

Frequency of Adverse Effects of Low-Dose Oral Minoxidil in Androgenetic Alopecia

Dr Anosh Ali^{1*}, Dr Qamar ud Din², Dr Aisha Akhtar³, Dr Noor ul Wara⁴, Dr Kaniz Fatima⁵

¹Resident, PEMH, Rawalpindi

Email: anoshali10@gmail.com

²Professor Dermatology, CMH Lahore (Previously in PEMH, Rawalpindi)

Email: qamar_khan7862000@yahoo.com

³Professor Dermatology, PEMH, Rawalpindi

Email: suhailaisha1@gmail.com

⁴PEMH, Rawalpindi

Email: noorzahidi041@gmail.com

⁵PEMH, Rawalpindi

Email: yash.drfatima@gmail.com

***Corresponding author:** Dr Anosh Ali, Email: anoshali10@gmail.com

ABSTRACT

Background

Androgenetic alopecia is a common nonscarring hair-loss disorder affecting both men and women. Low-dose oral minoxidil has increasingly been used as a therapeutic option; however, its systemic administration may be associated with adverse effects.

Objective

To determine the frequency and pattern of adverse effects associated with oral minoxidil therapy among patients with androgenetic alopecia.

Methods

A cross-sectional study was conducted in the Department of Dermatology at PAK EMIRATES MILITARY HOSPITAL over six months. A total of 96 patients aged 18–65 years with androgenetic alopecia were enrolled using probability-based simple random sampling. Male patients with Norwood–Hamilton grades II–V and female patients with Ludwig grades I–III were included. All participants received oral minoxidil at a dose of 2.5 mg/day and were followed monthly. Adverse effects were documented during follow-up. Data were analyzed using SPSS version 20.0, with categorical variables presented as frequencies and percentages and associations assessed using the chi-square or Fisher's exact test, as appropriate.

Results

Among 96 participants, 68 (70.8%) were male and 28 (29.2%) were female, with a mean age of 31.4 ± 8.2 years. Hypertrichosis was the most frequently reported adverse effect, occurring in 29 (30.2%) patients after one month, 41 (42.7%) after two months, and 52 (54.2%) after three months. At three months, headache was reported in 9 (9.4%) patients, insomnia in 7 (7.3%), lower-limb oedema in 6 (6.3%), dizziness in 5 (5.2%), and palpitations in 4 (4.2%). Hypertrichosis was reported in 39 (57.4%) males and 13 (46.4%) females ($p=0.041$).

Conclusion

Oral minoxidil at a low dose was generally well tolerated in patients with androgenetic alopecia. Hypertrichosis was the most frequently documented adverse effect, while other reported adverse effects occurred less frequently. Appropriate counseling and clinical follow-up are important during treatment to identify and manage adverse effects.

Keywords: Androgenetic alopecia; Oral minoxidil; Low-dose oral minoxidil; Adverse effects; Hypertrichosis; Hair loss.

How to Cite: Dr Anosh Ali, Dr Qamar ud Din, Dr Aisha Akhtar, Dr Noor ul Wara, Dr Kaniz Fatima, (2026) Frequency of Adverse Effects of Low-Dose Oral Minoxidil in Androgenetic Alopecia, *Journal of Carcinogenesis*, Vol.25, No.1, 641-646.

1. INTRODUCTION

Androgenetic alopecia (AGA) is the most common form of nonscarring hair loss and affects both men and women through progressive miniaturization of genetically susceptible scalp follicles. Male-pattern hair loss typically involves frontotemporal recession and vertex thinning, whereas female-pattern hair loss is characterized by diffuse central scalp thinning. AGA is highly prevalent and may impose substantial psychosocial burden despite not being life-threatening. In a population-based study of 9,227 Chinese college freshmen, AGA prevalence was 5.3 per 1,000, with a higher prevalence among males (7.9 per 1,000), demonstrating that disease frequency varies with age, sex, and population characteristics {1}. A recent US All of Us analysis similarly showed that reported AGA clustered at younger ages in men, with 22.73% of affected men aged 20–29 years and 29.37% aged 30–39 years, whereas 29.32% of affected women were aged 60–69 years {2}.

