Original Research Article

A Comparative Study of Liver Steatosis in Lean and Obese Patients with Non-Alcoholic Fatty Liver Disease Based on Bioelectrical Impedance Analysis and Controlled Attenuation Parameter

Abstract

Background: Due to the predominance of obesity, bad eating habits, and sedentary lifestyle patterns, non-alcoholic fatty liver disease (NAFLD) is becoming an international health issue and accounts for 25% of prevalence globally. Althoughthere was evidence that the pathophysiology of NAFLD was mostly influenced by increasing body fat, particularly abdominal visceral fat, recent epidemiological studies have reported an increase of non-obese individuals who have NAFLD worldwide. In order to evaluate the degree of steatosis and identify the metabolic profiles of lean NAFLD patients, this study evaluated the liver fatty liver disease and body composition of obese and lean NAFLD patients.

Methods: In this cross-sectional research, a hundred individuals participatedaged more than 18 years old, both sexes, with clinical criteria of bright liver by ultrasound then NAFLD diagnosed by Controlled Attenuation Parameter (CAP) determination of liver steatosis more than 240 dB/min. Patients were divided into two categories: 50 individuals with hepatic steatosis made up Group 1 (the study group), which was further split into: 1a: Count 25 individuals that are fatty or overweight (BMI 25 kg/m2), and 1b: Include 25 people who are not obese (BMI <25 kg/m2). Group 2 (control group): included 50 participants without liver steatosis, further subdivided into: 2a: include 25 overweight-obese participants (BMI≥25kg/m2) and 2b: include 25 non obese participants (BMI<25kg/m2).

Results: The proportion of body fat, visceral fat, subcutaneous fat, free-fat mass index (FFMI), and fat mass index (FMI) in the NAFLD group elevated substantially more than those in the non-NAFLD group (P <0.001). The steatosis score and the systolic, diastolic, and triglyceride (TG) levels were positively correlated in the obese NAFLD group (P=0.039, =0.002, and =0.012, respectively). The risk variables for NAFLD in lean individuals were elevated TG, reduced lymphocytes, increased neutrophil-to-lymphocyte ratio (NLR), increased Homeostatic model assessment (HOMA), and decreased FFMI.

Conclusions: While raised systolic blood pressure and elevated triglycerides were the only independent risk factors for the development of NAFLD in obese individuals, increasing visceral obesity and insulin resistance, HOMA IR were the only independent risk factor for the development of NAFLD in lean patients.

Keywords: NAFLD, lean NAFLD, Body composition analysis

Introduction:

People who drink very little or no alcohol are susceptible to non-alcoholic fatty liver disease (NAFLD), a clinico-pathological liver conditionand is characterized by an accumulation of large vesicular hepatic lipids [1]. With an estimated frequency of 20–40%, One of the most common liver diseases, both in developed and developing nations, is NAFLD[2]. Simple steatosis and nonalcoholic steatohepatitis are just two of the diseases included in NAFLD[3].

The gold standard for diagnosing NAFLD is a liver biopsy. Non-invasive technologies, such as transient elastography, controlled attenuation parameter, and magnetic resonance-based methods, have been developed recently for assessing liver fibrosis and hepatic steatosis. Their usefulness in the context of NAFLD is now being thoroughly researched [4].

The pathophysiology of NAFLD is still not completely understood. Physical inactivity and high-fat diets are both highly linked to the onset and progression of NAFLD. There was also evidence that increased body fat, particularly visceral fat in the belly, was a major factor in the development of NAFLD. Although, the syndrome is increasingly understood to exist in those who are not fat, notably in Asia[5]. Recent epidemiological studies have reported an increasein non-obese individuals who have NAFLD worldwide. Another important variable that influences metabolic balance is the compartment of skeletal muscle. Patients with NAFLD frequently have sarcopenia and an increase in adipose tissue mass[6].

As a diagnostic criterion, body mass index (BMI), which includes mortality-based cutoffs and is a trustworthy predictor of percentage fat mass (%FM) at the population level, has performed as expected. The development and use of body composition analyses have more recently raised doubts about the adipo-centric paradigm of obesity[7]. Body composition is evaluated utilizing the non-invasive bioelectrical impedance analysis (BIA) method. It achieves this by monitoring the resistance and capacitance of various body components, watching for a voltage drop in the applied current, and more[8].

Examining the hepatic steatosis in obese and lean NAFLD patients was the goal of the current study, analyze their body compositions, and determine their risk factors for developing the disease.

Methods:

100 patients altogether, both sexes older than 18, participated in this cross-sectional research. Patients were divided into two categories: 50 individuals with hepatic steatosis who had abdominal ultrasonography findings of "bright liver" and NAFLD made up Group 1 (the study group). determined by CAP 240 dB/min or greater of hepatic steatosis must be determined, the patients further subdivided into: 1a: include 25 overweight-obese (BMI≥25kg/m2) and 1b: include 25 non obese (BMI<25kg/m2). Group 2 (control group): included 50 participants without liver steatosis further subdivided into: 2a: include 25 overweight-obese participants (BMI≥25kg/m2) and 2b: include 25 non obese participants (BMI<25kg/m2).

After receiving clearance (34854/8/21) from the Tanta University Department of Tropical Medicine and Infectious Diseases Ethical Committee, the study was carried out from January 10, 2021, for a period of six months. The patients provided signed consent after being fully briefed.

Drug-induced liver illness, autoimmune liver disease, viral hepatitis B and C infections, hepatocellular carcinoma, and other cancers anywhere in the body were prohibited from participation.

- All patients were subjected to: history taking, clinical examination ,anthropometric estimations (weight, stature, abdomen circumference, hip circumference, midriff to hip ratio were calculated, BMI was calculated as body weight in kilograms partitioned by the square of stature (kg/m2), and body investigation estimation), research facility examinations [total blood count (CBC), prothrombin time, blood glucose, INR, add up to lipid profile, and liver work tests, imaging examinations: Ultrasound imaging, FibroScan estimation [Controlled Weakening Parameter (CAP) and liver firmness estimation (LSM)] by FibroScan® device.

Chart 1.

Interpretation of Fibroscan reading (CAP and TE) [9]

CAP score	Steatosis score	Amount of liver fatty changes
237 to 260	S1	11% to 33 %
260 to 290	S2	34% to 66%
Higher than 290	S3	67% or more

An in-body scale that measures the following factors was used to determine the body composition for bioelectrical impedance study.

