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Spectrum of Cutaneous Manifestations in Adults with Overweight and Obesity: A Cross-Sectional Study from Rural North Karnataka

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ABSTRACT

Background: Obesity is associated with a wide spectrum of cutaneous manifestations arising through metabolic, mechanical and inflammatory mechanisms. Data from rural Indian adult populations remain limited. **Objectives:** To document the spectrum and frequency of cutaneous manifestations among adults with overweight and obesity attending a rural tertiary care centre, and to examine their associations with demographic and clinical variables. **Methods:** Hospital-based cross-sectional study conducted at Dermatology Department of, KBN Hospital, Kalaburagi, from December 2023 to June 2024. Adults with BMI of 23 kg/m² or more were enrolled by consecutive sampling. Conditions that independently cause skin changes were excluded. All participants underwent a detailed dermatological examination. Association of skin manifestations with gender and duration of excess weight was assessed. **Results:** 127 participants were enrolled with mean age of 37.1 years and mean BMI of 28.6 kg/m². The common findings were striae distensae (63.0%), acanthosis nigricans (62.2%), skin tags (57.5%), fungal infections (53.5%) and intertrigo (52.0%). Hirsutism was significantly more common in females (36.1% vs 6.1%, p = 0.0001). AN was significantly associated with duration of excess weight (p = 0.0002). Duration was the only independent predictor of AN after adjusting for age, sex and BMI, with patients exceeding ten years had the highest odds. **Conclusion:** In adults with overweight and obesity were striae distensae, acanthosis nigricans, skin tags, fungal infections and intertrigo were the most frequently observed conditions. Duration of excess weight independently predicts AN regardless of BMI, age and sex, highlighting the need for early metabolic evaluation in this population.

KEYWORDS: Obesity, Cutaneous manifestations, Acanthosis nigricans, Striae distensae, Rural India

INTRODUCTION

Obesity has emerged as a major public health challenge of the current century. The World Health Organization estimates that more than 890 million adults worldwide are living with obesity and nearly 2.5 billion with overweight, with global prevalence having more than doubled since 1990[1]. India reflects this trend acutely. National Family Health Survey-5 data from 2019 to 2021 show that approximately one in four Indian adults now

meets criteria for overweight or obesity, with prevalence rising steeply across both urban and rural settings[2]. Rural populations, once considered relatively protected by physically demanding livelihoods and traditional diets, are now experiencing rapid increases driven by nutritional transition and declining occupational activity[3]. Projections suggest that obesity prevalence in India will triple between 2010 and 2040, with relative increase anticipated in rural populations and older age groups[4].

The skin is profoundly affected by the metabolic and physical consequences of excess adiposity. Increased adipose mass drives chronic low-grade inflammation through leptin, resistin, and tumour necrosis factor-alpha, while simultaneously impairing skin barrier function, disrupting sebaceous and sweat gland physiology, and altering lymphovascular dynamics[5, 6]. Friction within skin folds, localised hyperhidrosis and sustained occlusion of intertriginous surfaces create conditions that favour both infection and persistent dermatitis[7]. It is estimated that 60 to 70 percent of obese individuals will develop at least one cutaneous complication during the course of their illness[6].

Acanthosis nigricans (AN) holds particular clinical significance amongst obesity-associated dermatoses. This hyperpigmented velvety thickening of the neck, axillae and flexures occurs in 4.5 to 74 percent of obese individuals depending on the population studied and serves as a readily visible marker of underlying insulin resistance[8]. The lesion develops through hyperinsulinaemia-driven stimulation of insulin-like growth factor-1 receptors on keratinocytes, activating the Ras/MAP/ERK and PI3-K/Akt pathways and inducing epidermal proliferation[9]. Other commonly documented conditions include striae distensae, acrochordons, intertrigo, fungal infections, plantar hyperkeratosis and acne vulgaris, each arising through some combination of mechanical strain, impaired innate immunity and metabolic derangement[5, 6, 9]. Associations with psoriasis and atopic dermatitis through shared adipokine and cytokine pathways have also been described, and in women with co-existing polycystic ovarian syndrome, obesity-related hyperandrogenism contributes to hirsutism and acne[5, 6, 7].

Despite the high and increasing prevalence of overweight and obesity in rural India, dermatological manifestations in this population remain poorly characterised. The available literature is largely derived from urban or semi-urban centres, often with mixed or predominantly paediatric populations, and few studies have focused on adults attending rural dermatology services[10-12]. Rural patients face additional challenges in the form of delayed presentation and poor access to specialist care, which together contribute to underdiagnosis and late management of obesity-related skin disease. The present study was conducted at a rural tertiary care centre in North Karnataka with the aims of documenting the spectrum and frequency of cutaneous manifestations among adults with overweight and obesity, examining their associations with demographic and clinical variables, and providing evidence to support dermatological screening in resource-limited settings.

