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STEATOTIC LIVER DISEASE IN UNIVERSITY STUDENTS IN CHENNAI, INDIA

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Abstract

Introduction: Steatotic liver disease (SLD) is an umbrella term that represents unified terminology encompassing metabolic (MASLD, MASH), alcohol-related (MetALD, ALD) and overlapping aetiologies of steatosis, indicating the starting point of diagnosis being the feature of steatosis, regardless of aetiology. Recent advancements in understanding its pathophysiology have led to renaming of NAFLD to metabolic-dysfunction associated steatotic liver disease (MASLD). It is classified as a subcategory of SLD. Its prevalence is increasing in India, especially among young adults due to urbanization and lifestyle changes. This study aims to assess the prevalence and risk factors of SLD among university students in Chennai.

Materials & Methods: A cross-sectional study was conducted among university students in Chennai, India. Data on demographics, lifestyle, and dietary habits were collected via questionnaires. Liver stiffness (LSM) and steatosis (CAP) were assessed using transient elastography. Steatosis and fibrosis were diagnosed and graded based on CAP and LSM values.

Results: The study included 250 university students with a mean age of 24.3 ± 1.98 years, 52.4% of whom were female. Among participants, 40.8% were overweight, 6.8% obese, and the prevalence of SLD was 19.6%. Students with steatosis had higher BMI and low level of physical exercise. Significant positive correlations were found between CAP and LSM with BMI.

Conclusion: Our findings highlight a high prevalence of steatosis (19.6%) in healthy young individuals, emphasising the need for early diagnosis and targeted lifestyle interventions to address modifiable factors like higher BMI and low physical activity.

Keywords: Steatotic liver disease (SLD), MASLD, Metabolic-dysfunction associated steatotic liver disease, Transient elastography (TE), Obesity, University students

Introduction

Non-alcoholic fatty liver disease (NAFLD) is defined as the abnormal deposition of fat within the cytoplasm of hepatocytes (exceeding 5% of liver weight) in patients without a history of significant alcohol consumption.[1] Recent advancements in understanding its pathophysiology have led to the renaming of NAFLD to metabolic-dysfunction associated steatotic liver disease (MASLD). It is subclassified under an umbrella term known as steatotic liver disease (SLD). MASLD is defined as

SLD in presence of one or more cardiometabolic risk factors, and the absence of harmful alcohol intake.[2] The updated definition fully includes all patients who were previously classified as having NAFLD.[3] The term steatotic liver disease (SLD) was adopted to unify the classification and reduce stigma. This new term underscores steatosis as a central feature and the starting point of diagnosis being the feature of steatosis, regardless of the aetiology.[4] SLD is a spectrum of liver conditions, including simple steatosis and steatohepatitis. MASH (previously known as NASH) is a more advanced, inflammatory form of MASLD, associated with a higher risk of fibrosis, end-stage liver disease, and cardiovascular mortality.[5]

SLD prevalence is rising globally, affecting about 38% of adults.[2] In India, urbanization, dietary changes, and sedentary lifestyles have increased its incidence, especially among young adults. This population is often considered "healthy," but the presence of SLD could pose a significant public health issue and burden healthcare systems in the region. University students, a key segment of the young adult population, are exposed to lifestyle factors such as poor dietary habits, high stress, and sedentary behaviours, which may predispose them to develop liver steatosis. [6] However, limited data exist on the prevalence and risk factors of steatotic liver disease among university students in India, especially in cities like Chennai.

