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ARTICLE

Association Between Liver and Muscle Fat Fractions: A Study Using the Proton Density Fat Fraction MRI

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Abstract

Aims/Background Metabolic dysfunction-associated steatotic liver disease (MASLD) is a common condition linked to insulin resistance and metabolic syndrome, potentially leading to liver fibrosis. Myosteatosis shares common pathophysiological pathways with MASLD. This study aims to evaluate the relationship between psoas and paraspinal muscle fat content and liver fat content, and compare the muscle fat content in patients with and without fatty liver.

Methods Patients who underwent T2* Magnetic Resonance Imaging (T2*MRI) between January 2023 and November 2024 in the Bilkent City Hospital, Ankara, Turkey, were included in the study (n = 280). Fat fractions were determined using the Proton Density Fat Fraction (PDFF). The relationship between liver fat fraction and psoas and paraspinal muscle fat fractions was analysed using age- and sex-adjusted regression models.

Results Fatty liver was observed more in men than in women (68% vs. 50%, $p = 0.003$). Psoas and paraspinal muscle fat fractions were significantly higher in patients with versus without fatty liver ($p < 0.001$). The regression analysis revealed that both psoas ($p = 0.002$) and paraspinal muscle ($p < 0.001$) fat fractions had significant non-linear associations with liver fat fraction. The area under the receiver operating characteristic (ROC) curves demonstrated that the discriminative value of psoas and paraspinal muscle fat fractions for fatty liver were comparable (0.715 vs. 0.678, respectively; $p = 0.249$). Psoas muscle fat fraction of ≥4.5% and paraspinal muscle fat fraction of ≥7% had a sensitivity of 69.3% and 62.0%; specificity of 65.8% and 72.8%; positive predictive value of 74.7% and 76.9%; and negative predictive value of 59.5% and 56.8% for the diagnosis of fatty liver, respectively.

Conclusion There is a non-linear and significant relationship between liver fat fraction and psoas and paraspinal muscle fat fractions. The fat fractions of the psoas and paraspinal muscles were significantly higher in patients with fatty liver, and the diagnostic efficacy level for fatty liver was moderate, and the discriminant values of the two were comparable.

Key words: fatty liver; hepatosteatosis; myosteatosis; magnetic resonance imaging

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Introduction

Hepatosteatosis is an increasing health problem worldwide and is an important aetiological cause of chronic liver disease. The estimated global prevalence is around 30% (Le et al, 2022). It can progress to steatohepatitis, fibrosis, and cirrhosis (Rinella et al, 2023). Therefore, the diagnosis of liver steatosis and taking preventive measures are important for public health. Hepatic steatosis has been associated with metabolic syndrome and cardiometabolic diseases. Therefore, metabolic

dysfunction-associated steatotic liver disease (MASLD) has been the preferred terminology in recent years (Rinella and Sookoian, 2024).

Myosteatosis is an increased intramuscular lipid accumulation and is a pathological condition leading to impaired muscle function. A recent study has reported that myosteatosis is strongly correlated with the severity of liver injury (Nachit et al, 2021). Loss of muscle mass and muscle dysfunction are important causes of morbidity and mortality, especially among the elderly population. Myosteatosis leads to muscle dysfunction, which in turn leads to decreased mobility and muscle mass, and this can become a vicious cycle. Therefore, early detection and preventive measures are important.

The association of MASLD with myosteatosis and sarcopenia has been demonstrated in numerous studies. There is a crosstalk between the liver, skeletal muscle, and adipose tissue. Adipose tissue secretes bioactive substances called adipokines (Kim et al, 2022). Adipokines affect a number of systems in the body, including the liver and skeletal muscle, through various mechanisms, and some of them are associated with low-grade inflammation and metabolic syndrome (Kim et al, 2022). Myostatin is a myokine released from skeletal muscle, and it activates inflammation and fibrosis in the liver and proteolysis in skeletal muscle (Severinsen and Pedersen, 2020). Metabolic dysfunction and low-grade inflammation caused by these bioactive substances lead to the accumulation of free fatty acids, which in turn cause functional impairment in the affected tissues by lipotoxicity or other mechanisms. The liver and skeletal muscles are among the main target organs.

Liver biopsy is the gold standard for the diagnosis of hepatic steatosis. However, it is an invasive procedure, carries the risk of complications, and has the possibility of undersampling due to non-homogeneous fat distribution. Validation studies have demonstrated that imaging modalities correlate well with histopathological results in detecting the degree of fat accumulation in the liver (Kuru Öz et al, 2024). Using imaging modalities in diagnosis is more practical, non-invasive, and can also be used in the follow-up of disease progression.

Proton Density Fat Fraction (PDFF) is a Magnetic Resonance Imaging (MRI) method that can directly measure the fat content of muscle and liver as a percentage (De Munck et al, 2021). This new technique was found to be highly effective in the separation of signals from water and fat, and it correlates well with histopathologic results.

In this study, using the PDFF method with T2*MRI, we aimed to assess the relationship between liver and psoas and paraspinal muscle fat fraction in a single imaging and to evaluate how beneficial the muscle fat fraction is in showing fatty liver.

