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## Prevalence of non-alcoholic fatty liver disease in patients with prediabetes

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**Abstract. Background.** Diabetes mellitus (DM) is one of the largest global health emergencies. Prediabetes is an early stage in hyperglycemia continuum where individual is at an increased risk for development of DM. NAFLD represents a range of liver disorders characterized by hepatic steatosis or accumulation of fat in the liver cells in the absence of excessive alcohol consumption, viral or drug related etiologies. However, not many studies have been conducted to study the prevalence of non-alcoholic fatty liver disease (NAFLD) in persons with prediabetes. This study is an endeavor in that direction. **Materials and methods.** This was a cross-sectional observational study. 100 prediabetic patients, fulfilling the criteria as under, were included in the study over a period from November 2017 to March 2019, after informed consent. Investigations carried out on the patients included baseline biochemical parameters like complete hemogram, fasting plasma glucose, liver function tests, kidney function tests, serum electrolytes and specialized investigations like HbA1c, 2-hour-OGTT and serum insulin levels. **Results.** The study included 38 males and 62 females, with the median age for the study population being 46 years. The mean BMI was found to be  $24.29 \pm 3.98$  kg/m<sup>2</sup>, and the mean waist circumference was found to be  $81.26 \pm 8.71$  cm. A significant association was found between the level of fatty echotexture on ultrasound and BMI ( $p = 0.003$ ), and gender ( $0.05$ ). 30 % population was found to be insulin sensitive, 22 % was found to be depicting early insulin resistance and 48 % had significant insulin resistance. There was a statistically significant correlation between ultrasound and fibroscan findings. A significant statistical correlation was found between HOMA IR and level of fatty echotexture on ultrasound, as well as median liver stiffness on fibroscan. **Conclusions.** We found a significant correlation between insulin resistance and presence of NAFLD. Also, significant associations were observed between various demographic characteristics and grade of steatosis. There is a need to undertake further studies on a larger scale, to substantiate the observations of this study. This understanding is expected to go a long way in generating awareness and optimizing public health strategies.

**Keywords:** prediabetes; non-alcoholic fatty liver disease; prevalence


### Introduction

Diabetes mellitus (DM) is one of the largest global health emergencies. Prediabetes is an early stage in hyperglycemia continuum where individual is at an increased risk for development of DM. The global DM prevalence in 2019 is estimated to be 9.3 % (463 million people), rising to 10.2 % (578 million) by 2030 and 10.9 % (700 million) by 2045. The global prevalence of impaired glucose tolerance is estimated to be 7.5 % (374 million) in 2019 and projected to reach 8.0 % (454 million) by 2030 and 8.6 % (548 million) by 2045 [1].

Prediabetes, as defined by ADA is a condition where fasting plasma glucose is between 100–125 mg/dl, 2-hour plasma glucose in 75 g OGTT is 140–199 mg/dl, HbA1c levels are 5.7–6.4 percent [2].

Insulin resistance has been defined as a metabolic state in which a greater than normal amount of insulin is required to get a physiologically normal response [3]. In insulin resistance muscle, fat and liver cells do not respond properly to insulin and cannot easily absorb glucose from the blood stream. Failure of insulin to inhibit triglycerides (TGs) lipolysis in insulin-resistant states leads to an oversupply of free fatty acids to the liver, excess hepatic TGs synthesis and intracellular accumulation of toxic lipid products play a key role in the development of hepatic steatosis in non-alcoholic fatty liver disease (NAFLD).

NAFLD represents a range of liver disorders characterized by hepatic steatosis or accumulation of fat in the liver cells in the absence of excessive alcohol consumption, viral

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or drug related etiologies [4]. It is the most common cause of liver disease in the absence of viral hepatitis or alcohol excess, in the industrialised world affecting approximately 15–50 % of adult population. It includes a wide spectrum of liver disorders, ranging from pure steatosis to cirrhosis, liver failure and even hepatocellular carcinoma. Two hallmark components of pathophysiology of hepatic steatosis include mitochondrial dysfunction and insulin resistance [5].

