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Rosacea as a Skin Mark for Metabolic Syndrome: A Case–Control Study of Insulin Resistance, Dyslipidemia, and Hypertension

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Abstract: Background: Rosacea is an inflammatory facial skin disease that has become increasingly associated with systemic metabolic disorders but the significance of the connection and its implications for clinical practice have not been fully described especially beyond Western populations. **Objective**: To determine the frequency of metabolic syndrome and its specific manifestations among rosacea patients in comparison with age- and gender-matched controls, and investigate if there is any difference in the metabolic status according to the gender of patients. **Methods**: In this cross-sectional study carried out in one year in a combined dermatology and internal medicine clinic, 50 rosacea patients (35 females, 15 males aged 45–60 years) were compared with 50 age-matched controls (aged 43-62 years). Weight, body mass index, blood pressure, fasting blood glucose, lipids profile and HOMA-IR were measured in all participants. Definition of metabolic syndrome was performed according to NCEP-ATP III criteria. **Results**: Metabolic syndrome was observed in 60% of rosacea patients versus 34% of controls (χ^2 test, $p < 0.01$). Rosacea patients showed significantly higher fasting glucose (112 ± 15 vs 98 ± 12 mg/dL), HOMA-IR (3.2 ± 0.8 vs 2.1 ± 0.7), LDL-cholesterol (140 ± 20 vs 120 ± 18 mg/dL), systolic blood pressure (135 ± 10 vs 120 ± 8 mmHg) and diastolic blood pressure (85 ± 7 vs 78 ± 5 mmHg), together with significantly lower HDL-cholesterol (38 ± 5 vs 50 ± 6 mg/dL; all $p < 0.01$). Within the rosacea group, men showed higher fasting glucose and blood pressure than women, while dyslipidaemia was numerically more pronounced in women. **Conclusion:** Rosacea is associated with a substantially higher prevalence of metabolic syndrome and each of its principal components. These findings support the incorporation of routine metabolic screening into the dermatological management of rosacea patients.

Keywords: Rosacea; metabolic syndrome; insulin resistance; dyslipidaemia; hypertension; cardiovascular risk; systemic inflammation.

INTRODUCTION

Rosacea is a chronic, relapsing inflammatory dermatosis that predominantly affects the centrofacial skin of middle-aged and older adults, with a clinical spectrum ranging from transient flushing and persistent erythema to papulopustular lesions, phymatous change and ocular involvement [Rainer, B. M. *et al*., 2017]. Population-based and dermatological outpatient studies estimate its overall prevalence at roughly 5% of the adult population in Western cohorts, with considerable variation across settings and diagnostic criteria [Gether, L. *et al*., 2018]. Long regarded as a purely cutaneous nuisance, rosacea is now understood to be the visible facial expression of a broader dysregulation of the innate immune system: aberrant activation of Toll-like receptor 2 leads to excessive production of the antimicrobial peptide cathelicidin (LL-37) and the serine protease kallikrein-5, both of which drive the vasodilation, neovascularisation and leukocyte recruitment that characterise the disorder [Yamasaki, K., & Gallo, R. L. 2011]. Initial experiments revealed that the injection of these mediators, or of the enzymes producing them, into mouse skin recapitulates the changes in blood vessels and inflammation associated with rosacea [Yamasaki, K. *et al*., 2007].

Furthermore, later studies using drugs have shown that the inhibition of this cathelicidin-kallikrein axis can attenuate inflammation in reconstructed skin models [Thibaut de Ménonville, S. *et al*., 2017]. As this axis is not restricted to the skin and its initiators share many similarities with those causing systemic low-grade inflammation, rosacea has become increasingly recognized as a possible skin marker for systemic metabolic disease. Metabolic syndrome is a clinically recognized constellation of interrelated risk factors for heart diseases, including abdominal obesity, atherogenic dyslipidaemia, hypertension and insulin resistance, operationally defined by the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) criteria as the presence of at least three out of five risk factors [Cleeman, J. I. 2001]. Though previously thought of as a disease affecting people in Western countries, metabolic syndrome has been recognized as a global public health issue, which affects over one-fifth of adult populations in developed and developing countries [Saklayen, M. G. 2018] and is associated with increased chances of type 2 diabetes mellitus and

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atherosclerotic heart disease. Epidemiologic data have associated rosacea with various features of this metabolic cluster. Case–control studies from Turkey and Taiwan have reported an excess burden of dyslipidaemia, hypertension and elevated fasting glucose among rosacea patients relative to matched controls [8,9], and large Danish nationwide cohort data have confirmed an increased risk of composite cardiovascular disease in this population [Egeberg, A. *et al*., 2016].