METHODOLOGY

1. Study Design and Setting

This was a hospital-based cross-sectional study conducted in the Department of Dermatology, Venereology and Leprosy at KBN University's tertiary care teaching hospital, Kalaburagi, North Karnataka. The hospital serves a predominantly rural catchment population. The study was conducted from December 2023 to June 2024.

2. Sampling Frame and Patient Selection

All adults aged 18 years and above attending the Dermatology OPD during the study period were eligible for screening, regardless of their presenting complaint. Consecutive sampling was employed. Trained nursing staff measured the height and weight of all attendees at registration and calculated BMI using a standardised protocol. Those with BMI of 23 kg/m² or above were further assessed as per inclusion and exclusion criteria[12]. The study was approved by the Institutional Ethics Committee of KBN University, Kalaburagi (Approval No. KBNU/FOMS/IEC/2023-24/26, dated 6 November 2023). Written informed consent was obtained from all participants.

3. Sample Size

The sample size was estimated using the formula $n = Z^2 \times p(1-p) / d^2$, with Z = 1.96, p = 0.62 based on the prevalence of acanthosis nigricans reported by Geeta Sai *et al*.[10] in a comparable south Indian population, and d = 0.10. This yielded a minimum of 91 participants. Adding 20 percent for non-response, the target was set at 110. Consecutive screening over the full study period yielded 127 eligible participants, all of whom were enrolled.

4. Inclusion Criteria

Participants aged 18 years or above, having BMI of 23 kg/m² or above classified according to Asian Indian criteria[12] who provided written informed consent.

5. Exclusion Criteria

Several conditions were excluded because they independently produce cutaneous manifestations that would otherwise be attributed to excess weight. These

included confirmed type 2 diabetes mellitus or impaired fasting glucose, polycystic ovarian syndrome, hypothyroidism on replacement therapy, Cushing's syndrome or exogenous corticosteroid use of three months or more, pregnancy, malignancy associated with paraneoplastic acanthosis nigricans, drug-induced acanthosis nigricans and active primary dermatological conditions unrelated to obesity such as lichen planus or pemphigus. Patients unwilling to participate were also excluded.

6. Data Collection

Height was recorded to the nearest 0.1 cm using a wall-mounted stadiometer and weight to the nearest 0.1 kg on a calibrated digital scale. A structured proforma was used to record demographic and clinical history. Duration of excess weight was ascertained by patient self-report and corroborated against available medical records where possible.

All participants underwent a full head-to-toe dermatological examination by the principal investigator under standardised artificial lighting. Each finding was recorded by site, morphology and extent. Potassium hydroxide mount was performed for suspected fungal infections, Gram stain and bacterial culture for suspected bacterial infections and skin biopsy for diagnostically uncertain lesions. Hirsutism was assessed in female participants using the modified Ferriman-Gallwey scoring system, with a total score of 8 or above on nine androgen-sensitive body areas considered positive for hirsutism[13, 14].

7. Outcome Measures

The primary outcome was the spectrum and frequency of cutaneous manifestations among adults with overweight and obesity. Secondary outcomes were the association of these manifestations with gender and with duration of excess weight. The distribution across age groups and BMI categories was examined as a descriptive secondary analysis.

8. Statistical Analysis

Data were entered into Microsoft Excel 365 and analysed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corporation, Armonk, New York, USA). Descriptive statistics were used to summarise demographic and clinical characteristics as percentages.

Associations between the presence or absence of each cutaneous manifestation and categorical grouping variables (age group, gender, BMI category, and duration of excess weight) were evaluated using the Pearson chi-square test/Fisher Exact test. As 12 outcomes were tested within each grouping variable, Bonferroni correction was applied, setting the significance threshold at p less than 0.004. All tests were two-tailed.

A binary logistic regression model was constructed to identify independent predictors of acanthosis nigricans. Age, sex, BMI and duration of excess weight entered simultaneously, with duration treated as a categorical variable using greater than 10 years as the reference category. Results are reported as adjusted odds ratios with 95% confidence intervals.

RESULTS

Total 127 adults with overweight or obesity (BMI ≥23 kg/m²) were included in the study with mean age of 37.1 ± 12.8 years (range 18–64 years). The largest proportion belonged to the 21–30-year age group (26.8%), followed by the 41–50-year group (26.0%) and 31–40-year group (22.0%). There were 66 males (52.0%) and 61 females (48.0%) patients.