Review of literature reveals a clear link between NAFLD, insulin resistant states such as obesity, type 2 DM and prediabetes [6] and significant correlation between the presence of NAFLD in prediabetic patients [7–9]. Various studies also found significant correlation between demographic characteristics like age, BMI and the prevalence of NAFLD [7, 8]. Studies conducted by S. Suresh et al. [10] and A. Bugianesi et al. [11] found statistically significant correlation between the presence of NAFLD and level of insulin resistance.

An association between insulin resistance and NAFLD is now well recognized and accepted, but it remains a subject of active research whether increase in TGs, metabolic intermediates cause insulin resistance or insulin resistance causes excessive accumulation of fats in liver [12].

Some investigators hypothesize that liver fat accumulation is a result, of peripheral insulin resistance in obesity. In skeletal muscle, peripheral insulin resistance will mainly affect a large portion of the total glucose uptake (> 80–90 %), whereas in adipose tissue, insulin resistance induces an impaired anti-lipolytic action of insulin and therefore an increased release of non-esterified fatty acids [13]. Also, insulin clearance is affected in advanced liver disease, which is considered as one of the main causes of hyperinsulinemia in liver cirrhosis [14].

Various studies, all over the world, have concluded an increasing incidence of hepatic steatosis in DM patients. However, not many studies have been conducted to study the prevalence of NAFLD in persons with prediabetes. This study is an endeavor in that direction.

## Materials and methods

This was a cross-sectional observational study conducted at the Departments of Medicine and Biochemistry at Postgraduate Institute of Medical Education and Research, Dr. RML Hospital, New Delhi after receiving clearance from the Department and Institutional Review Board. 100 prediabetic patients, fulfilling the criteria as under, were included in the study over a period from November 2017 to March 2019, after informed consent.

Inclusion criteria: prediabetic population, > 18 years, with full informed consent having fasting plasma glucose between 100 to 125 mg/dl or 2-hour postprandial plasma glucose between 140–199 mg/dl (was included in the study reconfirming with standard 2 hour OGTT (after 75 gm glucose solution ingestion) or HbA1c 5.7 to 6.4 %.

Exclusion criteria:

1. HCV or HBV co-infection.
2. Alcohol consumption > 20 g/day for males and > 10 g/day for females.
3. History of DM, recent jaundice (last 6 months), dyslipidemia.
4. History of intake of corticosteroids, acetaminophen, methotrexate, amiodarone, tamoxifen, valproate, antiretroviral [15].
5. History of intake of oral contraceptive pills.

The study participants were first asked to fill a pre-determined proforma with baseline demographic characteristics and then they underwent a detailed clinical examination. Investigations carried out on the patients included baseline biochemical parameters like complete hemogram, fasting plasma glucose, liver function tests, kidney function tests, serum electrolytes and specialized investigations like HbA1c, 2-hour-OGTT and serum insulin levels. The basal state insulin resistance of the patients was calculated using the HOMA2 IR calculator. (Homeostatic Model Assessment of Insulin Resistance). Ultrasound and transient elastography methods were used to assess for the presence of NAFLD and further evaluation of extent of fibrosis.

## Statistical analysis

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean  $\pm$  SD and median. Normality of data was tested by the Kolmogorov-Smirnov test. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0. A p value of < 0.05 was considered statistically significant.

## Results

The study included 38 males and 62 females, with the median age for the study population being 46 years. The mean BMI was found to be  $24.29 \pm 3.98$  kg/m<sup>2</sup>, and the mean waist circumference was found to be  $81.26 \pm 8.71$  cm (table 1).

A significant association was found between the level of fatty echotexture on ultrasound and BMI ( $p = 0.003$ ), and gender (0.05).

