



OPEN Prevalence of metabolic dysfunction-associated fatty liver disease among information technology employees in India

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The Information Technology (IT) sector is a leading industry that fuels India's economic growth. However, the work culture in this sector often promotes sedentary lifestyle, inadequate physical activity, and unhealthy dietary patterns which are risk factors for various non-communicable disease (NCD). This study aims to assess the prevalence of metabolic dysfunction-associated fatty liver disease (MAFLD) among IT employees and its association with behavioural and biological risk factors. This cross-sectional study involved 345 IT employees in Hyderabad, India, who responded to a questionnaire on their occupational sitting, shift work, stress, sleep duration, smoking, physical activity, and food habits. Anthropometric, biochemical, metabolic, and liver function parameters were evaluated. MAFLD was diagnosed using a Vibration-Controlled Transient Elastography FibroScan. Chi-square test and Spearman's rank correlation were performed to analyse the associations and correlations between risk factors. The median age of the employees was 38 years (34–43 years) with a body mass index (BMI) of 24.4 (70.72%) obese. Approximately, 248 (71.88%), 89 (25.80%), 241 (69.86%) and 131 (37.97%) of employees were found to sit for long hours at work, had shift work, sleep deprivation and stress, respectively. Almost 72 (20.87%) of IT employees had elevated fasting blood glucose (FBG) and 264 (76.52%) had high low-density lipoprotein (LDL-C). Metabolic Syndrome (MetS) was present in 118 (34.20%) of the employees. A total of 290 (84.06%) employees had increased liver fat accumulation indicating MAFLD. There is high prevalence of MAFLD among IT employees, highlighting the urgent need for workplace interventions and health promotion initiatives addressing MAFLD risk in the IT workforce.

Keywords Liver disease, NAFLD, MAFLD, IT industry, Liver steatosis, Metabolic syndrome, Non-communicable disease

Abbreviations

ALP	Alkaline Phosphatase
ALT	Alanine aminotransferase
AST	Aspartate Aminotransferase
BMI	Body Mass Index
BP	Blood Pressure
CAP	Controlled Attenuated Parameter
FBG	Fasting Blood Glucose
HbsAg	Hepatitis B surface antigen
HCV	Hepatitis C virus
HDL-C	High-Density Lipoprotein Cholesterol
HOMA-IR	Homeostatic Model Assessment for Insulin Resistance
IEC	Institutional Ethics Committee
IT	Information Technology
LDL-C	Low-Density Lipoprotein Cholesterol
MAFLD	Metabolic Dysfunction-Associated Fatty Liver Disease

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MASH	Metabolic Dysfunction-Associated Steatohepatitis
MetS	Metabolic Syndrome
MRE	Magnetic Resonance Elastography
NCDs	Non-Communicable Diseases
OSPAQ	Occupational Sitting and Physical Activity Questionnaire
PSQI	Pittsburgh Sleep Quality Index
PSS4	Perceived Stress Scale
SSBs	Sugar-Sweetened Beverages
TC	Total Cholesterol
TG	Triglycerides
VLDL-C	Very-Low-Density Lipoprotein Cholesterol
W/H	Waist-to-Hip Ratio
WC	Waist Circumference

The Information Technology (IT) sector in India is one of the leading growth catalysts for the Indian economy, accounting for about 7% of India's Gross Domestic Product in fiscal year 2023–2024. In India, the IT industry currently employs 5.43 million employees, including 36% women¹. According to the National Association of Software and Services Companies (NASSCOM), an estimated revenue of 227 billion US dollars was generated from the Indian IT sector in 2021–22. By 2026, the country's IT sector will need almost 9.5 million skilled IT workers, leading India towards its potential to become a trillion-dollar digital economy². Among the IT hubs in India, Hyderabad is one of the major IT metropolises with around 1500 IT companies and over 5.8 lakh professionals employed³.

The IT sector is known for adapting to a work culture involving a sedentary lifestyle, physical inactivity, and changing dietary habits, linking it to a higher risk of developing non-communicable diseases (NCDs) including metabolic dysfunction-associated fatty liver disease (MAFLD)^{4,5}.

The metabolic risk factors include visceral adiposity, hypertension, hyperglycemia, lowered levels of high-density lipoprotein cholesterol (HDL-C), and increased triglycerides (TG). These risk factors can get aggravated in occupations with sedentary lifestyle and consumption of unhealthy, obesogenic diet. Additionally, food rich in refined carbohydrates, fructose, saturated fats, and sugar sweetened beverages (SSBs) increase the risk of obesity^{6–8}. Various studies across India have reported the prevalence of metabolic and behavioural risk factors such as overweight, hyperglycemia, high blood pressure (BP), dyslipidemia, stress, insomnia, and depression among IT employees^{9–11}. A recent study conducted among IT employees in South India investigated lifestyle-associated risk factors contributing to NCDs and estimated the prevalence of metabolic syndrome (MetS) to be 29.87%, with 44.02% of the subjects being overweight, 16.85% obese, 3.86% diabetic, and 64.93% having low HDL-C levels¹².

The risk factors associated with MetS are also implicated as a cause or consequence of MAFLD^{13,14}. The presence of more than 5% fat in the hepatocytes, in the absence of secondary causes of fat accumulation in liver either due to alcohol consumption, medication, diseases, or hereditary causes is defined as MAFLD. The metabolic risk factors are commonly associated with MAFLD, which ranges from the spectrum to the inflammatory state of metabolic dysfunction-associated steatohepatitis (MASH), advances to fibrosis, and later to liver cirrhosis and hepatocellular carcinoma^{8,14}. Various factors, including genetic predisposition, sex, age, race or ethnicity, obesity, dietary patterns, insulin resistance, diabetes, hypertension, and sleep deprivation, influence the development of MAFLD^{8,14}. Apart from overweight individuals, a considerable proportion of people with body mass index (BMI) < 23 kg/m² have MAFLD, addressed as lean MAFLD, found in the Asian population¹⁵. Lean MAFLD is closely linked to MetS¹⁶ with a global prevalence of 5.1%¹⁵. Due to the common causal pathways for NCDs, MetS and MAFLD, the Government of India included MAFLD in its National Programme for Prevention & Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke in 2021, and renamed the National Programme for Prevention and Control of Non-Communicable Diseases in 2023^{17,18}.

