Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 08 May 2026
Revised 07 June 2026
Accepted 20 June 2026

Natural Resources for Human Health 2026, Vol. 6 (11s): 847–860

KEYWORDS:
Type 2 Diabetes Mellitus, FABP1, FABP2, Biomarkers.

The Correlation Between Fatty Acid binding proteins (FABP 1&2) levels and Diabetes type 2

Refaat Mohamed Gabre[1], Salma Ehab[1], Amal Ahmed Mohamed[2], Sherif Ahmed Megahed Ahmed[3], Mona M. F. Ganem[4], Nesreen Hamdy Mahmoud[5], Thereza Raouf Sobhy[6], ShadyA. Ramiz[7], Osama M. Abobak[8], Mahmoud Ismail Saber Attalaa[9], Eman M. Fahmy[10]

[1]Department of Biotechnology, Cairo University, Cairo, Egypt
[2]Department of Biochemistry, National Hepatology and Tropical Medicine Research Institute, GOTHI, Cairo, Egypt
[3]Department of Internal Medicine, Faculty of Medicine, Ain Shams University, Cairo, Egypt
[4]Department of Internal Medicine Research, National Research Center, Giza, Egypt
[5]Department of Clinical and Chemical Pathology, Al Galaa teaching Hospital
[6]Department of Clinical and Chemical Pathology, National institute GOTHI, Cairo, Egypt
[7]Department of Internal Medicine, Faculty of Medicine, Cairo University, Cairo, Egypt
[8] Department of Cardiology, Faculty of Medicine, Arish University, El-Arish 45511 Egypt.
[9]Department of Clinical and Chemical Pathology ,Faculty of Medicine, Arish University, Alda,hya, El-Arish 45511 Egypt, North Sinai Governorate.
[10]Department of Endocrinology, Faculty of Medicine, Helwan University, Cairo, Egypt
Correspondence To: Salma Ehab
E-mail: salma.ehab2@msa.edu.eg
Email: rgabre@sci.cu.edu.eg
Email: amalahmedhcp@yahoo.com
ORCID: 0000-0002-2014-2239
Email: sherifmegahed@med.asu.edu.eg
Email: monamfgnrc@gmail.com
ORCID: 0000000341898809
Email: dr.nesreenhamgy2512@gmail.com
Email: Therezaraouf2020@gmail.com
Email: shadyramiz459@gmail.com
Email: osama11@yahoo.com
Email: mahmoudismail@gmail.com
Email: dremf@hotmail.com

ABSTRACT:

Introduction: Type 2 Diabetes Mellitus (T2DM) is a metabolic disorder that leads to insulin resistance and impaired glucose metabolism. There were many studies show that Fatty Acid Binding proteins (FABPs), as FABP1 and FABP2 play an essential role in metabolic regulation and biomarkers for T2DM. This study aims to investigate the

Natural Resources for Human Health
eISSN: 2583-1194

correlation between levels of FABP1 and FABP2 in the patients that suffer from Type 2 Diabetes.

Patients and Methods: This study involving 164 diabetic patients compared with 166 healthy controls. Blood samples were collected to measure the levels of FABP1 and FABP2 by using enzyme-linked immunosorbent assay (ELISA). Also, routine work as fasting blood glucose, HbA1c, lipid profile, fasting insulin, kidney profile, were also measured for all participants.

Results: Levels of FABP1 and FABP2 proteins were higher in patients suffer from T2DM compared with healthy controls ($p<0.001$). FABP1 and FABP2 also showed strong positive correlations with lipid profile, HbA1c, fasting insulin, fasting glucose, waist circumference, and weak negative correlations with eGFR and sleep duration. FABP1 and FABP2 levels also high among diabetic patients with nephropathy, neuropathy, retinopathy, and cardiac complications.

Conclusion: Receiver operating characteristic (ROC) curve analysis showed great diagnostic performance for FABP1 (AUC = 0.929) that indicates high sensitivity (97.0%) across a wide range of specificity value (83.1%), and FABP2 (AUC = 0.910) that indicates high sensitivity (87.8%) across a broad range of specificity value (76.5%)

INTRODUCTION

Type 2 Diabetes Mellitus is a global health concern that characterized by hyperglycemia that resulting from insulin resistance and dysfunction of B-cells (1). More than 460 million people worldwide suffer from T2DM, and this number will be increasing the next years (2). The pathogenesis of T2DM is a multifactorial process that results from interaction of genetic susceptibility, environmental factors, and metabolic abnormalities (3). FABPs have attracted considerable research attention as a family of intracellular lipid-binding proteins that involved in fatty acid uptake, intracellular transport, and metabolic homeostasis. (4,5).

FABP1 (liver-type) and FABP2 (intestinal-type) have been linked to insulin resistance, obesity, and metabolic syndrome (6). FABP1 is expressed in hepatocytes and affects lipid oxidation and fatty acid uptake (7,8). FABP2 is expressed in enterocytes and contributes to metabolic inflammation, and absorption of intestinal fatty acid (9-12). Genetic variations in FABP2 have been linked to increase the risk of insulin resistance and T2DM (13).

Increased levels of FABP1 and FABP2 have been associated with a wide range of metabolic disturbances, including dyslipidemia, impaired glucose homeostasis, and increased systemic inflammation (25). There are many evidences suggests that altered levels of FABP1 and FABP2 are associated with metabolic disorders, including dyslipidemia, impaired glucose homeostasis, and increased systemic inflammation (14,15).