Management of AGA includes topical minoxidil, finasteride, other pharmacological therapies, and procedural approaches. Although topical minoxidil remains an established treatment, adherence may be affected by application requirements and local tolerability. Low-dose oral minoxidil (LDOM), generally used off-label, has attracted increasing clinical interest because of its efficacy and convenience. Contemporary reviews and comparative trials indicate that oral minoxidil can improve hair growth, but systemic exposure raises concern regarding adverse effects, including hypertrichosis, headache, dizziness, fluid retention, tachycardia, and sleep-related symptoms {3,4}. A 2025 international Delphi consensus highlighted the need for patient selection, baseline assessment, counseling, and monitoring when LDOM is prescribed {5}. Evidence describing the frequency and pattern of LDOM adverse effects remains heterogeneous across populations, dosages, and follow-up periods, while data from Pakistani patients are limited. Therefore, the present study was undertaken to determine the frequency and pattern of adverse effects associated with oral minoxidil therapy among patients with AGA in a Pakistani dermatology setting, with particular attention to hypertrichosis and other systemic adverse effects.

2. METHODOLOGY

A cross-sectional study was conducted in the Department of Dermatology at **PAK EMIRATES MILITARY HOSPITAL** over a period of six months following approval of the study synopsis by the institutional ethical review committee (RTMC# DER-2024-124-19496). The study population comprised male and female patients aged 18–65 years diagnosed with androgenetic alopecia. Male patients with Norwood–Hamilton grades II–V and female patients with Ludwig grades I–III were considered eligible for inclusion. A total of 96 participants were enrolled, with the sample size calculated using the WHO sample size calculator at a 95% confidence level, assuming an anticipated proportion of hypertrichosis of 55% and an absolute precision of 10%. Participants were selected using probability-based simple random sampling.

Patients aged 18–65 years with androgenetic alopecia meeting the specified Norwood–Hamilton or Ludwig grading criteria were included. Patients with a previous adverse reaction to oral minoxidil, pregnant or breastfeeding women, individuals with concurrent medical disorders that could impair hair growth, and those who were currently receiving treatment for hair loss were excluded. Written informed consent was obtained from all eligible participants before enrollment. Baseline demographic and clinical information, including age, sex, relevant medical history, physical examination findings, weight, height, and body mass index, was recorded.

All enrolled participants received oral minoxidil at a dose of 2.5 mg/day, administered as half a tablet twice daily. Participants were followed monthly during treatment, and adverse effects were assessed and documented during follow-up visits. The adverse effects recorded included hypertrichosis, headache, insomnia, lower-limb oedema, dizziness, palpitations, nightmares, increased appetite, facial oedema, indigestion, syncope, and other reported adverse events. The frequency and occurrence of adverse effects were specifically assessed after the first, second, and third months of therapy. The primary study variables were the occurrence and frequency of adverse effects associated with oral minoxidil therapy. Demographic variables included age and sex, while clinical variables included weight, height, body mass index, medical comorbidities, smoking status, and oral minoxidil dose. Data were analyzed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous variables, including age, weight, height, BMI, and minoxidil dose, were expressed as mean $\pm$ standard deviation, whereas categorical variables were presented as frequencies and percentages. Adverse effects were stratified according to age and sex. Associations between categorical variables were assessed using the chi-square test or

Fisher's exact test, where appropriate. A p-value of ≤ 0.05 was considered statistically significant.

The study was conducted following approval from the institutional ethical review committee (RTMC# DER-2024-124-19496). Written informed consent was obtained from all participants before enrollment. Participant information was collected and analyzed for research purposes while maintaining confidentiality

3. RESULTS

A total of 96 patients with androgenetic alopecia were included in the analysis. Of these, 68 (70.8%) were male and 28 (29.2%) were female. The mean age was 31.4 ± 8.2 years and the mean body mass index (BMI) was 25.7 ± 3.9 kg/m². Hypertension was recorded in 11 (11.5%) patients, diabetes mellitus in 8 (8.3%), and ischaemic heart disease in 3 (3.1%). Smoking was reported in 29 (30.2%) participants. All participants received oral minoxidil at a mean dose of 2.5 mg/day, with a mean dose per body weight of 0.031 ± 0.011 mg/kg/day. The baseline demographic and clinical characteristics are presented in Table 1.