Methods

We planned to include all consecutive patients who met the inclusion and exclusion criteria between January 2023 and November 2024. The inclusion criteria were: (a) patients who underwent T2* PDFF MRI for liver fat fraction measurement, and (b) aged over 18 years. The exclusion criteria were: (a) poor image

quality, (b) a history of liver transplantation, and (c) presence of cirrhosis. As the relationship between muscle and liver fat fractions was assessed on the basis of in the same individuals using a single scan, therefore no restrictions were applied regarding the body mass index, presence or absence of diabetes mellitus, or a history of alcohol consumption. Among the 286 consecutive patients who underwent T2* PDFF MRI, only 6 were excluded due to poor image quality; thus, the final study population consisted of 280 patients (Fig. 1). All procedures were performed in compliance with the relevant laws and institutional guidelines. The study was conducted according to the Declaration of Helsinki and approved by the Institutional Ethics Committee of Bilkent City Hospital (approval number: TABED 2-25-925). In accordance with the national legislation and ethical guidelines in Turkey, written informed consent was waived by the Ethics Committee of Bilkent City Hospital due to the retrospective nature of the study, the use of anonymized data, lack of direct interventions and risk to participants, and the impracticability of contacting individuals, and this decision is also consistent with the principles outlined in the Declaration of Helsinki and complies with the data protection framework of the European Union General Data Protection Regulation 2016/679.

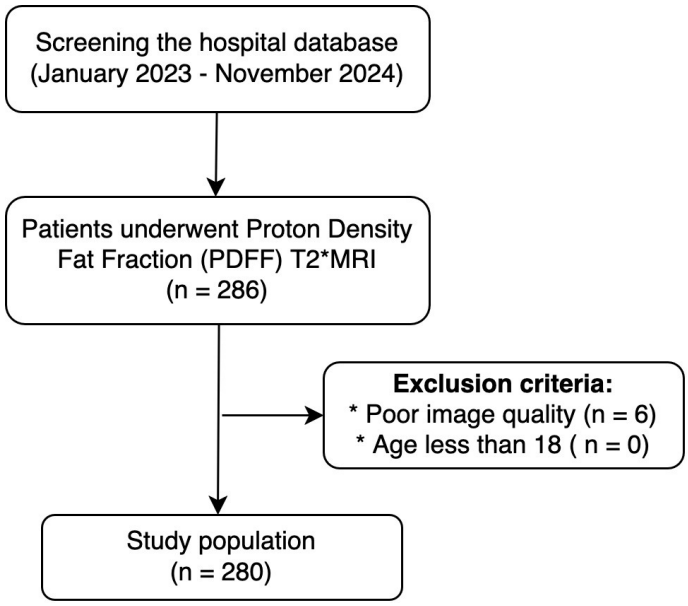

Fig. 1. Flowchart for patient selection. T2*MRI, T2* Magnetic Resonance Imaging.

Laboratory parameters that were performed within the two weeks preceding or following the MRI examination were used as baseline data.

MRI scans were done on SIGNA™ Pioneer3T MRI scanner (GE Healthcare, Waukesha, WI, USA) using the fat fraction sequence of IDEAL-IQ. MRI acquisition parameters for the PDFF sequence are as follows: Field of View (FOV): 44, Time to Repetition (TR): 5.8, Time to Echo (TE): min 0.7–max 4.2, slice thickness: 10, frequency phase: 160 × 160, Nex: 0.5.

Liver fat was measured by placing a region of interest (ROI) on the right lobe of the liver excluding vascular structures and biliary tract, and the average of three

measurements was used for analysis (Fig. 2). Signal intensity (SI) measurements were performed by placing ROIs in the centre of the right and left psoas major muscle and paraspinal muscle at the L1 vertebra and superior mesenteric artery level, respectively (Fig. 2). Muscle SI was determined by averaging two measurements from the right and left sides.

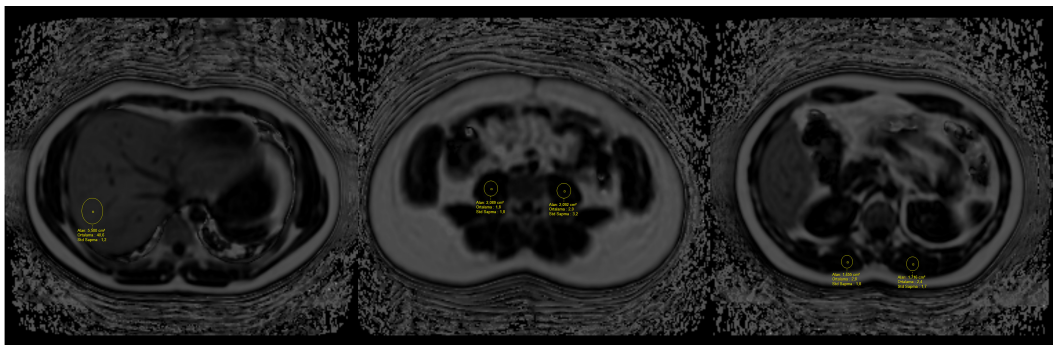

Fig. 2. Selection of region of interest (yellow circles) for the calculation of PDFF on liver (left panel), psoas muscle (middle panel), and paraspinal muscle (right panel). PDFF, Proton Density Fat Fraction.

Fatty liver disease was classified as mild (PDFF 5–14%), moderate (PDFF 15 to 24%), and severe steatosis (PDFF ≥25%) based on the average signal intensity obtained from the PDFF sequence (Starekova et al, 2021). A cut-off value of ≥5% was used to describe the presence or absence of fatty liver, and the discriminative performance of muscle fat fraction for the presence of fatty liver was assessed. Cut-off values for muscles were calculated based on the mean psoas and paraspinal muscle SI values in patients with and without fatty liver.

Statistical Analysis

Categorical data were expressed as frequencies and percentages and compared using the chi-squared test. Continuous variables were assessed for normality using the Kolmogorov-Smirnov test and quantile-quantile (QQ) plots. They were expressed as mean and standard deviation for normally distributed variables, and as median and interquartile range for non-normally distributed variables. Comparisons were made using the independent samples *t*-test for normally distributed data and the Mann-Whitney U test for non-normally distributed data.