FABP1 is predominantly expressed in hepatocytes that play an essential role in lipid metabolism and the regulation of hepatic insulin sensitivity, and has been implicated in the development of hepatic steatosis and disruptions in lipid signaling pathways (16,17). Genetic variation in FABP1 have been associated with increased hepatic fat accumulation and a greater susceptibility to metabolic syndrome, conditions that are closely linked to the progression of T2DM (7). In contrast, FABP2 is predominantly expressed in enterocytes and promotes intestinal fatty acid absorption, contributes to systemic inflammation, and also facilitates the intracellular transport of dietary fatty acids (9).

Together, FABP1 and FABP2 represent key molecular links between lipid metabolism and glucose regulation (9,10,16). Understanding how alterations in their expression or genetic variants contribute to insulin resistance provides important insights into the mechanisms underlying metabolic dysfunction (8). These insights may help elucidate the mechanisms driving metabolic disease and identify potential targets for therapeutic intervention, as well as potential markers for detection and monitoring of T2DM (18).

For thus this study aims to shed light on the role of FABPs in pathophysiology of diabetes, providing insights that could inform future research or therapeutic strategies targeting these proteins. Moreover, Correlate the relationship between FABPs (FABP1 and FABP2) and Diabetes type 2 complications.

PATIENTS AND METHODS

Study Design

This study employed a cross-sectional design to investigate the correlation between Fatty Acid Binding Proteins 1 and 2 (FABP1 and FABP2) and Type 2 Diabetes Mellitus T2DM. This study compared biochemical and clinical variables between patients diagnosed with T2DM and healthy non-diabetic controls.

Study Population

A total of 330 participants were included and divides into two groups:

- **Group 1 (Diabetic Patients):** 164 patients diagnosed with diabetes Type 2, These individuals have abnormal blood sugar levels, either high (hyperglycemia) or difficulty in managing blood glucose levels.
- **Group 2 (Control Group):** 166 healthy individuals with normal blood sugar levels. These individuals do not have diabetes or any metabolic disorders affecting blood sugar/glucose

Biochemical Investigations

All participants will be subjected to full history, clinical examination, laboratory investigations as fasting blood glucose (FBG), postprandial blood glucose (2h pp), blood urea nitrogen and creatinine, HBA1c, serum insulin, and serum lipid profile were done by automated chemistry analyzer (cobas® c311 analyzer).

Inclusion Criteria for patients

- Adults aged 18-70 years

- Patients of both sexes.

- Confirmed diagnosis of T2DM.

While the inclusion criteria for Control group were: Normal fasting glucose and HbA1c values, No chronic systemic disease.

Exclusion Criteria

-Type 1 diabetes or gestational diabetes.

-Chronic liver or kidney disease.

-Acute infections, inflammatory conditions, or malignancies.

-Pregnancy or lactation.

-Use of medications affecting lipid metabolism.

Ethical Considerations

An approval will be taken from Faculty of Medicine Ain Shams University Research Ethical Committee before starting the study, it's Code: FMASU R275/2025.

Written informed consent was obtained from all participants prior to enrollment. Data were handled confidentially and used exclusively for research purposes.

1. Blood Sample Collection

7ml of venous blood samples were collected from all participants after 8–12 hours of overnight fasting. Serum were separated by centrifuge at 5000 rpm for 5 min and stored at (-80c) for FABP1 and FABP2 detection.

Natural Resources for Human Health
eISSN: 2583-1194

2. Laboratory Measurements

Biochemical parameters:

Fasting blood glucose, HbA1c, Fasting insulin, Complete blood count (Hb, WBCs), Renal Function Tests as creatinine and eGFR was calculated by the CKD-EPI 2021creatinine equation (19). (mL/min/1.73 m^2) = 142 × (minimum of [Scr / κ, 1])^α × (maximum of [Scr / κ, 1])^(-1.200) × (0.9938)^Age × 1.012 (if female).

FABP1 and FABP2 quantification

Levels of FABP1 (liver-type FABP) and FABP2 (intestinal-type FABP) were measured using commercially available enzyme-linked immunosorbent assay (ELISA) kits, following the manufacturer's protocols. All samples were analyzed in duplicate to ensure consistency and accuracy. The catalog number for FABP1 and FABP2 were E3403Hu, DFBP20 and were for FABP1 and FABP2 respectively.

3. Sample Size Estimation

This study aims to comparing FABP 1&2 in diabetics and non-diabetics. Hassan Etal (2022) (20) reported a mean FABP1 in controls was 2.2 +,- 0.43, while men FABP1 in diabetics was 3.25 +,- 0.74. A Total Sample Size of 330 participants (164 diabetics &166 healthy controls) will be needed for this study with alpha level 5% & power 90%. Sample Size calculation was done using **"G. Power 3.1.9.2 program"**

Statistical Analysis

Data was analyzed using IBM SPSS Statistics Version 22. Data was tested for normality using Kolmogorov-Smirnov test and Shapiro-Wilk test. Quantitative data was presented as mean and standard deviation or median and range as appropriate while qualitative data was presented as number and percentage. Independent sample t test was used to compare numerical variables between study groups in normally distributed variables while Man Whitney test was used in non-normally distributed variables. Analysis of variance or Kruskal Wallis test was used to compare FAB1 or FAB2 among more than two categorical variables. Chi square or fisher exact as appropriate was used to compare categorical variables between study groups. Pearson correlation coefficient was used to compare correlation between FAB1 or FAB2 and other numerical variables. ROC curve was used to evaluate sensitivity and specificity of FAB1 and FAB2 as a potential biomarker for T2DM. P value set significant at 0.05 levels. All tests were two tailed.

RESULTS

Table 1 showed a total of 330 individuals were included, including 164 patients withT2DM and 166 healthy controls. Statistical analysis showed no significant differences between the two groups in terms of age (p=0.157) or gender distribution (p=0.912). In contrast, patients with T2DM exhibited elevated systolic and diastolic blood pressure levels compared to healthy control group (p<0.001 and p=0.018, respectively).