Epidemiological studies among the Indian population revealed the prevalence of MAFLD to be approximately 9% to 32%, with higher prevalence rates in obese and diabetic individuals¹⁸. In a large cohort of patients with MAFLD from South Asia, the prevalence of lean MAFLD was 10.6%¹⁹. In a systematic review published by Shalimar et al. the prevalence of MAFLD among adults and children was 38.6% and 35.4%, respectively²⁰. A cross-sectional study reported higher BMI and increasing age as significant predictors of MAFLD²¹. A substantially high prevalence of MAFLD was observed in both urban and rural Indian populations, signifying the need for urgent public health interventions and control measures²². However, few studies have determined the prevalence of MAFLD, specifically in a high-stress, highly sedentary workforce with more hours of occupational sitting and jobs involving shift work²⁰.

Despite reporting metabolic and lifestyle risk factors among IT employees in India, no study has assessed the prevalence of MAFLD in this group. If not screened at an early stage in the working-age group, the disease may go undiagnosed and become a huge public health burden. Hence, this study aimed to determine the prevalence of MAFLD and the associated behavioural and metabolic risk factors among IT employees in India.

Methods

Study design and participants recruitment

A cross-sectional study was conducted in Hyderabad, India from July, 2023 to July, 2024. The IT employees were randomly selected through wide publicity in the IT Hub situated in Hi-tech city locality of Hyderabad. Initially, a list of alumni students' email with the IT companies that employed them was procured from the placement cell of the University of Hyderabad. Emails were sent to the Human Resource section of the IT companies located in Hyderabad describing the purpose of our study and seeking their participation. Information about the study was

communicated to IT employees through text messages, emails, leaflets, banners, posters, and also by conducting camps. The link and QR codes for registration of participants were provided in all modes of communication. The consent form and study questionnaire were made available online and the research team also administered the questionnaire face-to-face to some IT employees. Their contact details were sought to follow up for biochemical tests.

Sample size Sample size was determined by considering a previous prevalence rate of 32%¹⁶, with a precision level of 5%, a sample size of 348 was determined by using the formula $4pq/L^2$. Given p = Prevalence rate 32%, $q = 100 - 32 = 68$, Level of precision (L) is 5% (absolute) $4(32 \times 68)/5 \times 5 = 8704/25 = 348$.

Inclusion and exclusion IT employees working in Hyderabad, India for at least one year and those aged between 30 and 60 years with minimal or no reported alcohol consumption (< 30 g/day for men or < 20 g/day for women) were included in the study. The participation was voluntary and we received 558 online responses and 200 offline responses. The research team reached out to all the participants who responded both online and offline. Based on the eligibility criteria and willingness to participate in the biochemical, metabolic and liver scan tests, 363 IT employees visited Asian Institute of Gastroenterology (AIG) Hospital, Hyderabad located in close proximity to the IT Hub. The recruitment rate in the study was 363 (47.88%). The anthropometric measurements, biochemical, metabolic, liver function tests and liver fibroscan were carried out at AIG Hospital, Hyderabad. All the tests were carried out after an overnight fasting of 8–12 h. The research team coordinated the scheduled visits and walked the study participants through the screening process. Participants who tested positive for hepatitis B (HbsAg), hepatitis C (HCV), and autoimmune diseases were excluded from the study. A total of 345 employees were included in the final data analysis (Fig. 1).

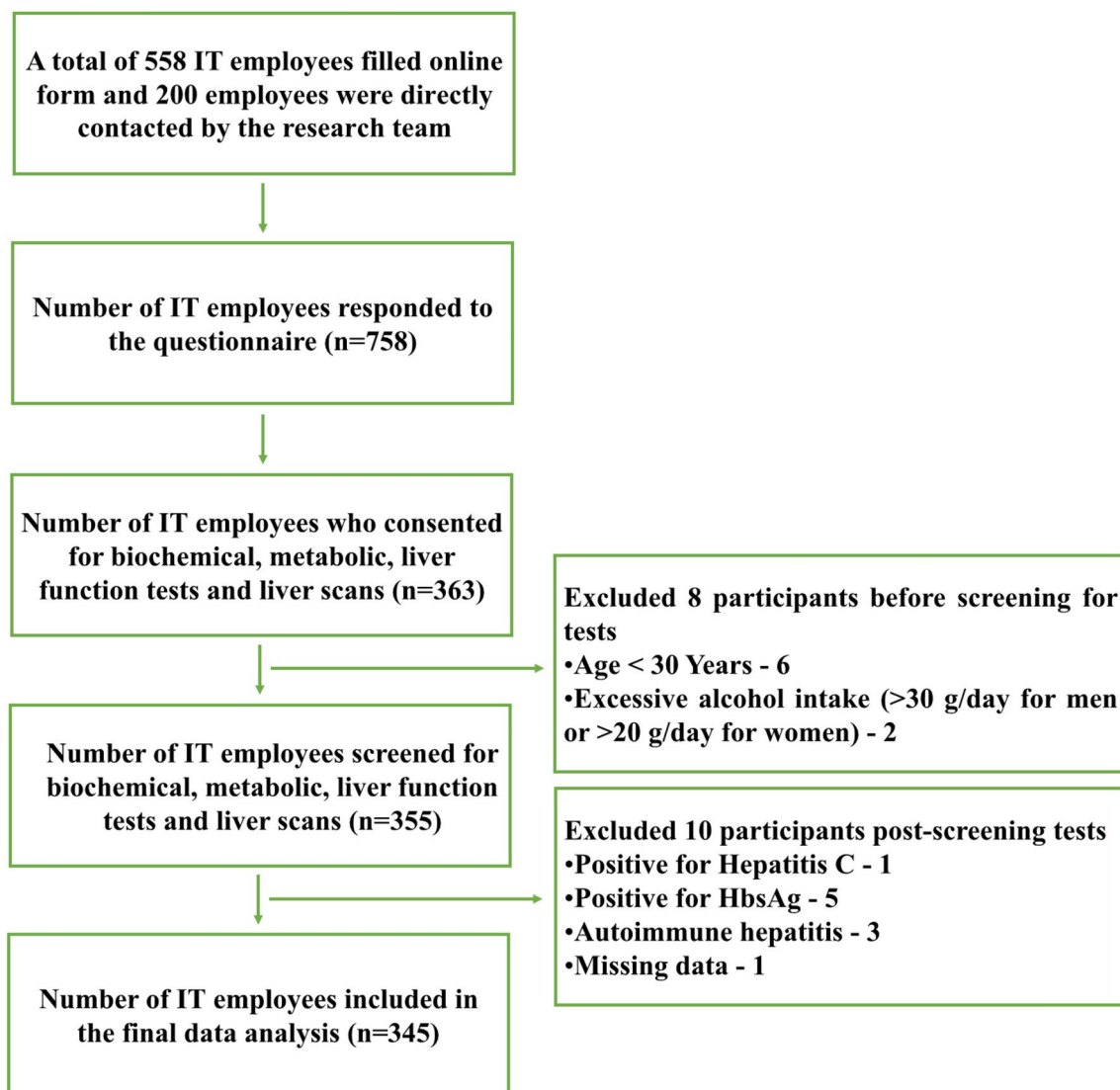


Fig. 1. Flow chart of recruitment of IT employees in the study.