Liver biopsy remains the reference standard for diagnosing SLD; however, its invasiveness limits its use as a screening tool in healthy individuals.[7,8] Consequently, non-invasive tests like ultrasound is widely used in suspected cases of fatty liver.[9,10] Ultrasound parameters to detect the presence and grade hepatic steatosis include increased echogenicity of the liver in comparison to spleen and right kidney, blurring of intravascular structures, deep attenuation of ultrasound signal, and difficulty in distinguishing the diaphragm from the posterior surface of the liver. However, the accuracy of ultrasound is limited in patients with hepatic steatosis of less than 30%, and overall subjective interpretation.[11] Advanced non-invasive imaging methods like CT, MRI, and proton MR spectroscopy have also been studied for SLD screening.[12] Recently, the controlled attenuation parameter (CAP) measured by transient elastography (TE) has gained interest as a non-invasive imaging based marker for hepatic steatosis, as it can identify less severe steatosis compared to traditional ultrasound.[1,13]

To date, there have been few studies published on the prevalence of steatosis in healthy subjects in India. In this study, we assessed the prevalence of steatotic liver disease and its associated risk factors in university students in Chennai.

Materials And Methods

Study Design and Setting: A cross-sectional study was conducted among university students aged between 18 to 30 years in Chennai, India after getting approval from institutional ethics committee.

Study population: Participants were selected through systematic sampling. Informed consent was obtained from each participant before enrolment, ensuring voluntary participation.

Inclusion Criteria

- University students aged 18–30 years
- Students of any gender.
- Currently enrolled in Sri Ramachandra Institute of higher education and research, Chennai, Tamil Nadu.
- Willing to participate and capable of providing informed consent.

Exclusion Criteria

- Students with known liver diseases or any significant medical conditions that could impact liver health.

Data Collection: Data were collected using structured questionnaires, which gathered information on demographics, lifestyle factors, and dietary habits. Body Mass Index (BMI) was categorized into underweight, normal weight, overweight, and obese according to WHO guidelines. Transient

elastography was performed to obtain liver stiffness measurement (LSM) and controlled attenuation parameter (CAP) values, which indicated liver fibrosis and steatosis levels, respectively.

Table 1: Grade of hepatic steatosis and fibrosis[14,15]

CAP (dB/m)	**Grade of steatosis**
<248	S0 (Normal)
248 to <268	S1 (Mild)
268 to <280	S2 (Moderate)
≥280	S3 (Severe)
LSM (kPa)	**Grade of Fibrosis**
< 7.9	F0–F1 (Normal)
7.9 to < 8.8	F2 (Mild)
8.8 to < 11.7	F3 (Moderate)
≥11.7	F4 (Severe)

Diagnosis and Grading: Steatosis and fibrosis were assessed based on CAP and LSM values. CAP values helped determine the presence and grading of liver steatosis, while LSM values were used to grade fibrosis.

Statistical Analysis: Data analysis was performed using Epi info version 7.1.4.0 . Descriptive statistics, such as means and standard deviations, were calculated for continuous variables. Independent sample t-tests and chi-square tests were used to compare characteristics between students with and without steatosis. Correlation analyses (Pearson correlation = r) examined the relationships between CAP, LSM, and BMI. Statistical significance was set at a p-value < 0.05.

Result

The mean age of the study participants was 24.3 ± 1.98 years. Out of 250 students, 52.4% were female (n = 131) and 47.6% were male (n = 119). The mean BMI was 23.4 ± 4.53, with 10.4% classified as underweight (n = 26), 42% having a normal BMI (n = 105), 40.8% being overweight (n = 102), and 6.8% classified as obese (n = 17). A high proportion of students, 58.0 % (n = 145) had sedentary life style, and 42% (n = 105) engaged in regular exercise (Table 2).

The liver stiffness measurement (LSM) had a mean of 5.01 ± 0.92 kPa, and the controlled attenuation parameter (CAP) averaged 210.4 ± 38.2 dB/m. The prevalence of steatosis in this population was 19.6% (n = 49). The degree of liver steatosis was graded as 0 in 81.6% (n = 201) of participants, grade 1 in 8.8% (n = 22), grade 2 in 4.4% (n = 11), and grade 3 in 6.4% (n = 16). As for fibrosis, 62% (n = 155) had no fibrosis, while fibrosis stages 1, 2, and 3 were found in 28% (n = 70), 7.2% (n = 18), and 2.8% (n = 7), respectively (Table 2).

