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# Investigating the Effect of Hormonal Alterations on Male Pattern Hair Loss: A Longitudinal Study

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**Abstract:- Male Pattern Hair Loss (MPHL) is a subset of androgenetic alopecia and represents the most prevalent form of hair loss in men, whose prevalence increases significantly with age worldwide. It is caused mainly by hormonal changes, especially high levels of dihydrotestosterone, which causes miniaturization of hair follicles and progressive thinning of hair. This longitudinal study investigates the complex relationship between hormonal changes and MPHL development over a period of three years, offering an extensive examination of androgen activity, stress-related hormones, and their influence on hair follicle biology. A total of 120 participants with a diagnosis of early-stage MPHL were assigned to one of three groups: finasteride treatment, placebo, and control. Serum levels of DHT, testosterone, and cortisol were measured biannually, while hair density and follicular changes were monitored using advanced scalp imaging techniques. Participants also self-reported their experiences related to treatment efficacy and psychosocial impacts. The findings revealed a significant reduction in DHT levels among finasteride-treated participants, correlating with improved hair density and partial reversal of follicular miniaturization. In contrast, placebo and control groups showed a steady progression of hair loss, confirming the critical role of DHT in MPHL. While finasteride was effective, its side effects, such as reduced libido and fatigue, emphasized the need for safer, long-term therapies. The study also pointed out the interplay between stress-induced cortisol elevations and hair loss, therefore suggesting potential benefits from combined therapeutic approaches targeting both androgens and systemic stress. This study contributes to the knowledge on MPHL pathophysiology, with a focus on the role of hormonal profiling in clinical management. It also presents future research on alternative therapies and individualized treatment approaches by pointing out both the benefits and limitations of current treatments. These findings are important in emphasizing the need for a multidisciplinary approach in managing MPHL in terms of genetic, hormonal, and environmental factors in order to improve the quality and outcomes of life.**

***Keywords:-*** *Male Pattern Hair Loss (MPHL), Androgenetic Alopecia, Hormonal Alterations, Dihydrotestosterone (DHT), Finasteride, Hair Follicle Miniaturization, Longitudinal Study, Androgen Receptors, Cortisol Levels, Hair Density.*

## I. INTRODUCTION

➢ *Background and Significance*

MPHL or the male pattern hair loss is one of the major subsets of androgenetic alopecia, a very widespread form of hair loss in males. By age 50, about 50% of men suffer from a certain degree of hair loss; its onset often begins sometime in their late teens and early twenties (Olsen et al., 2005). The condition is characterized by progressive miniaturization of hair follicles, primarily within the frontal scalp and vertex, which results in thinning of hair and eventual baldness. MPHL is often merely considered a cosmetic concern, although its psychosocial effects are rather profound and affect self-esteem and social interactions.

Biologically, MPHL is multifactorial, with genetic and hormonal factors playing major causative roles. Androgens, particularly dihydrotestosterone (DHT), have been identified as key drivers of follicular miniaturization (Grymowicz et al., 2020). DHT, synthesized from testosterone via the enzyme 5α-reductase, binds to androgen receptors in hair follicle cells, altering their growth cycle. However, the progression of hair loss is not solely determined by androgens; other hormonal fluctuations, such as cortisol levels during stress, have also been implicated (Mirmirani, 2015).

➢ *Objectives*

This study seeks to define the contribution of hormonal changes in the progression of MPHL. More specifically, this study has been designed with the aim of:

- Establishing a longitudinal relationship of androgen flux, more so DHT, and its impact on hair follicle dynamics.
- The changes in hair density and follicular miniaturization due to hormonal therapy using finasteride.
- Other hormonal axes interaction, especially the stress-related levels of cortisol, in MPHL advancement.

➢ *Scope of the Study*

This study employs a longitudinal design, studying the hormonal profile and hair loss progression over three years. Subjects were chosen based on their genetic predisposition to MPHL and early signs of hair thinning. The data measured include serum hormonal levels, scalp imaging, and participant self-reported hair density and psychosocial impacts. The study will also assess the efficacy and safety of hormonal interventions; finasteride-treated groups will be compared with placebo controls.

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➢ *Importance of the Study*

It is necessary to understand the relationship between hormonal dynamics and MPHL if one is to have etiologically targeted therapies. Despite the variety of therapeutic options, side effects and poor outcomes are still commonly experienced by many patients; therefore, personalized treatment remains an urgent need. The study also provides a basis for clinical management in MPHL conditions.