Body weight (kg), body fat mass (BFM, kg), and appendicular skeletal muscle mass (kg) were all determined. The body fat percentage was calculated using the formula (BFM/body weight) _ 100. The skeletal muscle mass index (SMI) was calculated by dividing the appendicular skeletal muscle mass by height in square meters. To calculate the proportion of muscle to fat mass, the BFM was divided by the appendicular skeletal muscle mass.

Fasting triglyceride (TG) levels over 150 mg/dl, blood pressure over 130/85 mmHg, fasting high-density lipoprotein (HDL) cholesterol levels under 40 mg/dl (men) or 50 mg/dl (women), and fasting blood sugar levels over 100 are the requirements for the **metabolic syndrome**.

Statistical analysis

IBM, Chicago, Illinois, USA's SPSS v27 was used for the statistical study. Histograms and the Shapiro-Wilks test were employed to assess the normality of the data distribution. The mean and standard deviation (SD) of quantitative parametric data were reported, and an ANOVA (F) test with a post hoc test (Tukey) was used to examine them. In order to compare each group, quantitative non-parametric data were provided as median and interquartile range (IQR) and were then analyzed using the Kruskal-Walli'stestand the Mann Whitney-test. The Chi-square test was used to examine qualitative data, which

were reported as frequency and percentage (%). Statistical significance was defined as a two tailed P value < 0.05.

Results:

While the laboratory examinations revealed a statistically noteworthy distinction between groups, the demographic data were comparable between groups. Table 1

Table 1: compares the examined groups in terms of demographic information and laboratory tests

		Group 1a (Obese NAFLD) (n = 25)	Group 1b (Lean NAFLD) (n = 25)	Group 2a (Obese non-NAFLD) (n = 25)	Group 2b (Lean non-NAFLD) (n = 25)	P
Demographic data						
Sex No (%)	**Male**	8 (32.0)	15 (60.0)	16 (64.0)	10 (40.0)	0.067
	Female	17 (68.0)	10 (40.0)	9 (36.0)	15 (60.0)	
Age (years)		41.72 ± 12.19	37.28 ± 9.24	42.44 ± 9.99	37.08 ± 10.81	0.153
Diabetes mellitus		5 (10.0)		3 (6.0)		FEp=0.715
Hypertension		11 (22.0)		1 (2.0)		0.002*
Systolic blood pressure (100-140) mmhg		121.70 ± 15.77		116.40 ± 10.79		0.053
Diastolic blood pressure (60-90) mmhg		74.10 ± 7.54		69.0 ± 6.47		<0.001*
Complete blood picture parameters (CBC)						
HB (male:13.2-16.6g/dl,		12.23 ± 1.29		12.07 ± 1.13		0.510

female:11.6-15g/dl)			
WBCs (4000-11000/L)	7.82 ± 2.0	8.13 ± 1.90	0.421
Lymphocyte percentage (20%-40%)	26.20 ± 2.17	35.50 ± 3.17	<0.001*
Neutrophil percentage (40%-60%)	52.02 ± 6.30	42.02 ± 1.32	<0.001*
Neutrophil / lymphocyte ratio (0.78-3.53)	2.0 ± 0.30	1.19 ± 0.13	<0.001*
Platelets (150000-450000 mcl)	298.82 ± 85.18	317.28 ± 70.15	0.044*
Liver functions tests & GGT & alkaline phosphatase			
Bilirubin(<1.2mg/dl)	0.92 ± 0.18	0.91 ± 0.13	0.825
ALT (up to 45 U/L)	34.94 ± 3.95	35.40 ± 3.86	0.528
AST (up to 45 U/L)	34.21 ± 3.81	33.96 ± 4.37	0.948
Albumin (3.5-5.5g/dl)	4.27 ± 0.37	4.25 ± 0.39	0.754
INR (<1.2)	1.01 ± 0.04	1.01 ± 0.05	0.725
GGT(5-40U/L)	34.96 ± 5.73	30.58 ± 5.83	0.001*
Alkaline phosphatase(44-147IU/L)	102.38 ± 19.76	89.12 ± 20.68	0.007*
kidney function tests & uric acid			
Urea	30.46 ± 3.74	30.66 ± 3.63	0.787
Creatinine (0.7-1.35 mg/dl in male) (0.59-1.2 mg/dl in female)	1.03 ± 0.10	1.04 ± 0.12	0.486
Uric acid (3.5-7.2mg/dl)	6.13 ± 0.89	5.03 ± 0.70	<0.001*
Glucose metabolism tests			
HOMA IR (1.7-2)	1.82 ± 0.20	1.79 ± 0.15	0.631
Fasting sugar (70-110mg/dl)	101.06 ± 10.94	99.64 ± 13.03	0.380
HbA1C (5.7-6.4%)	6.03 ± 0.43	5.62 ± 0.66	0.001*
Fasting insulin level	7.33 ± 0.83	7.36 ± 0.68	0.912

Lipid profile of two studied groups					
TG (<150mg/dl)	169.46 ± 42.82		124.34 ± 25.22		<0.001*
Cholesterol(<200mg/dl)	188.67 ± 52.04		184.68 ± 51.30		0.700
LDL(<100mg/dl)	156.97 ± 45.70		110.02 ± 29.89		<0.001*
HDL(>60mg/dl)	44.45 ± 14.75		81.50 ± 14.85		<0.001*
VLDL(2-30mg/dl)	31.83 ± 14.03		19.74 ± 5.19		<0.001*
lipid profile of four studied groups					
TG (<150mg/dl)	166.1 ± 57.43	172.8 ± 20.57	135.3 ± 29.22	113.4 ± 13.97	<0.001*
Significance between groups	p_1=0.187, p_2=0.014*, p_3<0.001*, p_4=0.015*				
Cholesterol (<200mg/dl)	210.0 ± 55.46	167.3 ± 38.79	220.0 ± 33.62	149.40 ± 40.62	<0.001*
Significance between groups	p_1=0.004*, p_2=0.845, p_3=0.455, p_4<0.001*				
LDL (<100mg/dl)	158.5 ± 57.44	155.4 ± 30.99	117.4 ± 33.08	102.6 ± 24.80	<0.001*
Significance between groups	p_1=0.992, p_2=0.002*, p_3<0.001*, p_4=0.528				
HDL (>60mg/dl)	36.89 ± 11.37	52.0 ± 13.99	75.40 ± 14.85	87.60 ± 12.34	<0.001*
Significance between groups	p_1=0.024*, p_2<0.001*, p_3<0.001*, p_4=0.092				
VLDL (2-30mg/dl)	30.02 ± 15.73	33.64 ± 12.15	20.93 ± 6.21	18.56 ± 3.66	<0.001*
Significance between groups	p_1=0.252, p_2=0.015*, p_3<0.001*, p_4=0.152				

