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Correlation of biochemical parameters with hepatic steatosis grade and visceral fat thickness in seborrheic dermatitis patients without cardiovascular disease

Bokebatur Ahmet Rasit Mendi[1], Banu Ismail Mendi[2], Mehmet Fatih Atak[3], Banu Farabi[4]

[1]Ankara Yıldırım Beyazıt University, Faculty of Medicine, Department of Radiology, Ankara, Türkiye
[2]Ankara Yıldırım Beyazıt University, Faculty of Medicine, Department of Dermatology, Ankara, Türkiye
[3]New York Medical College, Department of Dermatology, New York, USA
[4]Icahn School of Medicine at Mount Sinai, Department of Dermatology, New York, USA

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Abstract

This study investigated the correlations between biochemical parameters, hepatic steatosis grade, and visceral adipose tissue (VAT) thickness in seborrheic dermatitis (SD) patients without cardiovascular disease, aiming to enhance understanding of SD's systemic metabolic implications.Fifty-four SD patients and 54 age- and sex-matched healthy controls were included in this retrospective study (January 2019 - February 2024). Exclusion criteria involved known cardiovascular, metabolic, or chronic inflammatory conditions. Demographic and laboratory data (AST, ALT, GGT, ESR, CRP, complete blood count) were recorded. Ultrasonography assessed hepatic steatosis grade, carotid intima-media thickness (IMT), and subcutaneous, preperitoneal, and VAT thicknesses. SD patients showed a significantly higher prevalence of hepatic steatosis ($p = 0.028$), with Grade 2-3 steatosis in 18.5% of SD patients versus 3.7% of controls. Aorta-VAT thickness (37.61 ± 17.46 mm vs. 26.63 ± 9.56 mm, $p < 0.001$) and ALT levels (17.15 ± 8.86 U/L vs. 13.30 ± 3.55 U/L, $p = 0.036$) were significantly elevated in the SD group. IMT, ESR, and CRP values did not differ significantly. Multiple linear regression identified SD presence, male sex, and increasing age as robust independent predictors for increased Aorta-VAT thickness. This research demonstrates that SD patients, even without cardiovascular comorbidities, exhibit increased hepatic steatosis and visceral adiposity. These findings support SD's strong association with systemic metabolic dysregulation and emphasize the critical need for thorough metabolic risk factor assessment in this patient population.

Keywords: Seborrheic dermatitis, visceral fat, ultrasonography, hepatic steatosis, biochemical markers

Introduction

Seborrheic dermatitis (SD) is a prevalent chronic inflammatory skin disorder that affects regions of the body with a high concentration of sebaceous glands. It manifests as erythematous patches accompanied by yellowish dandruff. Commonly affected areas include the scalp, the regions behind the ears, nasolabial folds, eyebrows, beards, the anterior chest, and body folds. The incidence of this condition follows a multimodal distribution, peaking during the first three months of life, adolescence, early adulthood, and again after the age of 50. Although the precise cause remains unknown, it is generally considered unrelated to excessive sebum production. Malassezia species residing in seborrheic areas are believed to be a contributing factor [1,2]. Recent studies have demonstrated a significant association between SD and metabolic syndrome [3]. Current research findings also suggest that people with SD may exhibit a increased prevalence of metabolic disorders, such as dyslipidemia, insulin resistance, and central obesity—key features of metabolic syndrome [4,5].

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Corresponding Author: Bokebatur Ahmet Rasit Mendi, Ankara Yıldırım Beyazıt University, Faculty of Medicine, Department of Radiology, Ankara, Türkiye
Email: drbarmendi@gmail.com

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Hepatic steatosis, or fatty liver disease, is principally classified into two categories: alcoholic fatty liver disease and non-alcoholic fatty liver disease (NAFLD). NAFLD has emerged as the predominant chronic liver disease worldwide, with its prevalence directly correlated with the global rise in obesity, type 2 diabetes mellitus, and other components of metabolic syndrome [6,7]. NAFLD is widely acknowledged as a hepatic manifestation of metabolic syndrome and a multisystem disorder with potential implications for cardiovascular health, renal function, and endocrine regulation [8,9].