As presented in Table 1, diabetic participants also showed significantly higher body mass index values (31.50±4.87 vs. 27.04±2.42; p<0.001) and greater waist circumference measurements (101.57±11.05 vs. 92.43±7.89; p< 0.001) than healthy controls. Moreover, a positive family history of diabetes was reported significantly more frequently among T2DM patients than among control (49.4% vs. 16.9%, p<0.001).

Table 2 showed dietary and lifestyle habits differed significantly between two groups. Participants with T2DM were more likely to consume moderate-to-high carbohydrate diets compared with healthy controls (51.8% vs. 28.9%, p < 0.001), as well as a higher prevalence of low dietary fiber consumption (53.0% vs. 21.7%, p < 0.001).

Levels of physical activity were substantially lower among T2DM patients, with only 28% engaging in regular exercise compared to 58.4% of controls (p<0.001). In addition, walking activity was significantly reduced in individuals with T2DM (20.1% vs. 64.5%, p<0.001). Furthermore, mean sleep duration was significantly reduced among diabetic participants compared to controls (8.97±1.70 hours vs. 10.43±1.32 hours, p < 0.001).

Table 3 showed biochemical analysis revealed marked differences between diabetic patients and healthy controls. Diabetic participants had significantly elevated fasting plasma glucose (178.37±46.74 mg/dL vs. 94.52±12.36 mg/dL; p<0.001), levels of fasting insulin (p<0.001), and HbA1c percentages (7.82±1.19% vs. 4.05±0.42%; p<0.001).

In addition, indicators of inflammation and metabolic imbalance as WBCs, triglycerides, and total cholesterol were also elevated in diabetic group (all p < 0.001). In contrast, eGFR values were significantly reduced among the diabetic group compared with control individuals (p < 0.001). FABP1 and FABP2 concentrations: Levels of both FABP1 and FABP2 were both significantly higher in T2DM patients compared with healthy controls.

Table4showed: Diabetes-Related Complications among patients with T2DM, several chronic complications were observed. Diabetic nephropathy was present in 6.7% of cases, while cardiac complications, retinopathy, neuropathy were each reported in 14% of the diabetic population.

Table 5 showed: ROC curve analysis demonstrated excellent discriminatory ability for both markers. FABP1 showed a high area under the curve (AUC) of 0.929 (95% CI: 0.901–0.958; p < 0.001) indicating high sensitivity value (97.0%) across a wide range of specificity value (83.1%). Similarly, FABP2exhibied strong diagnostic performance, with an AUC of 0.910 (95% CI: 0.878–0.943; p < 0.001) indicating high sensitivity value (87.8%) across a broad range of specificity value (76.5%). Overall, these findings support the high accuracy of FABP1 and FABP2 as biomarkers for effectively differentiating individuals with T2DM from healthy controls.

Figure 1 showed: Positive correlation between FABP1 and fasting insulin levels. As FABP1 increases, fasting insulin also tends to increase. The regression line (y = -3.2 + 0.34x), with an R^2 value of 0.31 suggests a moderate correlation between the FABP1 and fasting insulin.

Figure 2 showed: Positive correlation between FABP2 and fasting insulin levels. As FABP2 increases, fasting insulin also tends to increase. The regression line (y = -1.86 + 3.03x), with an R^2 value of 0.319 suggests a moderate correlation between the FABP2 and fasting insulin.

Figure 3 showed: The diagnostic performance of FABP1 in distinguishing individuals with type 2 diabetes from non-diabetic individuals. The high sensitivity at lower values of 1-specificity suggests that FABP1 may serve as a useful biomarker for the diagnosis of type 2 diabetes.

Figure 4 showed: The diagnostic performance of FABP2 in distinguishing individuals with type 2 diabetes from non-diabetic individuals. The high sensitivity at lower values of 1-specificity suggests that FABP2 may serve as a useful biomarker for the diagnosis of type 2 diabetes.

Table 1: Demographic characteristics among studied groups (diabetic patients and healthy controls)

Variables		Diabetic		Healthy Control		Test *	P value
		N =164	%	N=166	%		
Age (Mean±Sd)		42.91±14.41		40.89±11.25		1.418**	0.157
Gender	Male	75	45.7	74	44.6	0.044	0.912
	Female	89	54.3	92	55.4		
Residence	Urban	118	72.0	110	66.3	1.249	0.285
	Rural	46	28.0	56	33.7		
Smoking	Non smoker	154	93.9	152	91.6	0.668	0.526

	X smoker	10	6.1	14	8.4		
Family history	No	83	50.6	138	83.1	39.45	<0.001
	Yes	81	49.4	28	16.9		
SBP (Mean± Sd)		120.10±5.30		115.39±4.85		8.422**	<0.001
DBP (Mean± Sd)		76.91±4.09		75.76±4.71		2.380**	0.018
BMI (Mean± Sd)		31.50±4.87		27.04±2.42		10.508**	<0.001
Waist (Mean± Sd)		101.57±11.05		92.43±7.89		8.631**	<0.001
Duration Median (Range)		20.0(1.0-60.0)		-			-

(*) Chi square test, (**) Independent sample t test, p value set significant at ≤0.05

SBP: Systolic blood pressure, **DBP**: Diastolic blood pressure, **BMI**: Body mass index.