The frequency (%) or mean and standard deviation of the data are presented. White blood cells (WBCs), haemoglobin (HB), non-alcoholic fatty liver disease (NAFLD), high-order metabolic assay (HOMA), alanine transaminase (ALT), aspartate aminotransferase (AST), and international normalized ratio (INR) IR: Assessment of the insulin resistance homeostatic model, Triglycerides, glycated haemoglobin (HbA1C), and the three different forms of lipoproteins are low-density lipoprotein, high-density lipoprotein, and very low-density lipoprotein. p: The significance level at which the two research groups were compared; *: @ $p \leq 0.05$ is statistically significant. The p-values used to compare Group 1a and Group 1b are P1, P2, P3, and P4, respectively. Group 1b and Group 2b are compared using P3 while Group 2a and Group 2b are compared using P4.

There was no statistically significant difference in height, weight, BMI, hip circumference, waist circumference, or waist/hip ratio between the two research

groups. There was no statistically significant difference in height between the studied groups (P>0.05).

The anthropometric measurements of the four study groups showed a statistically significant difference (P <0.001). Table 2

Table 2: Comparison of the examined groups' anthropometric measures is shown

	Group 1a (Obese NAFLD) (n = 25)	Group 1b (Lean NAFLD) (n = 25)	Group 2a (Obese non-NAFLD) (n = 25)	Group 2b (Lean non-NAFLD) (n = 25)	P
Height (cm)	162.8 ± 8.06	170.3 ± 5.49	168.2 ± 6.69	170.3 ± 4.96	0.199
Weight (kg)	97.21 ± 22.24	65.38 ± 7.04	94.61 ± 25.90	66.0 ± 10.86	<0.001*
Significance between groups	p_1<0.001*, p_2=0.580, p_3=0.753, p_4<0.001*				
BMI (kg/m²) (18.5-24.9)	37.71 ± 9.0	22.47 ± 1.60	33.18 ± 7.44	22.28 ± 2.39	<0.001*
Significance between groups	p_1<0.001*, p_2=0. 367, p_3=0.823, p_4<0.001*				
Waist circumference (cm)	109.6 ± 14.56	54.88 ± 13.54	97.0 ± 22.35	59.56 ± 13.33	<0.001*
Significance between groups	p_1<0.001*, p_2=0.084, p_3=0.531, p_4<0.001*				
Hip circumference (cm)	125.5 ± 15.32	57.28 ± 15.94	102.8 ± 20.43	70.60 ± 13.50	<0.001*
Significance between groups	p_1<0.001*, p_2=0.022*, p_3=0.098, p_4<0.001*				
WHR	0.96 ± 0.08	0.87 ± 0.06	0.93 ± 0.11	0.84 ± 0.22	0.001*
Significance between groups	p_1<0.001*, p_2=0.013*, p_3=0.064, p_4=0.753				
	(NAFLD) Group1 (n =50)		**(non-NAFLD) Group2**		

		(n =50)	
Height (cm)	166.54 ± 7.80	169.26 ± 5.92	0.199
Weight (kg)	81.30 ± 22.91	80.31 ± 24.39	0.866
BMI (kg/m²) (18.5-24.9)	30.09 ± 10.01	27.73 ± 7.76	0.632
Waist circumference(cm)	82.24 ± 30.94	78.28 ± 26.25	0.436
Hip circumference (cm)	91.40 ± 37.78	86.72 ± 23.64	0.652
WHR	0.91 ± 0.09	0.88 ± 0.18	0.661

The data are shown as mean and standard deviation. Waist to Hip Ratio (WHR) and Body Mass Index (BMI) p: The four study groups were compared using p values: P1 was used to compare Group 1a and Group 1b, P2 was used to compare Group 1a and Group 2a, P3 was used to compare Group 1b and Group 2b, and P4 was used to compare Group 2a and Group 2b. *: statistically significant at $p \leq 0.05$

There was no statistically significant difference in fat mass between the two research groups ($p>0.05$). There was a statistically significant difference between groups 1 and 2 in terms of weight without fat ($P=0.039$), muscle mass, protein mass, skeletal muscle mass, and skeletal muscle mass index ($P<0.001$). Visceral fat, subcutaneous fat, body fat ratio, free-fat mass index, and fat mass index all increased statistically significantly between groups 1 and 2 ($P< 0.001$). The bioelectrical impedance analysis demonstrated that there was a statistically significant difference between the four study groups ($P< 0.001$). There was a statistically significant rise in the proportion of people who fit the criteria for the metabolic syndrome between group 1a and group 1b ($p< 0.001$). Table 3

Table 3: Shows Comparison between the studied groups regarding to bioelectrical impedance analysis (BIA) and Comparison between group 1a to 1b regarding to metabolic syndrome criteria

