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Potential utility of the fatty liver index as a predictor of erectile dysfunction and its severity

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Abstract

Purpose The aim of this study was to evaluate the relationship between Fatty Liver Index(FLI) and Erectile Dysfunction(ED) and its severity.

Materials and methods A group of 230 male patients with ED complaints underwent evaluation. Comprehensive routine blood serum tests were conducted to identify potential etiological factors contributing to ED. Additionally, waist circumference(WC) measurements were obtained to facilitate the calculation of the FLI. Participants were also asked to complete the validated Turkish adaptation of the 5-item International Index of Erectile Function (IIEF-5) questionnaire to assess the severity and impact of ED.

Results Out of all participants, 55 were classified as non-ED, while 175 were diagnosed with ED, mostly in the mild to moderate category. According to FLI scores, 132 had hepatic steatosis(HS). Body mass index (BMI) and WC were significantly higher in the ED group. Fasting blood glucose, ALT, and triglycerides (TG) were elevated in those with ED, while AST and total testosterone levels were lower. A significant association was found between higher FLI scores and ED ($p < 0.05$). The FLI score was significantly higher ($p < 0.05$) in the severe ED group compared to the moderate, mild-moderate, and mild ED groups.

Conclusion Based on the results of our study, the FLI appears to be a simple method that shows a high correlation with the severity of ED. We believe that the use of the FLI in the diagnosis and follow-up of ED is noteworthy, and further prospective studies with larger sample sizes are needed to support this conclusion.

Keywords Erectile dysfunction, Fatty liver index, Hepatosteatosis, Metabolic syndrome

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Introduction

Non-alcoholic fatty liver disease (NAFLD), characterized by an increase in liver fat content due to factors other than excessive alcohol consumption. It has emerged as a global public health concern, particularly affecting individuals with type 2 diabetes mellitus and morbid obesity. Epidemiological studies estimate its prevalence to range between 20% and 30% in the general population, highlighting its widespread impact and the necessity for early detection and management [1].The etiology of NAFLD is closely associated with metabolic abnormalities, including dyslipidemia, obesity, and type 2 diabetes mellitus, which are also major contributors to the pathogenesis of metabolic syndrome and subsequent cardiovascular diseases. Given this strong association, NAFLD is widely recognized as the hepatic manifestation of metabolic syndrome(MetS) [2].

Ultrasonography remains the most widely utilized imaging modality for the diagnosis of NAFLD, primarily due to its cost-effectiveness, non-invasive nature, and broad accessibility. However, its diagnostic accuracy is inherently limited by operator dependency, introducing a degree of subjectivity. To address this limitation, Bedogni et al. developed the Fatty Liver Index(FLI), a simple and rapid clinical tool that has demonstrated a strong correlation with abdominal ultrasonography in population-based studies. Their findings indicate that a FLI score of ≤ 30 effectively excludes hepatosteatosis(HS), whereas a score ≥ 60 is strongly suggestive of the condition, offering a practical alternative for risk stratification in clinical and epidemiological settings [3].

FLI is a mathematical model derived from key metabolic parameters, Boddy Mass Index(BMI), waist circumference (WC), triglycerides(TG) levels, and gamma-glutamyl transferase (GGT) values. This index serves as a non-invasive tool for estimating HS. A study conducted in a European population demonstrated a significant association between FLI and metabolic dysfunctions, including insulin resistance (IR), coronary artery disease (CAD), and early atherosclerosis. These findings underscore the potential utility of FLI not only as a diagnostic marker for NAFLD but also as an indicator of cardiometabolic risk [4].

Erectile dysfunction (ED), defined as the impairment of sexual function, extends beyond its impact on sexual health and is increasingly regarded as an early clinical marker of MetS [5]. Recent meta-analytical data indicate that the prevalence of ED is 2.6 times higher in individuals with metabolic syndrome compared to the general population [5]. From an etiological perspective, the pathophysiological mechanisms underlying ED closely overlap with those of NAFLD, suggesting shared metabolic risk factors such as IR, dyslipidemia, obesity, and endothelial dysfunction. This association highlights the importance of a comprehensive metabolic assessment in patients presenting with ED [5].