**Table 1. Characteristics of the study population**

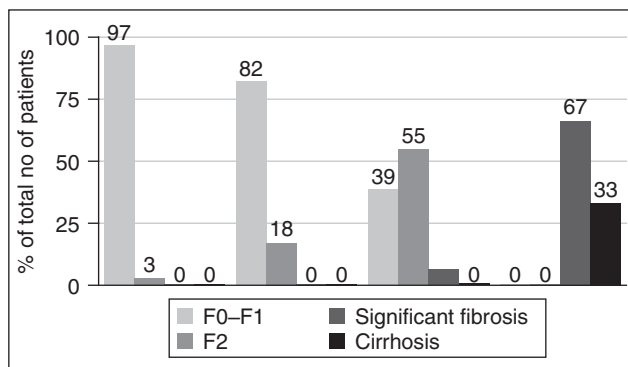
	n	Minimum	Maximum	Mean	Std Deviation
Height, cm	100	149.86	180.34	162.66	8.32
Weight, kg	100	38	98	64.49	12.14
Waist Circumference, cm	100	65	106.68	81.26	8.71
BMI, kg/m <sup>2</sup>	100	16.92	42.19	24.29	3.98
FBG, mg/dl	100	77	126	107.88	10.41
PPBG, mg/dl	100	106	198	150.4	19.13
HbA1c, %	100	5.4	6.4	5.97	0.24

68 percent study population was found to have NAFLD on the basis of ultrasound, out of which 34 % had Grade I, 31 % had Grade II and 3 percent study population were found to have Grade III fatty liver. The extent of liver fibrosis was further evaluated in the study subjects with the help of fibroscan. 24 % subjects were found to have F2 fibrosis, 4 % had F3 fibrosis and 1 % was found to have cirrhosis. Mean serum insulin levels was found to be  $10.95 \pm 5.73 \mu\text{IU/ml}$ . Insulin resistance was determined via HOMA IR method. 30 % population was found to be insulin sensitive, 22 % was found to be depicting early insulin resistance and 48 % had significant insulin resistance (table 2).

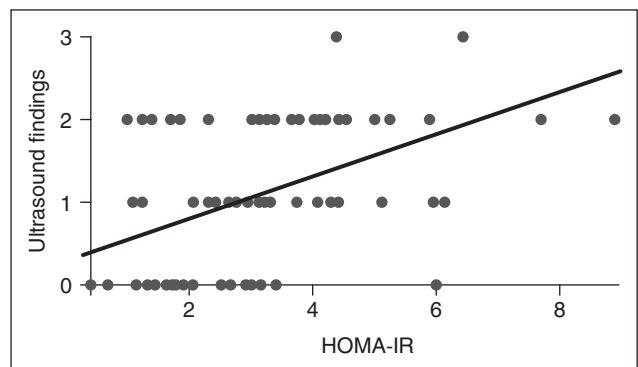
There was a statistically significant correlation between ultrasound and fibroscan findings ( $p = 0.0001$ ,  $r = 0.754$ ). A significant statistical correlation was found between HOMA IR and level of fatty echotexture on ultrasound ( $p < 0.0001$ ,  $r = 0.463$ ), as well as median liver stiffness on fibroscan ( $p < 0.0001$ ,  $r = 0.686$ ) (table 3; figure 1). Amongst the glucose profile of the study population, the fasting blood glucose levels was found to be significantly correlated to the level of fatty echotexture on Ultrasound ( $p = 0.018$ ), the level of insulin resistance ( $p = 0.026$ ) and median liver stiffness on fibroscan ( $p = 0.008$ ) (table 4; figure 2).