Beyond hepatic involvement, visceral adiposity has gained recognition as a critical driver of systemic inflammation and metabolic dysfunction. Visceral adipose tissue (VAT) is metabolically active and serves as a significant source of pro-inflammatory cytokines, such as TNF-α and IL-6, which may exacerbate chronic inflammatory skin conditions [10,11]. Sonographic measurement of VAT has emerged as a reliable, non-invasive, and cost-effective method to assess central obesity and its associated cardiometabolic risks, showing a strong correlation with gold-standard imaging techniques like CT and MRI [12,13]. Given that SD is associated with systemic inflammation, evaluating visceral fat thickness alongside hepatic parameters provides a more comprehensive understanding of the patient's metabolic status [14].

The potential interaction between SD, hepatic steatosis, and visceral adiposity remains a critical area of study due to their shared proinflammatory pathways and altered lipid metabolism. This study aimed to investigate demographic data, the presence and severity of hepatic steatosis, VAT thickness, and various biochemical markers in patients with SD compared to a healthy control group. Our objective was to elucidate these complex relationships through a comprehensive analysis of laboratory parameters and sonographic characteristics, thereby contributing to a better understanding of the systemic implications of SD.

Material and Methods

This study was conducted by examining the data of patients with SD aged 18 and over, who were followed at the Departments of Radiology and Dermatology, Niğde Ömer Halisdemir University Training and Research Hospital, between January 2019 and February 2024, along with age- and gender-matched healthy controls. The study was approved by the Institutional Review Board of Niğde Ömer Halisdemir University on 13 February 2025 (Decision No. 2025/12).

A total of 54 patients with SD and 54 age- and sex-matched healthy controls were included based on predetermined inclusion and exclusion criteria. Individuals with a diagnosis of cardiac disease, cerebrovascular disease, diabetes mellitus, hypertension, dyslipidemia, obesity, chronic kidney disease, inflammatory dermatological and/or connective tissue disease, and/or inflammatory bowel disease were excluded.

Demographic and laboratory data, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and complete blood count values, were recorded for all participants. Additionally, ultrasound (US) reports were documented for both groups.

Sonographic Procedures

Sonographic measures were acquired by a radiologist utilizing an ultrasound device (Samsung Medison V8; Samsung Healthcare, Seoul, Republic of Korea). A 3.5 MHz curved-array probe was employed to assess the degree of hepatic steatosis and abdominal adipose tissue parameters. Adipose tissue measurements included: subcutaneous adipose tissue thickness at the xiphoid level, preperitoneal adipose tissue thickness at the xiphoid level, the distance between the posterior wall of the aorta and the internal surface of the rectus abdominis muscle at the level of the umbilicus (aorta-VAT), and right posterior perirenal adipose tissue thickness (perirenal VAT) [15].

In addition, intima-media thickness (IMT) was measured from both the right (IMT1) and left (IMT2) common carotid arteries using an 11 MHz linear-array probe on the same device. Measurements were obtained at end-diastole in the longitudinal plane, focusing on plaque-free segments of each common carotid artery. All examinations were performed after an overnight fast, which was required for accurate abdominal measurements. Data were acquired with participants in the supine position at the end of expiration. To minimize compressing adipose tissue, the transducer was positioned perpendicular to the skin using minimal pressure. Adipose tissue thickness and IMT measurements are illustrated in Figure 1.

Statistical Analyses

The data analysis was conducted with a 95% confidence level using SPSS version 27.0. For categorical (qualitative) variables, frequency (n) and percentage (%) statistics were provided, while numerical (quantitative) variables were subjected to mean, standard deviation, minimum and maximum, and median statistics.

The study employed Pearson/Spearman correlation tests, independent samples t/Mann Whitney, and Chi-square tests.