In this study, we aimed to explore the relationship between two clinical manifestations of MetS; ED and NAFLD. Additionally, we sought to assess NAFLD status in patients diagnosed with ED. To enhance the originality of our study, we employed the FLI as a diagnostic parameter for NAFLD, given its strong correlation with ultrasonographic assessments. By utilizing FLI instead of conventional ultrasound-based evaluations, we aimed to provide a non-invasive, objective, and reproducible approach to investigating the association between ED and NAFLD. To our knowledge, this is the first study to investigate the relationship between FLI and ED and its severity.

Table 1 Exclusion criterias of study popullation

Receiving Medical Treatment For Hyperlipidemia or Diabetes Mellitus
Weekly Alcohol Intake Of ≥ 140 g
History of Advanced Cardiovascular Disease
History of Oncological Diseases
History of Viral, Autoimmune or Metabolic Liver and Biliary Tract Disorders
Corticosteroid Use
Immunodeficiency
Psychiatric Illnesses

Materials-methods

Ethics

This study was conducted in accordance with the ethical principles set forth in the Declaration of Helsinki. All participants were fully informed about the study's purpose and provided written informed consent. Ethical approval was granted by the Local Ethics Committee of Health Science University Derince Training and Research Hospital.(approval number: 2020–107).

Selection of participants

A total of 230 males, aged 18 to 75, who visited the Urology Clinic of Gebze Fatih State Hospital between Septtember 1 2020, and July 1 2022 with complain of ED participated in the study. The study population was initially classified into ED(group 1) and non-ED (group 2) groups based on the 5-item International Index of Erectile Function (IIEF-5) scores with scores of 5–21 indicating ED and scores of 22–25 indicating non-ED [6]. The ED group was further subdivided into subgroups: severe ED (5–7 points), moderate ED (8–11 points), mild-moderate ED (12–16 points), and mild ED (17–21 points).

Exclusion criters of participants ara summarised in Table 1. Patients were excluded from the study if they were receiving medical treatment for hyperlipidemia or

diabetes mellitus, had a weekly alcohol intake of ≥ 140 g, or had a history of advanced cardiovascular disease. Furthermore, individuals with a history of oncological diseases, viral or autoimmune hepatitis, liver and biliary tract disorders associated with cholestasis, metabolic liver diseases, corticosteroid use, immunodeficiency, or psychiatric illnesses were also excluded. These exclusion criteria were implemented to minimize potential confounding factors and ensure a more homogenous study population for the accurate assessment of the relationship between ED and NAFLD.

Study variables

In this planned study, the biochemical parameters of patients diagnosed with ED, including blood triglycerides, glucose, ALT, AST, GGT, low-density lipoprotein (LDL), and total cholesterol were evaluated. Additionally, patients were classified based on their recorded BMI and WC measurements. Fasting blood samples were collected from venous blood between 08:00 and 10:00 in the morning to ensure standardized metabolic assessments and minimize diurnal variations in biochemical parameters.

Table 2 Demographic and baseline clinical characteristics of study patients

		Median (IQR)
Age (year)		50 (41–57)
BMI (kg/m^2)		28,18 (25,38–31,10)
WS (cm)		101 (94–110)
Smoking(*n*, %)	No	158 (%68,7)
	Yes	72 (%31,3)
Glucose (mg/dL)		97 (90–108)
AST (U/L)		20 (18–24)
ALT (U/L)		23 (16–30)
Total Cholesterol (mg/dL)		192 (163–220)
LDL Cholesterol (mg/dL)		124 (102–148)
Triglyceride (mg/dL)		135 (100–205)
GGT (U/L)		26 (20–37)
Total Testosteron (ng/mL)		3,59 (2,77–4,50)
FLI Score		68,66 (39,32–84,40)
FLI Subgroup (*n*, %)	HS (-)	32 (%13,9)
	HS (Borderline)	66 (%28,7)
	HS (+)	132 (%57,4)
IIEF Score		14 (10–20)
IIEF Subgorup (*n*, %)	Severe	28 (%12,2)
	Moderate	57 (%24,8)
	Mild-Moderate	61 (%26,5)
	Mild	29 (%12,6)
	Non– ED	55 (%23,9)