	Group 1a (Obese NAFLD)	Group 1b (Lean NAFLD)	Group 2a (Obese non-NAFLD)	Group 2b (Lean non-NAFLD)	P
Fat mass (12.3-24.6kg)	43.63 ± 19.46	22.20 ± 1.86	36.98 ± 15.84	17.12 ± 5.11	**<0.001***
Significance between groups	$p_1<0.001^*$, $p_2=0.436$, $p_3=0.097$, $p_4<0.001^*$				
Weight without fat	53.54 ± 10.23	43.18 ± 7.16	57.63 ± 14.65	48.88 ± 9.62	**<0.001***
Significance between groups	$p_1=0.005^*$, $p_2=0.537$, $p_3=0.247$, $p_4=0.025^*$				
Muscle mass (44.8-67.1kg)	41.39 ± 13.41	39.94 ± 4.42	52.37 ± 5.16	54.11 ± 6.10	**<0.001***
Significance between groups	$p_1=0.194$, $p_2<0.001^*$, $p_3<0.001^*$, $p_4=0.490$				
Protein mass (17.9-20.1kg)	15.16 ± 1.82	16.16 ± 1.34	18.68 ± 0.77	18.98 ± 0.66	**<0.001***
Significance between groups	$p_1=0.252$, $p_2<0.001^*$, $p_3<0.001^*$, $p_4=0.472$				
Visceral fat (1-12healthy level,13-59 undesirable level).	19.36 ± 5.44	50.68 ± 5.80	9.24 ± 1.36	8.52 ± 1.26	**<0.001***
Significance between groups	$p_1<0.001^*$, $p_2<0.001^*$, $p_3<0.001^*$, $p_4=0.924$				
Subcutaneous fat (7-15%)	37.26 ± 11.96	17.14 ± 1.07	19.79 ± 2.66	7.80 ± 2.87	**<0.001***
Significance between groups	$p_1<0.001^*$, $p_2=0.002^*$, $p_3<0.001^*$, $p_4<0.001^*$				
BFR (11%-22%)	43.86 ± 12.06	26.20 ± 1.49	38.97 ± 9.55	16.44 ± 4.57	**<0.001***
Significance between groups	$p_1<0.001^*$, $p_2=0.252$, $p_3<0.001^*$, p4<0.001*				
SMM (>35%)	32.40 ± 1.15	32.16 ± 1.25	73.72 ± 7.08	70.76 ± 6.65	**<0.001***
Significance between groups	$p_1=0.998$, $p_2<0.001^*$, $p_3<0.001^*$, $p_4=0.155$				
SMI	27.89 ± 3.23	24.57 ± 2.53	36.92 ± 1.18	39.0 ± 1.83	**<0.001***
Significance between groups	$p_1<0.001^*$, $p_2<0.001^*$, $p_3<0.001^*$, $p_4=0.026^*$				
FFMI	20.25 ± 0.21	21.20 ± 0.36	14.48 ± 2.24	17.37 ± 3.58	**<0.001***

Significance between groups		$p_1=0.005^*$,	$p_2<0.001^*$,	$p_3<0.001$	*, $p_4=0.224$	
FMI		22.37 ± 4.48	19.64 ± 0.71	11.81 ± 3.17	6.14 ± 2.27	**<0.001***
Significance between groups		$p_1=0.012^*$, $p_2<0.001^*$, $p_3<0.001^*$, $p_4=0.006^*$				
		Group1a(Obese NAFLD) (n =25) No. (%)		**Group1b(Lean NAFLD) (n =25) No. (%)**		
Metabolic syndrome	**Absent**	7 (28.0)		23 (92.0)		<0.001*
	Present	18 (72.0)		2 (8.0)		
		Group1 (NAFLD) (n =50)		**Group2 (non-NAFLD) (n =50)**		
Fat mass (12.3-24.6kg)		25.15 (22.0 – 35.0)		24.45 (16.0 – 33.0)		0.085
Weight without fat		48.36 ± 10.18		53.25 ± 13.04		0.039*
Muscle mass (44.8-67.1kg)		40.67 ± 9.91		53.24 ± 5.66		<0.001*
Protein mass (17.9-20.1kg)		15.66 ± 1.66		18.83 ± 0.72		<0.001*
Visceral fat (1-12healthy level,13-59undesirable level)		35.02 ± 16.77		8.88 ± 1.35		<0.001*
Subcutaneous fat (7-15%)		27.20 ± 13.19		13.80 ± 6.65		<0.001*
BFR (11%-22%)		35.03 ± 12.32		27.70 ± 13.58		0.001*
Skeletal muscle mass (SMM) (>35%)		32.28 ± 1.20		72.24 ± 6.96		<0.001*
SMI		26.23 ± 3.32		37.96 ± 1.85		<0.001*
FFMI		20.72 ± 0.56		15.93 ± 3.29		<0.001*
FMI		21.01 ± 3.46		8.98 ± 3.96		<0.001*

The three main statistical measures of data are mean, SD, and median (IQR). FMI refers for "fat mass index," FFMI stands for "free-fat mass index," SMM is for "skeletal muscle mass," and BFR stands for "body fat ratio." p stands for the p-value used to compare the four study groups, p1 for the comparison between Group 1a and Group 1b, p2 for the comparison between Group 1a and Group 2a, p3 for the comparison between Group 1b and Group 2b, and p4 for the comparison between Group 2a and Group 2b. *: Statistically significant at $p \leq 0.05$

There was positive correlation between steatosis score in group 1 with weight (P=0.023), BMI, waist circumference, hip circumference, alkaline Phosphatase, GGT, neutrophil percentage, neutrophil/lymphocyte ratio, fat mass, weight without fat, subcutaneous fat, body fat ratio, fat mass index, and visceral fat (P<0.001), systolic blood pressure (P=0.004), diastolic blood pressure (P=0.010), fasting blood sugar (P=0.041). There was negative correlation between steatosis score in group 1 with HDL, platelets, and free-fat mass index (P =0.021, =0.0036, and < 0.001 respectively). Table 4

Table 4: demonstrates the correlation between the group 1 steatosis score and several factors(n= 50)

	Steatosis score	
	r_s	P
Age (years)	0.240	0.093
Height (cm)	-0.322	0.23
Weight (kg)	0.601	<0.001*
BMI (kg/m2)	0.663	<0.001*
Waist (cm)	0.679	<0.001*
Hip	0.681	<0.001*
WHR	-0.236	0.099
Systolic	0.399	0.004*
Diastolic	0.361	0.010*
ALT	0.092	0.526
AST	0.113	0.436
Bilirubin	-0.098	0.499
Albumin	-0.248	0.082
INR	0.027	0.854
Fasting sugar	0.290	0.041*
HbA1C	-0.126	0.385
TG	0.211	0.141
Cholesterol	0.199	0.166
LDL	-0.019	0.893
HDL	-0.325	0.021*
VLDL	-0.098	0.496
Alkaline phosphatase	0.518	<0.001*
GGT	0.619	<0.001*
Uric acid	-0.306	0.031*

HB	-0.089	0.537
WBC	-0.204	0.155
Lymphocyte	-0.045	0.758
Neutrophil	0.526	<0.001*
Neutrophil lymphocyte ratio	0.464	0.001*
Platelets	-0.298	0.036*
HOMA	-0.038	0.796
Fat mass	0.655	<0.001*
Weight without fat	0.444	0.001*
Muscle mass	0.098	0.496
Protein mass	-0.035	0.807
Visceral fat	0.452	0.001*
Subcutaneous fat	0.468	0.001*
BFR	0.634	<0.001*
SMM	-0.053	0.715
SMI	0.051	0.726
FFMI	-0.613	<0.001*
FMI	0.453	0.001*
Urea	0.038	0.792
Creatine	0.014	0.925

The waist-hip ratio (WHR) and body mass index (BMI) International normalized ratio (INR), aspartate aminotransferase (AST), and alanine transaminase (ALT) Triglycerides, glycated haemoglobin (HbA1C), and the three different forms of lipoproteins are low-density lipoprotein, high-density lipoprotein, and very low-density lipoprotein. Gamma-glutamyl transferase, also known as GGT, haemoglobin (HB), white blood cells, or WBC, and body fat ratio, or BFR mass of skeletal muscles (SMM) Index of skeletal mass (SMI) FMI, also known as "Free-Fat Mass Index," stands for "Fat Mass Index." Abbreviation for the Spearman coefficient: rs; $p \leq 0.05$ denotes statistical significance.