The effect of gender, age, BMI, and the presence of seborrheic dermatitis on Aorta-VAT, Perirenal VAT, Preperitoneal VAT, and Subcutaneous fat measurements was analyzed using multiple linear regression. Multiple linear regression is a type of regression analysis used to examine the effect of multiple independent variables on a quantitative dependent variable. For all statistical analyses, a p-value of less than 0.05 was considered to indicate statistical significance.

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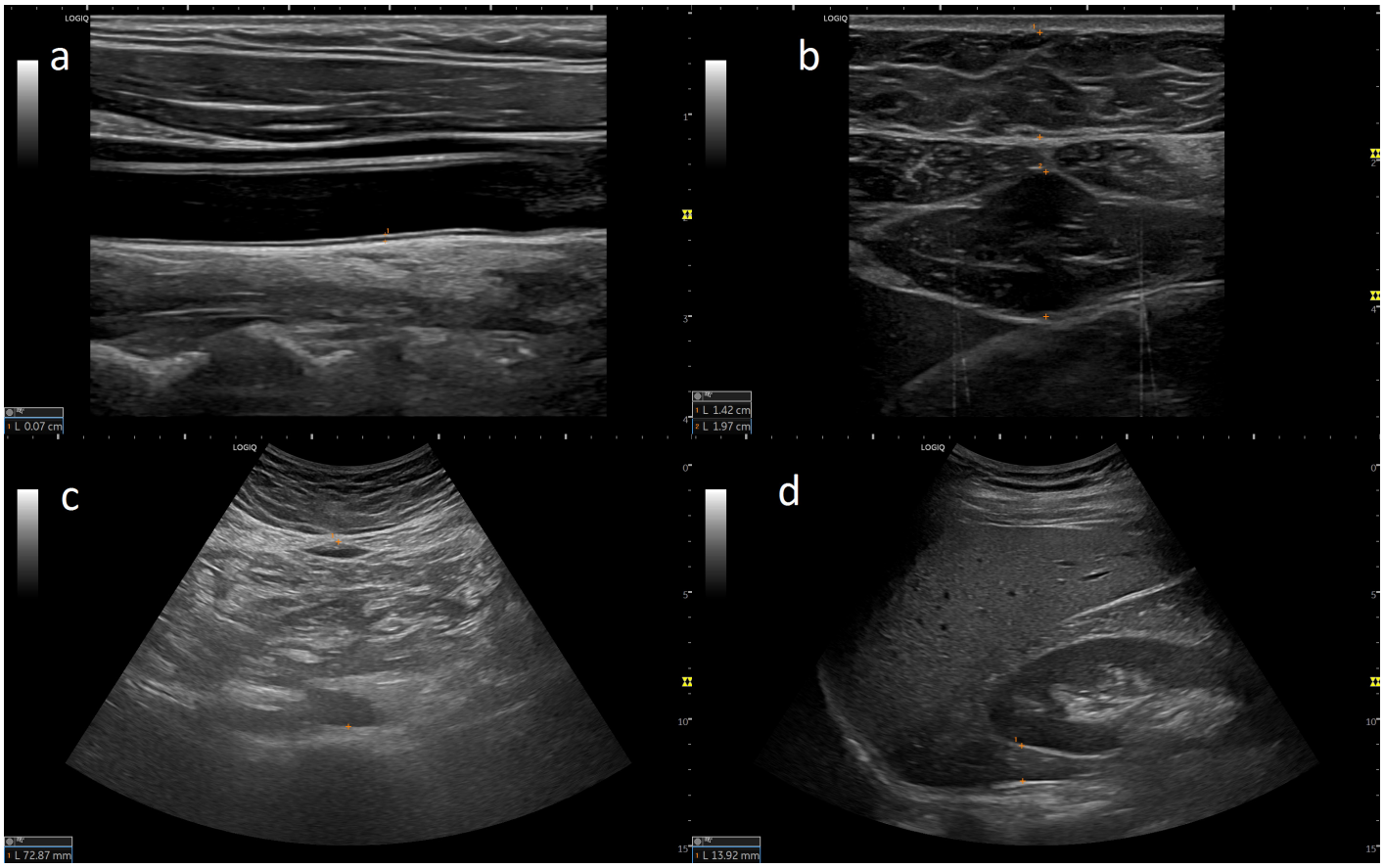