**Table 2. Occurrence of NAFLD according to USG findings**

Occurrence of NAFLD according to USG findings	
Normal	32.00 %
Grade 1	34.00 %
Grade 2	31.00 %
Grade 3	3.00 %
Extent of liver fibrosis in study subjects	
F0–F1	71.00 %
F2	24.00 %
Significant Fibrosis, F3	4.00 %
Cirrhosis, F4	1.00 %
Assessment for insulin resistance	
Insulin sensitive (< 1.9)	30.00 %
Early insulin resistance (1.9–2.9)	22.00 %
Significant insulin resistance (> 2.9)	48.00 %



**Figure 1. Ultrasound and fibroscan findings in patients with prediabetes**



**Figure 2. Correlation between insulin resistance and ultrasound findings in patients with prediabetes**

**Table 3. Fibroscan findings in patients with prediabetes**

		Fibroscan findings, KPa				Total	P value
		F0–F1	F2	Significant fibrosis	Cirrhosis		
Ultrasound findings	Normal	31 (96.88 %)	1 (3.13 %)	0 (0 %)	0 (0 %)	32 (100.00 %)	< 0.0001
	Grade 1	28 (82.35 %)	6 (17.65 %)	0 (0 %)	0 (0 %)	34 (100.00 %)	
	Grade 2	12 (38.71 %)	17 (54.84 %)	2 (6.45 %)	0 (0 %)	31 (100.00 %)	
	Grade 3	0 (0 %)	0 (0 %)	2 (66.67 %)	1 (33.33 %)	3 (100.00 %)	
Total		71 (71.00 %)	24 (24.00 %)	4 (4.00 %)	1 (1.00 %)	100 (100.00 %)	

**Table 4. Ultrasound findings and insulin resistance in patients with prediabetes**

		Ultrasound Findings				Total	P value
		Normal	Grade 1	Grade 2	Grade 3		
HOMA IR	Insulin sensitive	19 (63.33 %)	3 (10.00 %)	8 (26.67 %)	0 (0 %)	30 (100.00 %)	< 0.0001
	Early IR	8 (36.36 %)	13 (59.09 %)	1 (4.55 %)	0 (0 %)	22 (100.00 %)	
	Significant IR	5 (10.42 %)	18 (37.50 %)	22 (45.83 %)	3 (6.25 %)	48 (100.00 %)	
Total		32 (32.00 %)	34 (34.00 %)	31 (31.00 %)	3 (3.00 %)	100 (100.00 %)	

## Discussion

The occurrence of NAFLD and the statistical correlation of its presence with insulin resistance were the primary outcomes of the study. In addition, the study also secondarily analyzed the demographic characteristics of the study population and grade of steatosis, fibrosis and level of insulin resistance. A comprehensive review of our various results is as under.

Our study found the occurrence of NAFLD to be 68 %. Out of these 68 subjects, 34 % had grade I, 31 % had grade II and 3 % study population were found to have grade III fatty liver.

In contrast, F. Mansour-Ghanaei et al. [7] found the prevalence of prediabetes around 48.69 %. A similar study conducted by V. Mohan et al. [9] in Chennai in 2008, found the prevalence of NAFLD in prediabetics in South India to be 33 percent. The higher occurrence of NAFLD in this study may be attributable to the differences in demographic characteristics and biochemical parameters of the study population among the studies. The mean age ( $46.49 \pm 8.18$  years) of the study population was higher in the current study in comparison to the study by F. Mansour-Ghanaei et al. ( $40 \pm 10$  years) [7]. Similarly, in comparison to the study conducted by V. Mohan et al. [9], the mean BMI ( $22.8 \pm 3.8$  kg/m<sup>2</sup> vs  $24.29 \pm 3.98$  kg/m<sup>2</sup>), fasting plasma glucose ( $99 \pm 11$  mg/dl vs  $107.88 \pm 10.41$  mg/dl) and total cholesterol levels ( $175 \pm 35$  mg/dl vs  $196.04 \pm 45.54$  mg/dl) of the subjects in this study were significantly higher.

In the current study mean liver stiffness measure was similarly observed to be 5, 8.43, 11.3 and 13.2 kPa, for study subjects with F0–F1, F2, F3 and F4 fibrosis respectively. A significant increase in mean fibroscan reading from F2 to F3 (p value = 0.002), and a marginal association between increase in liver stiffness measure readings from F2 to F4 (p value = 0.09) was noted, which is comparable to the findings of G. Zhang et al. [16].