Data collection

Information related to history of tobacco and alcohol use, diet (food frequency questionnaire), 24-h dietary recall, physical activity, and medication use were gathered using a modified WHO surveillance (STEPS) questionnaire for NCDs²³. Details of sleep duration, stress and occupational sitting were obtained through modified Pittsburgh Sleep Quality Index (PSQI)²⁴, Perceived Stress Scale (PSS4)²⁵, and Occupational Sitting and Physical Activity Questionnaire (OSPAQ)²⁶, respectively.

Anthropometric and blood pressure measurements

The weight and height of all participants were measured using Quick Vital Sign-QVS-105 (Vortex Med Solutions Pvt. Ltd). Waist and hip circumferences were measured using standard techniques with a non-stretchable flexible tape with readings in centimetres, separately for men and women. The BP of each participant was measured in a sitting position using the Quick Vital Sign- QVS-105 (Vortex Med Solutions Pvt. Ltd). Hypertension was classified based on the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure guidelines²⁷.

Evaluation of biochemical parameters

After an overnight fast of 8–12 h, a total of 15 ml of venous blood was drawn from each participant by trained phlebotomy technicians and subjected to specific biochemical tests. Fasting blood glucose (FBG) levels were analysed using the hexokinase method in the Abbott Alinity c diagnostic system, and fasting insulin levels were analysed using the electrochemiluminescence immunoassay method in the Abbott Alinity i diagnostic system. The fasting lipid profile- Total cholesterol (TC) was evaluated using the cholesterol oxidase–peroxidase method, HDL-C was assayed using the enzymatic colorimetric method, and TG was analysed using the glycerol phosphate oxidase–peroxidase method in Beckman Coulter AU5800. Low-density lipoprotein cholesterol (LDL-C) was calculated using the formula $LDL-C = (TC) - (HDL-C) - (TG)/5$, and very-low-density lipoprotein cholesterol (VLDL-C) was calculated using the formula $(TG)/5$. Liver function test- Total bilirubin was determined using the 3,5-dichlorophenyl diazonium method, and alanine aminotransferase (ALT) was analysed using the International Federation of Clinical Chemistry and Laboratory Medicine reference method for measuring ALT activity without Pyridoxal-5'-Phosphate, aspartate aminotransferase (AST) was assayed using the IFCC reference method for measuring AST activity without P5P, alkaline phosphatase (ALP) was evaluated using the 2-Amino-2-methyl-1-propanolbuffer method after optimization to International Federation of Clinical Chemistry and Laboratory Medicine using Beckman Coulter AU500. The presence of viral markers-HbsAg, and anti-HCV was investigated using Enhanced Chemiluminescence Immunoassay method in VITROS 3600.

Assessment of liver steatosis and liver fibrosis

Liver biopsy the “gold standard” for diagnosing MAFLD and assessing its severity has limitations of histological staging and is not applicable on large scale for screening. Hence, non-invasive imaging techniques such as vibration-controlled transient elastography (VCTE) and magnetic resonance elastography (MRE) are used to evaluate hepatic steatosis and fibrosis. A trained technician at AIG Hospital performed VCTE with FibroScan 502 Touch (ECHOSENS, Paris, France) using an M probe in participants with BMI < 30 kg/m² and an XL probe in participants with BMI ≥ 30 kg/m² for the measurement of the controlled attenuated parameter (CAP) and liver stiffness measurement (LSM) for liver steatosis and liver stiffness, respectively.

Statistical analysis

The analysis was performed using Microsoft Excel 2019, IBM SPSS 25.0 (SPSS, Inc., Chicago IL, USA), and GraphPad Prism 9.5. The normality of the data was checked using Kolmogorov–Smirnov Tests of Normality. As most of the data were skewed, median values, 25th (P₂₅) and 75th (P₇₅) percentile were considered. Associations between categorical variables were assessed using the chi-square test. The correlation between various anthropometric, behavioural, and biochemical parameters and MAFLD was evaluated using Spearman's correlation coefficient (r_s). A probability level of alpha < 0.05 was considered as significant.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee (IEC) of the University of Hyderabad (approval number: UH/IEC/2022/412) and AIG Hospital, Hyderabad (approval number: AIG/IEC-BH&R43/03.2023–06). All research was performed in accordance with relevant guidelines/regulations and informed consent was obtained from all participants. Participation in the study was voluntary and there were no financial incentives. As a benefit to study participation, their biochemical and FibroScan test reports were shared with them, providing health insights without compromising the integrity of the study.

Results

A total of 363 IT employees were initially enrolled in the study through a voluntary recruitment process. Participants with secondary causes of liver steatosis like alcohol consumption, hepatitis B, hepatitis C or autoimmune diseases and those not meeting the inclusion criteria for age 30–60 years were excluded. After exclusion for secondary causes of liver steatosis and missing data, 345 IT employees included in the final analysis, of which 294 (85.20%) were men and 51 (14.80%) were women. Most 327 (94.80%) belonged to the age group of 30–49 years with a small proportion (5%) over 50 years. All the participants were literate and had graduation or post-graduation degrees. The median number of years of work was 14 years (9.8–18.0 years) and the work pattern was 125 (36.23%) worked in office, 165 (47.80%) worked in hybrid mode and 55 (15.90%) worked from home (WFH) (Table 1).

Variables	n = 345, Frequencies (%)
Age Category	
30—39	202 (58.60%)
40—49	125 (36.20%)
50—60	18 (5.20%)
Gender	
Male	294 (85.20%)
Female	51 (14.80%)
Education	
Graduate	153 (44.30%)
Post Graduate	189 (54.80%)
Others	3 (0.90%)
Work Pattern	
WFH	55 (15.90%)
Office	125 (36.20%)
Hybrid	165 (47.80%)
Working in IT Profession (years)	
1 to 10 years	115 (33.33%)
> 10 to ≤ 20	195 (56.52%)
> 20 Years	35 (10.14%)
BMI (kg/m ²)	
Normal	51 (14.78%)
Overweight	50 (14.49%)
Obesity	244 (70.72%)
WC (cm)	
Men: ≥ 90 cm	253 (73.33%)
Women: ≥ 80 cm	43 (12.46%)

Table 1. Socio-demographic and anthropometric characteristics of the study participants. BMI for the Asian population: < 18.5 (underweight), 18.5–22.9 (normal), 23.0–24.9 (overweight), and ≥ 25.0 (obese)²⁸.