There was a positive correlation between steatosis score in group 1a with systolic blood pressure, diastolic blood pressure, and elevated triglycerides (P=0.039, =0.002, and =0.012 respectively). There was positive correlation between steatosis score in group 1b with LDL, and HOMA IR (P=0.022, and =0.008 respectively). There was negative correlation in steatosis score in group 1b with Skeletal mass index (P=0.036). Table 5

Table 5: demonstrates the correlation between the steatosis score and several parameters in groups 1a and 1b

	Steatosis score

	Group 1a (Obese NAFLD)		Group 1b (Lean NAFLD)	
	r_s	P	r_s	P
Age (years)	-0.026	0.902	0.222	0.286
Height (cm)	0.079	0.706	-0.226	0.277
Weight (kg)	0.296	0.151	-0.002	0.991
BMI (kg/m2)	0.252	0.224	0.225	0.280
Waist (cm)	0.325	0.113	0.339	0.098
Hip	0.289	0.162	0.326	0.112
WHR	0.245	0.237	0.154	0.464
Systolic	0.415	0.039*	-0.054	0.797
Diastolic	0.579	0.002*	0.030	0.887
ALT	-0.296	0.151	0.372	0.067
AST	0.081	0.701	-0.023	0.914
Bilirubin	0.128	0.543	-0.103	0.623
Albumin	-0.026	0.900	-0.080	0.705
INR	0.163	0.436	0.251	0.226
Fasting sugar	0.069	0.742	0.217	0.297
HbA1C	0.048	0.819	-0.139	0.507
TG	0.492	0.012*	0.120	0.568
Cholesterol	-0.217	0.298	-0.157	0.453
LDL	-0.233	0.262	0.456	0.022*
HDL	-0.135	0.520	0.173	0.408
VLDL	0.219	0.293	-0.135	0.519
Alkaline phosphatase	-0.151	0.472	-0.054	0.796
GGT	0.156	0.457	0.125	0.552
Uric acid	0.064	0.761	-0.306	0.137
HB	-0.089	0.672	-0.258	0.213
WBC	0.030	0.886	-0.156	0.458
Lymphocyte	-0.004	0.986	-0.228	0.274
Neutrophil	-0.061	0.774	-0.156	0.457
Neutrophil lymphocyte ratio	-0.009	0.965	0.188	0.369
Platelets	0.334	0.102	0.208	0.319
HOMA IR	0.078	0.710	0.519	0.008*
Fat mass	0.118	0.575	0.312	0.129
Weight without fat	0.370	0.069	-0.091	0.664
Muscle mass	0.061	0.771	0.127	0.545
Protein mass	0.239	0.250	0.254	0.220
Visceral fat	0.344	0.092	0.074	0.725
Subcutaneous fat	0.172	0.412	-0.388	0.055
BFR	0.067	0.752	0.339	0.097
SMM	-0.071	0.737	-0.278	0.178
SMI	-0.354	0.082	-0.421	0.036*
FFMI	-0.038	0.858	0.112	0.593
FMI	-0.046	0.827	0.113	0.591

Urea	-0.244	0.241	-0.167	0.426
Creatine	-0.011	0.960	-0.015	0.945

The waist-hip ratio (WHR) and body mass index (BMI) International normalized ratio (INR), aspartate aminotransferase (AST), and alanine transaminase (ALT) glucose-added haemoglobin Triglycerides of HbA1C, or TG The three different forms of lipoprotein are low-density lipoprotein, high-density lipoprotein, and very low-density lipoprotein. Gamma-glutamyl transferase, also known as GGT, haemoglobin (HB), white blood cells, or WBC, and body fat ratio, or BFR mass of skeletal muscles (SMM) Free-fat mass index (FFMI), fat mass index (FMI), and skeletal mass index (SMI). Spearman coefficient, and * denotes a ≤0.05 level of statistical significance.

Elevated systolic blood pressure, elevated diastolic blood pressure, and elevated triglycerides were risk factors for the development of NAFLD in obese patients (P=0.042, =0.002, and =0.003 respectively) These risk variables were identified using a univariate analysis. When multivariate analysis was done to determine these risk factors, high systolic blood pressure and high triglycerides were the only independent risk factors for the development of NAFLD in obese individuals (P=0.017 and =0.024, respectively). Table 6

Table 6: shows Analysis of the characteristics influencing the steatosis score in group 1a using univariate and multivariate linear regression

	Univariate		#Multivariate	
	P	B (LL – UL 95%C.I)	P	B (LL – UL 95%C. I)
Age (years)	**0.832**	**-0.139 (-1.481 – 1.203)**		
Height (cm)	**0.860**	**0.175 (-1.857 – 2.207)**		
Weight (kg)	**0.199**	**0.454 (-0.256 – 1.164)**		
BMI (kg/m2)	**0.272**	**0.963 (-0.809 – 2.736)**		
Waist (cm)	**0.081**	**0.929 (-0.122 – 1.980)**		
Hip	**0.191**	**0.670 (-0.359 – 1.700)**		
WHR	**0.22**	**150.907 (-**		