Spearman correlation was used to assess the correlation between liver fat fraction and other continuous variables. Age- and sex-adjusted linear regression analysis was conducted to assess the relationship between liver fat fraction and psoas and paraspinal muscle fat fractions. In these models, restricted cubic splines with 4 knots were applied to the psoas and paraspinal muscle fat fraction to allow a non-linear relationship. The models with the psoas and paraspinal muscle fat fractions were conducted separately, and compared using the Akaike Information Criteria (AIC), for which lower values suggest a better model.

A liver fat fraction of ≥5% was considered fatty liver is present. Logistic regression was applied to assess the relationship between psoas and paraspinal muscle

fat fractions and the presence of fatty liver in age- and sex-adjusted models. The area under the receiver operating characteristic (ROC) curves was calculated separately for psoas and paraspinal muscle fat fractions. Subsequently, the best cut-off value that maximises the Youden's index was determined. Using those cut-off values, sensitivity, specificity, and positive and negative predictive values (PPV and NPV, respectively) were calculated.

Data were analysed using the R software version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) with "rms", "tidyverse", "ggcorrplot", "cutpointr", "plotROC", "epiR", and "patchwork" packages. A p-value of <0.05 was considered significant.

Results

The study population includes 280 patients. Nearly half of the patients (49%) were women. There was no significant difference in age between women and men ($p = 0.582$, Table 1). Biochemical parameters were given in Table 1, and suggest slight differences between women and men for alanine transaminase (ALT) ($p = 0.044$), albumin ($p = 0.016$), low-density lipoprotein (LDL)-cholesterol ($p = 0.013$), high-density lipoprotein (HDL)-cholesterol ($p < 0.001$), C-reactive protein ($p = 0.018$), and platelets ($p < 0.001$). The fibrosis-4 (FIB-4) score was similar, but the FIB-5 score was slightly, but significantly, higher in women than in men ($p = 0.008$). Liver fat fraction was higher in men than in women ($p = 0.010$). While the psoas muscle fat fraction was similar, the paraspinal muscle fat fraction was higher in women than in men ($p = 0.005$).

Table 2 shows the baseline characteristics of the patients with and without fatty liver. Half of the women had fatty liver, while the proportion was significantly higher in men (68%, $p = 0.003$). Patients with fatty liver were older compared to those without fatty liver ($p = 0.011$). As expected, glucose ($p < 0.001$), transaminases (p-values for ALT and aspartate transaminase (AST) were <0.001, and 0.006, respectively), LDL-cholesterol ($p = 0.020$), and triglycerides ($p < 0.001$) were significantly higher, and HDL-cholesterol levels ($p = 0.015$) were significantly lower in patients with fatty liver. Albumin level was also slightly, but significantly, higher in patients with fatty liver ($p < 0.001$). Also, psoas and paraspinal muscle fat fractions were significantly higher in patients with versus without fatty liver ($p < 0.001$; Table 2). No significant differences were observed in the FIB-4 and FIB-5 levels between the patients with and without fatty liver (p-values 0.052 and 0.725, respectively).

The correlation coefficients for fatty liver, metabolic parameters, and psoas and paraspinal muscle fat fraction are displayed in Fig. 3. There was a significant positive correlation between liver fat fraction and glucose ($p < 0.001$, r = 0.239), LDL-C ($p = 0.001$, r = 0.205), triglycerides ($p < 0.001$, r = 0.447), and psoas and paraspinal muscle fat fractions ($p < 0.001$, and r values 0.418 and 0.311, respectively), while a mild and negative correlation was observed between liver fat fraction and HDL-C ($p = 0.003$, r = –0.179).

Table 1. Baseline characteristics of the study population.

	Women	Men	Total	*t*/Z	*p*-value
n (%)	138 (49)	142 (51)	280 (100.0)		
Age, year	48.4 ± 13.2	47.5 ± 14.9	48.0 ± 14.1	0.551	0.582
Glucose, mg/dL	92.0 (83.8, 113.0)	93.0 (85.0, 115.0)	92.0 (84.0, 113.0)	–0.696	0.487
AST, U/L	20.0 (15.0, 34.0)	22.0 (15.0, 31.0)	21.0 (15.0, 31.8)	–0.603	0.547
ALT, U/L	28.0 (17.8, 54.2)*	33.0 (22.8, 63.0)*	30.0 (21.0, 56.0)	–2.013	0.044
ALP, U/L	86.0 (65.8, 112.2)	80.0 (63.0, 99.2)	84.0 (64.0, 104.0)	1.448	0.148
PLT ($\times 10^3$)	256.0 (206.8, 300.5)**	221.0 (178.2, 271.2)**	238.0 (189.2, 286.8)	3.522	<0.001
Albumin, g/L	44.5 (42.6, 46.1)*	45.4 (43.0, 47.6)*	45.0 (42.8, 46.9)	–2.409	0.016
LDL-C, mg/dL	105.5 (88.4, 128.3)*	97.9 (78.0, 117.8)*	102.4 (83.5, 126.8)	2.483	0.013
HDL-C, mg/dL	48.1 ± 14.1**	40.8 ± 11.8**	44.4 ± 13.5	4.444	<0.001
Triglycerides, mg/dL	124.5 (86.0, 170.7)	135.5 (93.0, 201.2)	128.5 (88.2, 187.0)	–1.617	0.106
CRP, mg/L	4.0 (1.6, 6.6)*	2.0 (0.8, 5.2)*	3.0 (1.0, 6.0)	2.377	0.018
FIB-4 score	0.8 (0.4, 1.1)	0.7 (0.5, 1.2)	0.7 (0.5, 1.1)	–0.379	0.704
FIB-5 score	42.7 (40.3, 45.0)*	41.1 (38.7, 44.4)*	42.1 (39.3, 44.9)	2.654	0.008
Liver fat fraction	4.5 (3.0, 11.0)*	8.0 (4.0, 15.0)*	6.0 (3.2, 12.8)	–2.595	0.010
Psoas muscle fat fraction	4.5 (3.5, 5.5)	4.5 (3.5, 6.0)	4.5 (3.5, 6.0)	–0.933	0.353
Paraspinal muscle fat fraction	7.0 (4.9, 11.0)*	6.0 (4.0, 8.5)*	6.5 (4.5, 10.0)	2.807	0.005