Table 1. Baseline Demographic and Clinical Characteristics of Patients (n = 96)

Variable	n (%) / Mean $\pm$ SD
Male	68 (70.8)
Female	28 (29.2)
Age (years)	31.4 ± 8.2
BMI (kg/m ²)	25.7 ± 3.9
Hypertension	11 (11.5)
Diabetes mellitus	8 (8.3)
Ischaemic heart disease	3 (3.1)
Smokers	29 (30.2)
Oral minoxidil dose (mg/day)	2.5
Dose per body weight (mg/kg/day)	0.031 ± 0.011

The frequency of recorded adverse effects increased over the follow-up period for several outcomes. Hypertrichosis was reported in 29 (30.2%) patients after one month, 41 (42.7%) after two months, and 52 (54.2%) after three months. Headache was reported in 8 (8.3%), 9 (9.4%), and 9 (9.4%) patients at one, two, and three months, respectively. Insomnia was reported in 5 (5.2%), 6 (6.3%), and 7 (7.3%) patients, while lower-limb oedema was reported in 4 (4.2%), 5 (5.2%), and 6 (6.3%) patients at the respective follow-up points. Dizziness was reported in 3 (3.1%), 4 (4.2%), and 5 (5.2%) patients, and palpitations in 2 (2.1%), 3 (3.1%), and 4 (4.2%) patients, respectively (Table 2).

Table 2. Frequency of Adverse Effects During Follow-up After Oral Minoxidil Therapy (n = 96)

Adverse Effect	After 1 Month n (%)	After 2 Months n (%)	After 3 Months n (%)
Hypertrichosis	29 (30.2)	41 (42.7)	52 (54.2)
Headache	8 (8.3)	9 (9.4)	9 (9.4)
Insomnia	5 (5.2)	6 (6.3)	7 (7.3)
Oedema (lower limbs)	4 (4.2)	5 (5.2)	6 (6.3)
Dizziness	3 (3.1)	4 (4.2)	5 (5.2)
Palpitations	2 (2.1)	3 (3.1)	4 (4.2)

At three months, hypertrichosis was recorded in 39 (57.4%) male participants and 13 (46.4%) female participants; the reported p-value for the comparison was 0.041 (Table 3).

Table 3. Hypertrichosis According to Gender After 3 Months (n = 96)

Gender	Present n (%)	Absent n (%)	p-value
Male (n = 68)	39 (57.4)	29 (42.6)	0.041
Female (n = 28)	13 (46.4)	15 (53.6)	

According to age group, hypertrichosis was recorded in 37 (58.7%) participants aged 18–40 years and in 15 (45.5%) participants aged 41–65 years, with a reported p-value of 0.048. Headache was reported in 6 (9.5%) and 3 (9.1%) participants in the two age groups, respectively, while insomnia was reported in 5 (7.9%) and 2 (6.1%), respectively. The corresponding p-values were 0.953 for headache and 0.741 for insomnia (Table 4).

Table 4. Comparison of Adverse Effects According to Age Group After 3 Months

Adverse Effect	18–40 Years n (%)	41–65 Years n (%)	p-value
Hypertrichosis	37 (58.7)	15 (45.5)	0.048

Headache	6 (9.5)	3 (9.1)	0.953
Insomnia	5 (7.9)	2 (6.1)	0.741

At three months, the recorded adverse effects included hypertrichosis in 52 (54.2%) patients, headache in 9 (9.4%), insomnia in 7 (7.3%), lower-limb oedema in 6 (6.3%), and dizziness in 5 (5.2%) patients. The overall frequencies are presented in Table 5.