The mean BMI was 28.6 ± 4.9 kg/m²; Obesity Class I was the most common category (41.7%), followed by overweight (28.3%). The mean waist circumference was 105.9 ± 7.9 cm. The mean duration of excess weight was 7.8 ± 3.6 years, with 39.4% of participants reporting 6–10 years. Baseline characteristics are summarised in [Table. 1].

Baseline Characteristics	Category	No. (%)
Age group (years)	18–20	12 (9.4)
	21–30	34 (26.8)
	31–40	28 (22.0)
	41–50	33 (26.0)
	51–64	20 (15.7)
Gender	Male	66 (52.0)
	Female	61 (48.0)
BMI category	Overweight	36 (28.3)
	Obesity Class I	53 (41.7)
	Obesity Class II	27 (21.3)
	Obesity Class III	11 (8.7)
Duration of obesity (years)	≤5	43 (33.9)
	6–10	50 (39.4)
	>10	34 (26.8)

Table 1: Baseline Demographic and Anthropometric Characteristics (N = 127)

Spectrum of Cutaneous Manifestations

All 127 participants (100%) demonstrated at least one cutaneous manifestation, and 121 (95.3%) had two or more. The mean number of manifestations per participant was 4.5 ± 1.7 (range 1–9). The most frequently observed conditions were striae distensae (63.0%, 95% CI 54.3–70.9%) and acanthosis nigricans (62.2%, 95% CI 53.5–70.2%), as shown in [Table. 2].

Other common manifestations included skin tags (57.5%), fungal infections (53.5%), intertrigo (52.0%), and hyperpigmentation of flexural areas (50.4%). Less frequent conditions included bacterial infections (26.8%), acne vulgaris (23.6%), hirsutism (20.5%), and plantar keratoderma (19.7%). The least common manifestations were eczema (11.0%) and Psoriasis Vulgaris (10.2%).

Manifestation	No. (%)	95% CI
Striae distensae	80 (63.0)	54.3–70.9
Acanthosis nigricans	79 (62.2)	53.5–70.2
Skin tags	73 (57.5)	48.8–65.7
Fungal infections	68 (53.5)	44.9–62.0
Intertrigo	66 (52.0)	43.3–60.5
Hyperpigmentation	64 (50.4)	41.8–58.9
Bacterial infections	34 (26.8)	19.8–35.1
Acne vulgaris	30 (23.6)	17.1–31.7
Hirsutism	26 (20.5)	14.4–28.3
Plantar keratoderma	25 (19.7)	13.7–27.4
Eczema	14 (11.0)	6.7–17.7
Psoriasis Vulgaris	13 (10.2)	6.1–16.7

Table 2: Spectrum of Cutaneous Manifestations (N = 127)

95% confidence intervals computed using the Wilson score method.

Most dermatological manifestations showed similar prevalence in males and females [Table. 3]. The prevalence of striae, acanthosis nigricans, skin tags, fungal infections, and intertrigo did not differ substantially between genders. However, hirsutism was observed predominantly in female participants (36.1%) compared with males (6.1%).

Manifestation	Male (n = 66) n (%)	Female (n = 61) n (%)
Striae distensae	39 (59.1)	41 (67.2)
Acanthosis nigricans	44 (66.7)	35 (57.4)
Skin tags	40 (60.6)	33 (54.1)
Fungal infections	33 (50.0)	35 (57.4)
Intertrigo	34 (51.5)	32 (52.5)
Hyperpigmentation	37 (56.1)	27 (44.3)
Bacterial infections	16 (24.2)	18 (29.5)
Acne vulgaris	15 (22.7)	15 (24.6)
Hirsutism**	4 (6.1)	22 (36.1)

Table 3: Cutaneous Manifestations According to Gender

*Hirsutism was the only manifestation with a marked sex difference. ** Significant after Bonferroni correction. All other associations: p > 0.05, non-significant.*

Distribution According to Age Group

The prevalence of dermatological manifestations was broadly similar across all age groups [Table. 4]. Striae, acanthosis nigricans, and skin tags were consistently observed across all age categories without any clear age-related trend.

Manifestation	18–20 (n=12)	21–30 (n=34)	31–40 (n=28)	41–50 (n=33)	51–64 (n=20)	Total (N=127)
Acanthosis nigricans	7	24	14	23	11	79
Striae distensae	9	21	17	20	13	80
Skin tags	7	18	18	16	14	73
Fungal infections	5	21	16	14	12	68

Table 4: Distribution of Major Manifestations by Age Group

Values are number of participants with the manifestation. Table is descriptive; subgroup sizes preclude formal inferential testing.