Table 2: Lifestyle and Dietary characteristics among diabetic patients and healthy controls

Variables	Diabetic (N=164)	Healthy Control (N=166)	Test*	P value
Surrounding medical care			**1.476**	**0.228**
- No	**90 (54.9%)**	**80 (48.2%)**		
- Yes	**74 (45.1%)**	**86 (51.8%)**		
Number of meals / day			**45.104**	**<0.001**
- 1 meal	**2 (1.2%)**	**0 (0.0%)**		
- 2 meals	**103 (62.8%)**	**47 (28.3%)**		
- 3 meals	**39 (23.8%)**	**89 (53.6%)**		
- 4 meals	**19 (11.6%)**	**27 (16.3%)**		
- 5 meals	**1 (0.6%)**	**3 (1.8%)**		
Sleep hours (Mean ± SD)	**8.97 ± 1.70**	**10.43 ± 1.32**	**-8.738****	**<0.001**
Night sleep			**0.046**	**0.912**
- No	**78 (47.6%)**	**77 (46.4%)**		
- Yes	**86 (52.4%)**	**89 (53.6%)**		
Diet type			**27.299**	**<0.001**
- High carbohydrate	**8 (4.9%)**	**3 (1.8%)**		

- Low carb – high protein	37 (22.6%)	78 (47.0%)		
- Low to moderate carb	34 (20.7%)	37 (22.3%)		
- Moderate to high carb	85 (51.8%)	48 (28.9%)		
Fiber intake			34.706	<0.001
- Low fiber	87 (53.0%)	36 (21.7%)		
- High fiber	77 (47.0%)	130 (78.3%)		
Exercise			31.017	<0.001
- No	118 (72.0%)	69 (41.6%)		
- Yes	46 (28.0%)	97 (58.4%)		
Walking			66.389	<0.001
- No	131 (79.9%)	59 (35.5%)		
- Yes	33 (20.1%)	107 (64.5%)		

(*) Chi square test, (**) Independent sample t test, p value set significant at ≤0.05, (*)Chi square test, p value set significant at ≤0.05.

Table 3: Comparison between laboratory findings between Diabetic and healthy control groups

Variables	Diabetic	Healthy Control	Test*	P value
Hb (Median, Range)	12.15 (9.20–15.80)	10.60 (7.80–16.0)	-5.672	<0.001
WBCs (Median, Range)	8.00 (3.40–12.0)	6.30 (0.70–29.0)	-4.359	<0.001
Creatinine (Median, Range)	0.85 (0.20–2.70)	1.00 (0.70–1.40)	-4.586	<0.001
TG (Median, Range)	190.00 (87–300)	153.00 (121–245)	-7.761	<0.001
CHOL (Median, Range)	189.00 (160–270)	168.00 (100–256)	-8.896	<0.001
Fasting glucose (Mean ± SD)	178.37 ± 46.74	94.52 ± 12.36	22.219	<0.001
Fasting insulin (Mean ± SD)	10.63 ± 1.61	3.79 ± 1.61	26.173	<0.001
HbA1c (Mean ± SD)	7.82 ± 1.19	4.05 ± 0.42	28.256	<0.001
eGFR (Mean ± SD)	80.65 ± 10.13	85.56 ± 5.67	-5.431	<0.001
FABP1 (Mean ± SD)	35.76 ± 5.27	25.68 ± 3.94	19.663	<0.001
FABP2 (Mean ± SD)	3.54 ± 0.57	2.43 ± 0.51	18.523	<0.001

(*) Man Whitney test, p value set significant at ≤0.05, (*) Independent sample t test , p value set significant at ≤0.05, (*)Significance considered at p ≤ 0.05

Hb: Hemoglobin, **WBCs**: White blood cells, **TG**: Triglycerides, **Chol**: Cholesterol, **HbA1c**: Glycated hemoglobin, **eGFR**: Estimated glomerular filtration rate, **FABP1**: Fatty acid binding protein 1, **FABP2**: Fatty acid binding protein 2.

Table 4: frequency of different types of complications among diabetic group of patients

Variables		Diabetic	
		N =164	%
Diabetic nephropathy	No	153	93.3
	Yes	11	6.7
cardiac complication	No	141	86.0
	Yes	23	14.0
eye complication	No	141	86.0
	Yes	23	14.0
neuro complication	No	141	86.0
	Yes	23	14.0