Figure 1. Sonographic measurements of various adipose tissue thicknesses and carotid intima–media thickness are illustrated. **(a)** Carotid intima–media thickness; **(b)** subcutaneous (upper) and preperitoneal (lower) adipose tissue thickness measured at the xiphoid process level; **(c)** distance between the aorta and the anterior abdominal wall; and **(d)** posterior perirenal adipose tissue thickness

Results

Demographic Characteristics

The study included a total of 108 participants, comprising 54 patients with SD and 54 age- and sex-matched healthy controls. The mean age of the study population was 30.89 ± 10.98 years (range: 18–69 years). No significant differences were observed between the SD and control groups regarding age (31.69 ± 12.37 vs. 30.09 ± 9.43 years, p = 0.454) or sex distribution (p = 0.844), confirming the adequacy of the matching process. The relationships between groups in terms of age and gender were presented in Table 1 and Table 2.

Table 1. Comparison of sex and sonographic steatosis measurements between the groups

Variable (n)	Control group (n = 54)		SD group (n = 54)		Total (n = 108)		p-value
	%	n	%	n	%		
Sex							
Male	22	40.7	20	37.0	42	38.9	0.844
Female	32	59.3	34	63.0	66	61.1	
Steatosis grade							
0	36	66.7	27	50.0	63	58.3	
1	16	29.6	17	31.5	33	30.6	**0.028**
2-3	2	3.7	10	18.5	12	11.1	
Chi-square test							

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Table 2. Comparison of age, sonographic measurements and biochemical parameters between the groups

Variable	Control group (n = 54)		SD group (n = 54)		Total (n = 108)		p
	Min-Max (M)	Mean±sd	Min-Max (M)	Mean±sd	Min-Max (M)	Mean±sd	
Age	18.0–5.0 (27.5)	30.09 ± 9.43	18.0–69.0 (28.0)	31.69 ± 12.37	18.0–69.0 (28.0)	30.89 ± 10.98	0.454
Subcutaneous	3.0–22.0 (9.5)	10.93 ± 4.44	3.0–25.0 (10.0)	11.26 ± 5.01	3.0–25.0 (10.0)	11.09 ± 4.72	0.715
Preperitoneal	5.0–22.0 (12.0)	13.00 ± 4.43	5.0–26.0 (12.0)	13.19 ± 4.83	5.0–26.0 (12.0)	13.09 ± 4.61	0.836
Aorta VAT	11.0–55.0 (25.5)	26.63 ± 9.56	14.0–86.0 (33.5)	37.61 ± 17.46	11.0–86.0 (29.0)	32.12 ± 15.06	**0.000***
Perirenal VAT	3.0–16.0 (7.0)	6.98 ± 2.51	4.0–12.0 (8.0)	7.76 ± 1.96	3.0–16.0 (7.0)	7.37 ± 2.28	0.076
IMT1	0.5–1.4 (0.6)	0.69 ± 0.18	0.5–1.4 (0.6)	0.67 ± 0.18	0.5–1.4 (0.6)	0.68 ± 0.18	0.459
IMT2	0.5–1.3 (0.7)	0.69 ± 0.18	0.5–1.3 (0.6)	0.67 ± 0.18	0.5–1.3 (0.6)	0.68 ± 0.18	0.459
AST	10.0–41.0 (18.6)	20.61 ± 6.99	10.0–41.0 (15.9)	18.33 ± 6.77	10.0–41.0 (17.5)	19.47 ± 6.94	0.087
ALT	5.0–24.0 (12.5)	13.30 ± 3.55	5.0–54.0 (15.5)	17.15 ± 8.86	5.0–54.0 (14.0)	15.22 ± 6.99	**0.036***
GGT	7.0–82.0 (15.5)	18.33 ± 13.65	7.0–86.0 (16.0)	19.19 ± 14.80	7.0–86.0 (16.0)	18.76 ± 14.18	0.728
ESR	2.0–26.0 (8.0)	9.33 ± 6.01	2.0–27.0 (8.5)	10.31 ± 6.95	2.0–27.0 (8.0)	9.82 ± 6.48	0.434
CRP	0.1–16.0 (1.5)	2.17 ± 2.60	0.1–16.0 (1.5)	2.31 ± 2.77	0.1–16.0 (1.5)	2.24 ± 2.68	0.842
Neutrophil count	2.5–6.9 (3.9)	4.30 ± 1.19	2.5–6.8 (3.9)	4.19 ± 1.11	2.5–6.9 (3.9)	4.25 ± 1.15	0.640
Lymphocyte count	0.8–4.9 (2.4)	2.52 ± 0.73	0.8–4.3 (2.4)	2.42 ± 0.66	0.8–4.9 (2.4)	2.47 ± 0.70	0.468
PLT	185–485 (272)	271.46 ± 51.98	191–485 (283.5)	281.61 ± 53.77	185–485 (274)	276.54 ± 52.88	0.296
NLR	0.8–4.6 (1.6)	1.84 ± 0.73	0.9–4.6 (1.7)	1.85 ± 0.68	0.8–4.6 (1.6)	1.84 ± 0.70	0.763
PLR	48.7–269.4 (116.9)	116.72 ± 40.86	55.1–269.4 (119.2)	124.83 ± 40.86	48.7–269.4 (117.3)	120.77 ± 40.87	0.273
MPV	8.1–12.0 (10.3)	10.22 ± 0.83	8.1–12.3 (10.5)	10.37 ± 0.89	8.1–12.3 (10.3)	10.30 ± 0.86	0.389