Manifestation	Overweight (n=36)	Obesity Class I (n=53)	Obesity Class II (n=27)	Obesity Class III (n=11)	Total
Striae distensae	21	34	19	6	80
Acanthosis nigricans	21	31	22	5	79
Skin tags	23	29	15	6	73
Fungal infections	21	27	14	6	68
Intertrigo	18	28	14	6	66
Hyperpigmentation	14	27	16	7	64
Bacterial infections	9	13	8	4	34
Acne vulgaris	7	13	7	3	30
Hirsutism	12	5	7	2	26
Plantar keratoderma	8	10	6	1	25
Eczema	6	4	4	0	14
Psoriasis Vulgaris	4	7	1	1	13

Table 5: Distribution of Cutaneous Manifestations According to BMI Category (N = 127)

Most manifestations were observed across all BMI groups with overlapping confidence intervals (not shown in the [Table. 5]), indicating no clear BMI-dependent pattern in this study.

Distribution According to Duration of Obesity

Participants with longer duration of excess weight had higher prevalence of acanthosis nigricans [Table. 6]. Among individuals with duration >10 years, acanthosis nigricans was present in 88.2% of cases, compared with 62.8% in the ≤5-year group and 44.0% in the 6–10-year group. This association was statistically significant (χ^2 = 16.85, p = 0.0002). Other manifestations showed broadly similar distribution across duration categories.

Multivariable Analysis: Predictors of Acanthosis Nigricans

A binary logistic regression model was constructed to identify independent predictors of acanthosis nigricans [Table. 7]. When duration of excess weight was entered as a continuous linear predictor, the model was non-significant overall (LR $\chi^2(4)$ = 4.29, p = 0.369), indicating that duration's effect on AN is not linear. Duration was

therefore re-entered as a categorical variable, using >10 years as the reference category.

Manifestation	≤ 5 years (n=43) n (%)	6–10 years (n=50) n (%)	> 10 years (n=34) n (%)
Acanthosis nigricans	27 (62.8)	22 (44.0)	30 (88.2)
Striae distensae	29 (67.4)	30 (60.0)	21 (61.8)
Skin tags	25 (58.1)	26 (52.0)	22 (64.7)
Fungal infections	23 (53.5)	28 (56.0)	17 (50.0)
Intertrigo	22 (51.2)	26 (52.0)	18 (52.9)

Table 6: Cutaneous Manifestations According to Duration of Obesity

Acanthosis nigricans: $\chi^2 = 16.85$, $p = 0.0002$ (Bonferroni-corrected threshold $\alpha = 0.004$). Other manifestations showed no significant association with duration (all $p > 0.05$).

The categorical model was statistically significant (LR $\chi^2(5) = 19.43$, $p = 0.0016$; Nagelkerke $R^2 = 0.162$). Duration of excess weight was the only independent predictor of AN after adjusting for age, sex, and BMI. Both the ≤5-year group (adjusted OR 0.22, 95% CI 0.07–0.75; $p = 0.016$) and the 6–10-year group (adjusted OR 0.11, 95% CI 0.03–0.35; $p = 0.0002$) had significantly lower odds of AN compared with the >10-year group. Age, sex, and BMI were not independently associated with AN (all $p > 0.05$). These findings confirm that the duration of exposure to metabolic perturbations, rather than the degree of adiposity per se, is the primary determinant of AN in this study.

Predictor	Adjusted OR	95% CI	p-value
Age (per year)	0.995	0.965–1.025	0.727
Sex (female vs male)	0.706	0.326–1.531	0.378
BMI (per kg/m²)	1.015	0.935–1.101	0.722
Duration ≤5 yr vs >10 yr	**0.222**	**0.065–0.752**	**0.016***
Duration 6–10 yr vs >10 yr	**0.106**	**0.032–0.347**	**0.0002****

Table 7: Binary logistic regression: independent predictors of acanthosis nigricans (N = 127)

*Reference category: duration >10 years. * $p < 0.05$; ** $p < 0.001$ (survives Bonferroni correction at $\alpha = 0.004$). Overall model: LR $\chi^2(5) = 19.43$, $p = 0.0016$; Nagelkerke $R^2 = 0.162$. OR = odds ratio adjusted for all other variables in the model.*

DISCUSSION

The present study documented a broad spectrum of cutaneous manifestations in all 127 adults with overweight and obesity attending a rural dermatology centre in North Karnataka. Every participant had at least one skin condition. The mean number of manifestations was 4.5 per person, which is consistent with published estimates that 60 to 70 percent of obese individuals develop at least one cutaneous complication during the course of their illness[6]. High figure in this study likely reflects the tendency of rural patients to present with longstanding, undertreated disease.