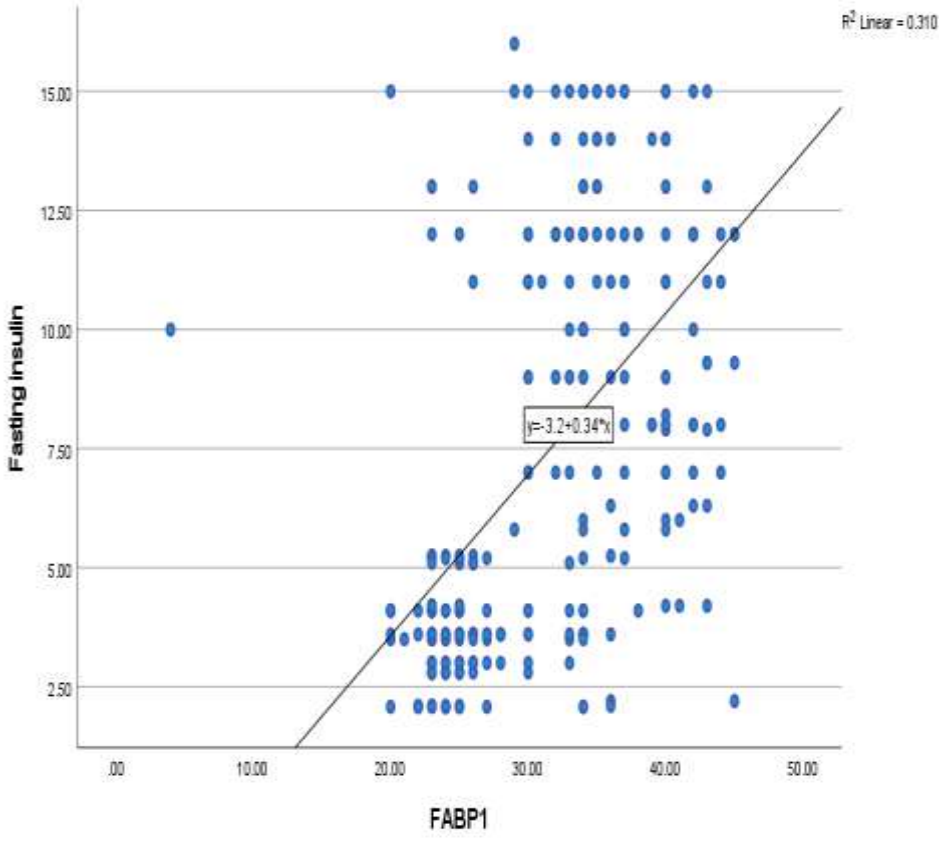

Fig 1: Correlation between serum FABP1 levels and fasting insulin in patients with type 2 diabetes mellitus.

Natural Resources for Human Health
eISSN: 2583-1194

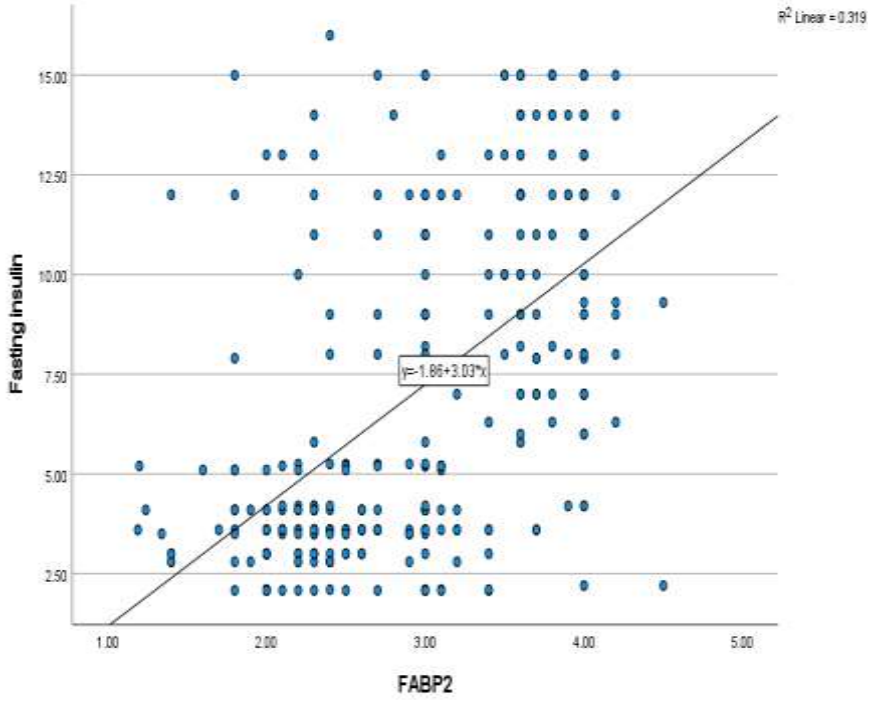

Fig 2: Correlation between serum FABP2 levels and fasting insulin in patients with type 2 diabetes mellitus.

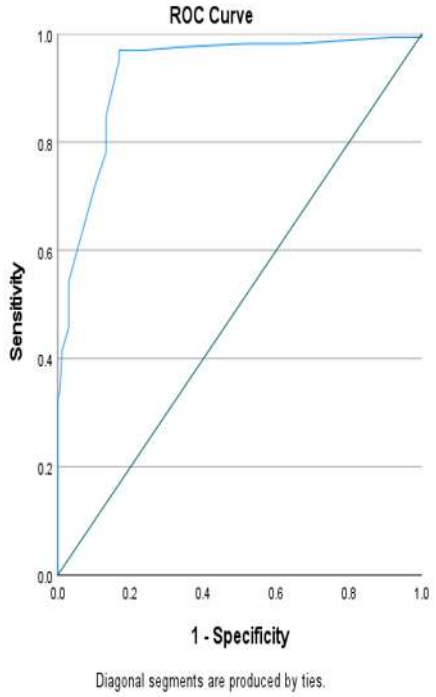

Fig 3: Roc curve analysis of FABP1 for the diagnosis of type 2 diabetes mellitus.

Natural Resources for Human Health
eISSN: 2583-1194

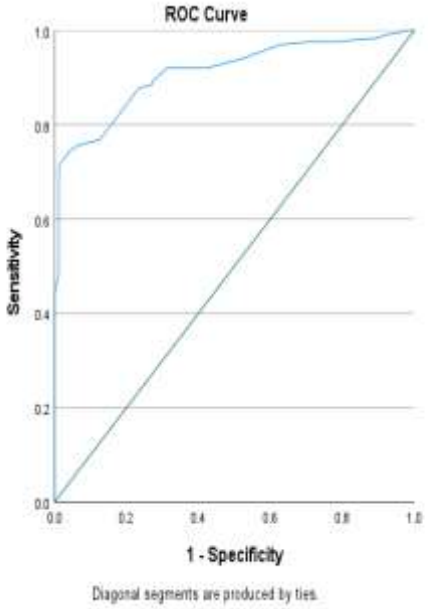

Fig 4: Roc curve analysis of FABP2 for the diagnosis of type 2 diabetes mellitus.