IQR Interquartile range, *BMI* Bodd mass index, *WS* Waist circumfrance, *AST* Aspartate aminotransferase, *ALT* Alanine aminotransferase, *LDL* Low-density lipoprotein, *GGT* Gamma-glutamyl transferase, *FLI* Fatty liver index, *HS* Hepatosteatosis, *IIEF* International Index of Erectile Function, *ED* Erectile dysfunction

FLI was calculated using the following formula:

$$FLI = (e\ 0.953 * \log e\ (triglycerides) + 0.139 * BMI + 0.718 * \log e\ (ggt) + 0.053 * waist\ circumference - 15.745) / (1 + e\ 0.953 * \log e\ (triglycerides) + 0.139 * BMI + 0.718 * \log e\ (ggt) + 0.053 * waist\ circumference - 15.745) * 100$$

Interpretation of FLI scores; FLI score below 30 was considered to effectively exclude hepatic steatosis, FLI score above 60 was indicative of HS, individuals with an FLI score between 30 and 60 were classified as the borderline group, requiring further evaluation. This classification allowed for a standardized, non-invasive assessment of HS, minimizing the reliance on imaging-based diagnostic methods.

Statistical analysis

The Kolmogorov Smirnov test was used to check the normality of data for quantitative variables. Descriptive data were expressed in median and interquartile range, and frequency. The Pearson chi-square, and Mann-Whitney-U tests were used wherever possible. ROC curve analysis was conducted to determine effect size and cutoff values, and both univariate and multivariate logistic regression analyses were performed to assess the strength of associations. All statistical analyses were performed using SPSS version 27.0 software. Furthermore, a separate Receiver Operating Characteristic (ROC) analysis was conducted to calculate the area under the curve (AUC), and the relevance of the cut-off value for significant efficacy of FLI in differentiating control and case group patients.

Results

After applying the exclusion criteria, the demographic and biochemical parameters of the remaining 230 patients are summarised in Table 2. Based on the IIEF-5 scoring, 55 patients were classified as non-ED(group 2), while 175 patients were diagnosed with ED(group 1). Among the patients with ED, the majority were categorized within the mild to moderate ED group. Furthermore, according to FLI scores, 132 patients were classified as having HS, representing the majority of the study population.

Comparison of demographic characteristics and biochemical parameters of groups are summarised in Table 3. The analysis revealed that the age of the patients did not differ significantly between the groups ($p > 0.05$). However, BMI and WC were significantly higher in the group 1($p < 0.05$).The smoking rate did not show a significant difference between the groups ($p > 0.05$). In contrast, fasting blood glucose, ALT, and TG levels were significantly higher in the group 1 ($p < 0.05$).Total cholesterol, LDL cholesterol, and GGT levels did not differ significantly between the groups ($p > 0.05$). However, AST and

Table 3 Comparison of demographic characteristics and biochemical parameters between groups

		Groups				
		Group 1(ED +) (*n* = 175, %76,1)		Group 2 (ED -) (*n* = 55, %23,9)		
		Median (IQR)	*n*, %	Median (IQR)	*n*, %	*p*-value
Age (year)		49 (41–55)		50 (32–63)		[a]0,763
BMI (kg/m^2)		29,09 (26,29–32,07)		24,92 (23,40–28,39)		[a]<0,001*
WC (cm)		104 (95–110)		92 (87–100)		[a]<0,001*
Smoking (yes)			54 (%30,9)		18 (%32,7)	[b]0,794
Glucose (mg/dL)		101 (91–109)		93 (87–102)		[a]0,006*
AST (U/L)		20 (17–24)		22 (19–29)		[a]0,011*
ALT (U/L)		23 (17–31)		17 (14–29)		[a]0,008*
Total Cholesterole (mg/dL)		191 (163–224)		192 (172–211)		[a]0,479
LDL Cholesterole (mg/dL)		124 (105–148)		124 (100–150)		[a]0,693
Triglyceride (mg/dL)		151 (105–220)		104 (68–155)		[a]<0,001*
GGT (U/L)		26 (20–36)		27 (20–38)		[a]0,869
Total Testosteron (ng/mL)		3,44 (2,61–4,45)		3,94 (3,38–4,83)		[a]0,004*
FLI Score		73,69 (50,03–86,26)		36,12 (22,45–71,48)		[a]<0,001*
FLI Subgroup	HS (-)		11 (%6,3)		21 (%38,2)	[b]<0,001*
	HS (Borderline)		51 (%29,1)		15 (%27,3)	
	HS (+)		113 (%64,6)		19 (%34,5)	