More directly relevant to the present study, Akin Belli and colleagues demonstrated a significantly higher prevalence of both metabolic syndrome and insulin resistance among rosacea patients using the Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) as the operational measure of insulin sensitivity [Akin Belli, A. *et al*., 2016], while a large United States cohort of nurses showed a dose-dependent relationship between body-mass index and incident rosacea risk over 14 years of follow-up [Li, S. *et al*., 2017]. These findings were subsequently consolidated in a systematic review and update of rosacea comorbidities [Haber, R., & El Gemayel, M. 2018] and in a formal meta-analysis of thirteen studies encompassing more than 50,000 rosacea patients, which confirmed a robust pooled association between rosacea and both hypertension and dyslipidaemia, alongside higher fasting glucose and less consistent evidence for ischaemic heart disease [Chen, Q. *et al*., 2020]. A subsequent large retrospective cohort study corroborated an elevated cardiovascular risk specifically among women with rosacea [Choi, D. *et al*., 2021].

Mechanistically, the co-occurrence of rosacea and metabolic syndrome is thought to be explained not by a simple cause-and-effect relationship in either direction, but by a shared upstream biology of chronic low-grade inflammation. Adipose-tissue-derived cytokines such as tumour necrosis factor-α and interleukin-6 are now recognised as central drivers of insulin resistance and endothelial dysfunction in metabolic disease [Hotamisligil, G. S. 2006], and this inflammatory paradigm has since been extended to dermatology, where several cutaneous disorders including rosacea cluster with metabolic syndrome more often than would be expected by chance [Stefanadi, E. C. *et al*., 2018]. Because C-reactive protein, a downstream marker of this same inflammatory cascade, directly impairs endothelial nitric-oxide-mediated vasodilation and independently predicts cardiovascular events [Ridker, P. M. *et al*., 2003], the facial vascular changes of rosacea and the systemic vascular risk of metabolic syndrome may be two visible manifestations of one underlying inflammatory process rather than sequential causes of one another.

In regard to causality, one recent two-sample MR study was unable to identify any genetic evidence supporting the role of obesity as a risk factor for developing rosacea [Yao, H. *et al*., 2024], which suggests that the metabolic clustering seen in rosacea may be better explained by common inflammatory susceptibility rather than an unidirectional cause-and-effect process. Despite this expanding evidence base, most published cohorts originate from European, North American or East Asian populations, and dedicated case–control data quantifying the full metabolic syndrome burden rather than isolated components in Middle Eastern rosacea patients remain scarce. The present study was therefore designed to determine, in a case–control framework, the prevalence of metabolic syndrome and each of its individual components in patients with clinically diagnosed rosacea compared with matched controls, and to explore whether this metabolic burden differs between women and men within the rosacea group.

METHODS

Study Design and Setting

This was a cross-sectional, case–control study conducted over a 12-month period in a combined dermatology and internal medicine clinic. The study was designed to compare clinical, anthropometric and metabolic parameters between patients with clinically diagnosed rosacea and rosacea-free controls.

Participants

Two groups of 50 participants each were enrolled. **Group 1 (Rosacea)** comprised 50 patients (35 women, 15 men; age range 45–60 years) with a clinical diagnosis of rosacea established by a dermatologist. **Group 2 (Control)** comprised 50 age- and sex-matched individuals without rosacea (age range 43–62 years) recruited from the same clinical setting. Participants with pre-existing diabetes mellitus under pharmacological treatment, known dyslipidaemia on lipid-lowering therapy, or a prior diagnosis of established cardiovascular disease were excluded from both groups to minimise confounding by treated disease. Baseline characteristics of both groups are summarised in Table 1.

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Data Collection

For all participants, clinical measures such as BMI, waist circumference, and resting blood pressure were measured by standardized methods. Blood specimens from venous punctures were collected after an overnight fasting period of more than eight hours for estimation of fasting plasma glucose, lipid profile (total cholesterol, LDL-cholesterol, HDL-cholesterol and triglycerides), and fasting insulin, with the latter used to estimate insulin resistance using the HOMA-IR equation of Matthews *et al*. [Matthews, D. R. *et al*., 1985]. Diagnosis of metabolic syndrome was done using the NCEP-ATP III criteria [Cleeman, J. I. 2001], based on the presence of three or more out of the following five risk factors: abdominal obesity, increased serum triglyceride concentration, decreased HDL-cholesterol, elevated blood pressure and increased fasting glucose. The above definition was preferred over alternative definitions such as the International Diabetes Federation criteria, based on comparative studies showing similar or higher incidence of atherosclerotic cardiovascular disease among the NCEP-ATP III definition [Yousefzadeh, G. *et al*., 2024].