Description of Anthropometric characteristics of participants

The height, weight was measured and the BMI was calculated as per Asian population cut-off: < 18.5 kg/m² (underweight), 18.5–22.9 kg/m² (normal), 23.0–24.9 kg/m² (overweight), and ≥ 25.0 kg/m² (obese)²⁸. BMI was normal among 51 (14.78%) [95% CI 11.20–19.00], overweight 50 (14.49%) [95% CI 11.00–18.70] and obese 244 (70.72%) [95% CI 65.60–75.50]. Men with waist circumference (WC) ≥ 90 cm were 253 (73.33%), while women with WC ≥ 80 cm were 43 (12.46%) (Table 1).

Behavioural risk factors among IT employees

Behavioural risk factors, such as sitting for long hours, shift work, sleep deprivation, stress, and smoking were assessed. A total of 248 (71.88%) were engaged in sedentary work (sitting > 8 h/day). Out of 345 employees, 256 (74.20%) reported working in general shift (9.00 am to 5.00 pm) and 89 (25.80%) worked in non-general shift (outside of 9.00 am to 5.00 pm). About 241 (69.86%) reported inadequate sleep (< 7 h/day). About 131 (37.97%) reported work-related stress, as assessed using the PSS-4. Less than 10% of them reported having ever smoked 34 (9.86%) (Fig. 2a).

Unhealthy diet consumption of SSBs like soft drinks, energy drinks, tea, and coffee reported by 98 (28.41%) participants, high fat diet like meat, dairy, and oils by 91 (26.38%), high-salt diet like consumption of fried items by 41 (11.88%), high-sugar diet by 126 (36.52%) and low-fibre diet by 134 (38.84%) participants. Intentional daily physical activity reported by 194 (56.23%) participants, while 78 (22.61%) reported < 150 min of moderate-intensity physical activity per week (Fig. 2b).

High LDL-C in 264 (76.52%) [95% CI 71.70–80.90], TC/HDL ratio in 294 (85.21%), and TG/HDL ratio in 196 (56.81%) were found among the study participants. An elevated homeostatic model assessment for insulin resistance (HOMA-IR) ratio was observed in 180 (52.17%) [95% CI 46.80–57.60] participants. (Fig. 2c).

Liver function parameters showed increased total bilirubin in 86 (24.92%) participants. The liver enzymes among the participants, 71 (20.57%) had elevated ALT levels, 52 (15.07%) had increased AST levels, and 51 (14.78%) had elevated ALP levels (Fig. 2d).

The prevalence of MetS (metabolic risk factors ≥ 3) was found in 118 (34.20%) [95% CI 29.20–39.50] participants. The high WC was 296 (85.80%) [95% CI 81.70–89.30], followed by elevated BP 129 (37.83%) [95% CI 32.30–42.70], and low HDL-C levels 121 (35.07%) [95% CI 30.0–40.40]. Twenty (5.80%) participants had no metabolic risk factors, while 6 (1.76%) participants had all five risk factors associated with MetS (Fig. 2e).