IQR Interquartile range, *BMI* Bodd mass index, *WS* Waist circumfrance, *AST* Aspartate aminotransferase *ALT* Alanine aminotransferase, *LDL* Low-density lipoprotein, *GGT* Gamma-glutamyl transferase, *FLI* Fatty liver index, *HS* Hepatosteatosis, *IIEF* International Index of Erectile Function, *ED* Erectile dysfunction

[a]Mann-Whitney U test, [b]Pearson Chi-Square test, *$p < 0,05$

Table 4 Outcomes of the univariate and multivarete logistic regression analyses assesing the association between clinical variables and ED

	Univariate Model					Multivariate Model				
	OR	%95 CI			*p*	OR	%95 CI			*p*
BMI	1.308	1.181	-	1.448	***< 0.001***					
WC(cm)	1.113	1.072	-	1.156	***< 0.001***	1.063	1.001	-	1.129	***0.046***
FLI Score	1.039	1.025	-	1.053	***< 0.001***	1.028	1.004	-	1.053	***0.022***
Fasting Blood Sugar	1.017	1.001	-	1.033	***0.033***					
AST	0.954	0.921	-	0.988	***0.008***	0.919	0.878	-	0.963	***< 0.001***
ALT	1.009	0.988	-	1.029	0.410					
TG	1.008	1.003	-	1.012	***< 0.001***					
Total Testosterone(ng/ml)	0.791	0.638	-	0.980	***0.032***					

*Lojistik Regresyon (Forward LR), *p < 0,05*

BMI Bodd mass index, *WS* Waist circumfrance, *FLI* Fatty liver index, *AST* Aspartate aminotransferase, *ALT* Alanine aminotransferase, *GGT* Gamma-glutamyl transferase

total testosterone levels were significantly lower in the group 1 ($p < 0.05$).Furthermore, FLI score was significantly higher in the group 1 ($p < 0.05$), suggesting a stronger association between HS and the ED.

In the univariate analysis, several factors demonstrated a significant impact ($p < 0.05$) on the discrimination between the groups, including BMI, WC, FLI score, fasting blood glucose, AST, TG, and total testosterone levels. However, no significant effect ($p > 0.05$) was observed for the ALT levels in distinguishing between the groups. In the multivariate analysis, WC, FLI score, and AST levels were identified as significant independent factors ($p < 0.05$) in the discrimination of patients between the groups (Table 4).

A significant efficiency was observed in using the FLI for discriminating between the groups patients, with an AUC of 0.756 (95% CI: 0.681–0.831). Additionally, the FLI with a cutoff value of 51 demonstrated significant efficiency in distinguishing between the groups, with an AUC of 0.715 (95% CI: 0.629–0.800). At a cut-off value of 51, the FLI had a sensitivity of 74.3%, a positive predictive value of 87.2%, a specificity of 66.5%, and a negative predictive value of 44.4% in distinguishing between patients with and without ED (Fig. 1).

Association between ED severity and FLI scores is summarized in Table 5. The analysis demonstrated a significant corelation between the severity of ED and the FLI score. The FLI score was significantly higher ($p < 0.05$) in the severe ED group compared to the moderate, mild-moderate, and mild ED groups. Similarly, the moderate ED group exhibited significantly higher ($p < 0.05$) FLI scores than the mild-moderate and mild ED groups.These