Statistical Analysis

Continuous data were represented by mean ± standard deviation, while comparisons between groups were made by applying independent-samples t-test. The categorical data, such as metabolic syndrome prevalence, were compared using chi-square ($\chi 2$) test. Two-tailed p-values less than 0.05 were regarded to be statistically significant.

RESULTS

Overall findings are summarized in Tables 1–3 and illustrated in Figures 1–6.

Baseline Characteristics

The two groups were well matched for age and sex distribution, with no statistically significant differences between them (Table 1). Rosacea patients had a modestly but significantly higher BMI than controls (28.9 ± 4.1 vs 27.1 ± 3.7 kg/m², p = 0.03), consistent with prior reports linking adiposity to rosacea risk [Li, S. *et al*., 2017], and indicating that the metabolic differences described below cannot be attributed to imbalances in age or sex.

Table 1. Baseline characteristics of study participants

Parameter	Rosacea Group (n = 50)	Control Group (n = 50)	p-value
Female / Male ratio	35 : 15	34 : 16	0.87
Mean age (years)	52.5 ± 3.8	53.1 ± 4.2	0.62
BMI (kg/m²)	28.9 ± 4.1	27.1 ± 3.7	0.03

Values are mean ± SD unless otherwise stated. BMI, body-mass index.

Prevalence of Metabolic Syndrome and Its Components

Metabolic syndrome, defined by NCEP-ATP III criteria, was present in 60% of rosacea patients compared with 34% of controls, a difference confirmed as statistically significant by chi-square testing (p < 0.01) (Table 2, Figure 1). Every individual component of the syndrome was more pronounced in the rosacea group (Table 2). Fasting glucose was significantly higher among rosacea patients (112 ± 15 vs 98 ± 12 mg/dL), as was HOMA-IR (3.2 ± 0.8 vs 2.1 ± 0.7), indicating a greater degree of insulin resistance (Figure 2).

Table 2. Prevalence of metabolic syndrome and its individual components

Parameter	Rosacea Group (n = 50)	Control Group (n = 50)	p-value
Metabolic syndrome (%)	60	34	< 0.01
Fasting glucose (mg/dL)	112 ± 15	98 ± 12	< 0.01
HOMA-IR	3.2 ± 0.8	2.1 ± 0.7	< 0.01
LDL-C (mg/dL)	140 ± 20	120 ± 18	< 0.01
HDL-C (mg/dL)	38 ± 5	50 ± 6	< 0.01
Systolic BP (mmHg)	135 ± 10	120 ± 8	< 0.01
Diastolic BP (mmHg)	85 ± 7	78 ± 5	< 0.01

BP, blood pressure; HOMA-IR, Homeostatic Model Assessment of Insulin Resistance; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

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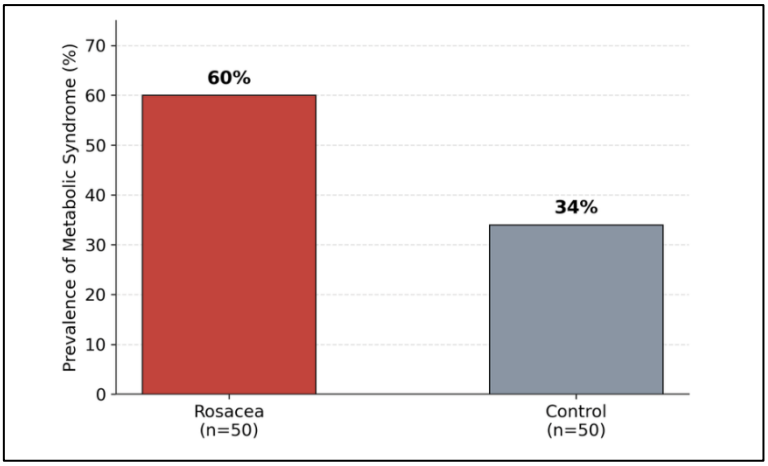


Figure 1. Prevalence of metabolic syndrome in rosacea patients versus controls (χ^2 test, $p < 0.01$).