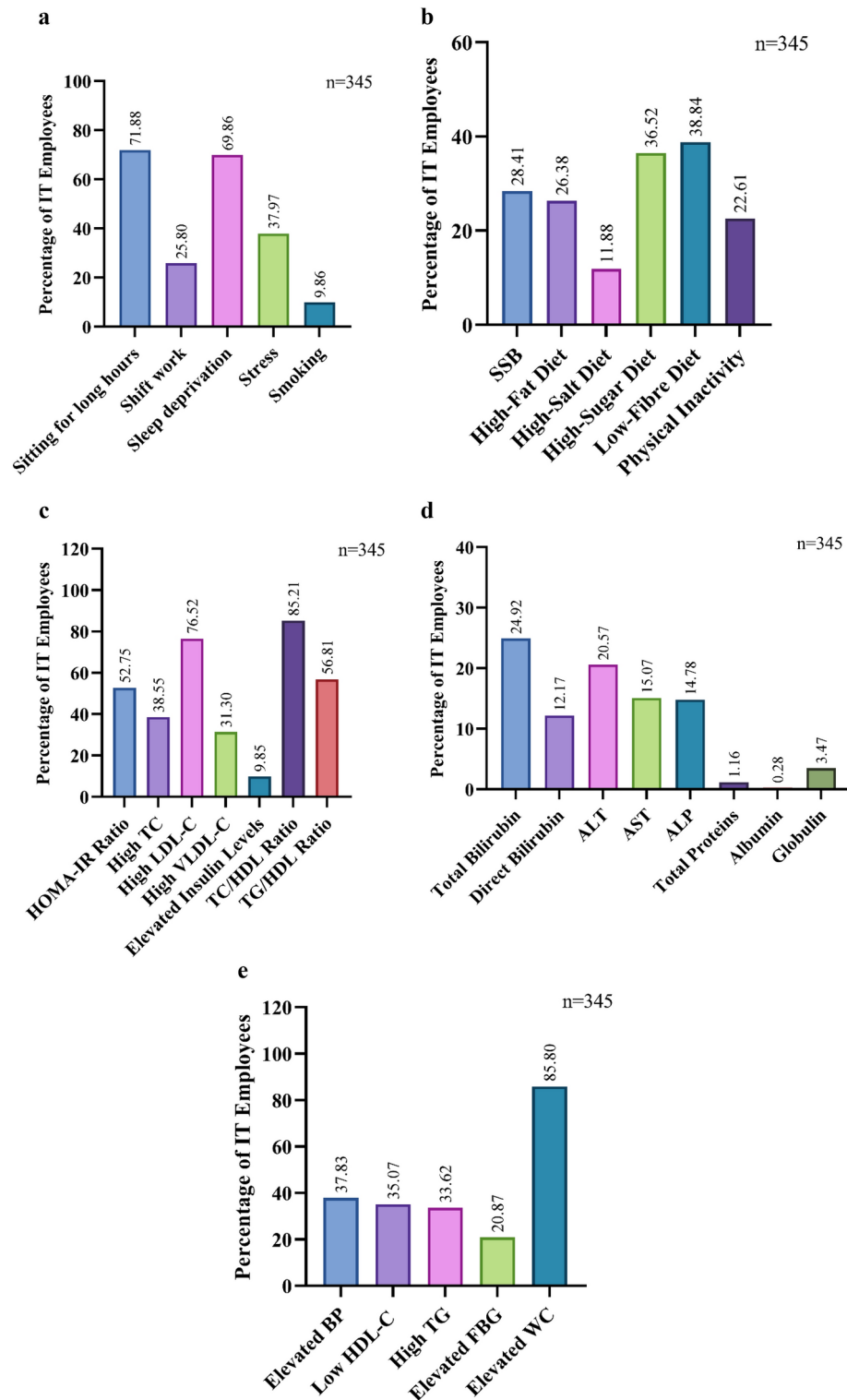


Fig. 2. Behavioural, biochemical parameters, and metabolic risk factors. (a) Occupation related behaviour –sitting > 8 h/day; Shift work (outside 9.00 AM to 5.00 PM); sleeping < 7 h/ day; Perceived Stress Score (PSS-4) ≥ 10 ; (b) Unhealthy diet and physical inactivity – Consumption of SSBs, High-Fat Diet, High-Salt Diet, High-Sugar Diet and Low-Fibre consumption; Physical Inactivity: having < 150 min of moderate-intensity physical activity/week. (c) Biochemical parameters – HOMA-IR Ratio > 2.5²⁹; TC ≥ 200 mg/dL; LDL-C ≥ 100 mg/dL; VLDL-C > 30 mg/dL; Fasting Insulin > 24.9 mIU/L; TC/HDL Ratio > 3.5; TG/HDL Ratio > 2.5³⁰. (d) Liver enzymes and proteins – Total Bilirubin > 1.0 mg/dL; Direct Bilirubin > 0.2 mg/dL; ALT > 34 U/L; AST > 31 U/L; ALP > 105 U/L; Total Proteins > 8.3 gm/dL; Albumin > 5.3 gm/dL; Globulin > 3.5 gm/dL³¹. (e) Metabolic risk factors (MetS) – BP $\geq 130/85$ mmHg; HDL-C in Men: < 40 mg/dL and Women: < 50 mg/dL; TG ≥ 150 mg/dL; FBG ≥ 100 mg/dL; WC in Men: ≥ 90 cm and Women: ≥ 80 cm³².

Biochemical, liver function parameters and metabolic risk factors:

The median (P_{25} - P_{75}) values of the biochemical and liver function parameters of the participants are presented in Table 2.

Prevalence of MAFLD among the IT employees

The overall prevalence of MAFLD among IT employees revealed that 290 (84.06%) [95% CI 78.80–87.80] out of 345 participants had liver steatosis. The age-specific prevalence of MAFLD between the age of 30–40 years was 50.14% and 33.91% between the ages of 41–60 years. The prevalence of MAFLD was high in men 255 (73.91%) than in women 35 (10.14%) (Fig. 3a). Liver steatosis: Grade-S1 (11–33% Liver Fat) CAP score 238–259 dB/m; Grade-S2 (34–66% Liver Fat) CAP score 260–289 dB/m; Grade-S3 (> 67% Liver Fat) CAP score > 290 dB/m, indicating mild to severe steatosis³³. While 55 employees (15.94%) [95% CI 12.20–20.20] had Grade-S0 (0–10% Liver Fat) CAP score between 150 and 237 dB/m indicating no liver steatosis and 70 (20.29%) [95% CI 16.20–24.90] had Grade-S1, 103 (29.86%) [95% CI 25.10–35.00] had Grade S2 and 117 (33.91%) [95% CI 28.90–39.20] had Grade-S3 liver steatosis (Fig. 3b). Liver fibrosis was assessed using fibrosis score ranging from F0 to F4^{33,34}. Fibrosis was absent in most participants, with 336 (97.39%) having score F0 and F1 (kPa < 8.0), suggesting no to mild fibrosis. Eight participants (2.32%) had moderate fibrosis (F2) (kPa 8.0–10.0) and severe fibrosis with a score of F3 (kPa 11.0–16.0) was seen only in one participant (0.29%) (Fig. 3c).

The study examined the occupation related behavioural risk factors namely sedentary work, shift work, sleep deprivation, stress, and smoking. No behavioural risk was reported by 18 (5.22%) participants yet, MAFLD was observed in 14 (4.06%) of them. Presence of at least one risk factor was reported in 59 (17.10%) participants and the prevalence of MAFLD was 49 (14.20%). Two risk factors were found in 153 (44.35%) participants of whom 129 (37.39%) had MAFLD followed by 84 (24.35%) who had three risk factors with 70 (20.29%) MAFLD. All five risk factors were present in two participants and both had MAFLD. (Fig. 4a).

Unhealthy dietary intake and physical inactivity were assessed for the presence of MAFLD. A total of 107 (31.01%) participants, had at least one risk factor, and MAFLD was observed in 85 (24.64%) participants. Two risk factors were observed in 101 (29.28%) participants, with 81 (23.48%) having MAFLD. The presence of all six risk factors was found in 11 participants (3.19%), with 10 (2.90%) having MAFLD (Fig. 4b).

Metabolic risk factors were assessed for the presence of MAFLD among the participants. The presence of one metabolic risk factor (increased WC, elevated FBG, increased BP, low-HDL-C, and high TG) was reported in 85 (24.64%) participants, with MAFLD found in 65 (19.84%). At least two of the five metabolic risk factors were observed in 122 (35.36%) participants, and 108 (31.30%) had MAFLD. All metabolic risk factors were seen in six (1.74%), of which five (1.45%) of them had MAFLD. Despite a meagre 20 (5.80%) participants with no metabolic risk factors, six (1.74%) of them had MAFLD (Fig. 4c).

Association of behavioural and metabolic risk factors with MAFLD

MAFLD was associated with age ($p=0.036$). Shift work was associated with elevated FBG, HOMA-IR, TC, LDL-C, and BMI ($p<0.05$). Low HDL-C levels and inadequate sleep hours had association ($p=0.036$). Physical activity of < 150 min/week showed association with overweight and obesity ($p=0.004$) and MAFLD ($p=0.009$). Consumption of low-fibre diet was associated with TC ($p=0.001$). Intake of SSBs and smoking were associated with MAFLD ($p=0.012$) and ($p=0.029$), respectively. The behavioural risk factors were associated with the MetS

Biochemical parameters	Median (P_{25} – P_{75}) values
Fasting Insulin mg/dL	11.20 (7.90–16.86)
FBG mg/dL	89 (84–97)
HOMA-IR	2.62 (1.72–3.98)
TC mg/dL	189.00 (168.00–215.50)
HDL-C mg/dL	44 (38–50)
LDL-C mg/dL	118.0 (101.0–137.5)
VLDL-C mg/dL	24 (18–33)
TG mg/dL	122.0 (89.5–165.5)
Liver function parameters	
Total Bilirubin mg/dL	0.80 (0.60–1.05)
Direct Bilirubin mg/dL	0.20 (0.10–0.20)
Indirect Bilirubin mg/dL	0.60 (0.50–0.90)
ALT U/L	23 (17–32)
AST U/L	23 (19–28)
ALP U/L	81 (67–96)
Total Proteins mg/dL	7.50 (7.20–7.80)
Albumin g/dl	4.60 (4.40–4.80)
Globulin mg/dL	2.90 (2.70–3.20)

Table 2. Median (P_{25} - P_{75}) values of the biochemical and liver function parameters of the IT employees (n = 345).