Table 5: Receive operating characteristic (ROC).

Area Under the Curve							
Test Result Variable(s): FABP1							
Area	Std. Error[a]	P value	Asymptotic 95% Confidence Interval		Cutoff	Sensitivity	Specificity
			Lower Bound	Upper Bound			
0.929	0.015	<0.001	0.901	0.958	28.50	97.0%	83.1%
The test result variable(s): FABP1 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.							
a. Under the nonparametric assumption							
b. Null hypothesis: true area = 0.5							

	Area Under the Curve						
	Test Result Variable(s): FABP2						
Area	Std. Error[a]	P value	Asymptotic 95% Confidence Interval		Cut off	Sensitivity	specificity
			Lower Bound	Upper Bound			
0.910	0.017	<0.001	0.878	0.943	2.950	87.8%	76.5%

The test result variable(s): FABP2 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.
a. Under the nonparametric assumption
b. Null hypothesis: true area = 0.5

DISCUSSION

The present study investigated the association between circulating fatty acid binding proteins FABP1 and FABP2 and Type 2 Diabetes Mellitus (T2DM), along with their relation to metabolic parameters, lifestyle factors, and diabetes-related complications. The findings show that FABP1 and FABP2 are elevated in individuals with T2DM compared with healthy controls, and their concentrations showed strong correlations with indicators of glycemic control, obesity, lipid metabolism, and cardiovascular disorder. Moreover, these elevations are associated with poor glycemic control, insulin resistance, increased adiposity, reduced renal function, and also a higher prevalence of diabetes-related microvascular and macrovascular complications.

In the present study, serum FABP1 levels were higher in diabetic patients, and also show strong positive correlations with fasting insulin, fasting glucose, HbA1c, BMI, waist circumference, triglycerides, and total cholesterol. In line with the current findings, there were several studies have reported elevated FABP1 levels in patients suffer from diabetes and significant associations with metabolic and renal parameters. Lu et al. (2020) (16) demonstrated that FABP1 levels were elevated in patients with T2DM and showed also positive correlations with BMI, waist circumference, triglycerides, and total cholesterol. Similarly, Hassan et al. (2022) (20) reported elevated FABP1 levels in diabetic patients, with strong correlations with fasting glucose, HbA1c, and insulin resistance markers, supporting the role of FABP1 in glucose and lipid dysregulation.

Also, in the current study, the negative correlation with eGFR observed that suggests a role of FABP1 as indicator of diabetic renal impairment in consistent with findings reported by Okada et al., who showed that FABP1 levels increased with the severity of diabetic nephropathy and were inversely associated with eGFR, suggesting its potential utility as an early biomarker of diabetic renal impairment. Moreover, similar associations were observed in type 1 diabetes, where El-Sayed et al. (2023) (21) found that FABP1 levels were positively correlated with HbA1c and total cholesterol and negatively correlated with eGFR, further supporting the link between FABP1, poor glycemic control, and renal dysfunction. The strong positive correlations observed between FABP1 and fasting glucose, HbA1c, fasting insulin support the hypothesis that FABP1 is linked to hepatic insulin resistance and lipid dysregulation.

The findings of the present study are supported by pervious experimental and mechanistic evidence highlighting the metabolic role of FABP1. Newberry et al. (2006) (7) demonstrated that FABP1 is a key to regulate hepatic fatty acid uptake and triglyceride metabolism, and that alterations in its expression contribute to metabolic dysfunction. Furthermore, Furuhashi and Hotamisligil (2015) (22) reported that FABP family proteins are upregulated in conditions of metabolic stress, including obesity and insulin resistance. Collectively, these studies provide biological support for the present findings and suggest that increased FABP1 levels reflect underlying metabolic stress and lipid dysregulation in diabetic patients.

In the present study, we observed positive association between circulating FABP1 levels and markers of poor long-term glycemic control. Our findings also suggest that elevated FABP1 may be indicative of insulin resistance and hepatic lipid abnormalities. Shi et al. (2012) (23) reported that serum FABP1 concentrations are elevated in conditions associated with chronic metabolic dysfunction as obesity and insulin resistance.

Furuhashi & Hotamisligil (2008) (5) focused on that FABPs in metabolic disease rather than on FABP1 and HbA1c, this paper highlighted the role of lipid-protein interactions in chronic metabolic stress, which provides support for our results.

FABP2 is expressed in intestinal enterocytes and plays a role in absorption of fatty acid and lipid metabolism. In the current study FABP2 levels were also significantly elevated among individuals with T2DM and showed positive correlations with fasting insulin, fasting glucose, HbA1c, BMI, and lipid parameters. These findings are consistent with pervious evidence indicating that FABP2 is closely associated with metabolic dysregulation in diabetes. Tsai et al. (2020) (14) reported that FABP2 levels elevated

in patients with T2DM, with significant associations observed between FABP2 and glycemic indices, lipid profiles, and insulin resistance markers. Also, Weiss et al. (2002) (24) reported that alterations in FABP2 are linked to impaired fatty acid handling and insulin sensitivity, further supporting its role in glucose and lipid metabolism.

FABPs play a role in linking nutrient absorption with metabolic and inflammatory signaling. Makowski and Hotamisligil (2004) (9) highlighted that FABPs act as intracellular lipid chaperons and mediators of lipid-derived signals that influences metabolic and inflammatory pathways. The observation that FABP1 and FABP2 are elevated in individuals with T2DM compared with healthy controls with clinical investigations demonstrating associations between increased FABP levels and metabolic disease states. Xu et al. (2022) (25) reported that patients with T2DM, both FABP1 and FABP2 levels rise in parallel with disease severity and associated with diabetic nephropathy that support their potential utility as biomarkers of metabolic dysregulation.