Independent Samples T/Mann Whitney-U Test

Sonographic and Biochemical Findings

A comparison of sonographic measurements and biochemical parameters between the two groups is summarized in Table 1 and Table 2. The degree of hepatic steatosis was significantly higher in the SD group compared to the control group ($p = 0.028$). Specifically, Grade 2-3 steatosis was observed in 18.5% of SD patients, whereas it was present in only 3.7% of the control group.

Regarding visceral adiposity, the SD group exhibited significantly higher Aorta-VAT thickness (37.61 ± 17.46 mm) compared to the control group (26.63 ± 9.56 mm, $p < 0.001$). Perirenal VAT thickness also showed a trend toward higher values in the SD group (7.76 ± 1.96 mm vs. 6.98 ± 2.51 mm), although this did not reach statistical significance ($p = 0.076$). No significant differences were found in subcutaneous fat ($p = 0.715$) or preperitoneal fat ($p = 0.836$) thicknesses between the groups. Furthermore, IMT measurements were comparable between the groups, with mean IMT1 values of 0.67 ± 0.18 mm in the SD group and 0.69 ± 0.18 mm in the control group ($p = 0.459$). Similarly, IMT2 values did not differ significantly (0.67 ± 0.18 mm vs. 0.69 ± 0.18 mm, $p = 0.459$).

Among the biochemical markers, ALT levels were significantly elevated in the SD group (17.15 ± 8.86 U/L) compared to the control group (13.30 ± 3.55 U/L, $p = 0.036$). Other laboratory parameters, including AST, GGT, ESR, CRP, and hematological indices (neutrophil count, lymphocyte count, PLT, NLR, PLR, and MPV), did not differ significantly between the two groups ($p > 0.05$).

Subgroup Analysis by Sex

Subgroup analyses revealed sex-specific differences in several parameters within both groups. In the SD group, males had significantly higher preperitoneal fat ($p = 0.017$), Aorta-VAT ($p = 0.003$), perirenal VAT ($p = 0.046$), ALT ($p = 0.011$), and GGT ($p < 0.001$) levels compared to females. Conversely, females in the SD group showed significantly higher ESR ($p < 0.001$), PLT ($p = 0.015$), NLR ($p = 0.007$), PLR ($p = 0.004$), and MPV ($p = 0.004$) values. Similar sex-based trends for Aorta-VAT, GGT, ESR, PLT, NLR, and MPV were also observed in the control group ($p < 0.05$).