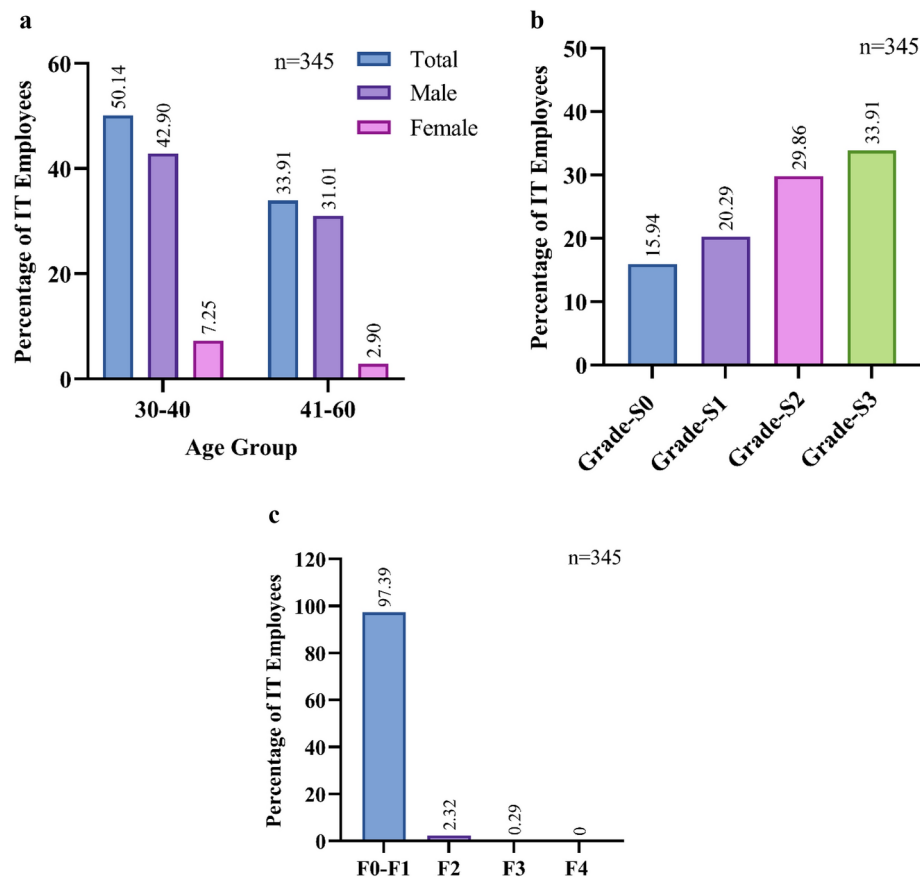


Fig. 3. Prevalence of MAFLD among the IT employees. (a) Age specific prevalence of MAFLD among men and women (b) Prevalence of MAFLD – Grade-S0 (0–10% Liver Fat) CAP score – 150–237 dB/m; Grade-S1 (11–33% Liver Fat) CAP score—238–259 dB/m; Grade-S2 (34–66% Liver Fat) CAP score—260–289 dB/m; Grade-S3 (>67% Liver Fat) CAP score—>290 dB/m³³. (c) Prevalence of liver fibrosis – F0-F1 (kPa <8.0)—normal; F2 (kPa 8.0–10.0)—moderate scarring; F3 (kPa 11.0–16.0)—severe scarring; F4 (kPa >16.0) – cirrhosis^{33,34}.

among participants. Higher BMI, WC, elevated HOMA-IR, FBG, and BP showed a significant association with MAFLD ($p < 0.001$) (Table 3).

Correlation of anthropometric and metabolic risk factors with MAFLD

WC and BMI showed a significantly positive correlation with MAFLD $r_s = 0.66$ ($p < 0.0001$), followed by waist-to-hip ratio (W/H) $r_s = 0.50$ ($p < 0.0001$). Elevated fasting insulin, HOMA-IR, and FBG showed a significant positive correlation with MAFLD, $r_s = 0.53$, 0.52 , and 0.18 , respectively ($p < 0.0001$). TG levels were also positively correlated with MAFLD $r_s = 0.27$ ($p < 0.0001$). The liver enzymes ALT and AST had a positive correlation with MAFLD $r_s = 0.38$ and $r_s = 0.23$ respectively ($p < 0.0001$) (Fig. 5).

Discussion

This study aimed to assess the prevalence of MAFLD and its associated behavioural and metabolic risk factors among IT employees in India. The study revealed an alarming 84.06% prevalence of MAFLD among the IT employees. A systematic review recorded the prevalence of MAFLD in the general Indian population at 38.6%²⁰. The recent large cross-sectional study in the capital city of Delhi, India among general population has revealed a higher prevalence of 56.4%³⁵. A city in western region of India, Goa has for a long time reported alcoholic liver disease but a recent study has reported 34.8% prevalence of MAFLD³⁶. As per a survey conducted by Asian Institute of Gastroenterology in Telangana region, fatty liver diseases were 20% and 25% in rural and urban population respectively³⁷. As there are no comparable studies in the region our study is the first to report MAFLD prevalence in among IT employees. The Indian population has predilection for lean MAFLD and we found 20 IT employees (5.80%) from our study participants with BMI < 23 kg/m² had MAFLD. The study findings by Sarin et al., showed a prevalence of lean MAFLD at 11.3%³⁵. MAFLD was more prevalent among males and older individuals that is reflected in our study also with 73.91% males and 10.14% females having MAFLD^{21,35,36}. The sex differential in our study could be due to the paucity of women in the age group of 30–60 years in the Indian IT sector³⁸. The work culture in the IT industry often involves engagement in sedentary activities for extended periods, shift work and irregular work hours, sleep deprivation, stress, and smoking, combined with unhealthy