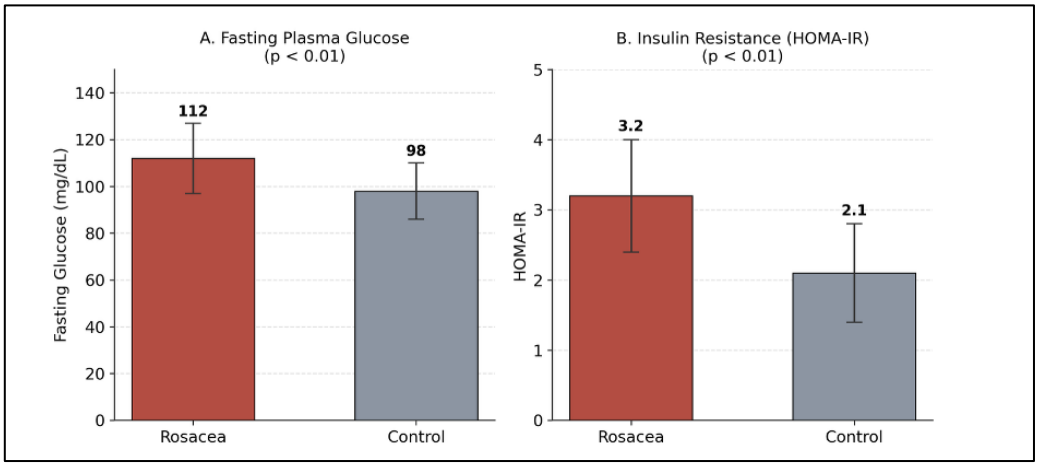


Figure 2. Fasting plasma glucose (A) and insulin resistance measured by HOMA-IR (B) in rosacea patients versus controls. Bars represent mean ± SD.

Lipid Profile and Blood Pressure

Rosacea patients showed a significantly more atherogenic lipid profile, with higher LDL-cholesterol (140 ± 20 vs 120 ± 18 mg/dL) and lower HDL-cholesterol (38 ± 5 vs 50 ± 6 mg/dL) compared with controls (both $p < 0.01$) (Figure 3). Triglycerides were numerically higher in the rosacea group but did not reach statistical significance. Systolic and diastolic blood pressure were both significantly elevated in rosacea patients relative to controls (135 ± 10 vs 120 ± 8 mmHg and 85 ± 7 vs 78 ± 5 mmHg respectively; both $p < 0.01$) (Figure 4), consistent with the increased cardiovascular risk previously reported in this population.

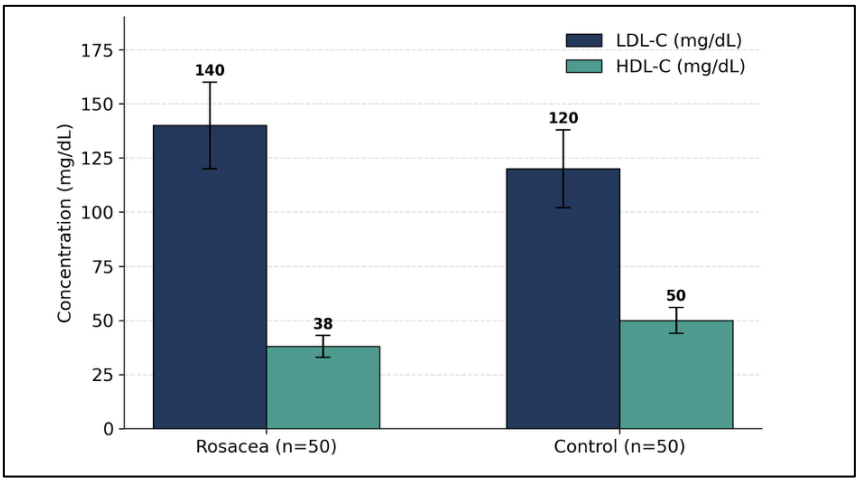


Figure 3. Lipid profile (LDL-C and HDL-C) of rosacea patients versus controls. Bars represent mean ± SD.