*$p < 0.005$; **$p < 0.001$. Continuous variables were expressed as mean ± standard deviation or median (quartile-1, quartile-3). ALP, alkaline phosphatase; ALT, alanine transaminase; AST, aspartate transaminase; CRP, C-reactive protein; FIB-4, fibrosis-4; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PLT, platelet.

Table 2. Baseline characteristics in patients with and without fatty liver.

	No fatty liver (n = 114)	Fatty liver (n = 166)	$t/Z/\chi^2$	*p*-value
Sex			8.977	0.003
Women	69/138 (50%)*	69/138 (50%)*		
Men	45/142 (32%)*	97/142 (68%)*		
Age, year	45.4 ± 14.1*	49.7 ± 13.8*	–2.551	0.011
Glucose, mg/dL	89.5 (82.0, 100.8)**	96.0 (86.2, 120.8)**	–4.131	<0.001
ALT, U/L	26.0 (17.2, 40.8)**	35.5 (23.2, 69.8)**	–4.237	<0.001
AST, U/L	18.0 (14.0, 27.0)*	23.0 (15.0, 33.0)*	–2.772	0.006
PLT ($\times 10^3$)	245.5 (191.0, 278.2)	232.0 (187.2, 292.8)	0.326	0.745
ALP, U/L	84.0 (61.2, 105.0)	84.0 (67.0, 102.8)	–0.403	0.687
Albumin, g/L	43.9 (41.5, 45.7)**	45.5 (43.6, 47.8)**	–4.564	<0.001
LDL-C, mg/dL	97.0 (79.0, 116.9)*	108.2 (86.8, 128.1)*	–2.428	0.020
HDL-C, mg/dL	46.9 ± 15.4*	42.7 ± 11.8*	–2.575	0.015
Triglycerides, mg/dL	99.0 (74.0, 136.5)**	151.5 (105.5, 215.8)**	–6.050	<0.001
CRP, mg/L	2.0 (0.6, 6.0)	3.0 (1.8, 6.0)	–1.623	0.105
Psoas muscle fat fraction	3.5 (3.0, 4.5)**	5.0 (4.0, 6.5)**	–6.143	<0.001
Paraspinal muscle fat fraction	5.5 (3.5, 7.4)**	7.8 (5.0, 11.5)**	–5.072	<0.001
FIB-4 score	0.6 (0.4, 1.1)	0.8 (0.5, 1.2)	–1.947	0.052
FIB-5 score	42.6 (38.8, 44.6)	41.8 (39.5, 44.9)	–0.353	0.725

*$p < 0.005$; **$p < 0.001$. Continuous variables were expressed as mean ± standard deviation or median (quartile-1; quartile-3). ALP, alkaline phosphatase; ALT, alanine transaminase; AST, aspartate transaminase; CRP, C-reactive protein; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PLT, platelet.

In the age- and sex-adjusted models, both psoas and paraspinal muscle fat fractions had significant non-linear associations with liver fat fraction (*p*-values were 0.002 and <0.001, respectively, Fig. 4). The Akaike Information Criteria (AIC) suggested that the model with psoas muscle was slightly better than that of paraspinal muscle in explaining the liver fat fraction (AIC values 666.30 vs. 684.33, respectively).

Using a liver fat fraction cut-off value of ≥5% to define fatty liver, the ROC curve analysis showed an area under the curve of 0.715 (95% confidence interval (CI): 0.654–0.776, $p < 0.001$) for the psoas major muscle fat fraction and 0.678 (95% CI: 0.615–0.742, $p < 0.001$) for the paraspinal muscle fat fraction, with both demonstrating significant and comparable discrimination abilities ($p = 0.249$; Fig. 5). The diagnostic performance of psoas muscle fat fraction of ≥4.5% and paraspinal muscle fat fraction of ≥7% were given in Table 3.

Discussion

Fatty liver disease is an increasing health problem that, if not prevented, can have serious consequences for many systems. Despite its importance, lack of sufficient awareness delays diagnosis and preventive measures. It has been reported that 3% of MASLD patients progress to cirrhosis within 15 years (Allen et al, 2022). In