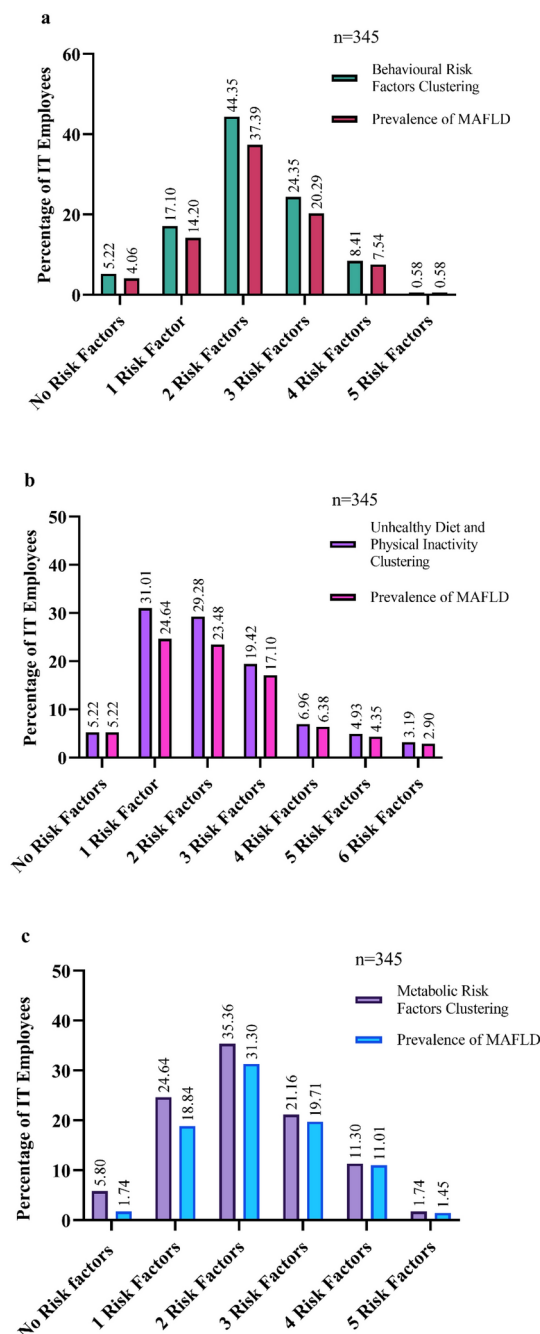


Fig. 4. Clustering of behavioural risk factors, unhealthy diet, physical inactivity, metabolic risk factors, and prevalence of MAFLD among IT employees. **(a)** Clustering of behavioural risk factors and prevalence of MAFLD – sitting for long hours, shift work, sleep deprivation, stress, and smoking constituting the five risk factors and the associated prevalence of MAFLD. **(b)** Clustering of unhealthy diet and physical inactivity and prevalence of MAFLD – Reported consumption of SSBs, and diets with high-fat, high-salt, high-sugar, and low-fibre diet, and physical inactivity constituting the six risk factors and the associated prevalence of MAFLD. **(c)** Clustering of metabolic risk factors and prevalence of MAFLD – raised WC, elevated FBG, increased BP, low-HDL-C, and high TG.

food options, creating the perfect storm for the development of MetS and MAFLD. Occupational sitting for > 8 h in a workday, inadequate sleep hours, high perceived stress, and physical inactivity as the major behavioural risk factors leading to the development of MAFLD. Reports on the impact of sedentary behaviour, shift work, and lack of exercise on metabolic parameters are fairly evident^{6,7,39}. Studies have also reported the prevalence of behavioural and metabolic risk factors among IT professionals in India^{9,10,12}. To our knowledge, this study is the first in India to report the association of behavioural risk with MAFLD in IT employees.

Behavioural risk factors	Metabolic risk factors	Effect Size	p-value * ^
Shift Work	FBG	0.121	$p = 0.0240$
	HOMA-IR	0.153	$p = 0.0043$
	TC	0.118	$p = 0.0280$
	LDL-C		$p = 0.0483$
	BMI	0.152	$p = 0.0464$
Inadequate Sleep (< 7 h)	Low HDL-C levels	0.113	$p = 0.0360$
Physical Activity min/ week	BMI	0.195	$p = 0.0045$
Low-Fiber Diet	TC	0.175	$p = 0.0011$
Behavioural risk factors			
SSBs	MAFLD	0.250	$p < 0.0001$
Smoking		0.179	$p = 0.0115$
Physical Activity min/week		0.157	$p = 0.0360$
Years worked in IT industry		0.129	$p = 0.0167$
Work Pattern (WFH, Office, Hybrid)		0.032	$p = 0.8356$
Metabolic risk factors			
WC (Abdominal obesity)	MAFLD	0.485	$p < 0.0001$
HOMA-IR		0.378	$p < 0.0001$
FBG		0.238	$p = 0.0002$
Elevated BP		0.195	$p = 0.0043$

Table 3. Associations of behavioural and metabolic risk factors with MAFLD. *Chi-square test, ^Fisher's exact test, One-sided. Effect Size is Cramer's V.

The prevalence of MetS in our study was 34.3%, which is in line with observations by Banerjee et al. study¹². The high prevalence of MetS among the participants was driven primarily by elevated WC, BMI, BP, and dyslipidaemia. The two parameters of BMI and WC indicating abdominal obesity is associated with highest risk for MAFLD. Reducing the abdominal obesity provides MAFLD remission^{12,40}. Though elevated WC is associated with a sedentary work life, factors other than abdominal obesity can also lead to MetS⁷. The common covariates for MAFLD, like BP, FBG, TG, and TC, were associated with the long working hours in workers < 60 years⁴¹. This is on par with our observation that MAFLD correlates to age, along with other metabolic parameters-FBG, HOMA-IR, fasting insulin, TG, and TC. There is paucity of studies among various occupational groups. However, two studies examined workplace MAFLD among steel workers in Korea and China using abdominal ultrasound and found high prevalence^{42,43}. Our study brings to fore the occupational context that is a critical factor in understanding the prevalence of MAFLD. This study has significant public health implications given the natural progression of the disease to fibrosis and cirrhosis that are irreversible and have no cure. As the progressive form of MASH (liver fibrosis) in the MAFLD spectrum was found in only few participants, there is a scope to prevent the progression to the severe form. Further longitudinal studies are required to establish the causal relationship and also fill in the research gap that exists.

Limitations The study sample predominantly had males (85.2%) and hence we did not extensively analyze female subgroup due to the paucity of women in the age group of 30–60 years in the Indian IT sector. Further research is needed to understand the unique risk factors and mechanisms in subgroups with MAFLD in participants with normal BMI. The study lacks a comparison between IT employees and the general Indian population regarding behavioral and metabolic risk factors which can help determine whether the observed risk factors are unique to the IT sector or prevalent across the broader population. There could be both selection and information bias as the behavioural information obtained relied on voluntary participants' self-reported behavioural pattern as there was no means of verification.