The study compared various characteristics between university students with no steatosis (n = 201) and those with steatosis (n = 49). The mean age was slightly higher in the steatosis group (25.1 ± 1.00 years) compared to the non-steatosis group (23.2 ± 1.01 years), though the difference was not statistically significant (p = 0.26). Gender distribution was similar between the two groups, with females constituting 51.7% and 55.1% in the no steatosis and steatosis groups, respectively (p = 0.75). BMI was significantly higher in the steatosis group (27.2 ± 8.65 kg/m²) compared to the non-steatosis group (21.2 ± 5.21 kg/m²) (p < 0.0001). The prevalence of overweight and obesity was more pronounced in the steatosis group, with 49% overweight and 14.3% obese, compared to 38.8% overweight and 5% obese in the no steatosis group. Sedentary life style was more common in the steatosis group (69.4% vs. 55.2%, p = 0.07) (Table 3).

Table 2: Characteristics of study participants

Characteristics	Mean ± SD, n (%)
Age (years)	24.3 ± 1.98
Gender	
– Female	131 (52.4%)
– Male	119 (47.6%)
BMI (kg/m²)	23.4 ± 4.53
– Underweight (<18.5 kg/m²)	26 (10.4%)
– Normal weight (18.5 to 22.9 kg/m²)	105 (42%)
– Overweight (23.0 to 24.9 kg/m²)	102 (40.8%)
– Obese (≥25 kg/m²)	17 (6.8%)
Lifestyle habits	
– Sedentary life style	145 (58.0%)
– Exercise	105 (42%)
LSM (kPa)	5.01± 0.92
CAP (dB/m)	210. 4 ± 38.2
Liver steatosis	49 (19.6%)
Degree	
– Grade 0	201 (81.6%)
– Grade 1	22 (8.8%)
– Grade 2	11 (4.4%)
– Grade 3	16 (6.4%)
Fibrosis degree	
– Grade 0	155 (62%)
– Grade 1	70 (28%)
– Grade 2	18 (7.2%)
– Grade 3	7 (2.8%)

Table 3: Comparison of characteristics between students with and without steatosis

Characteristics	No steatosis (n=201)	Steatosis (n=49)	p value
Age (years)	23.2 ± 1.01	25.1 ± 1.00	0.26
Gender			
– Female	104 (51.7%)	27 (55.1%)	0.75
– Male	97 (48.3%)	22 (44.9%)	
BMI (kg/m²)	21.2 ± 5.21	27.2 ± 8.65	**<0.0001**
– Underweight (<18.5 kg/m²)	22 (10.9%)	4 (8.2%)	**<0.0001**
– Normal weight (18.5 to 22.9 kg/m²)	89 (44.3%)	16 (32.7%)	
– Overweight (23.0 to 24.9 kg/m²)	78 (38.8%)	24 (49%)	
– Obese (≥25 kg/m²)	10 (5%)	7 (14.3%)	
Life style habits			
– Exercise regularly	90 (44.8%)	15 (30.6%)	0.07
– Sedentary life style	111 (55.2%)	34 (69.4%)	

Table 4: Correlation between CAP, LSM, and BMI

Parameter	Correlation coefficient (r), p value
CAP v/s BMI	r=0.42, P<0.001
LSM v/s BMI	r=0.32, p- 0.001

CAP showed a moderate correlation with BMI ($r = 0.42$, $p < 0.001$). Likewise, LSM was moderately correlated with BMI ($r = 0.32$, $p = 0.001$) (Table 4).

Discussion

SLD is often asymptomatic until advanced stages, making screening increasingly important. The starting point of diagnosis is the feature of steatosis, regardless of the aetiology.[4] Ultrasound is widely accessible and cost-effective for detecting moderate to severe steatosis but lacks sensitivity for mild steatosis and is operator-dependent.[16] Transient elastography (Fibroscan) provides quantitative CAP measurements with greater sensitivity for early steatosis. It also evaluates liver stiffness, aiding fibrosis detection.[14,16]

Characteristics of study participants

This study on prevalence of steatotic liver disease among university students in Chennai, India, found a young cohort with a mean age of 24.3 ± 1.98 years. Of the participants, 52.4% were female, similar to the 54.1% female distribution in study of Tomah et al.[5] Mean BMI 23.4 ± 4.53. Notably, 40.8% were overweight, and 6.8% were obese, suggesting that elevated BMI may contribute to early steatotic changes, as seen in other studies linking higher BMI to increased fatty liver risk in youth.