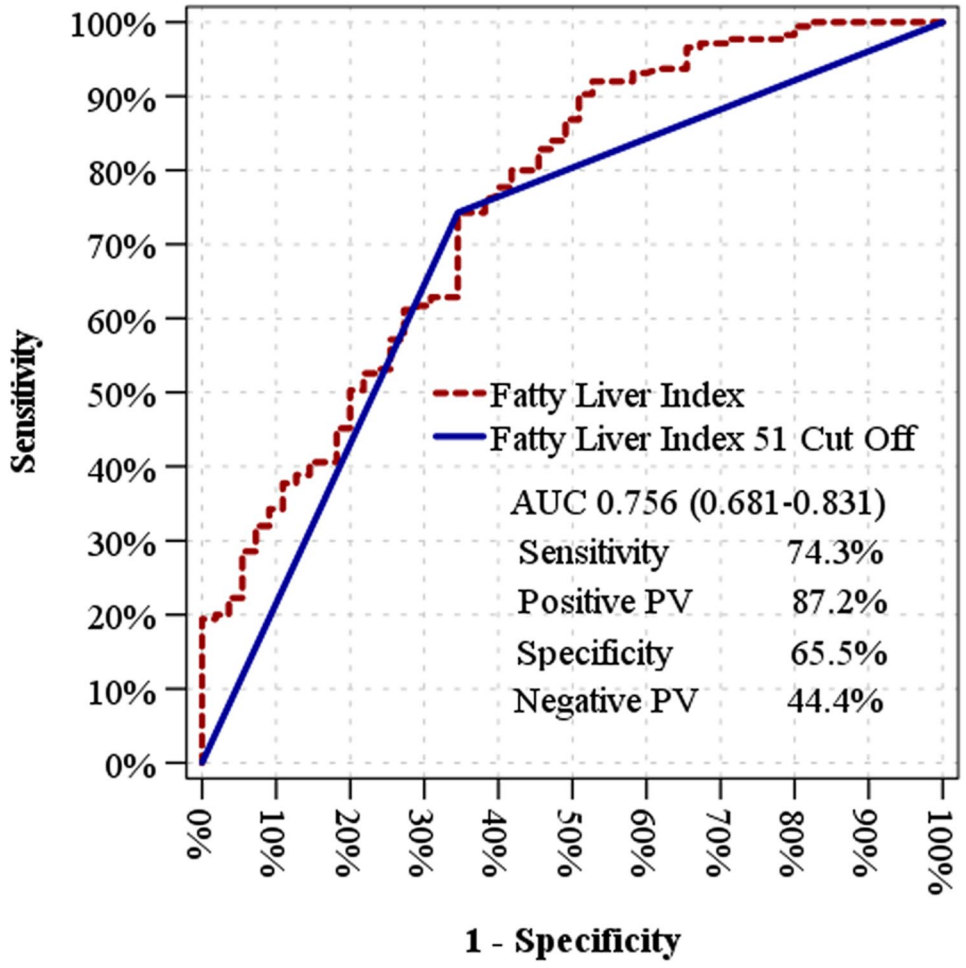

Fig. 1 The FLI was found to have a significant effectiveness in distinguishing between patients with and without erectile dysfunction [Area under the curve 0.756 (0.681–0.831)]. The FLI with a cut-off value of 51 was also found to have significant effectiveness in distinguishing between patients with and without erectile dysfunction [Area under the curve 0.715 (0.629-0.800)]

Table 5 Association Between ED Severity and FLI

		Fatty Liver Index							*p*	
		Min-Max			Median	Mean ± sd				
IIEF Score	[1]Severe ED	15.7	-	99.5	90.3	84.5	±	17.6	***< 0.001***	K
	[2]Moderate ED	17.0	-	99.0	82.8[1]	79.6	±	15.4		
	[3]Mild-Moderate ED	16.7	-	96.9	56.9[12]	58.5	±	20.5		
	[4]Mild ED	26.8	-	87.9	43.1[123]	49.1	±	18.7		

[K]*Kruskal-wallis test* [1]Difference with severe ED

[2]Difference with moderate ED, [3]Difference with mild-moderate ED, *p < 0,05

findings indicate a progressive increase in FLI scores with increasing severity of erectile dysfunction, suggesting a potential association between HS and ED severity.