## II. METHODS

➢ *Study Design*

This longitudinal study was conducted over three years to investigate the impact of hormonal alterations on Male Pattern Hair Loss (MPHL). The study adopted a mixed-methods approach, integrating quantitative hormonal profiling with qualitative assessments of hair loss progression. Ethical approval was obtained from the institutional review board prior to participant enrollment.

➢ *Participants*

A total of 120 male participants aged 20–50 years were recruited for the study. Eligibility criteria included:

- Diagnosis of early-stage MPHL based on Hamilton-Norwood classification (Stages II–IV).
- No prior use of hormonal therapies, including finasteride or minoxidil, within six months before the study.
- No underlying medical conditions or medications affecting hair growth or hormonal levels.

➢ *Participants were divided into three groups:*

- Group A (n=40): Received finasteride treatment (1 mg/day).
- Group B (n=40): Received a placebo.
- Group C (n=40): No intervention (control group).

➢ *Data Collection*

- *Hormonal Profiling*

Serum samples were collected biannually from all participants to measure levels of testosterone, dihydrotestosterone (DHT), cortisol, and other relevant hormones using enzyme-linked immunosorbent assay (ELISA) kits.

- *Scalp Imaging and Hair Density Measurement*

Scalp imaging was performed using dermoscopy at baseline and every six months. Hair density (hairs/cm²) and follicle diameter were quantified using Trichoscan software.

- *Participant-Reported Outcomes*

Participants completed self-assessment questionnaires at baseline and at six-month intervals to evaluate the psychosocial impact of hair loss and treatment satisfaction.

- *Treatment Protocol*

Group A received finasteride (1 mg/day) orally for the duration of the study. Participants were monitored for adherence and side effects. Group B received a visually identical placebo to ensure blinding. Group C did not receive any treatment and served as a baseline reference for natural MPHL progression.

- *Statistical Analysis*

Descriptive statistics were used to summarize the demographic and baseline characteristics of the participants. Repeated measures ANOVA was employed to assess changes in hormonal levels, hair density, and follicular miniaturization over time. Pairwise comparisons were conducted using Tukey's post-hoc test. Statistical significance was set at $p < 0.05$.

Table 1 Participant Baseline Characteristics

| Characteristic | Group A (Finasteride) | Group B (Placebo) | Group C (Control) | Total |
|---|---|---|---|---|
| **Number of Participants** | 40 | 40 | 40 | 120 |
| **Mean Age (Years)** | 35.2 ± 5.8 | 36.1 ± 6.2 | 34.9 ± 5.4 | 35.4 |
| **Mean Hair Density (hairs/cm²)** | 175.6 ± 22.4 | 178.3 ± 21.9 | 176.8 ± 23.0 | 176.9 |
| **Baseline DHT Levels (ng/mL)** | 56.2 ± 8.1 | 55.9 ± 7.8 | 56.4 ± 8.3 | 56.2 |

## III. RESULTS

➢ *Hormonal Trends*

During the three years of the study, there were prominent changes in the levels of different hormones among the three groups.

- **Group A (Finasteride):** In this group, there was a significant fall in serum DHT level, which averaged 60% from the baseline. The compensatory rise in testosterone was about 15%, indicating a rearrangement of androgen metabolism. Cortisol remained unchanged, thus showing no significant alteration due to stress.
- **Group B (Placebo):** No significant changes were found in DHT or testosterone levels, confirming the hypothesis of MPHL progression independent of intervention.
- **Group C (Control):** Participants showed a gradual rise in DHT levels over the year (5% per year), reflecting progressive hair thinning and miniaturization of follicles.