58 percent male study subjects (36 out of 62) and 84 percent females (32 out of 38) were found to have NAFLD, thus female gender was found to be associated with NAFLD (p = 0.05), a finding that is in concordance with the observations of G. Bedogni et al. [17] and U. Summart et al. [18].

A 5 year cohort based study was conducted by M. Liu et al. [19] which also found out the mean BMI of prediabetic study subjects with NAFLD to be  $24.86 \pm 2.67$  kg/m<sup>2</sup>, which is comparable to the mean BMI calculated in the current study  $24.29 \pm 3.98$  kg/m<sup>2</sup>. The positive statistical association between the BMI of study subjects and the presence of NAFLD (p = 0.003) is in concordance with the findings of F. Mansour-Ghanaei et al. [7].

The level of insulin resistance was calculated by the HOMA IR computational method, requiring serum fasting blood glucose, and serum fasting insulin levels. A significant correlation was found between the level of insulin resistance and grade of fatty liver on ultrasound with p value < 0.0001, r = 0.463.

Similar observations have been made in various studies in the past — G. Privitera et al. [20] and M. Li et al. [21]. Similarly, C. Ortiz-Lopez et al. [6], had studied 118 apparently healthy individuals with a diagnosis of NAFLD. They also found a significantly raised HOMA IR value of  $3.5 \pm 0.2$   $\mu$ U/mmol

in subjects with NAFLD, than the subjects without NAFLD ( $1.2 \pm 0.4$   $\mu$ U/mmol), with a p value < 0.001.

The level of insulin resistance was also found to be significantly related to fasting blood glucose values (p = 0.026) of study subjects. Y. Singh et al. [22] also concluded a correlation of fasting plasma glucose was found with HOMA IR values in this study as well (r = 0.350, p < 0.0001) in their study carried out in Delhi.

## Conclusions

In this small study conducted at ABVIMS and Dr RML Hospital, New Delhi, we found a significant correlation between insulin resistance and presence of NAFLD. Also, significant associations were observed between various demographic characteristics and grade of steatosis. There is a need to undertake further studies on a larger scale, to substantiate the observations of this study. This understanding is expected to go a long way in generating awareness and optimizing public health strategies.

## Limitations of the current study

The current study was a hospital based cross-sectional study comprising of 100 prediabetic study subjects. Certain limitations that were observed are as follows.

The study had a small sample size (n = 100), which cannot be extrapolated to conclusions at a large scale. Regional variations were not taken into account in this study.

Cause-effect conclusions cannot be made definitively owing to cross-sectional nature of the study.

**Conflicts of interests.** Authors declare the absence of any conflicts of interests and their own financial interest that might be construed to influence the results or interpretation of their manuscript.

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### Поширеність неалкогольної жирової хвороби печінки у хворих на предіабет

**Резюме.** *Актуальність.* Цукровий діабет (ЦД) є одним із глобальних і надзвичайних викликів у галузі охорони здоров'я. Предіабет — це рання стадія в континуумі гіперглікемії, при якій організм схильний до підвищеного ризику розвитку ЦД. Неалкогольна жирова хвороба печінки (НАЖХП) становить собою низку порушень функції печінки, які характеризуються стеатозом печінки або накопиченням жиру в клітинах печінки

за відсутності надмірного вживання алкоголю, вірусної етіології чи вживання наркотиків. На сьогодні проведено не так багато досліджень із метою вивчення поширеності НАЖХП в осіб із предіабетом. Дане дослідження є зусиллям у цьому напрямку. *Матеріали та методи.* Проведене поперечне обсерваційне дослідження. 100 пацієнтів із предіабетом були включені в дослідження протягом періоду з листопада 2017 року по