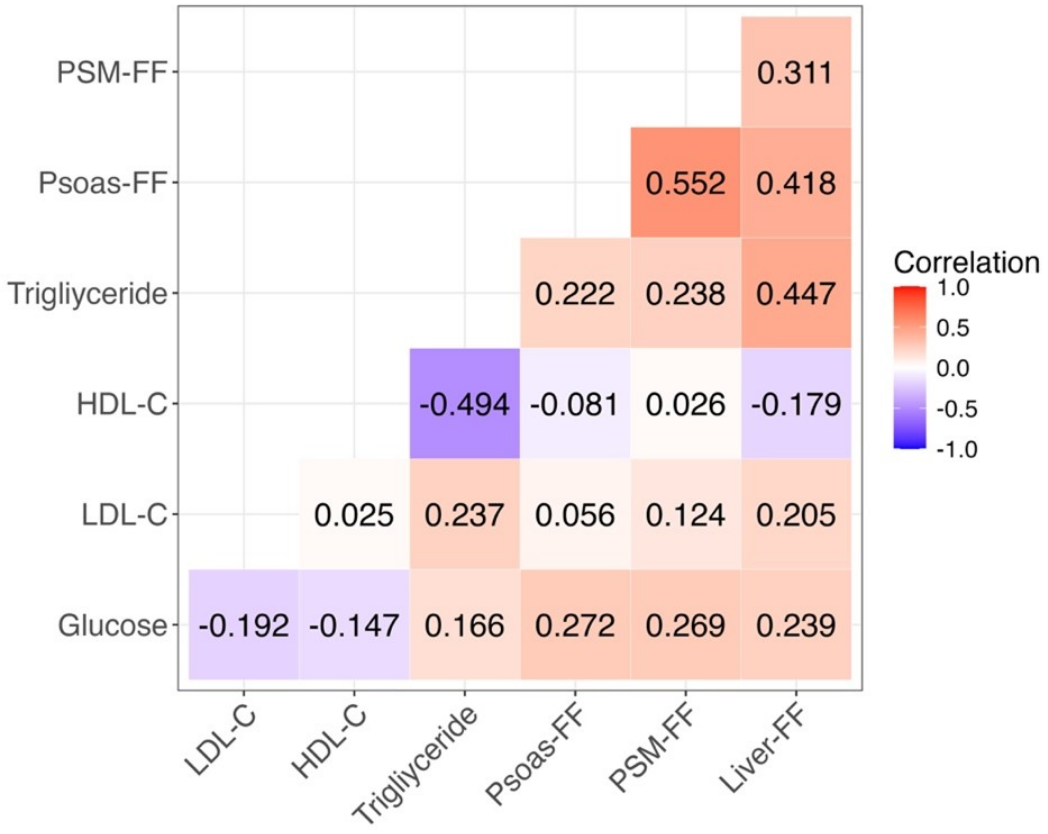

Fig. 3. The correlation coefficients for fatty liver, metabolic parameters, and psoas and paraspinal muscle fat fraction. Abbreviations: FF, fat fraction; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PSM, paraspinal muscle.

the present study, we found that fatty liver disease is common, and its prevalence is higher in men (68%) than in women (50%) in this selected population.

Several methods have been used for assessing hepatic steatosis. Chemical shift gradient-echo sequences are widely used in the detection of hepatic steatosis with MRI (Benetolo et al, 2019). PDFF MRI is a technique used in recent years and is known to give more accurate results by separating signals from different tissues since multiple corrections are used to obtain signals from tissue (Orcel et al, 2023). Iterative Decomposition of water and fat with Echo asymmetry and Least Square Estimation (IDEAL) MRI technique was found to be highly effective in the separation of signals from water and fat, outperforming chemical shift-based techniques (Reeder et al, 2005). This ensures an accurate measurement of the fat content in each image voxel. Various studies have demonstrated the accuracy, precision, and reproducibility of PDFF quantification using methods based on the IDEAL approach (Beyer et al, 2025). At the same time, PDFF MRI correlates well with histopathologic results in demonstrating liver fat (Wibulpolprasert et al, 2024).

The present study shows that psoas and paraspinal muscle fat fractions assessed with PDFF MRI are significantly higher in individuals with fatty liver. Also, there is a significant non-linear relationship between liver fat fraction and psoas and paraspinal fat fractions. Our study does not have a design to show a causal link between fatty liver, myosteatosis, and metabolic dysfunction. However, both psoas

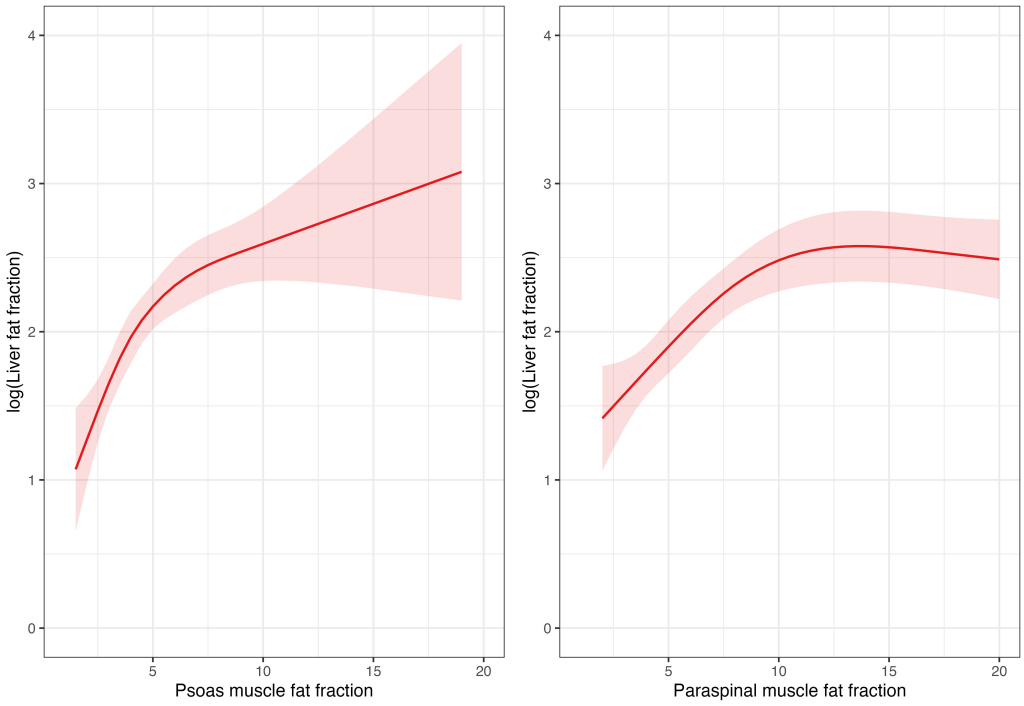

Fig. 4. Age- and sex-adjusted relationship between liver fat fraction (in logarithmic scale) and psoas and paraspinal muscle fat fraction.