Correlation Analysis

Correlation analysis (Table 3) demonstrated that age was positively and significantly correlated with several adiposity

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markers in both groups. In the SD group, age showed a strong positive correlation with Aorta-VAT (r = 0.705, p < 0.001), perirenal VAT (r = 0.683, p < 0.001), IMT1 (r = 0.712, p < 0.001), and IMT2 (r = 0.742, p < 0.001). Additionally, weak to moderate positive correlations were found between age and subcutaneous fat (r = 0.311, p = 0.022), preperitoneal fat (r = 0.404, p = 0.002), GGT (r = 0.295, p = 0.030), CRP (r = 0.451, p = 0.001), and lymphocyte count (r = 0.317, p = 0.020).

Table 3. Age-related correlations with sonographic measurements and biochemical parameters ın the control and SD groups

Variable		Age	
		Control group (n=54)	**SD group (n=54)**
Subcutaneous	**r**	.380**	.311*
	p	**0.005**	**0.022**
Preperitoneal	**r**	.362**	.404**
	p	**0.007**	**0.002**
Aorta VAT	**r**	.403**	.705**
	p	**0.002**	**0.000**
Perirenal VAT	**r**	0.180	.683**
	p	0.193	**0.000**
IMT1	**r**	.595**	.712**
	p	**0.000**	**0.000**
IMT2	**r**	.624**	.742**
	p	**0.000**	**0.000**
AST	**r**	-0.066	-0.182
	p	0.636	0.187
ALT	**r**	0.209	0.183
	p	0.129	0.185
GGT	**r**	0.224	.295*
	p	0.104	**0.030**
ESR	**r**	.361**	0.248
	p	**0.007**	0.070
CRP	**r**	.422**	.451**
	p	**0.001**	**0.001**
Neutrophil count	**r**	0.164	0.176
	p	0.235	0.202
Lymphocyte count	**r**	.352**	.317*
	p	**0.009**	**0.020**
PLT	**r**	0.160	0.063
	p	0.247	0.652
NLR	**r**	-0.260	-0.167
	p	0.057	0.226
PLR	**r**	-0.225	-0.259
	p	0.102	0.059
MPV	**r**	-0.210	-0.169
	p	0.128	0.221

**p < 0.001, *p < 0.05 significant relationship, p > 0.05 no significant relationship, 0 ≤ r ≤ 0.25 very weak, 0.26 ≤ r ≤ 0.49 weak, 0.50 ≤ r ≤ 0.69 moderate, 0.70 ≤ r ≤ 0.89 strong, 0.90 ≤ r ≤ 1 very strong; Pearson/Spearman correlation test

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Multivariable Regression Analysis

Multiple linear regression models were constructed to evaluate the independent effects of sex, age, BMI, and the presence of SD on various fat measurements (Table 4).

The model for Aorta-VAT was highly significant ($F = 28.708$, $p < 0.001$) and explained 52.7% of the variance ($R^2 = 0.527$). The presence of SD was a strong independent predictor of increased Aorta-VAT thickness ($B = 10.246$, $p < 0.001$). Furthermore, male sex ($B = 7.699$, $p = 0.001$) and advancing age ($B = 0.713$, $p < 0.001$) were also significantly associated with higher Aorta-VAT levels, while BMI did not show a significant effect ($p = 0.537$).

For Subcutaneous Fat, the model ($R^2 = 0.193$, $p < 0.05$) showed that female sex ($B = -2.755$, $p = 0.003$), age ($B = 0.121$, $p = 0.005$), and BMI ($B = 0.377$, $p = 0.045$) were significant predictors, whereas SD was not ($p = 0.819$).