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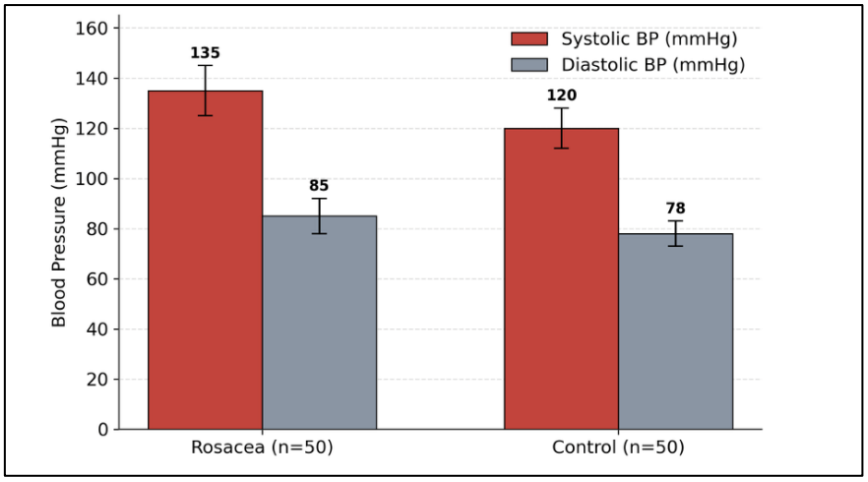


Figure 4. Systolic and diastolic blood pressure in rosacea patients versus controls. Bars represent mean ± SD.

Sex-Specific Analysis Within the Rosacea Group

Within the rosacea group, sex-specific comparisons revealed a distinct metabolic pattern (Table 3, Figure 5). Male rosacea patients had significantly higher fasting glucose (115 ± 14 vs 110 ± 12 mg/dL, p = 0.04) and significantly higher systolic and diastolic blood pressure than female patients (both p ≤ 0.02). Conversely, dyslipidaemia reflected in a numerically lower HDL-cholesterol was more pronounced among women, although this difference did not reach statistical significance (p = 0.32). These patterns broadly mirror sex-specific trends reported in the general metabolic syndrome literature, in which men tend to accumulate glycaemic and vascular risk while women more often manifest atherogenic dyslipidaemia.

Table 3. Sex-specific analysis of metabolic components within the rosacea group

Parameter	Female Rosacea (n = 35)	Male Rosacea (n = 15)	p-value
Fasting glucose (mg/dL)	110 ± 12	115 ± 14	0.04
HDL-C (mg/dL)	37 ± 5	39 ± 4	0.32
Systolic BP (mmHg)	132 ± 9	140 ± 8	< 0.01
Diastolic BP (mmHg)	83 ± 6	88 ± 5	0.02

BP, blood pressure; HDL-C, high-density lipoprotein cholesterol.

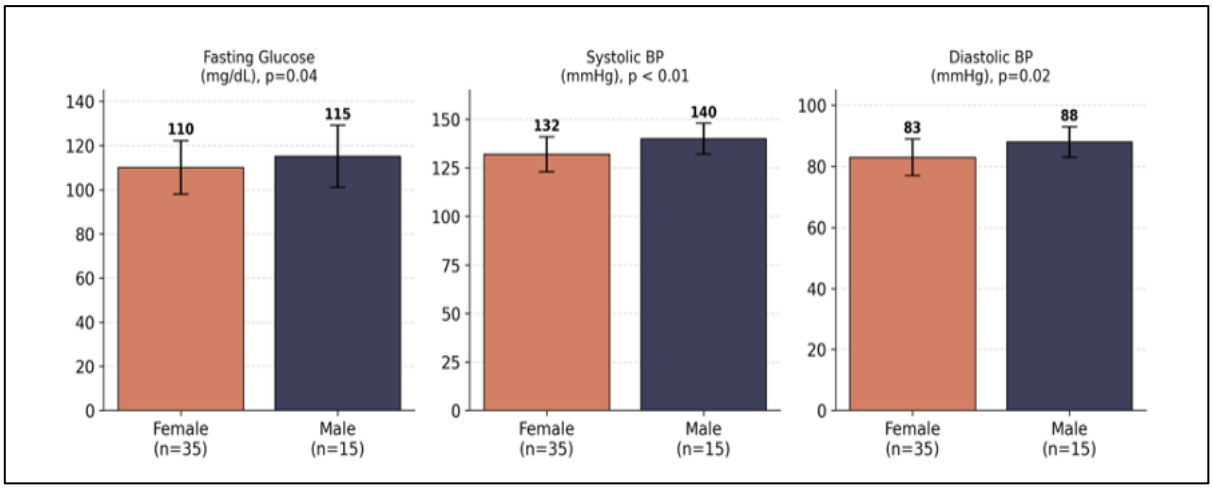


Figure 5. Sex-specific distribution of fasting glucose, systolic blood pressure and diastolic blood pressure within the rosacea group. Bars represent mean ± SD.