Discussion

In the present study, we investigated the relationship between NAFLD and ED and its severity using the FLI as a diagnostic parameter of HS. Our study results demonstrated that men diagnosed with ED had higher FLI scores. Additionally, subgroup analysis revealed a positive correlation between ED severity and FLI scores, suggesting a potential association between the progression of ED and the degree of HS.

In this study, we tried to reveal the relationship between NAFLD, one of the early findings of MetS, and ED. Recent evidence suggests that endothelial dysfunction may represent one of the earliest contributors to hepatic fat accumulation and subsequent liver injury [7]. Liver sinusoidal endothelial cells function similarly to vascular endothelial cells and play a pivotal role in

anti-inflammatory and antifibrotic processes [8, 9]. Moreover, impaired nitric oxide (NO) production has been implicated in the initiation and progression of hepatic inflammation, ultimately leading to the development of NAFLD and its potential progression to advanced liver disease [10]. Recent human studies have demonstrated significant endothelial NO synthase (eNOS) dysfunction in patients with NAFLD, while animal models indicate that eNOS deficiency exacerbates the early stages of the disease [10, 11]. Notably, vascular endothelial dysfunction is also a well-established factor in the pathogenesis of ED [12]. A hallmark of endothelial dysfunction is the reduced bioavailability of NO, which impairs the regulation of vascular tone, hindering the balance between vasodilation and vasoconstriction is one of the key mechanisms underlying ED development [13]. NAFLD is recognized as one of the mixed pathophysiological pathways contributing to the development of ED [14]. Duman et al. were the first to prospectively investigate the relationship between NAFLD and ED in a cohort of 40 individuals. Their study demonstrated that patients with ED had significantly higher NAFLD scores compared to those without ED. Furthermore, histological analysis revealed that the severity of ED worsened as NAFLD-related liver damage progressed, suggesting a potential link between hepatic dysfunction and erectile impairment [15]. The findings of the present study indicate that the FLI score was significantly higher in the ED group compared to the non-ED group ($p < 0.05$). This finding reinforces the potential association between NAFLD and ED. Hasanain et al. found that older age, obesity, and hypertension were significantly more frequent in patients with NAFLD and ED, but multivariate analysis yielded only age as a variable associated with ED [16]. In the present study, similar to previous findings, BMI and WC values were significantly higher in the group with ED. When ED was evaluated in general, it was found to be more common in older men, and therefore, the higher the average age of the population analysed, the higher the prevalence of ED was found [17]. In contrast to previous literature, no age difference was observed between the groups in our study. This result could be due to the smaller sample size in the non-ED group.

Previous studies have reported varying degrees of association between ED and different components of MetS, including obesity, hypertension, hyperglycemia, dyslipidemia, BMI, and elevated levels of cholesterol and high-density lipoprotein cholesterol [18, 19]. Consistent with the existing literature, our study revealed that, in the univariate analysis, factors such as BMI, WC, fasting blood glucose, AST, TG, total testosterone, and the FLI significantly differentiated between patients with and without ED. Moreover, in the multivariate analysis, WC, AST, and the FLI exhibited significant and independent associations in distinguishing ED patients from those without the condition. In addition to these studies, it has been reported that NAFLD, another component of MetS, is an independent factor influencing ED. NAFLD is considered a hepatic manifestation of MetS, and recent animal and human studies have focused on evaluating the relationship between NAFLD and ED [16, 20, 21]. Our present study is the first study in the literature to examine the relationship between FLI and ED. The FLI is recognized as a surrogate marker for histological fatty liver. Previous studies have indicated that FLI is effective in identifying NAFLD when compared to ultrasound and in detecting the presence of hepatic fat infiltration in contrast to magnetic resonance spectroscopy [4, 22]. The advantage of using FLI lies in its ability to indicate a higher degree of hepatic steatosis with a higher score. An FLI score of < 30 is typically used to rule out HS, while an FLI of ≥ 60 suggests the presence of the disease in Caucasian populations [4]. However, the optimal cutoff value of FLI for predicting NAFLD may vary for some populations. A study conducted in China suggested that FLI accurately detected NAFLD, with an optimal cutoff value of 30 in middle-aged and elderly Chinese individuals [22]. In our ROC analysis, an FLI cutoff value of 51 predicted the presence of ED with a sensitivity of 74.3%, a PPV of 87.2%, and a specificity of 65.5%.