In the Preperitoneal VAT model ($R^2 = 0.205$, $p < 0.05$), male sex ($B = 2.297$, $p = 0.011$) and age ($B = 0.153$, $p < 0.001$) were significant predictors. For Perirenal VAT ($R^2 = 0.218$, $p < 0.05$), only age ($B = 0.076$, $p < 0.001$) emerged as a significant independent predictor.

Table 4. Multivariable linear regression analysis of factors associated with adiposity measurements

Dependent variable	Independent variable	B	SE	β	t	p-value	95% CI (Lower)	95% CI (Upper)
Aorta-VAT (R^2=0.527)	Sex (Male=1)	7.699	2.248	0.250	3.424	0.001	3.240	12.158
	Age	0.713	0.103	0.520	6.931	<0.001	0.509	0.917
	BMI	0.281	0.454	0.050	0.619	0.537	-0.619	1.181
	SD Presence	10.246	2.051	0.342	4.996	<0.001	6.179	14.313
Subcutaneous fat (R^2=0.193)	Sex (Male=1)	-2.755	0.920	-0.286	-2.995	0.003	-4.579	-0.931
	Age	0.121	0.042	0.281	2.866	0.005	0.037	0.204
	BMI	0.377	0.186	0.213	2.028	0.045	0.008	0.745
	SD Presence	0.193	0.839	0.021	0.230	0.819	-1.471	1.857
Preperitoneal VAT (R^2=0.205)	Sex (Male=1)	2.297	0.892	0.244	2.574	0.011	0.527	4.067
	Age	0.153	0.041	0.365	3.757	<0.001	0.072	0.234
	BMI	-0.025	0.180	-0.014	-0.137	0.891	-0.382	0.333
	SD Presence	0.016	0.814	0.002	0.020	0.984	-1.599	1.630
Perirenal VAT (R^2=0.218)	Sex (Male=1)	0.363	0.437	0.078	0.830	0.409	-0.504	1.230
	Age	0.076	0.020	0.367	3.810	<0.001	0.037	0.116
	BMI	0.080	0.088	0.093	0.901	0.370	-0.096	0.255
	SD Presence	0.702	0.399	0.155	1.761	0.081	-0.089	1.493

B: Unstandardized coefficient; SE: Standard error; β: Standardized coefficient; t: t-statistic; CI: Confidence interval; SD: Seborrheic dermatitis; VAT: Visceral adipose tissue

Discussion

SD is a chronic inflammatory skin condition increasingly recognized for its systemic associations, particularly with metabolic disorders. Our study aimed to investigate the correlation of biochemical parameters with hepatic steatosis grade and VAT thickness in SD patients without cardiovascular disease, thereby seeking to contribute to a better understanding of the systemic implications of this dermatological condition.

Our primary findings indicate a significantly higher prevalence of hepatic steatosis and elevated ALT levels in patients with SD compared to age- and sex-matched healthy controls. These observations are largely consistent with prior research linking SD to metabolic syndrome and its components [16,17]. Furthermore, SD patients exhibited significantly greater Aorta-VAT thickness. These results suggest an association between SD and metabolic dysregulation, even within a cohort carefully selected to minimize confounding by established cardiovascular comorbidities.

The observed higher incidence of hepatic steatosis in SD patients is consistent with a growing body of literature suggesting a link between SD and metabolic syndrome [3-5,16,18]. Hepatic steatosis, particularly NAFLD, is widely acknowledged as a hepatic manifestation of metabolic syndrome, closely associated with insulin resistance and systemic inflammation [17,19]. The elevated ALT levels in our SD cohort further support the presence of hepatic involvement, as ALT is a recognized biomarker for

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liver injury and inflammation [20]. This pattern suggests that SD may serve as a cutaneous indicator of underlying systemic metabolic disturbances, prompting further investigation into shared pathophysiological mechanisms.