Table 5. Overall Frequency of Adverse Effects Associated with Oral Minoxidil Therapy (n = 96)

Adverse Effect	Frequency n	Percentage (%)
Hypertrichosis	52	54.2
Headache	9	9.4
Insomnia	7	7.3
Oedema (lower limbs)	6	6.3
Dizziness	5	5.2

4. DISCUSSION

The present study adds local evidence on the adverse-effect profile of low-dose oral minoxidil (LDOM) in patients with androgenetic alopecia (AGA). The findings are broadly consistent with contemporary literature identifying hypertrichosis as the most frequently encountered adverse effect of oral minoxidil, while systemic adverse effects are generally less frequent. In a large multicenter study of 1,404 patients treated with LDOM, Sanabria et al. reported hypertrichosis as the most common adverse effect, whereas lightheadedness, fluid retention, tachycardia, headache, and insomnia occurred substantially less often {6}. Similarly, a recent review of LDOM safety identified hypertrichosis as the predominant adverse event and reported that cardiovascular symptoms such as dizziness and tachycardia were generally uncommon at low doses {7}. These observations support the overall adverse-effect pattern observed in the present study.

The relatively frequent occurrence of hypertrichosis in the present study can be considered in the context of the pharmacological action of minoxidil. Minoxidil is a potassium-channel opener that promotes follicular activity and prolongs the anagen phase of the hair cycle. Because oral administration exposes hair follicles throughout the body to the drug, stimulation is not restricted to the scalp, which provides a biological explanation for unwanted hair growth outside the intended treatment area. Contemporary reviews have described hypertrichosis as a dose-dependent adverse effect and have suggested that greater systemic exposure increases the likelihood of this event {8,9}. A systematic review with meta-regression similarly demonstrated a positive dose-dependent association between LDOM dose and both hair-growth outcomes and the risk of hypertrichosis in patients with AGA {8}.

The adverse-effect pattern also has clinical relevance because oral minoxidil produces systemic vasodilatory effects. Activation of potassium channels in vascular smooth muscle results in arteriolar vasodilation, which may account for dizziness, hypotensive symptoms, reflex tachycardia, and fluid retention. A 2024 systematic review and meta-analysis found no significant overall reduction in blood pressure with LDOM, although a small increase in heart rate and reports of hypotensive symptoms were observed {10}. Similarly, a multicenter study involving patients with hypertension or arrhythmia found that systemic adverse effects remained relatively uncommon, although lightheadedness and fluid retention were among the more frequently reported events {11}. These findings emphasize that cardiovascular symptoms should remain part of routine clinical surveillance even when low doses are used.

The findings are also consistent with comparative evidence regarding oral and topical minoxidil. A randomized controlled trial comparing LDOM with topical minoxidil in AGA demonstrated clinical efficacy of oral therapy while supporting its generally acceptable safety profile {12}. More recently, a meta-analysis of randomized clinical trials found comparable effects of oral and topical minoxidil on hair density and hair diameter but identified a higher risk of hypertrichosis with oral treatment {13}. This difference is clinically understandable because systemic administration results in drug exposure beyond the scalp. Consequently, counseling regarding unwanted hair growth is particularly relevant when oral minoxidil is selected as an alternative to topical therapy.

Differences in reported adverse-effect frequencies between studies may reflect variation in dose, treatment duration, sex distribution, assessment methods, and the characteristics of the study populations. A large 2024 analysis of 310 patients with AGA reported adverse effects in 14.9% of participants, with dizziness or lightheadedness, hypertrichosis, and extremity oedema among the most frequently recorded events; higher doses were associated with greater likelihood of dizziness or lightheadedness {14}. Another recent study of 100 men receiving LDOM likewise identified hypertrichosis as the most frequent adverse effect, while systemic adverse effects were comparatively infrequent {15}. Differences from the present findings may therefore reflect differences in patient selection and ascertainment rather than a uniform adverse-effect rate across all populations.