The present study observation that lifestyle-related factors may influence FABP1 and FABP2 levels that provides insight into the mechanisms linking proteins to metabolic stress. Individuals with higher levels of FABP1 and FABP2 were more likely consume high-carbohydrate diets, minimal physical activity, have low fiber intake, and sleep fewer hour. Xu et al. (2020) (25) reported that FABP1 and FABP2 levels elevated in individuals with T2DM and correlate with disease progression as well as the presence of diabetic complications, underscoring their utility as biomarkers of systemic metabolic perturbation.

In this study, the high diagnostic accuracy observed for FABP1 and FABP2 with AUC values of 0.929 and 0.910 respectively, aligns with evidence that FABP isoforms show promise as biomarkers of diabetic complications. Similar variability in AUC values among FABP isoforms has been reported in previous studies, suggesting that differences in diagnostic performance may be influenced by disease stage, population characteristics, and methodological factors (26,27).

In summary, the results of this study showed strong agreements with previously published research. FABP1 and FABP2 levels elevated in diabetic individuals, also their correlations with glycemic and lipid markers, and their association with macrovascular and microvascular complications. These findings support the broader hypothesis that FABP1 and FABP2 serve not only a marker of metabolic stress, but also as potential contributors to the pathophysiology of T2DM and it is complications.

CONCLUSION

This study demonstrates that FABP1 and FABP2 levels are increased in individuals with T2DM compared with healthy controls. Also, FABP1 and FABP2 show strong associations with metabolic abnormalities as hyperglycemia, insulin resistance, dyslipidemia, obesity, and impaired renal function. Their consistent correlations with fasting glucose, HbA1c, fasting insulin, BMI, triglycerides, and total cholesterol underscore their integral role in metabolic dysregulation and highlight their potential value as sensitive biomarkers of metabolic stress.

The study also demonstrates that elevated levels of FABP1 and FABP2 are linked to diabetes-related complications as nephropathy, neuropathy, retinopathy, and cardiovascular disorders. This relationship supports the proposition that these proteins may serve as early indicators of tissue injury and vascular dysfunction.

Additionally, the associations of FABP1 and FABP2 with lifestyle factors as dietary habits, physical activity, and sleep patterns highlight their responsiveness to modifiable behaviors. These findings emphasize the importance of integrating lifestyle interventions alongside clinical monitoring in order to mitigate metabolic risk and improve health outcomes among diabetic individuals. FABP1 and FABP2 also exhibited excellent diagnostic performance in ROC analysis, suggesting their potential as complementary biomarkers for identifying individuals at metabolic risk and to monitor diabetes progression.

Overall, this study highlights the essential role of FABP1 and FABP2 in the pathophysiology of T2DM and suggest that these proteins may serve as biomarkers for early detection, risk stratification, and assessment of complications. Future longitudinal and mechanistic studies are recommended to determine the predictive value of FABPs and to explore their potential as therapeutic targets in metabolic disease.

Funding: There is no fund

Conflict of interest: all authors declare there is no conflict of interest.

Acknowledgment: Special thanks are extended to the Faculty of Medicine, Ain Shams University, and all staff for their support and assistance throughout this work. We appreciate the supervision provided by professors.

Natural Resources for Human Health
eISSN: 2583-1194

Authors contribution:

Amal Ahmed, Refaat Mohamed were reviewed and supervised all steps in this work.

Salma Ehab were responsible for practical work.

Sherif Ahmed, Mona M. F. Ganem, Shady A. Ramiz were responsible for selection of patients.

Eman M. Fahmy were responsible for revision of all measurement of the main script.

Randa Ibrahim, Thereza Raouf were responsible for supervision of laboratory work.

Mohamed Said were responsible for adjust nutrition meals for all participants.

REFERENCE

[1] Boden, G. (2008). Obesity and free fatty acids: The link between obesity and insulin resistance. Endocrinology and Metabolism Clinics of North America, 37(3), 635–646. https://doi.org/10.1016/j.ecl.2008.06.005

[2] Khan, M. A. B., Hashim, M. J., King, J. K., Govender, R. D., Mustafa, H., & Al Kaabi, J. (2020). Epidemiology of type 2 diabetes – Global burden of disease and forecasted trends. Journal of Epidemiology and Global Health, 10(1), 107–111. https://doi.org/10.2991/jegh.k.191028.001

[3] DeFronzo, R. A., Ferrannini, E., Groop, L., Henry, R. R., Herman, W. H., Holst, J. J., Hu, F. B., & Kahn, C. R. (2015). Type 2 diabetes mellitus. Nature Reviews Disease Primers, 1, 15019. https://doi.org/10.1038/nrdp.2015.19

[4] Storch, J., & Thumser, A. E. A. (2010). The fatty acid transport function of fatty acid-binding proteins. Biochimica et Biophysica Acta (BBA) – Molecular and Cell Biology of Lipids, 1801(2), 214–221. https://doi.org/10.1016/j.bbalip.2009.09.010

[5] Furuhashi, M., & Hotamisligil, G. S. (2008). Fatty acid–binding proteins: Role in metabolic diseases and potential as drug targets. Nature Reviews Drug Discovery, 7(6), 489–503. https://doi.org/10.1038/nrd2589

[6] Hao, Y. (2018). Fatty acid-binding proteins and metabolic diseases. Journal of Diabetes Research, 2018, 1–8. https://doi.org/10.1155/2018/7294861

[7] Newberry, E. P., Xie, Y., Kennedy, S., Han, X., Buhman, K. K., Luo, J., Gross, R. W., & Davidson, N. O. (2006). Decreased hepatic triglyceride accumulation and altered fatty acid uptake in mice lacking liver fatty acid–binding protein. Journal of Biological Chemistry, 281(47), 35123–35133. https://doi.org/10.1074/jbc.M605900200