DISCUSSION

This case–control study demonstrates a markedly higher prevalence of metabolic syndrome nearly double that of matched controls among patients with rosacea, together with a significant excess of every individual metabolic component: insulin resistance, dyslipidaemia and hypertension (Tables 2 and 3; Figures 1–5). These findings extend, in an under-represented population, the pattern already described in Turkish, Taiwanese and Danish

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cohorts [Duman, N. *et al*., 2014; Hua, T. C. *et al*., 2015; Egeberg, A. *et al*., 2016; Akin Belli, A. *et al*., 2016] and are consistent with the pooled estimates from the largest available meta-analysis of rosacea and cardiometabolic disease, which similarly identified robust associations with hypertension, dyslipidaemia and elevated fasting glucose across more than 50,000 patients [Chen, Q. *et al*., 2020].

Insulin Resistance as a Central Metabolic Feature

The near 50% elevation in mean HOMA-IR observed in the rosacea group (Figure 2B) is the most striking single finding of this study and closely reproduces the magnitude reported by Akin Belli and colleagues, who first demonstrated a direct link between rosacea and both insulin resistance and metabolic syndrome using the same index [Akin Belli, A. *et al*., 2016]. Chronic hyperinsulinemia has been shown to promote skin inflammation through several converging mechanisms, such as induction of the signaling pathway of insulin-like growth factor-1 as well as enhancement of inflammation induced by cytokines from fat tissue, thus making this an important biological link between insulin resistance and skin inflammation in rosacea. [Yamasaki, K., & Gallo, R. L. 2011].

Dyslipidaemia and Vascular Risk

The combination of elevated LDL-cholesterol and depressed HDL-cholesterol identified here (Figure 3) reproduces the atherogenic lipid signature described in earlier case–control work [Duman, N. *et al*., 2014] and aligns with the pooled meta-analytic estimate showing consistently higher LDL-cholesterol and lower HDL-cholesterol in rosacea patients across studies [Chen, Q. *et al*., 2020]. Because systemic inflammation is known to impair the cholesterol-efflux capacity of HDL particles and to promote LDL oxidation [Hotamisligil, G. S. 2006; Ridker, P. M. *et al*., 2003], the chronic low-grade inflammatory state that characterises rosacea provides a mechanistically coherent explanation for this pattern, rather than implying that rosacea itself directly causes dyslipidaemia.

Hypertension and Endothelial Dysfunction

Both systolic and diastolic blood pressure were significantly elevated in the rosacea group (Figure 4), corroborating the excess cardiovascular risk reported in Danish and Korean nationwide cohorts [Egeberg, A. *et al*., 2016; Choi, D. *et al*., 2021]. Rosacea and hypertension may share a common substrate of endothelial dysfunction: the same cathelicidin–kallikrein pathway responsible for facial vasodilation and telangiectasia in rosacea skin has vasoactive and pro-angiogenic properties systemically [Yamasaki, K., & Gallo, R. L. 2011; Yamasaki, K. *et al*., 2007], and circulating C-reactive protein a marker of the same inflammatory process has been shown to directly impair endothelium-dependent, nitric-oxide-mediated vasodilation [Ridker, P. M. *et al*., 2003]. This mechanistic overlap reinforces the case for routine blood pressure assessment in rosacea patients, independent of traditional cardiovascular risk stratification.

Shared Inflammatory Pathways

A unifying explanation for the clustering of metabolic abnormalities in rosacea is chronic systemic low-grade inflammation. Adipose-tissue and circulating levels of interleukin-6, tumour necrosis factor-α and C-reactive protein are elevated in both rosacea and metabolic syndrome, and these mediators are directly implicated in insulin resistance, endothelial injury and dyslipidaemia [Hotamisligil, G. S. 2006], a mechanism that has been proposed to explain the broader clustering of inflammatory skin disease with metabolic syndrome [Stefanadi, E. C. *et al*., 2018]. The cathelicidin–kallikrein-5 axis that drives cutaneous inflammation in rosacea is therefore best understood not as an isolated dermatological curiosity but as the visible facial component of a broader inflammatory phenotype that also manifests as insulin resistance, dyslipidaemia and hypertension elsewhere in the body (Figure 6).