Prevalence of Hepatic steatosis

This study found a 19.6% prevalence of steatosis among young adults, comparable to the UK rate of 20.7%.[17] Tomah et al.[5] from Egypt reported a higher prevalence of 31.6%, linked to greater obesity rates in Egypt. Similarly, a Middle Eastern meta-analysis noted a 31.8% prevalence[18], while Kaya et al.[1] reported 23.2% among healthy students. In contrast, Okur et al.[19] found only 10.6% prevalence among male participants, and Nastasa et al.[20] observed 17.4% among medical students, highlighting regional and lifestyle influences on SLD rates.

Severity of Hepatic steatosis

In our study, the mean controlled attenuation parameter (CAP) was 210.4±38.2 dB/m, 8.8% had mild steatosis (grade 1), 4.4% moderate steatosis (grade 2), and 6.4% severe steatosis (grade 3). Fibrosis staging revealed that stages F1, F2, and F3 fibrosis were found in 28%, 7.2%, and 2.8% of participants, respectively.

Tomah et al.[5] reported a median CAP of 211.4 dB/m, with 31.6% showing steatosis (S1 or greater), 57.9% of whom had severe steatosis (S3). Kaya et al.[1] found a mean LSM of 4.7 ± 0.9 kPa and CAP of 205.6 ± 43.8 dB/m, with 23.2% steatosis prevalence. Nastasa et al.[20] observed a 17.4% steatosis prevalence, a mean CAP of 215.76 ± 48.38 dB/m, and significant steatosis (S2-S3) in 56.8% of cases. They also reported fibrosis with 31.9% in F1, 2.4% in F2, and 0.7% in F3, with a mean LSM of 5.29 ± 1.35 kPa.

Factor associated with Hepatic steatosis

Age and Gender: In this study, age ($p = 0.26$) and gender ($p = 0.75$) were not significantly associated with hepatic steatosis. In contrast, Tomah et al.[5] reported an age-related increase in SLD prevalence, while Nastasa et al.[20] found a higher steatosis prevalence among males ($p = 0.026$).

Lifestyle factors: In this study, lifestyle factors like sedentary life style ($p = 0.07$) showed no significant association with steatosis. Similarly, Tomah et al.[5] found no association between lifestyle habits and steatosis. Another study showed that NAFLD risk is linked to unhealthy dietary choices, reduced fresh food intake, obesity, and food environment factors, including greater reliance on processed foods and restaurants.[21] However, a large multicenter study in Hispanic/Latino populations found no association between lifestyle or socioeconomic factors and NAFLD.[22]

Obesity: In this study, BMI was significantly higher in the steatosis group (27.2 ± 8.65 kg/m²) compared to the non-steatosis group (21.2 ± 5.21 kg/m²) ($p < 0.0001$), with 49% of participants in the steatosis group classified as overweight and 14.3% as obese, versus 38.8% and 5%, respectively, in the non-steatosis group. Tomah et al.[5] similarly found that BMI and adiposity were independent predictors of steatosis, with BMI category significantly associated with steatosis risk (AOR: 13.87; 95% CI: 4.41–43.6, $p < 0.0001$). In line with these findings, Kaya et al.[1] observed that CAP scores correlated with BMI ($r = 0.40$, $p < 0.001$), waist circumference ($r = 0.39$, $p < 0.001$), and hip circumference ($r = 0.34$, $p < 0.001$); however, in multivariable analysis, only BMI maintained an independent association with CAP ($\beta = 0.36$, $p < 0.001$). Nastasa et al.[20] also found significant associations between hepatic steatosis and BMI ($p < 0.001$), waist circumference ($p < 0.001$), waist-to-height ratio ($p < 0.001$), weight ($p < 0.001$), and male gender ($p = 0.03$).