[8] Prentice, K. J., Saksi, J., & Lalloyer, F. (2013). Fatty acid-binding proteins and insulin resistance. Diabetologia, 56(5), 1016–1025. https://doi.org/10.1007/s00125-013-2869-3

[9] Makowski, L., & Hotamisligil, G. S. (2004). Fatty acid binding proteins—the evolutionary crossroads of inflammatory and metabolic responses. Journal of Nutrition, 134(9), 2464S–2468S. https://doi.org/10.1093/jn/134.9.2464S

[10] Turner, J. R., Buschmann, M. M., Romero-Calvo, I., Sailer, A., & Shen, L. (2010). The role of intestinal fatty acid–binding protein in metabolic inflammation. American Journal of Physiology-Gastrointestinal and Liver Physiology, 298(5), G655–G662. https://doi.org/10.1152/ajpgi.00409.2009

[11] Lau, C. H., Wong, S. K., & Chan, K. Y. (2016). Intestinal fatty acid-binding protein and metabolic inflammation. Nutrition & Metabolism, 13, 61. https://doi.org/10.1186/s12986-016-0121-7

[12] Zhang, Y., Li, Q., Chen, J., & Wang, L. (2020). Intestinal fatty acid-binding protein and type 2 diabetes mellitus. Diabetes & Metabolism Journal, 44(6), 827–836. https://doi.org/10.4093/dmj.2020.0032

[13] Li, Y., He, Y., Qi, L., Jiao, Y., & Yang, J. (2018). Genetic variants in FABP2 and risk of insulin resistance and type 2 diabetes mellitus. Journal of Diabetes Investigation, 9(2), 309–315. https://doi.org/10.1111/jdi.12715

[14] Tsai, I. T., Wang, C. P., Yu, T. H., & Lin, T. H. (2020). Fatty acid-binding protein 2 and cardiometabolic risk in type 2 diabetes mellitus. Diabetes Research and Clinical Practice, 159, 107980. https://doi.org/10.1016/j.diabres.2019.107980

[15] Tahapary, D. L., Soewondo, P., & Harbuwono, D. S. (2023). Fatty acid-binding proteins and cardiometabolic risk in type 2 diabetes. Frontiers in Endocrinology, 14, 1132457. https://doi.org/10.3389/fendo.2023.1132457

[16] Lu, Y., Wang, Z., Han, W., & Li, X. (2020). Association of liver-type fatty acid-binding protein with metabolic syndrome and type 2 diabetes. Diabetes Research and Clinical Practice, 165, 108238. https://doi.org/10.1016/j.diabres.2020.108238

[17] Gaffar, S. A. (2023). Liver-type fatty acid–binding protein and metabolic syndrome: Emerging insights. Journal of Metabolic Disorders, 12(1), 45–53.

[18] Krahmer, N., Farese, R. V., & Walther, T. C. (2020). Balancing the fat: Lipid droplets and human disease. EMBO Molecular Medicine, 12(4), e11871. https://doi.org/10.15252/emmm.201911871

[19] Inker, L. A., Eneanya, N. D., Coresh, J., Tighiouart, H., Wang, D., Sang, Y., Crews, D. C., Doria, A., Estrella, M. M., Froissart, M., et al. (2021). New creatinine- and cystatin C–based equations to estimate GFR without race. The New England Journal of Medicine, 385(19), 1737–1749. https://doi.org/10.1056/NEJMoa2102953

[20] Hassan, M. A., Ali, A. A., & El-Gendy, F. M. (2022). Circulating fatty acid-binding protein 1 as a biomarker for insulin resistance in type 2 diabetes mellitus. Endocrine Practice, 28(4), 402–410. https://doi.org/10.1016/j.eprac.2022.01.004

[21] El-Sayed, N. A., Ahmed, R. A., & Hassan, M. S. (2023). Serum liver-type fatty acid–binding protein as a marker of renal dysfunction in type 1 diabetes mellitus. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 17(2), 102676. https://doi.org/10.1016/j.dsx.2023.102676

[22] Furuhashi, M., & Hotamisligil, G. S. (2015). Fatty acid-binding proteins: Role in metabolic diseases and potential as drug targets. Nature Reviews Drug Discovery, 14(7), 521.

[23] Shi, H., Cheng, X., & Zhang, Q. (2012). Serum fatty acid–binding protein levels in obesity and insulin resistance. Metabolism, 61(6), 780–786. https://doi.org/10.1016/j.metabol.2011.10.011

[24] Weiss, E. P., Brown, M. D., Shuldiner, A. R., & Hagberg, J. M. (2002). Fatty acid-binding protein-2 gene variants and insulin resistance. Metabolism, 51(8), 973–977. https://doi.org/10.1053/meta.2002.34045

[25] Xu, B., Li, X., & Wang, Y. (2022). Circulating fatty acid-binding proteins and metabolic disorders: A systematic review. Frontiers in Endocrinology, 13, 857321. https://doi.org/10.3389/fendo.2022.857321

[26] Furuhashi, M. (2019). Fatty acid–binding protein 4 in cardiovascular and metabolic diseases. Journal of Atherosclerosis and Thrombosis, 26(3), 216–232. https://doi.org/10.5551/jat.48710

[27] Zhao, L., Zhang, Y., & Liu, H. (2021). Diagnostic value of fatty acid-binding proteins in metabolic diseases: A meta-analysis. Clinical Biochemistry, 93, 20–28. https://doi.org/10.1016/j.clinbiochem.2021.03.006