (59.2)	1517 (57.7)	629 (56.6)	1855 (63.1)	
Triglyceride (mg/dL)	218.0 (168.0-280.0)	200.0 (148.0-264.8)	200.0 (160.0-245.3)	194.0 (150.0-245.0)	<0.001, <0.001 ^{a,b,c} , 0.429 ^d , 0.015 ^e , 0.003 ^f
Total cholesterol (mg/dL)	230.0 (200.0-260.0)	209.0 (178.0-242.0)	220.0 (193.0-250.0)	209.0 (176.0-240.0)	<0.001, <0.001 ^{a,b,c,d,f} , 0.445 ^e
Low density lipoprotein cholesterol (mg/dL)	154.0 (125.0-177.5)	125.0 (100.0-151.7)	145.0 (113.0-170.0)	126.0 (101.0-159.0)	<0.001, <0.001 ^{a,b,c,d,f} , 0.044
High density lipoprotein cholesterol (mg/dL)	40.0 (35.0-45.1)	40.0 (36.0-46.0)	39.4 (34.8-45.0)	39.2 (35.0-45.0)	<0.001, 0.044 ^a , 0.111 ^b , 0.113 ^c , <0.001 ^{d,e} , 0.628 ^f

Data shown as median (IQR), unless otherwise specified. *n=1050; **n=2732; #n=1175; ##n=3178, unless otherwise specified. ^agroup A vs B; ^bgroup A vs C; ^cgroup A vs D; ^dgroup B vs C; ^egroup B vs D; ^fgroup C vs D. DM, diabetes mellitus; HTN, hypertension; IQR, interquartile range

with HbA1c <6.5% ($P < 0.001$) [Table 4]. Regression analysis showed large variability in triglyceride and HbA1c and between triglyceride and blood pressure [Figure 2].

Discussion

Dyslipidaemia alone or along with associated comorbidities, mainly diabetes and hypertension, poses a significant risk of premature atherosclerotic CVDs and therefore early diagnosis and appropriate management have become a fundamental step in alleviating morbidity and mortality. Current evidence highlights the grave status quo of the alarming rise in the prevalence of lipid

abnormalities in the Indian population aged ≤45 years.^[14] The major attributable risk factors include a sedentary lifestyle, lack of physical activity, increased intake of junk food, smoking/tobacco use, alcohol consumption, mental stress, etc., However, there is a lot of variation in the reported prevalence of dyslipidaemia in young Indians with a higher proportion of affected men.^[2,7-9,15-18]

The present study retrospectively determined the patterns of dyslipidaemia and associated comorbidities in a large-scale study that included young Indian cohort diagnosed with dyslipidaemia. The salient observations were; (1) overall 87.1% of population had one or comorbidities that included diabetes and/or

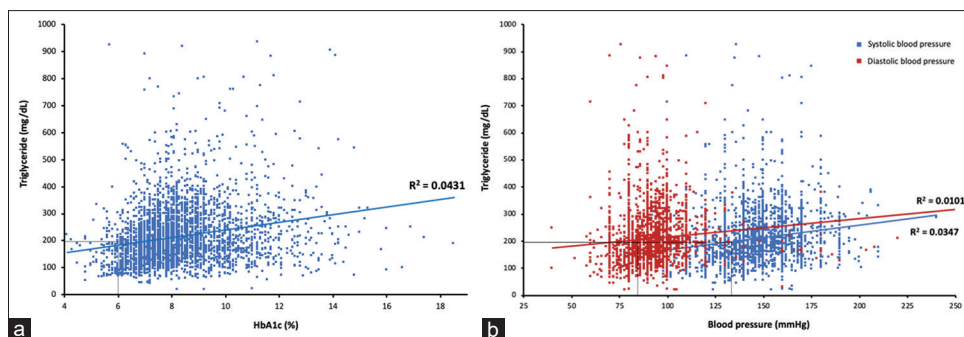


Figure 2: Regression analysis ([a] triglyceride versus HbA1c; [b] triglyceride versus blood pressure). Three patients with triglyceride >1000 mg/dL are not shown in the figures

Table 4: Lipid parameters according to HbA1c levels

Parameter	Hb1Ac <6.5% (n=395)	Hb1Ac ≥6.5% (n=4447)	P
TG (mg/dL)	139 (96-190)	200 (154-260)	<0.001
TC (mg/dL)	161 (112-203)	210 (180-240)	<0.001
LDL-C (mg/dL)	94 (72-127)	127 (101-155)	<0.001
HDL-C (mg/dL)	41 (38-45)	40 (36-45)	<0.001

Data shown as median (IQR).Hb1Ac, glycated haemoglobin; HDL-C, high-density lipoprotein cholesterol;IQR, interquartile range; LDL-C, low density lipoprotein cholesterol; TC, total cholesterol; TG, triglycerides

hypertension; (2) family history of diabetes and hypertension were the predominant non-modifiable risk factors; (3) overall the population was obese with median BMI >27 kg/m² illustrating the contribution of BMI to dyslipidaemia in young adult population; (4) sedentary lifestyle was observed in more than half of the patients across all the age groups depicting it as a plausible risk factor; and (5) hypercholesterolemia, hypertriglyceridemia, high LDL-C, and low HDL-C were significant findings across the population; further, an alarming observation was 41.9% of youngest individuals (≥18 to ≤25 years) had atherogenic dyslipidaemia which was the highest among all groups.

A recently published study has established evidence that the role of repeated evaluation of lipids during childhood and young adulthood is useful in the prediction of future dyslipidaemia development in adults.^[19] However, literature reveals that the serum cholesterol levels in early adult life were associated with cardiovascular mortality in the middle age life after a median follow-up of 30.5 years.^[20] Hence, young adults with dyslipidaemia are more prone to develop CVDs.^[21] A higher incidence rate (87.1%) of patients with one or multiple comorbidities in the present study suggest the high prevalence of diabetes and/or hypertension among patients with dyslipidaemia. Altogether these comorbidities may contribute to the increased risk of atherosclerotic CVDs.