In this study, we also examined the subgroups of ED based on the IIEF-5 scores in relation to the FLI. Our findings demonstrated that patients with ED exhibited significantly higher FLI values, which were positively correlated with the severity of ED. Although this study represents the first investigation into the relationship between ED severity and FLI, various markers of MetS have previously been explored in connection with ED severity. In accordance with the findings of Sambel et al., when assessing all ED subgroups, a significant difference was observed only between the mild and severe ED groups with respect to the triglyceride-glucose (TyG) index [23]. Our analyses further revealed that the FLI was notably effective in distinguishing severe ED from other ED subgroups. Likewise, the moderate ED group exhibited significantly higher FLI scores compared to the mild-moderate and mild ED groups. Additionally, the FLI score in the mild-moderate ED group was significantly elevated relative to the mild ED group. Given that ED may serve as an early indicator of underlying cardiovascular disease (CVD), assessing its severity could facilitate the identification of patients who may benefit from targeted interventions, including lifestyle modifications aimed at reducing both morbidity and mortality. Given the simplicity and accessibility of FLI, its use as an early indicator for ED risk may offer an opportunity for timely lifestyle and metabolic interventions in clinical practice.

This study has several limitations that should be considered. Firstly, the relatively small sample size, particularly in the control group, may restrict the generalizability and accuracy of the results. Secondly, while a thorough biochemical analysis was conducted for all participants, the lack of measurements for sex hormone-binding globulin (SHBG) and free testosterone levels represents a notable limitation. Thirdly, the diagnosis of ED was solely based on the IIEF-5 questionnaire, which provides a less objective assessment compared to more precise diagnostic methods, such as penile Doppler ultrasound. Furthermore, patients receiving treatment for ED were excluded from the study, thereby preventing the assessment of treatment effects and associated biomarkers within the scope of this research.

Regarding the strengths of our study, it is the first study in the literature to explore the relationship between the FLI and ED. While FLI is not considered the gold standard for diagnosing fatty liver disease, as is the case with pathological results, it offers a practical and easily applicable method. In addition to the blood analyses recommended by the European Association of Urology (EAU) guidelines, anthropometric measurements, which can be conveniently performed in outpatient settings, may provide valuable insights into the potential metabolic syndrome status of patients presenting with ED. Besides these, ED has been evaluated using the IIEF-5 questionnaire in this study. The IIEF-5 is a commonly used, simple, and cost-effective tool for assessing the severity of ED. This questionnaire enables individuals to self-identify their ED status without the need for blood tests or other diagnostic examinations. This presents a significant advantage in clinical practice, as it not only saves time and costs for patients but also aids healthcare providers in making faster and more effective diagnoses.

Conclusion

This study reveals that FLI was significantly positively correlated with ED. Despite some limitations, the FLI proves to be a cost-free and practical marker for estimating the severity of organic ED. In conclusion, the results of our single-center study suggest that this index has the potential to be a valuable tool for both diagnosing and assessing the severity of ED. However, further research, particularly multi-center studies, is necessary to validate these findings and to explore the potential role of the FLI in informing treatment strategies for ED.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12894-025-01865-w.

Supplementary Material 1.

Supplementary Material 2.

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None.

Conflict of interest
The authors have nothing to disclose.

Authors' contributions
Research conception and design: H.A.A. Data acquisition: H.A.A.,Y.S. and E.O. Statistical analysis: N.K. Data analysis and interpretation: H.A.A. and E.K. Drafting of the manuscript: H.A.A., Y.S. and E.O. Supervision: All authors Approval of the final manuscript: All authors.

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Data availability
Data is provided within the supplementary information files.

Declarations

Ethics approval and consent to participate
This study has been performed in accordance with the Declaration of Helsinki and the protocol was reviewed and approved by Health Sciences University Derince Training and Research Hospital Local Ethics Committee (approval number:2020/107). All participants were fully informed about the study's purpose and provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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