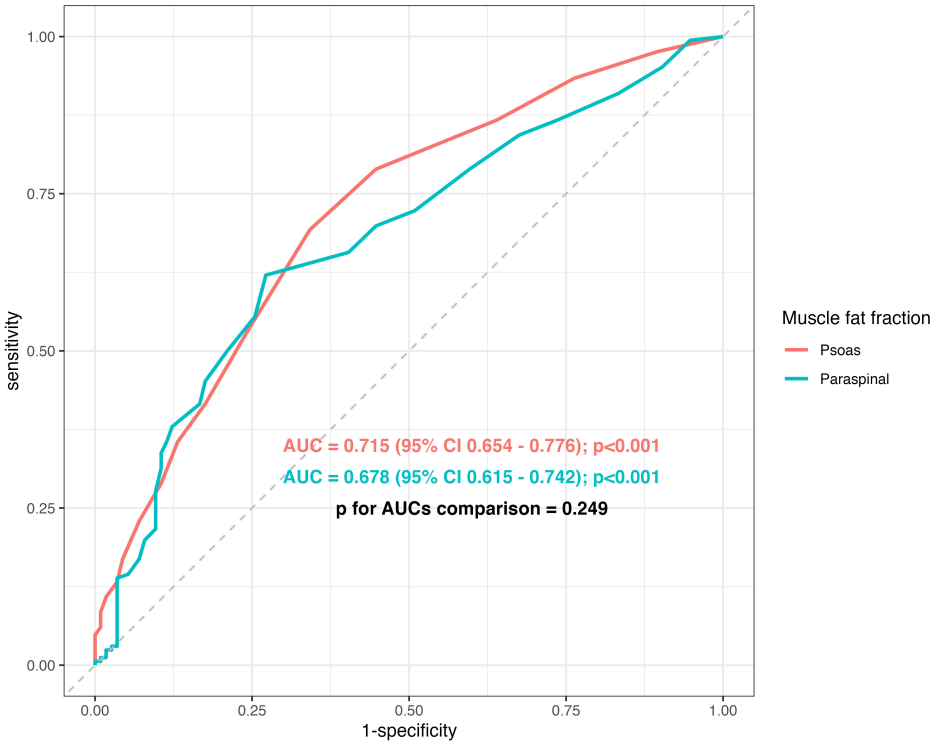

Fig. 5. The receiver operating characteristic (ROC) curves for psoas and paraspinal muscle fat fractions in discriminating fatty liver. AUC, area under the curve.

Table 3. Diagnostic performances of psoas and muscle fat fraction for the presence of fatty liver.

	Psoas muscle fat fraction of ≥4.5%	Paraspinal muscle fat fraction of ≥7%
Sensitivity, %	69.3 (61.7–76.2)	62.0 (54.2–69.5)
Specificity, %	65.8 (56.3–74.4)	72.8 (63.7–80.7)
Positive predictive value, %	74.7 (67.0–81.3)	76.9 (68.8–83.7)
Negative predictive value, %	59.5 (50.4–68.2)	56.8 (48.4–65.0)

The numbers in the brackets correspond to the 95% confidence interval.

and paraspinal muscle fat fractions are, as expected, correlated with metabolic parameters, such as glucose, triglycerides, and HDL-cholesterols. Of note, these biochemical parameters are among the components of the metabolic syndrome definition. This suggests that these biochemical parameters, fatty liver, and myosteatosis are several aspects of the same pathophysiological process, which is probably insulin resistance. Decreased skeletal muscle mass and impaired muscle function lead to decreased myokine secretion. Myokines are involved in the oxidation of fatty acids in the liver, which may be one of the reasons explaining the association between MASLD and myosteatosis (Severinsen and Pedersen, 2020).

As skeletal muscles are the largest insulin-sensitive tissues, they have a substantial role in glucose homeostasis. Recently, myosteatosis has been taken an interest for its role in insulin resistance and its consequences, such as fatty liver and MASLD. However, there is no standard cut-off value for defining myosteatosis, or as to which method(s) should be used for this aim. In this study, we used PDFF MRI, which is believed to be a promising tool for the assessment of myosteatosis. Several studies used different imaging methods and developed different cut-off values for various endpoints. As we have focused on the early diagnosis of MASLD, we calculated cut-off values for the fat fraction of psoas and paraspinal muscles in discriminating the presence or absence of fatty liver. For psoas muscle fat fraction, a cut-off value of ≥4.5 had a sensitivity of 69.3%, specificity of 65.8%, PPV of 74.7%, and NPV of 59.5%. For paraspinal muscle, fat fraction of ≥7 had a sensitivity of 62.0%, specificity of 72.8%, PPV of 76.9%, and NPV of 56.8%. The discriminative values of psoas and paraspinal muscle fat fractions were comparable.

No significant difference was observed in the FIB-4 and FIB-5 levels between the patients with and without fatty liver. This was interpreted as being related to the fact that the patient population in our study mostly consisted of individuals with preserved liver function.