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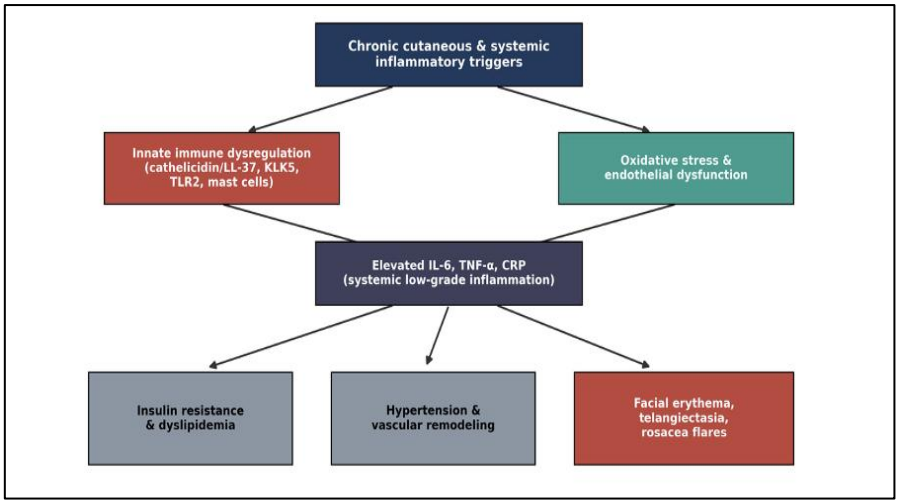


Figure 6. Proposed shared pathophysiological pathway linking chronic cutaneous and systemic inflammatory triggers, innate immune dysregulation and oxidative stress to both the cutaneous manifestations of rosacea and the metabolic derangements of metabolic syndrome.

Sex Differences

The sex-specific analysis (Table 3, Figure 5) suggests that men with rosacea concentrate their metabolic risk in glycaemic and blood-pressure parameters, while women trend toward more pronounced dyslipidaemia. This pattern parallels well-recognised sex differences in the general metabolic syndrome population [Saklayen, M. G. 2018] and suggests that screening strategies in rosacea patients may benefit from being tailored by sex rather than applying a uniform panel to all patients.

Clinical Implications

Taken together, these findings support incorporating basic metabolic screening blood pressure measurement, fasting glucose and a lipid panel into the routine dermatological assessment of rosacea patients, particularly those with additional risk factors such as elevated BMI. This methodology was also suggested in the largest studies conducted on this issue, which recommended screening for cardiometabolic markers in rosacea patients for the purpose of early detection and treatment of any issues [13,14,17]. Using a multidisciplinary approach by combining dermatological and internal or endocrinological services can lead to early detection of at-risk patients before the development of cardiovascular disease.

Causality and Study Limitations

Several limitations warrant caution in interpreting these results. First, the cross-sectional, case–control design cannot establish causal directionality between rosacea and metabolic syndrome; a recent Mendelian randomisation study did not find genetic evidence that obesity causally increases rosacea risk, favouring a model of shared inflammatory susceptibility over a simple unidirectional cause-and-effect relationship [19]. Second, the sample size, while adequate to detect the differences reported, remains modest, and the male subgroup in particular (n = 15) limits the precision of sex-specific estimates. Third, rosacea subtype (erythematotelangiectatic, papulopustular, phymatous or ocular) was not stratified in this analysis, and metabolic risk may differ across subtypes [Rainer, B. M. *et al*., 2017]. Finally, single-centre recruitment may limit generalisability to other populations and healthcare settings [Gether, L. *et al*., 2018]. Larger, prospective, multicentre studies stratified by rosacea subtype are needed to clarify temporal relationships and to determine whether metabolic intervention improves rosacea severity.

CONCLUSION

This case–control study demonstrates that patients with rosacea carry a significantly greater burden of metabolic syndrome and each of its constituent abnormality's insulin resistance, dyslipidaemia and hypertension (Tables 1–3; Figures 1–6) than age- and sex-matched controls, with a distinct sex-specific distribution of risk. The results further confirm the idea of rosacea as a skin indicator of underlying systemic inflammation and disruption of metabolism, rather than being just a dermatological disorder, and they emphasize the need to take a multidisciplinary approach by combining dermatology care with metabolic testing of the patients.

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