Our study's finding of increased Aorta-VAT thickness in SD patients warrants particular attention. VAT is known to be metabolically active, serving as a significant source of pro-inflammatory cytokines that contribute to systemic inflammation and metabolic dysfunction [21,22]. While previous studies have explored the relationship between SD and general obesity, body composition, or epicardial fat thickness [3,17,22], the specific assessment of Aorta-VAT thickness using ultrasonography in SD patients, particularly in a cohort without established cardiovascular disease, appears to be less extensively reported. To our knowledge, this study is among the first to specifically investigate Aorta-VAT thickness as a precise sonographic marker of visceral adiposity in SD patients without cardiovascular disease. This approach offers a more granular and potentially more relevant evaluation of central obesity in this population compared to broader measures. The observed correlation between SD and increased Aorta-VAT supports the hypothesis that shared inflammatory pathways and altered lipid metabolism may contribute to the comorbidity of SD with metabolic disorders [23,24]. The absence of significant differences in subcutaneous or preperitoneal fat thicknesses further emphasizes the specific role of visceral adiposity in the context of SD, distinguishing it from generalized adiposity.

Interestingly, while perirenal VAT showed a trend towards higher values in the SD group, it did not reach statistical significance. This observation might suggest a differential impact of SD on various visceral fat depots or could be attributed to the relatively small sample size for this specific parameter. The lack of significant differences in IMT between the groups is a crucial finding, as it indicates that the observed metabolic alterations in our SD cohort had not yet progressed to detectable subclinical atherosclerosis. This highlights the potential importance of early identification and intervention for metabolic risk factors in SD patients, especially before the onset of overt cardiovascular complications.

Subgroup analysis by sex indicated distinct patterns. Males in the SD group exhibited higher preperitoneal fat, Aorta-VAT, perirenal VAT, ALT, and GGT levels compared to females. Conversely, females in the SD group showed higher ESR, PLT, NLR, PLR, and MPV values. These sex-specific differences suggest that metabolic and inflammatory pathways may manifest differently between genders in SD patients, underscoring the need for further investigation into sex-specific risk stratification and management strategies.

Correlation analysis further supported the role of age as a significant factor, showing positive correlations with various adiposity markers in both groups. In the SD group, age was strongly correlated with Aorta-VAT, perirenal VAT, IMT1, and IMT2, and weakly to moderately with subcutaneous fat, preperitoneal fat, GGT, CRP, and lymphocyte count. These correlations underscore the cumulative effect of aging on metabolic health and its interplay with SD pathogenesis.

Multivariable linear regression analysis indicated the presence of SD as a strong independent predictor of increased Aorta-VAT thickness, even after accounting for sex, age, and BMI. This finding is a key aspect of our study, suggesting that SD may not merely be a coincidental finding with visceral adiposity but could be intrinsically linked. Male sex and advancing age were also significant predictors of higher Aorta-VAT, consistent with known demographic risk factors for visceral obesity.

Our study has some limitations. Its cross-sectional design, for instance, restricts the ability to establish causality, suggesting a need for longitudinal studies to delineate the temporal relationship between SD and metabolic abnormalities. Furthermore, while US offers a non-invasive and accessible assessment of hepatic steatosis and Aorta-VAT thickness, its operator-dependency and the absence of more advanced imaging techniques like MRI or CT for fat quantification represent inherent limitations. The relatively modest sample size, particularly for subgroup analyses, also necessitates caution in generalizing some sex-specific findings.

Conclusion

In conclusion, our findings suggest a potential association between SD, hepatic steatosis, and increased visceral adiposity, even in individuals without established cardiovascular disease. These observations highlight the importance of considering metabolic health in SD patients. Future research, particularly longitudinal studies and those employing advanced imaging with larger cohorts, is warranted to further explore causal pathways, underlying mechanisms, and potential interventions.

Ethical Approval

The study was performed in accordance with ethical principles outlined in the Declaration of Helsinki. The study was approved by the Institutional Review Board of Niğde Ömer Halisdemir University on 13 February 2025 (Decision No. 2025/12). A waiver of informed consent was granted by the IRB.

Patient Consent

The Institutional Review Board (IRB) granted a waiver of informed consent.

Conflict of Interest

The authors confirm the absence of any conflicts associated with this work.

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