	0	96.655 – 398.47)		
Systolic	0.042*	0.913 (0.037 – 1.790)	0.017*	-0.480 (-1.596 – 0.636)
Diastolic	0.002*	2.467 (1.022 – 3.912)	0.381	2.401 (0.351 – 4.451)
ALT	0.185	–2.427 (-6.101 – 1.247)		
AST	0.525	1.735 (-3.825 – 7.295)		
Bilirubin	0.387	31.509 (-42.421 – 105.438)		
Albumin	0.788	6.696 (-44.221 – 57.614)		
INR	0.777	82.112 (-509.53 – 673.75)		
Fasting sugar	0.736	0.258 (-1.305 – 1.820)		
HbA1C	0.598	8.794 (-25.200– 42.788)		
TG	0.003*	0.378 (0.143 – 0.612)	0.024*	0.282 (0.042 – 0.523)
Cholesterol	0.495	-0.098 (-0.390 – 0.194)		
LDL	0.362	-0.126 (-0.406 – 0.154)		
HDL	0.406	-0.580 (-1.999 – 0.838)		
VLDL	0.116	0.778 (-0.208 – 1.764)		
Alkaline phosphatase	0.458	-0.546 (-2.042 – 0.949)		
GGT	0.361	2.849 (-3.472 – 9.469)		
Uric acid	0.904	1.253 (-19.900 – 22.406)		
HB	0.574	-3.537 (-16.354 – 9.280)		
WBC	0.597	2.106 (-6.027 – 10.239)		
Lymphocyte	0.83	-0.846 (-9.105 –		

	4	7.414)		
Neutrophil	0.749	-0.505 (-3.732 – 2.721)		
Neutrophil lymphocyte ratio	0.869	-4.798 (-64.387 – 54.791)		
Platelets	0.376	0.076 (-0.095 – 0.246)		
HOMA	0.366	-32.514 (-105.52–40.49)		
Fat mass	0.553	0.243 (-0.592 – 1.079)		
Weight without fat	0.090	1.285 (-0.218 – 2.788)		
Muscle mass	1.000	0.0 (-1.222 – 1.222)		
Protein mass	0.209	5.422 (-3.263 – 14.107)		
Visceral fat	0.076	2.522 (-0.287 – 5.332)		
Subcutaneous fat	0.463	0.488 (-0.866 – 1.841)		
BFR	0.899	0.085 (-1.274 – 1.443)		
SMM	0.912	-0.762 (-14.946 – 13.421)		
SMI	0.133	-3.633 (-8.460 – 1.194)		
FFMI	0.657	-17.183 (-96.210 – 61.844)		
FMI	0.485	1.242 (-2.379 – 4.863)		
Urea	0.277	-2.482 (-7.097 – 2.132)		
Creatine	0.996	-0.334 (-153.96–153.29)		

The waist-hip ratio (WHR) and body mass index (BMI) International normalized ratio (INR), aspartate aminotransferase (AST), and alanine transaminase (ALT) TG: HbA1C Triglycerides, or glycated haemoglobin the three different forms of lipoprotein are low-density lipoprotein, high-density lipoprotein, and very low-density lipoprotein. White blood cells, or WBC, gamma-glutamyl transferase, or GGT, haemoglobin (HB), and Body Fat Ratio (BFR) and the Homeostatic Model Assessment (HOMA) mass of skeletal muscles (SMM)

Free-fat mass index (FFMI), fat mass index (FMI), and skeletal mass index (SMI). B: Variable Coefficients Indicator of confidence (C.I. Lower Limit: LL, Upper Limit: UL #: All variables with p <0.05, *: Significant statistically at p ≤ 0.05, were included in the multivariate analysis.

The risk variables for NAFLD in lean individuals were increased triglycerides, reduced lymphocytes, increased neutrophil/lymphocyte ratio, increased HOMA, and decreased free-fat mass index (P=0.028, 0.015, =0.039, 0.001, and =0.002, respectively). These risk variables were found using univariate analysis.

The only other independent risk factor for the emergence of NAFLD in thin people was an increase in HOMA IR (P=0.008). The independent risk factors for the development of NAFLD in lean patients were found using multivariate analysis. Table7

Table 7: shows Analysis of the characteristics influencing the steatosis score in group 1b using univariate and multivariate linear regression

	Univariate		#Multivariate	
	P	B (LL – UL 95%C. I)	P	B (LL – UL 95%C. I)
Age (years)	0.229	0.602(-0.407 – 1.610)		
Height (cm)	0.497	-0.579(-2.314 – 1.156)		
Weight (kg)	0.484	0.465(-0.887 – 1.818)		
BMI (kg/m2)	0.066	5.206(-0.380 – 10.792)		
Waist (cm)	0.238	0.404(-0.285 – 1.093)		
Hip	0.392	0.251(-0.343 – 0.844)		
WHR	0.463	41.926(-74.292 – 158.145)		
Systolic	0.822	0.098(-0.788 – 0.984)		
Diastolic	0.706	0.353(-1.559 –		

		2.265)		
ALT	0.450	2.451(0.055 – 4.847)		
AST	0.321	1.013(-1.053 – 3.080)		
Bilirubin	0.808	8.455(-62.516 – 79.425)		
Albumin	0.925	1.108(-22.876 – 25.092)		
INR	0.828	23.356(-197.10 – 243.81)		
Fasting sugar	0.714	-0.150(-0.84 – 0.685)		
HbA1C	0.465	-8.772(-33.196 – 15.652)		
TG	0.028*	0.475(0.055 – 0.896)	0.238	0.188(-0.136 – 0.513)
Cholesterol	0.648	0.055(-0.192 – 0.302)		
LDL	0.222	0.182(-0.118 – 0.483)		
HDL	0.321	0.330(-0.343 – 1.002)		
VLDL	0.424	-0.307(-1.088 – 0.473)		
Alkaline phosphatase	0.966	0.025(-1.166 – 1.216)		
GGT	0.679	0.587(-2.315 – 3.489)		
Uric acid	0.088	-8.192(-17.695 – 1.311)		
HB	0.379	-3.082(-10.189 – 4.024)		
WBC	0.820	-0.565(-5.631 – 4.501)		
Lymphocyte	0.015*	-4.564(-8.167 –-0.962)	0.384	-4.742(-15.905 – 6.420)
Neutrophil	0.885	-0.469(-7.069 – 6.132)		
Neutrophil lymphocyte ratio	0.039*	44.239(2.333 – 86.145)	0.643	-30.806(-168.20 –