Information about the amount of fat in the muscle and muscle quality is mostly based on computerised tomography (CT) attenuation values. Radiation exposure in CT is an important limitation. In a study comparing skeletal muscle measurements performed simultaneously on CT and MRI in the same subject, a high correlation was found between CT and MR measurements in the detection of fat in the muscle (Faron et al, 2020). MRI has the advantages of not having radiation and better tissue characterisation. PDFF imaging has several advantages over biopsy. First, it

is a non-invasive technique that allows the assessment of both liver and muscle fat content simultaneously. Additionally, the distribution of fat or fibrosis may not be homogeneous, meaning that biopsy sampling could lead to false-negative results. PDFF imaging also has advantages over other non-invasive techniques, such as FibroScan. While FibroScan primarily assesses fibrosis, PDFF imaging can detect the earliest stages of fibrosis caused by hepatosteatosis. Therefore, it is valuable for the prevention of future liver fibrosis. Also, a recent study has shown that fat quantification using MRI is a cost-effective method for patients with suspected fatty liver compared to standard care (Shumbayawonda et al, 2025).

We performed psoas and paraspinal muscle (PSM) measurements at the level of the L1 vertebra and superior mesenteric artery, respectively. Measurements obtained from the psoas muscle at the L3 vertebral level are widely used in body composition studies. However, since this level is not included in the upper abdominal MRI, paraspinal muscle measurements from the L1 vertebra or superior mesenteric artery (SMA) origin are used instead. A good correlation between L3 and L1 vertebra level and SMA origin has been reported in CT and MR-based studies (Guichet et al, 2021; Xu et al, 2022).

Segmentation and multiple ROI methods are used for fat percentage measurement in MR PDFF. A study comparing whole segmentation and ROI sampling methods for liver fat fraction measurement in IDEAL-IQ found an excellent correlation between both methods (Zhang et al, 2021). Since the whole liver segmentation technique is time-consuming and requires software, ROI sampling is a preferable method.

There are several limitations to our study. First, it is a single-centre retrospective study with a relatively low number of patients. Second, as we did not aim to explore the mechanistic causal relationship between fatty liver, myosteatosis, and metabolic abnormalities, and our data were obtained from the hospital database, we do not have information regarding insulin sensitivity or body composition. However, many studies, including ours, reveal that both myosteatosis, fatty liver, and metabolic abnormalities coexist. Also, we have many missing values related to body mass index and alcohol use. Therefore, we did not adjust for these variables. However, considering that our study does not follow a causal model and instead evaluates the relationship between muscle and liver fat fraction within the same individuals using the same images, the potential impact of this limitation may be less critical compared to causal models. Furthermore, enrolling consecutive patients without imposing any restrictions based on metabolic profile or alcohol consumption may enhance the generalizability of our study.

Third, we aimed to provide a simple and easily applicable tool and cut-off values, therefore, we did not assess the intra- or peri-muscular fat compartments separately.

Conclusion

The present study shows that psoas and paraspinal muscle fat fractions are significantly higher in patients with fatty liver compared to those without fatty liver.

There is a non-linear and significant relationship between liver fat fraction and psoas and paraspinal muscle fat fractions. The diagnostic performance of muscle fat scores for fatty liver is moderate.

Our study provides information about both liver fat and skeletal muscle fat infiltration in a single MR examination and may contribute to improving the prognosis with lifestyle changes and appropriate patient management in individuals with hepatic steatosis and myosteatosis.

Key Points

- Liver fat fraction and psoas and paraspinal muscle fat fractions have a non-linear and significant relationship.
- Psoas and paraspinal muscle fat fractions are significantly higher in patients with vs. without fatty liver (defined as the liver fatty fraction of $\geq$5%), with a comparable discriminative value.
- The diagnostic performance of muscle fat scores for fatty liver is moderate.
- The potential of the assessment of psoas and paraspinal muscle fat fractions using PDFF MRI seems to be encouraging in the assessment of patients with metabolic syndrome, sarcopenia, or myosteatosis. In this respect, it requires further studies.

Availability of Data and Materials

All data included in this study are available from the corresponding author upon reasonable request.

Author Contributions

GK designed the study, wrote and revised the manuscript. MCK handled data collection. Both authors contributed to the important editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

All procedures were performed in compliance with relevant laws and institutional guidelines. The study was conducted according to the Declaration of Helsinki and approved by the institutional ethics committee of Bilkent City Hospital (approval number: TABED 2-25-925). In accordance with the national legislation and ethical guidelines in Turkey, written informed consent was waived by the Ethics Committee of Bilkent City Hospital due to the retrospective nature of the study, the use of anonymized data, lack of direct interventions and risk to participants, and the impracticability of contacting individuals, and this decision is also consistent with

the principles outlined in the Declaration of Helsinki and complies with the data protection framework of the European Union General Data Protection Regulation 2016/679.

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Conflict of Interest

The authors declare no conflict of interest.

References

Allen AM, Therneau TM, Ahmed OT, Gidener T, Mara KC, Larson JJ, et al. Clinical course of non-alcoholic fatty liver disease and the implications for clinical trial design. Journal of Hepatology. 2022; 77: 1237–1245. https://doi.org/10.1016/j.jhep.2022.07.004

Benetolo PO, Fernandes MIM, Ciampo IRLD, Elias-Junior J, Sawamura R. Evaluation of nonalcoholic fatty liver disease using magnetic resonance in obese children and adolescents. Jornal De Pediatria. 2019; 95: 34–40. https://doi.org/10.1016/j.jped.2017.12.010

Beyer C, Andersson A, Shumbayawonda E, Alkhouri N, Banerjee A, Pandya P, et al. Quantitative MRI for Monitoring Metabolic Dysfunction-Associated Steatotic Liver Disease: A Test-Retest Repeatability Study. Journal of Magnetic Resonance Imaging. 2025; 61: 1947–1955. https://doi.org/10.1002/jmri.29610