Among the previous Indian studies that evaluated dyslipidaemia prevalence, only ICMR-INDIAB study involved a large population (n = 16,607). The key observation was the higher prevalence of low HDL-C levels in patients of age group 20-44 years (72.3%) as compared to the older adult population and

remarkable prevalence in the youngest individuals aged within 20-24 years (~60-90%).^[6] Another noteworthy study in Indian literature that had a relatively small sample size (n = 403) also showed low HDL-C (69.5%) and hypertriglyceridemia (41.9%) were the predominant dyslipidaemias in young patients aged <40 years with CAD.^[22]

Establishment of high TG as a direct risk factor for CVD has been in controversy and debated for many years. However, high triglyceride level is one of the important components that defines metabolic syndrome and is recognized as a contributing factor in addition to other components for the development of CVD. According to the editorial published in the Clinical lipidology, authors recommended determination of mild and moderate hypertriglyceridemia (TG of 150-999 mg/dL) will benefit in the evaluation of cardiovascular risk.^[23,24] Lipid Association of India recommends to exclude secondary causes of hypertriglyceridemia and maintain serum TG levels below 150 mg/dL, and preferably less than 100 mg/dL.^[25] It is noteworthy to consider the 2018 American College of Cardiology/American Heart Association Guidelines on the management of blood cholesterol that highlights the importance of identifying the continuously increased TGs in enhancing the risk of CVD. Various observational epidemiology and genetic studies were in concordance with the fact that a causal association exists between the risk of atherosclerotic CVD and TGs, triglyceride-rich lipoproteins and remnant cholesterol.^[26-28]

Evidence from studies that included adult Indian population demonstrated corroborating observations thereby suggesting low HDL-C and hypertriglyceridemia are the two most prevalent clinical manifestations of dyslipidaemia in young as well as adult Indians.^[2,8,9,14] In parallel to these studies, the present study revealed significantly high median levels of TC, TG, LDL-C, and lower HDL-C in the youngest age group (18-25 years) compared to the older age groups in the study. The youngest age group had higher prevalence of hypertriglyceridemia, high LDL-C levels, and low HDL-C levels, while patients from the age group >25 to ≤35 years had the highest incidence of hypercholesterolemia. However, these observations cannot be inferred in the similar manner due to widely different sample size in each group and lack of matched cohort. Atherogenic dyslipidaemia has been shown to elevate the risk of

CVD and therefore, high prevalence of atherogenic dyslipidaemia in young Indian adults may predispose them to premature CVDs and associated morbidities. Previous studies in Asian Indians demonstrated higher prevalence of atherogenic dyslipidaemia in contrast to trends observed in the Western population and factors responsible for this trend were higher physical inactivity, low exercise and diet deficient in polyunsaturated fatty acids.^[29-31] Therefore, overall screening of these four lipid abnormalities in young Indian adults may aid in early diagnosis of dyslipidaemia thereby attenuating the risk of premature CVDs.

A sedentary lifestyle was the most common lifestyle-related risk factor seen in this study population. The majority of patients had a family history of diabetes mellitus followed by hypertension and dyslipidaemia. This trend indicates that a family history of diabetes mellitus may predispose young individuals to dyslipidaemia and individuals need to be careful and vigilant about their health. The BMI analysis suggested the overall study population was overweight. However, patients with higher HbA1c $\geq 6.5\%$ had significantly higher levels of TG, TC, LDL-C, and lower HDL-C compared to those with normal HbA1c ($< 6.5\%$). These findings are in concordance with ICMR-INDIAB study wherein obesity, sedentary lifestyle, diabetes, dysglycemia and hypertension were the factors shown to be strongly associated with dyslipidaemia.^[6]

Several limitations of this study should be considered and observations should be interpreted cautiously. This study did not record the socioeconomic and educational status of the patients which could have added valuable data while inferring the observations. However, these observations need to be vigilantly interpreted as factors such as unawareness of symptoms, an unhealthy lifestyle, ignorance toward behavioral habits (smoking, alcohol consumption) in very young age (< 25 years) may contribute to these findings.

Conclusion

Overall observations indicate high prevalence of comorbidities, hypertriglyceridemia, high LDL-C, low HDL-C, and atherogenic dyslipidaemia in young Indian cohort; sedentary lifestyle, obesity, family history of diabetes mellitus, male gender, and HbA1c $\geq 6.5\%$ were the predominant risk factors attributable to dyslipidaemia. Hence, accurate assessment of lipid parameters as a part of global risk assessment among the young Indian adults will aid in alleviating the long-term risk of premature atherosclerotic CVD and associated morbidity and mortality.

Key points

- In young Indian cohort, high prevalence of hypertriglyceridemia, high LDL-C, low HDL-C, and atherogenic dyslipidaemia were reported. These lipid abnormalities are known to increase the long-term risk of premature atherosclerotic CVD.
- Among the risk factors of dyslipidaemia sedentary lifestyle, obesity, family history of diabetes mellitus, male gender, and HbA1c $\geq 6.5\%$ were most common.

- Therefore, it is crucial to keep a regular check on these risk factors from young age to prevent or delay the occurrence of premature atherosclerotic CVD and associated mortality and morbidity.

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Compliance with ethics guidelines

This article is based on previously conducted studies and does not contain any studies with human participants or animals performed by any of the authors.

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Conflicts of interest

Dr. Mahesh V. Abhyankar and Dr. Santosh Revankar are employees of USV Pvt Ltd, Mumbai. All other authors have no conflict of interest to declare.

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