Correlation of CAP and LSM with anthropometric measures

In this study, CAP showed moderate correlations with BMI ($r = 0.42$, $p < 0.001$) and LSM was moderately correlated with BMI ($r = 0.32$, $p = 0.001$). Nastasa et al.[20] found similar correlations for CAP and LSM with BMI.

Strengths and weaknesses

This study evaluates steatosis prevalence among young, apparently healthy university students in Chennai, emphasizing early detection and modifiable risk factors like BMI and physical activity. It uses transient elastography (CAP and LSM) for non-invasive assessment, providing objective grading of steatosis and fibrosis. The systemic sampling and adequate sample size enhance generalizability.

The cross-sectional design limits causal inference between risk factors and SLD. Self-reported data on lifestyle may introduce bias. The study excludes other hepatic or systemic comorbidities, potentially underestimating associations. It does not subclassify SLD into MASLD, MetALD, MASH or ALD, limiting etiological insights. Key cardiometabolic risk factors such as insulin resistance and dyslipidemia were not assessed as restricting metabolic associations. Dietary patterns and alcohol intake were not evaluated, making it difficult to distinguish between metabolic and non-metabolic contributors. Despite these limitations, this study highlights the need for early screening and targeted interventions in young adults.

Conclusion

Our findings indicate a high prevalence of steatosis (19.6%) among young individuals, emphasizing the importance of early diagnosis in this population. Higher BMI and lower levels of physical activity were more common among those with steatosis, highlighting the need for targeted lifestyle interventions to address these modifiable risk factors.

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References

1. Kaya E, Demir D, Alahdab YO, Yilmaz Y. Prevalence of hepatic steatosis in apparently healthy medical students: a transient elastography study on the basis of a controlled attenuation parameter. European journal of gastroenterology & hepatology. 2016 Nov 1;28(11)1264-7.
2. Yang Z, Li A, Jiang Y, Maidaiti X, Wu Y, Jin Y. Global burden of metabolic dysfunction-associated steatotic liver disease attributable to high fasting plasma glucose in 204 countries and territories from 1990 to 2021. Sci Rep 2024 Sep 27;14(1)22232.
3. Rinella ME, Lazarus JV, Ratziu V, Francque SM, Sanyal AJ, Kanwal F, et al. A multisociety Delphi consensus statement on new fatty liver disease nomenclature. Ann Hepatol 2024 Jan-