				106.59)
Platelets	0.734	0.021(-0.107 – 0.150)		
HOMA	<0.001*	96.334(67.386 – 125.282)	0.008*	74.094(21.665 – 126.523)
Fat mass	0.111	3.910(-0.966 – 8.786)		
Weight without fat	0.779	0.184(-1.157 – 1.525)		
Muscle mass	0.608	0.544(-1.620 – 2.708)		
Protein mass	0.493	2.396(-4.721 – 9.513)		
Visceral fat	0.101	1.290(-0.272 – 2.853)		
Subcutaneous fat	0.087	-7.321(-15.782 – 1.141)		
BFR	0.072	5.467(-0.526 – 11.461)		
SMM	0.571	-2.127(-9.785 – 5.530)		
SMI	0.193	-2.374(-6.036 – 1.288)		
FFMI	0.002*	-36.668(-58.325 –- 15.010)	0.729	-4.438(-30.914 – 22.038)
FMI	0.664	-2.865(-16.348 – 10.617)		
Urea	0.298	-1.238(-3.644 – 1.168)		
Creatine	0.800	-12.613(-114.65 – 89.43)		

The waist-hip ratio (WHR) and body mass index (BMI) The aspartate aminotransferase (AST), alanine transaminase (ALT), and the international normalized ratio (INR) TG: HbA1C Triglycerides, or glycated haemoglobin the three different forms of lipoprotein are low-density lipoprotein, high-density lipoprotein, and very low-density lipoprotein. White blood cells, or WBC, gamma-glutamyl transferase, or GGT, haemoglobin (HB), and Body Fat Ratio (BFR) and the Homeostatic Model Assessment (HOMA) mass of skeletal muscles (SMM) Free-fat mass index (FFMI) and skeletal mass index (SMI) the FMI, or fat mass index.B: Variable Coefficients Indicator of confidence (C.I. Lower Limit: LL, Upper Limit:

UL #: All variables with a p-value of <0.05 or below were included in the multivariate analysis. *: statistically significant at p≤ 0.05

Discussion

NAFLD is one of the most common liver illnesses in both developed and developing nations, with an estimated prevalence of 20–40%[10]. However, it is now understood that the illness can also affect people who are not fat, particularly in Asia[5].

Recent epidemiological studies have reportedan increasein non-obese individuals who have NAFLD worldwide.Our study's objectives were to evaluate the degree of liver steatosis, metabolic profiles, and risk factors in lean NAFLD patients as well as to compare hepatic steatosis and body composition analyses between obese and lean NAFLD patients[6].

In the current study, the waist/hip ratios of both the obese NAFLD group and the obese non-NAFLD group increased statistically significantly when compared to the lean NAFLD group and the obese NAFLD group, respectively. These results corroborate those of **Hartz et,** who discovered that even in women with similar total body fat, having much more fat around the waist than the hips were associated with a higher incidence of disease**[11]**.

There was a statistically significant increase in neutrophil percentage in the NAFLD group when compared to the control group, in the obese NAFLD group when compared to the lean NAFLD group 1b, in the obese NAFLD group when

compared to the group lean non-NAFLD, and in the group lean NAFLD when compared to the group lean non-NAFLD, according to **Jaeschke & Hasegawa** [12].This might be explained by neutrophils being present in the hepatic inflammatory infiltrate of NAFLD. Neutrophils become up due to oxidative stress and hepatocyte necrosis [12].It is now understood that neutrophils, the most common leukocytes in blood, are the first immune cells to enter adipose tissue[11]. Following their activation, neutrophils discharge inflammatory substances that draw in macrophages and other immune cells. Lipotoxicity, insulin resistance, and inflammation are all thought to cause an increase in lymphocytes [13]. Through the production of cytokines and chemokines that can spread to other bodily areas, these immune cells in turn help to keep the inflammatory condition going[13].

The study found that the ratio of neutrophils to lymphocytes was higher in people with NAFLD compared to those without it. People who were both obese and had NAFLD had a higher ratio than those with NAFLD who were not obese. The ratio was also higher in lean people with NAFLD compared to lean people without it. Obese people without NAFLD also had a higher ratio than lean people without NAFLD.

Also, regarding correlation analysis done for NAFLD group,there was positive correlation between steatosis score in NAFLD group withneutrophil/lymphocyte ratio. Our work is conglomerate with ***Paquissi***who statedthat NLR increase in NAFLD either obese or lean patients. In NAFLD,

there are differences in the immune system at a tiny level that can show up as signs in the body. NLR means there are more neutrophils than lymphocytes in the body. This can predict how well someone with NAFLD will do in the future[14].

The study found that people with NAFLD had higher levels of triglycerides compared to those without the condition. This was true for both obese and lean people with NAFLD. Obese people without NAFLD also had higher triglyceride levels compared to lean people without NAFLD. Our findings support the same conclusion as ***Difilippis & his colleagues*** that having non-alcoholic fatty liver disease (NAFLD) is linked to having higher levels of triglycerides in the blood when not eating [15].Our findings match those of **Kawano &Cohen,**they found that people with NAFLD who are obese tend to have high levels of triglycerides in their blood. NAFLD is when fat builds up in the liver cells. This happens when the body takes in too much fat and doesn't burn it off enough. When a person is overweight, they can have problems with their heart and blood. These problems include high triglycerides, bad cholesterol, low good cholesterol, high sugar and insulin levels, and high blood pressure[16].

There was not a big difference in cholesterol between the two groups that were studied. But the group of obese people who had NAFLD had more of an increase in cholesterol than the group of lean people who had NAFLD. Also, the group of obese people who did not have NAFLD had more of an increase in

cholesterol than the group of lean people who did not have NAFLD. This study agrees with **Nestel and colleagues**, who found that having too much cholesterol in the form of LDL is a part of the metabolic syndrome that overweight people with NAFLD often have [17]. Our results are inconsistent with those of **Malhotra. They** suggested that NAFLD is associated with higher-than-normal cholesterol levels [18].

The NAFLD group had a statistically significant rise in VLDL compared to the control group, the NAFLD obese group had a statistically significant increase compared to the non-NAFLD obese group, and the NAFLD lean group had a statistically significant increase. There was a noticeable rise. Comparing the group to a lean non-NAFLD group. These results agree with those of **Fon Tacer & Rozman,** in insulin resistant patients he agrees with those who found increased secretion of VLDL [19].

In the NAFLD group, our study's correlation analysis revealed a positive link between the steatosis score and the systolic and diastolic blood pressure. In the obese NAFLD group, there was a positive association between the steatosis score and the systolic and diastolic blood pressure. Our findings agree with those of **Yoo et,** in obese NAFLD patients in South Korea, researchers find significant positive correlations between ALT, lipid profile, BMI, waist circumference, and systolic and diastolic blood pressure **[20]**.