De Munck TJI, Verhaegh P, Lodewick T, Bakers F, Jonkers D, Masclee AAM, et al. Myosteatosis in nonalcoholic fatty liver disease: An exploratory study. Clinics and Research in Hepatology and Gastroenterology. 2021; 45: 101500. https://doi.org/10.1016/j.clinre.2020.06.021

Faron A, Sprinkart AM, Kuetting DLR, Feisst A, Isaak A, Endler C, et al. Body composition analysis using CT and MRI: intra-individual intermodal comparison of muscle mass and myosteatosis. Scientific Reports. 2020; 10: 11765. https://doi.org/10.1038/s41598-020-68797-3

Guichet PL, Taslakian B, Zhan C, Aaltonen E, Farquharson S, Hickey R, et al. MRI-Derived Sarcopenia Associated with Increased Mortality Following Yttrium-90 Radioembolization of Hepatocellular Carcinoma. Cardiovascular and Interventional Radiology. 2021; 44: 1561–1569. https://doi.org/10.1007/s00270-021-02874-6

Kim JE, Kim JS, Jo MJ, Cho E, Ahn SY, Kwon YJ, et al. The Roles and Associated Mechanisms of Adipokines in Development of Metabolic Syndrome. Molecules. 2022; 27: 334. https://doi.org/10.3390/molecules27020334

Kuru Öz D, Ellik Z, Gürsoy Çoruh A, Adıgüzel M, Gümüşsoy M, Kiremitci S, et al. Assessing hepatic steatosis by magnetic resonance in potential living liver donors. Diagnostic and Interventional Radiology. 2024; 30: 351–356. https://doi.org/10.4274/dir.2024.242697

Le MH, Yeo YH, Li X, Li J, Zou B, Wu Y, et al. 2019 Global NAFLD Prevalence: A Systematic Review and Meta-analysis. Clinical Gastroenterology and Hepatology. 2022; 20: 2809–2817.e28. https://doi.org/10.1016/j.cgh.2021.12.002

Nachit M, De Rudder M, Thissen JP, Schakman O, Bouzin C, Horsmans Y, et al. Myosteatosis rather than sarcopenia associates with non-alcoholic steatohepatitis in non-alcoholic fatty liver disease preclinical models. Journal of Cachexia, Sarcopenia and Muscle. 2021; 12: 144–158. https://doi.org/10.1002/jcsm.12646

Orcel T, Chau HT, Turlin B, Chaigneau J, Bannier E, Otal P, et al. Evaluation of proton density fat fraction (PDFF) obtained from a vendor-neutral MRI sequence and MRQuantif software. European Radiology. 2023; 33: 8999–9009. https://doi.org/10.1007/s00330-023-09798-4

Reeder SB, Pineda AR, Wen Z, Shimakawa A, Yu H, Brittain JH, et al. Iterative decomposition of water and fat with echo asymmetry and least-squares estimation (IDEAL): application with fast spin-echo imaging. Magnetic Resonance in Medicine. 2005; 54: 636–644. https://doi.org/10.1002/mrm.20624

Rinella ME, Neuschwander-Tetri BA, Siddiqui MS, Abdelmalek MF, Caldwell S, Barb D, et al. AASLD Practice Guidance on the clinical assessment and management of nonalcoholic fatty liver disease. Hepatology. 2023; 77: 1797–1835. https://doi.org/10.1097/HEP.0000000000000323

Rinella ME, Sookoian S. From NAFLD to MASLD: updated naming and diagnosis criteria for fatty liver disease. Journal of Lipid Research. 2024; 65: 100485. https://doi.org/10.1016/j.jlr.2023.100485

Severinsen MCK, Pedersen BK. Muscle-Organ Crosstalk: The Emerging Roles of Myokines. Endocrine Reviews. 2020; 41: 594–609. https://doi.org/10.1210/endrev/bnaa016

Shumbayawonda E, French M, Carolan JE, Beyer C, Lorgelly P, Tonev D, et al. Utility and cost-effectiveness of LiverMultiScan for MASLD diagnosis: a real-world multi-national randomised clinical trial. Communications Medicine. 2025; 5: 74. https://doi.org/10.1038/s43856-025-00796-9

Starekova J, Hernando D, Pickhardt PJ, Reeder SB. Quantification of Liver Fat Content with CT and MRI: State of the Art. Radiology. 2021; 301: 250–262. https://doi.org/10.1148/radiol.2021204288

Wibulpolprasert P, Subpinyo B, Chirnaksorn S, Shantavasinkul PC, Putadechakum S, Phongkitkarun S, et al. Correlation between magnetic resonance imaging proton density fat fraction (MRI-PDFF) and liver biopsy to assess hepatic steatosis in obesity. Scientific Reports. 2024; 14: 6895. https://doi.org/10.1038/s41598-024-57324-3

Xu Z, Luo J, Yang D, Xu H, Jia J, Yang Z. Agreement and correlation of abdominal skeletal muscle area measured by CT and MR imaging in cirrhotic patients. BMC Medical Imaging. 2022; 22: 205. https://doi.org/10.1186/s12880-022-00932-0

Zhang QH, Zhao Y, Tian SF, Xie LH, Chen LH, Chen AL, et al. Hepatic fat quantification of magnetic resonance imaging whole-liver segmentation for assessing the severity of nonalcoholic fatty liver disease: comparison with a region of interest sampling method. Quantitative Imaging in Medicine and Surgery. 2021; 11: 2933–2942. https://doi.org/10.21037/qims-20-989