Conclusion and recommendations

This study highlights the high prevalence of MAFLD (84.06%) among IT employees in India, linked to sedentary lifestyles, unhealthy diets, and metabolic risk factors. Therefore, we recommend urgent and appropriate interventions to increase their physical activity and reduce sedentary lifestyle. Considering dietary modification by reducing HFSS (High fat, sugar and salt), consuming diet low in calories and rich in fibre may aid in reducing their abdominal obesity. It is worth noting that occupational risk factors involving prolonged sitting, shift work and physical inactivity among IT employees puts them at specific risk for MAFLD and therefore, routine periodic screening for MAFLD is required. As IT employees are not addressed in India's National Programme for Non-Communicable Diseases programme, urgent workplace interventions are needed to address MAFLD and its associated risks, emphasizing the need for routine liver function screenings in this population.

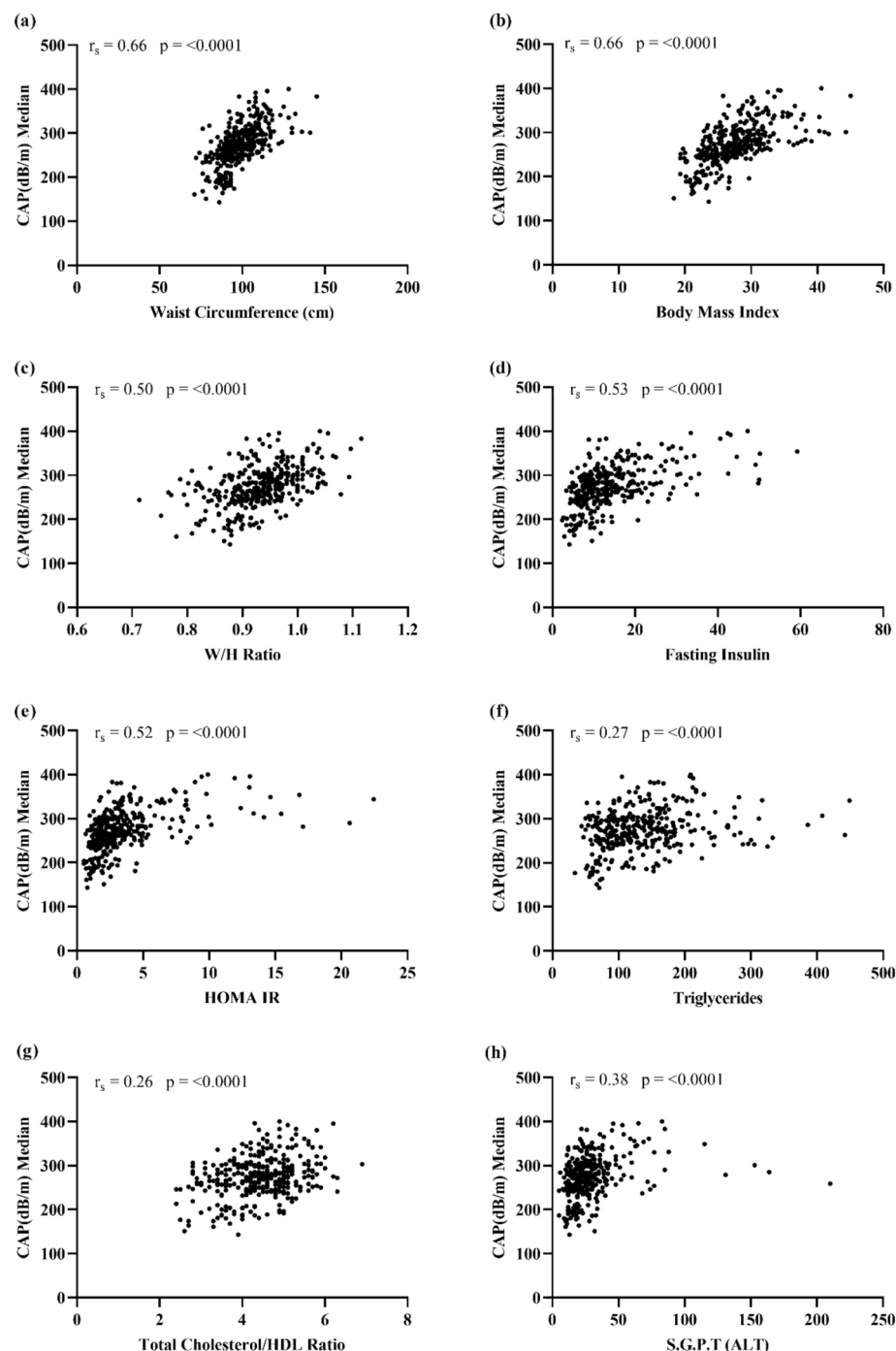


Fig. 5. Spearman correlation plots for the correlation of anthropometric, biochemical, and metabolic risk factors with MAFLD. Correlation of (a) WC vs MAFLD; (b) BMI vs MAFLD; (c) W/H ratio vs MAFLD; (d) Fasting Insulin vs MAFLD; (e) HOMA-IR vs MAFLD; (f) TG vs MAFLD; (g) TC/HDL ratio vs MAFLD; (h) ALT vs MAFLD.

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Author contributions

BB participated in data collection, curation, formal analysis, validation, visualization, writing- original draft, review and editing. PNR, AVK and RV participated in project administration, methodology and investigation. NP participated in writing- original draft, review and editing. CTA participated in investigation, methodology, project administration, resources, funding acquisition, supervision, validation, visualization, writing the original draft, review and editing. KM participated in conceptualisation, funding acquisition, investigation, methodology, project administration, data curation, formal analysis, resources, supervision, validation, visualization, writing the original draft, review and editing.

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Declarations

Ethics approval and consent to participate

The study protocol was approved by the Institutional Ethics Committee (IEC) of the University of Hyderabad (approval number: UH/IEC/2022/412) and Asian Institute of Gastroenterology Hospital, Hyderabad (approval number: AIG/IEC-BH&R43/03.2023-06). Participation in the study was voluntary and there were no financial incentives. As a benefit to participants, their biochemical and FibroScan test reports were shared with them, providing health insights without compromising the integrity of the study. Written informed consent obtained from all the participants.

Consent for publication

Consent for publication obtained from all the study participants.

Availability of data and materials

The data used in this study are presented here. The raw data underlying this article cannot be shared publicly because of privacy concerns of the participants and the legal regulations of the Institutional Ethical Committee of the University of Hyderabad and the Asian Institute of Gastroenterology. Raw data were stored and analysed only on designated computers at the University of Hyderabad. The data that support the findings of this study are available from the corresponding authors, KM and CTA, upon reasonable request.

Competing interests

The authors declare no competing interests.

Additional information

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