The presence of diastolic hypertension in NAFLD patients suggests that increased hepatic fat impairs the proper functioning of the cardiovascular

system, and that diastolic hypertension alone is associated with high levels of triglycerides and body fat, which is It is explained by the fact that it causes vascular resistance [21]. In our study, there was a negative correlation between adiposity score and skeletal mass index in the lean NAFLD group. These findings are in line with those of **Donini et,** who have demonstrated that obesity may cause muscle mass loss on its own [22].

Comparing the obese NAFLD group to the obese non-NAFLD group, a statistically significant drop in protein abundance was observed. In comparison to the lean non-NAFLD group, a statistically significant decrease was seen in the lean NAFLD group. Our findings concur with those of **Yodoshi et,** who demonstrated that NAFLD is connected to a reduction in protein abundance**[23]**. This may be attributed to the role of skeletal muscle and liver in insulin metabolism,they are crucial for the metabolism of glucose and are insulin target tissues. Both muscle and liver glycogen are involved in the human body's energy metabolism. A pathological condition known as insulin resistance (IR) occurs when cells do not react to the hormone insulin as they should. Recent studies have shown that IR can disrupt glucose metabolism and may also have a significant role in the loss of muscle mass and the emergence of her NAFLD[24]**.**

The link between adiposity score and platelets in the NAFLD group in the current study's correlation analysis of that group revealed a negative correlation. The outcomes here agree with those of **Garjani et** c. According to **López-Trujillo and his team,** almost a quarter of NAFLD patients have

thrombocytopenia[25][26]. These results are also shared by **Rivera-Alvarez and his collegues**demonstrated that NAFLD is a hepatic component of insulin resistance. Insulin resistance by itself does not cause thrombocytopenia in the absence of NAFLD [27]. A decrease in platelet count seems to need structural or circulatory abnormalities inside the liver. Although various theories have been put up, the precise etiology of thrombocytopenia in NAFLD is uncertain. These theories include some degree of hypersplenism, bone marrow hypoplasia, and peripheral blood cell depletion.Survival, thrombopoietin deficiency, etc. Due to possible hypersplenism, if symptoms lead to granulocytopenia, the association between NAFLD and granulocytopenia, as well as thrombocytopenia and hypersplenism, is somehow responsible for the cytopenia seen in NAFLD patients. There is a possibility. On the other hand, these results are inconsistent with those of his **Garjani et,** I agree with those who found that NAFLD is associated with thrombocytosis[28].

In this study of correlation analysis performed on the NAFLD group, a positive correlation was found between adiposity score and GGT and alkaline phosphatase in the NAFLD group. Furthermore, our results are consistent with those of **López-Amador et,** I agree with those who noted a slight increase in ALP values**[29]**.

This shows that extracellular glutathione, a crucial antioxidant in the body's defense systems, is triggered by oxidative stress in NAFLD patients who also

have insulin resistance, and that GGT plays a significant role in extracellular glutathione production and metabolism[30].

Regarding the investigation of the relationship between steatosis score and high triglycerides in the group of obese NAFLD patients, a positive relationship was found. Additionally, **Kawano and Cohen's** findings that obese NAFLD was linked to elevated blood triglycerides are consistent with our findings[16].

There was a positive link between the steatosis score in the lean NAFLD group and LDL according to the correlation analysis of the steatosis score. Our findings concur with those of **Fon Tacer and Rozeman,** who reported that individuals with NAFLD also had higher plasma LDL[19].

Regarding the correlation study performed for the NAFLD group, the steatosis score in the NAFLD group and HDL had a negative connection. Our findings are consistent with those of **Difilippis et**, who found no differences in total cholesterol or LDL levels and that NAFLD was related with decreased serum HDL[31].

In terms of the examination of the relationship between waist circumference and steatosis score in the NAFLD group, the relationship was favorable. Our findings support those of **Tominaga with his collegues,** who found a tight connection between WC and the incidence of NAFLD in children and adolescents[32].

According to our study on the correlation analysis performed for the NAFLD group, there was a positive association between the NAFLD group's steatosis

score and visceral fat. These findings are in line with those of **Ko et**[33], who claimed that a greater amount of body and visceral fat and the MS greatly increased the likelihood of developing NAFLD. Additionally, these findings support those of **Dai et,** who found that both non-obese and obese people's risk of developing NAFLD and fibrosis was strongly correlated with their FM/FFM ratio[34].

According to the correlation analysis performed for the NAFLD group, subcutaneous fat and steatosis score were positively correlated. These findings support those of **Ranasinghe et**, who found a substantial correlation between obesity in NAFLD patients and body fat percentage (BF%) as measured by bioelectrical impedance[35].

Only high TG and raised systolic blood pressure were independent risk factors for NAFLD in obese people. These findings support those of **Sookoian & Pirola,** who found that obese NAFLD had greater levels of systolic, diastolic, and TG elevations than lean NAFLD had[36].

Reduced FFMI was one of the risk variables for NAFLD in lean people**. Dai et's** findings, which showed that fat mass increased but fat-free mass (FFM) decreased in lean NAFLD, were consistent with our findings[34].

Elevated TG was a risk factor for NAFLD in lean people. Our results support **Wang et**'s discovery that lean NAFLD seems to have a greater TG level than obese NAFLD [37], which is supported by their data. However, **Li et** reached a different conclusion and discovered that lean NAFLD patients had a higher

prevalence of normal TG patients and that the proportion of elevated TG patients was larger in the obese NAFLD group[38].

Limitations: small sample size, short duration of collecting cases, lack of evaluation of diagnosis NAFLD and fibrosis with liver biopsy because of its invasive nature.

Conclusions:

Insulin resistance and sarcopenia were the two risk factors for NAFLD that were most common in slim people. BMI is less reliable than visceral obesity for detecting NAFLD suspicion. Despite not presenting with obesity, those with lean/non-obese NAFLD have increased visceral adiposity, and sarcopenia is a typical symptom. The evaluation of body composition may aid in the identification of high-risk individuals since both traits interact to affect the outcome.

Ethical Approval:

After receiving clearance (34854/8/21) from the Tanta University Department of Tropical Medicine and Infectious Diseases Ethical Committee, the study was carried out from January 10, 2021, for a period of six months.

Consent

The patients provided signed consent after being fully briefed.

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