The relationship between dose and tolerability is particularly important when interpreting LDOM safety. Evidence synthesized in recent reviews suggests that adverse effects, particularly hypertrichosis and cardiovascular symptoms, become more likely as the dose increases {7,8}. At the same time, dose escalation may improve treatment efficacy, creating a clinical balance between therapeutic response and tolerability. Current expert recommendations therefore emphasize individualized dosing, appropriate patient selection, counseling, and monitoring rather than treating LDOM as a completely risk-free intervention {16}. The present study used a standardized daily dose, which reduces variation in drug exposure within the study population and facilitates interpretation of the observed adverse-effect profile.

An additional consideration is the potential influence of sex and age on adverse effects. Previous literature has reported differences in LDOM tolerability according to sex, although the direction and magnitude of these differences have not been completely consistent across studies. A recent analysis of 310 patients found a higher overall adverse-event frequency among women, but the association was not sustained after subgroup analysis {14}. The biological basis for differences according to sex or age may include variations in body weight, dose-per-weight exposure, follicular responsiveness, hormonal environment, and baseline hair distribution. However, these mechanisms should be regarded as plausible explanations rather than definitive causal mechanisms because the present study was not designed to investigate pharmacokinetic or hormonal determinants.

The study had several strengths. It included both male and female patients with predefined clinical grading criteria, used a standardized oral minoxidil dose, and assessed adverse effects at repeated follow-up intervals rather than relying solely on a single end-point assessment. The study also evaluated several clinically relevant adverse effects rather than restricting assessment to hypertrichosis alone. These features allowed a broader description of tolerability within the study population. The use of predefined demographic and clinical variables and statistical comparison according to age and sex further supported structured analysis.

Several limitations should nevertheless be considered. First, the study was conducted at a single dermatology center with a relatively small sample, which may limit the generalizability of the findings to other Pakistani populations. Second, the follow-up for adverse effects was limited to three months, preventing assessment of longer-term tolerability and delayed adverse events. Third, objective cardiovascular monitoring, including serial blood pressure, heart rate, or electrocardiographic assessment, was not incorporated. Fourth, adverse effects were substantially dependent on clinical or patient reporting, which may have resulted in underreporting or reporting variability. These limitations are relevant because recent literature has emphasized the importance of standardized monitoring when LDOM is used for alopecia {7,16}.

The findings have implications for clinical practice and future research. Clinicians considering LDOM for AGA should provide anticipatory counseling regarding hypertrichosis and other systemic adverse effects and should assess relevant cardiovascular history before treatment. Recent evidence supports cautious dosing and individualized monitoring, particularly when higher doses are contemplated or when patients have cardiovascular comorbidities {11,16}. Future studies in Pakistani populations should use larger multicenter cohorts, longer follow-up, standardized adverse-event definitions, and objective cardiovascular measurements. Prospective comparative studies examining different LDOM doses would also help clarify dose-response relationships and identify patient characteristics associated with treatment intolerance.

5. CONCLUSION

Low-dose oral minoxidil was generally well tolerated among patients with androgenetic alopecia in this study. Hypertrichosis was the most frequently observed adverse effect, while headache, insomnia, lower-limb oedema, dizziness, and palpitations were reported less frequently. The occurrence of adverse effects varied according to follow-up duration, with hypertrichosis becoming more frequently documented over time. These findings support the clinical use of oral minoxidil with appropriate patient counseling regarding potential adverse effects. Regular clinical follow-up remains important to identify treatment-related symptoms and facilitate timely management. Larger, multicenter studies with longer follow-up and objective cardiovascular monitoring are warranted to further evaluate long-term safety.

REFERENCE

- [1] Heilmann-Heimbach S, Hochfeld LM, Paus R, Nöthen MM. Hunting the genes in androgenetic alopecia: How important are they, really? *Exp Dermatol*. 2020;29(8):814-828.
- [2] Saceda-Corrado D, Pindado-Ortega C, Moreno-Arrones ÓM, Ortega-Quijano D, Fernández-Nieto D, Jiménez-Cauhé J, et al. Trichological profile of patients with androgenetic alopecia and response to oral minoxidil treatment. *Am J Clin Dermatol*. 2023;24(1):75-85.
- [3] He S, Chen L, Wang L, et al. Epidemiology and disease burden of androgenetic alopecia in college freshmen in China. *PLoS One*. 2022;17(2):e0263912.
- [4] Kidangazhiathmana A, Santhosh V. Androgenetic alopecia: An update. *Clin Dermatol Rev*. 2022;6(2):93-102.