Feb;29(1)101133.
4. Israelsen, M, Francque S, Tsochatzis EA, Krag A. Steatotic liver disease. Lancet 2024;404(10323), 1761-78.
5. Tomah S, Hamdy O, Abuelmagd MM, Hassan AH, Alkhouri N, Al-Badri MR, Gardner H, Eldib AH, Eid EA. Prevalence of and risk factors for non-alcoholic fatty liver disease (NAFLD) and fibrosis among young adults in Egypt. BMJ open Gastroenterol 2021 Oct 1;8(1)e000780.
6. Younossi Z, Anstee QM, Marietti M, et al. Global burden of NAFLD and NASH: trends, predictions, risk factors and prevention. Nat Rev Gastroenterol Hepatol 2018;1511–20.
7. Obika M, Noguchi H. Diagnosis and evaluation of nonalcoholic fatty liver disease. Exp Diabetes Res 2012; 2012145754.
8. Campbell MS, Reddy KR. Review article: the evolving role of liver biopsy. Aliment Pharmacol Ther 2004; 20249–259.
9. Roldan-Valadez E, Favila R, Martínez-López M, Uribe M, Méndez- Sánchez N. Imaging techniques for assessing hepatic fat content in nonalcoholic fatty liver disease. Ann Hepatol 2008; 7212–220.
10. Schwenzer NF, Springer F, Schraml C, Stefan N, Machann J, Schick F. Non-invasive assessment and quantification of liver steatosis by ultrasound, computed tomography and magnetic resonance. J Hepatol 2009; 51433–445.
11. Duseja A, Singh SP, De A, Madan K, Rao PN, Shukla A, et al. Indian National Association for Study of the Liver (INASL) Guidance Paper on nomenclature, diagnosis and treatment of nonalcoholic fatty liver disease (NAFLD). J Clin Exp Hepatol. 2023 Mar-Apr;13. Epub 2022 Dec 7 PMID 36950481; PMCID PMC10025685.
12. Kinner S, Reeder SB, Yokoo T. Quantitative imaging biomarkers of NAFLD. Dig Dis Sci 2016; 611337–1347.
13. Sasso M, Beaugrand M, de Ledinghen V, Douvin C, Marcellin P, Poupon R, et al. Controlled attenuation parameter (CAP): a novel VCTE guided ultrasonic attenuation measurement for the evaluation of hepatic steatosis: preliminary study and validation in a coh. Ultrasound Med Biol 2010; 361825–1835.
14. Karlas T, Petroff D, Sasso M, et al. Individual patient data meta-analysis of controlled attenuation parameter (CAP) technology for assessing steatosis. J Hepatol 2017;661022–30.
15. Wong VW-S, Vergniol J, Wong GL-H, et al. Diagnosis of fibrosis and cirrhosis using liver stiffness measurement in nonalcoholic fatty liver disease. Hepatol 2010;51454–62.
16. Hernaez R, Lazo M, Bonekamp S, et al. Diagnostic accuracy and reliability of ultrasonography for the detection of fatty liver: A meta-analysis. Hepatol 2011;54(3)1082-90.
17. Abeysekera KWM, Fernandes GS, Hammerton G, et al. Prevalence of steatosis and fibrosis in young adults in the UK: a population-based study. Lancet Gastroenterol Hepatol 2020;5:295–305.
18. Younossi ZM, Koenig AB, Abdelatif D, et al. Global epidemiology of nonalcoholic fatty liver disease-meta- analytic assessment of prevalence, incidence, and outcomes. Hepatol 2016;6473–84.
19. Okur G, Karacaer Z. The prevalence of non-alcoholic fatty liver disease in healthy young persons. North Clin Istanbul 2016;3(2)111-117.
20. Nastasa R, Stanciu C, Zenovia S, Singeap AM, Cojocariu C, Sfarti C, Girleanu I, Chiriac S, Cuciureanu T, Huiban L, Muzica CM. The prevalence of liver steatosis and fibrosis assessed by vibration-controlled transient elastography and controlled attenuation. . Diagnostics 2021 Dec 13;11(12)2341-2351.
21. Leslie T, Pawloski L, Kallman-Price J, et al. Survey of health status, nutrition and geography of food selection of chronic liver disease patients. Ann Hepatol 2014;13533–40.
22. Kallwitz ER, Daviglus ML, Allison MA, et al. Prevalence of suspected nonalcoholic fatty liver disease in hispanic/latino individuals differs by heritage. Clin Gastroenterol Hepatol 2015;13569–76.
22. Yang Z, Li A, Jiang Y, Maidaiti X, Wu Y, Jin Y. Global burden of metabolic dysfunction-

associated steatotic liver disease attributable to high fasting plasma glucose in 204 countries and territories from 1990 to 2021. Sci Rep. 2024 Sep 27;14(1):22232.

23. Rinella ME, Lazarus JV, Ratziu V, Francque SM, Sanyal AJ, Kanwal F, et al. A multisociety Delphi consensus statement on new fatty liver disease nomenclature. Ann Hepatol. 2024 Jan-Feb;29(1):101133.
24. Duseja A, Singh SP, De A, Madan K, Rao PN, Shukla A, et al. Indian National Association for Study of the Liver (INASL) Guidance Paper on nomenclature, diagnosis and treatment of nonalcoholic fatty liver disease (NAFLD). J Clin Exp Hepatol. 2023 Mar-Apr;13(2):273-302. doi: 10.1016/j.jceh.2022.11.014. Epub 2022 Dec 7. PMID: 36950481; PMCID: PMC10025685.