березень 2019 року після отримання інформованої згоди. Дані дослідження включали визначення біохімічних показників, рівня глікемії в плазмі натще, електролітів та HbA1c, інсуліну в сироватці крові, проведення загального аналізу крові, функціональних тестів печінки та нирок, 2-годинного орального глюкозотолерантного тесту. **Результати.** Дослідження включало 38 чоловіків та 62 жінки, середній вік досліджуваної популяції становив 46 років. Установлено, що середній індекс маси тіла (ІМТ) становить  $24,29 \pm 3,98$  кг/м<sup>2</sup>, окружність талії —  $81,26 \pm 8,71$  см. Виявлений вірогідний зв'язок між показниками ехоструктури печінки при ультразвуковому дослідженні (УЗД) та ІМТ ( $p = 0,003$ ) і статтю. Установлено, що 30 % обстежених мають порушену чутливість до інсуліну, у 22 % виявлені ранні прояви резистентності до інсуліну, у

48 % — виражена інсулінорезистентність. Показано статистично значущу кореляцію між результатами УЗД й еластографії. Виявлено статистичну кореляцію між НОМА-IR та показниками ехоструктури на УЗД, а також середньою жорсткістю печінки при еластографії. **Висновки.** Виявлено вірогідну кореляцію між резистентністю до інсуліну та наявністю НАЖХП. Спостерігалися вірогідні зв'язки між різними демографічними характеристиками та ступенем стеатозу. Існує необхідність провести подальші дослідження в більш широкому масштабі, щоб обґрунтувати отримані результати цього дослідження. Очікується, що це значною мірою сприятиме підвищенню обізнаності й оптимізації стратегій охорони здоров'я.

**Ключові слова:** предіабет; неалкогольна жирова хвороба печінки; поширеність

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### Распространенность неалкогольной жировой болезни печени у больных предиабетом

**Резюме. Актуальность.** Сахарный диабет (СД) — один из глобальных и чрезвычайных вызовов в области здравоохранения. Предиабет — это ранняя стадия в континууме гипергликемии, при которой организм подвержен повышенному риску развития СД. Неалкогольная жировая болезнь печени (НАЖБП) представляет собой ряд заболеваний печени, характеризующихся стеатозом печени или накоплением жира в клетках печени при отсутствии чрезмерного употребления алкоголя, вирусной или лекарственной этиологии. На сегодняшний день проведено недостаточно исследований для изучения распространенности НАЖБП у лиц с предиабетом. Данное исследование является попыткой в этом направлении. **Материалы и методы.** Проведено перекрестное обсервационное исследование. 100 пациентов с предиабетом были включены в исследование в период с ноября 2017 года по март 2019 года после получения информированного согласия. Данные исследования включали определение биохимических показателей, уровня гликемии в плазме натощак, электролитов и HbA1c, инсулина в сыворотке крови, проведение общего анализа крови, функциональных тестов печени и почек, 2-часового орального глюкозотолерантного теста. **Результаты.** Исследование включало 38 мужчин и 62 женщины, средний воз-

раст исследуемой популяции составлял 46 лет. Установлено, что средний индекс массы тела составил  $24,29 \pm 3,98$  кг/м<sup>2</sup>, а окружность талии —  $81,26 \pm 8,71$  см. Обнаружена достоверная связь между уровнем эхоструктуры при ультразвуковом исследовании (УЗИ) и ИМТ ( $p = 0,003$ ) и полом. Установлено, что 30 % обследованных имеют нарушенную чувствительность к инсулину, 22 % имели ранние ее признаки и 48 % — выраженную резистентность к инсулину. Показана статистически значимая корреляция между результатами УЗИ и эластографии. Виявлена статистическая корреляция между НОМА-IR и показателями эхоструктуры на УЗИ, а также средней жесткостью печени при эластографии. **Выводы.** Обнаружена достоверная корреляция между инсулинорезистентностью и наличием НАЖБП. Наблюдались достоверные ассоциации между различными демографическими характеристиками и степенью стеатоза. Необходимо провести дальнейшие исследования в более крупном масштабе, чтобы подтвердить наблюдения этого исследования. Ожидается, что это в значительной степени будет способствовать повышению осведомленности и оптимизации стратегий общественного здравоохранения.

**Ключевые слова:** предиабет; неалкогольная жировая болезнь печени; распространенность