Striae distensae (63.0%) and acanthosis nigricans (62.2%) were the two most prevalent findings. The prevalence of striae is comparable to rates reported by Geeta Sai et al. from a similar south Indian outpatient population.[10] The high frequency of striae across all age groups and BMI categories, without a significant association with either, supports the view that rapid weight change and mechanical skin stretching rather than absolute adiposity are the primary drivers, as described by Hirt *et al.*[5] The acanthosis nigricans prevalence falls within the wide range of 4.5 to 74 percent documented in the literature and is broadly consistent with other Indian hospital-based studies[8, 10, 15]. Skin tags were present in 57.5 percent of participants. The close co-occurrence of skin tags with acanthosis nigricans in this study is biologically plausible, as both share insulin-like growth factor-1 receptor-mediated keratinocyte proliferation as a common pathogenic mechanism[9]. Their value as a clinical marker of insulin resistance in resource-limited settings has been well demonstrated by Sherin et al. in a South Indian population[17].

Fungal infections and intertrigo were each present in more than half the study population, a finding attributable to the sustained skin fold occlusion, localised hyperhidrosis and impaired innate immunity that characterise obesity[6, 7]. Bacterial infections were noted in 26.8 percent of participants, in keeping with the 15 to 25 percent range reported by Boza *et al.*[11] Psoriasis Vulgaris and eczema were each observed at rates exceeding general population estimates. This is consistent with the adipokine-mediated bidirectional relationship between obesity and chronic inflammatory skin disease described by Hirt *et al.* and Darlenski *et al.*, though the absence of a control group in the present study limits causal attribution[5, 6].

Hirsutism was present in 36.1% of female participants versus 6.1% in males and was the only manifestation to show a statistically significant gender association (p = 0.0001). Obesity-related reduction in sex hormone-binding globulin and increased peripheral androgen aromatisation are the established drivers of this pattern in women[7, 14]. The relatively high prevalence among females in this study may partly reflect the real-world outpatient setting, where polycystic ovarian syndrome, though an exclusion criterion here, is widely prevalent in the background rural population and contributes to the overall androgenic burden.

The most clinically significant finding of this study is the non-linear association between acanthosis nigricans and duration of excess weight. AN prevalence was 62.8 percent among those with five or fewer years of excess weight. It fell to 44.0 percent in the six to ten year group,

then rose sharply to 88.2 percent in patients with more than ten years (p = 0.0002). On logistic regression, duration was the only independent predictor of AN after adjusting for age, sex and BMI. The odds of AN were 0.11 times in the six to ten year group and 0.22 times in the five or fewer year group compared to those with more than ten years. BMI, age and sex contributed nothing independently. This is a finding of practical importance. It suggests that cumulative metabolic exposure is the primary determinant of AN development. A patient with a moderate BMI and a long history of excess weight may therefore carry greater metabolic risk than a heavier patient presenting earlier in their disease course. The unexpected dip in AN prevalence at six to ten years cannot be explained within a cross-sectional design and requires prospective evaluation. A North Indian study by Singh et al. similarly found that the AN-insulin resistance relationship was not proportional to BMI, which offers some contextual support to this interpretation[16].

The main limitations of this study are its single-centre cross-sectional design, self-reported duration of excess weight, absence of biochemical metabolic profiling and the small Obesity Class III subgroup. A non-obese control group would have strengthened causal inference, particularly for inflammatory dermatoses. Multicentre studies from rural India incorporating biochemical profiling and matched controls would add considerably to the evidence in this underserved population.

CONCLUSION

This study found that skin manifestations are nearly universal among adults with overweight and obesity, with every participant demonstrating at least one cutaneous finding. Striae distensae and acanthosis nigricans were the most prevalent conditions, followed by skin tags, fungal infections and intertrigo. Most findings were distributed evenly across age groups, gender and BMI categories, suggesting that the presence of excess weight rather than its severity drives cutaneous disease in this population.

The important observation of this study is that duration of excess weight independently predicted acanthosis nigricans on multivariable analysis, with the highest prevalence seen in patients with more than ten years of excess weight. BMI, age and sex were not independent predictors. This finding suggests that cumulative metabolic exposure is a more important determinant of acanthosis nigricans than current adiposity, and that clinicians should not rely on BMI alone when assessing metabolic risk in overweight and obese patients. The presence of acanthosis nigricans or skin tags in any obese patient, regardless of BMI class, should prompt evaluation for insulin resistance and metabolic syndrome.

DISCLOSURE

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