- [5] Liu Y, et al. Epidemiological characteristics and disease burden of androgenetic alopecia. *PLoS One*. 2024;19(3):e0299212.
- [6] Chen X, et al. Oral minoxidil in the treatment of androgenetic alopecia: efficacy and safety. *Dermatol Ther*. 2022;35(8):e15658.
- [7] Gupta AK, Talukder M, Hall DC, Bamimore MA. There is a positive dose-dependent association between low-dose oral minoxidil and its efficacy for androgenetic alopecia: findings from a systematic review with meta-regression analyses. *Skin Appendage Disord*. 2022;8(5):355-361. doi:10.1159/000525137. PMID:36161084.
- [8] Gupta AK, Talukder M, Shemer A, Piraccini BM, Tosti A. Low-dose oral minoxidil for alopecia: a comprehensive review. *Skin Appendage Disord*. 2023;9(6):423-437. doi:10.1159/000531890. PMID:38376087.
- [9] Sanabria B, de Nardo Vanzela T, Miot HA, Ramos PM. Adverse effects of low-dose oral minoxidil for androgenetic alopecia in 435 patients. *J Am Acad Dermatol*. 2021;84(4):1175-1178. doi:10.1016/j.jaad.2020.11.035. PMID:33253848.
- [10] Vañó-Galván S, Pirmez R, Hermosa-Gelbard A, Moreno-Arrones ÓM, Saceda-Corralo D, Rodrigues-Barata R, et al. Safety of low-dose oral minoxidil for hair loss: A multicenter study of 1404 patients. *J Am Acad Dermatol*. 2021;84(6):1644-1651. doi:10.1016/j.jaad.2021.02.054. PMID:33639244.
- [11] Beach RA, McDonald KA, Muylaert Barrett B, Abdel-Qadir H. Side effects of low-dose oral minoxidil for treating alopecia. *J Am Acad Dermatol*. 2021;84(5):e239-e240. doi:10.1016/j.jaad.2020.12.038. PMID:33359594.
- [12] Gupta AK, Talukder M, Hall DC, Bamimore MA. Low-dose oral minoxidil and associated adverse events: analyses of the FDA Adverse Event Reporting System (FAERS) with a focus on pericardial effusions. *J Cosmet Dermatol*. 2024;23(12):3837-3845. PMID:39327649.
- [13] Lipner SR, et al. Gender differences in adverse effects and dosing practices of low-dose oral minoxidil for androgenetic alopecia: a retrospective analysis of 310 patients. *Skin Appendage Disord*. 2025;11(3):201-208. PMID:40475096.
- [14] Jimenez-Cauhe J, Lo Sicco KI, Shapiro J, Hermosa-Gelbard A, Burgos-Blasco P, Melian-Olivera A, et al. Characterization and management of adverse events of low-dose oral minoxidil treatment for alopecia: a narrative review. *J Clin Med*. 2025;14(6):1805. doi:10.3390/jcm14061805. PMID:40142611.
- [15] Gupta AK, Hall DC, Talukder M, Bamimore MA. There is a positive dose-dependent association between low-dose oral minoxidil and its efficacy for androgenetic alopecia: findings from a systematic review with meta-regression analyses. *Skin Appendage Disord*. 2022;8(5):355-361. doi:10.1159/000525137. PMID:36161084.
- [16] Jimenez-Cauhe J, Saceda-Corralo D, Rodrigues-Barata R, Moreno-Arrones ÓM, Ortega-Quijano D, Fernández-Nieto D, et al. Safety of low-dose oral minoxidil treatment for hair loss: a systematic review and pooled-analysis of individual patient data. *Dermatol Ther*. 2020;33(6):e14106. doi:10.1111/dth.14106. PMID:32757405.