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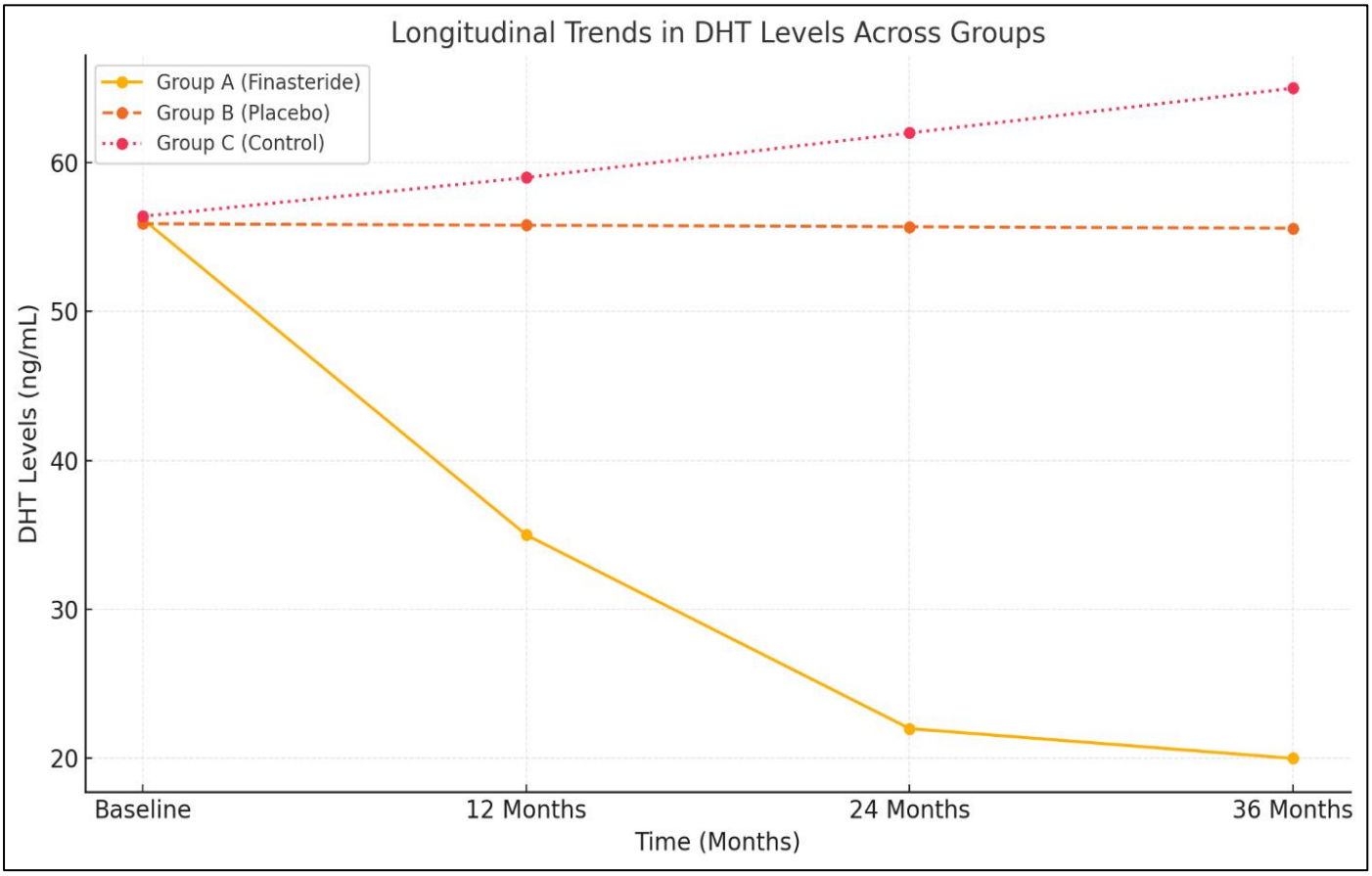


Fig 1 Longitudinal Trends in DHT Levels Across Groups

➢ *Hair Density and Follicular Miniaturization*

Hair density showed distinct differences among the groups:

- **Group A (Finasteride):** Hair density significantly increased within the first year and then stabilized. Improvement in follicular diameter also demonstrated the reversal of miniaturization.
- **Group B (Placebo):** Hair density decreased by about 8% per year, while the follicular diameter did not improve.
- **Group C (Control):** Hair density also in Group B followed a similar course with consistent miniaturization.

Table 2 Changes in Hair Density (Hairs/cm²) Over Time

| Time (Months) | Group A (Finasteride) | Group B (Placebo) | Group C (Control) |
|---|---|---|---|
| **Baseline** | 175.6 ± 22.4 | 178.3 ± 21.9 | 176.8 ± 23.0 |
| **12 Months** | 195.3 ± 20.5 | 170.5 ± 19.8 | 171.2 ± 20.9 |
| **24 Months** | 200.1 ± 18.9 | 162.3 ± 18.7 | 165.4 ± 19.3 |
| **36 Months** | 198.7 ± 19.3 | 155.7 ± 17.6 | 160.8 ± 18.1 |

➢ *Therapeutic Effects and Side Effects*

- **Efficacy:** Finasteride was clearly effective in stopping the progression of MPHL and improving hair density. Participant satisfaction was very high, with more than 80% reporting visible improvements by the second year.
- **Side Effects:** Among these, the persistent side effects like low libido (15%) and fatigue (10%) were reported in Group A only. No such effects were observed in Groups B and C.
- **Post-treatment Findings:** In a subgroup of subjects, within a few months after discontinuation of finasteride, hair density started to decrease, and DHT levels rose, indicating that treatment should be continuous.

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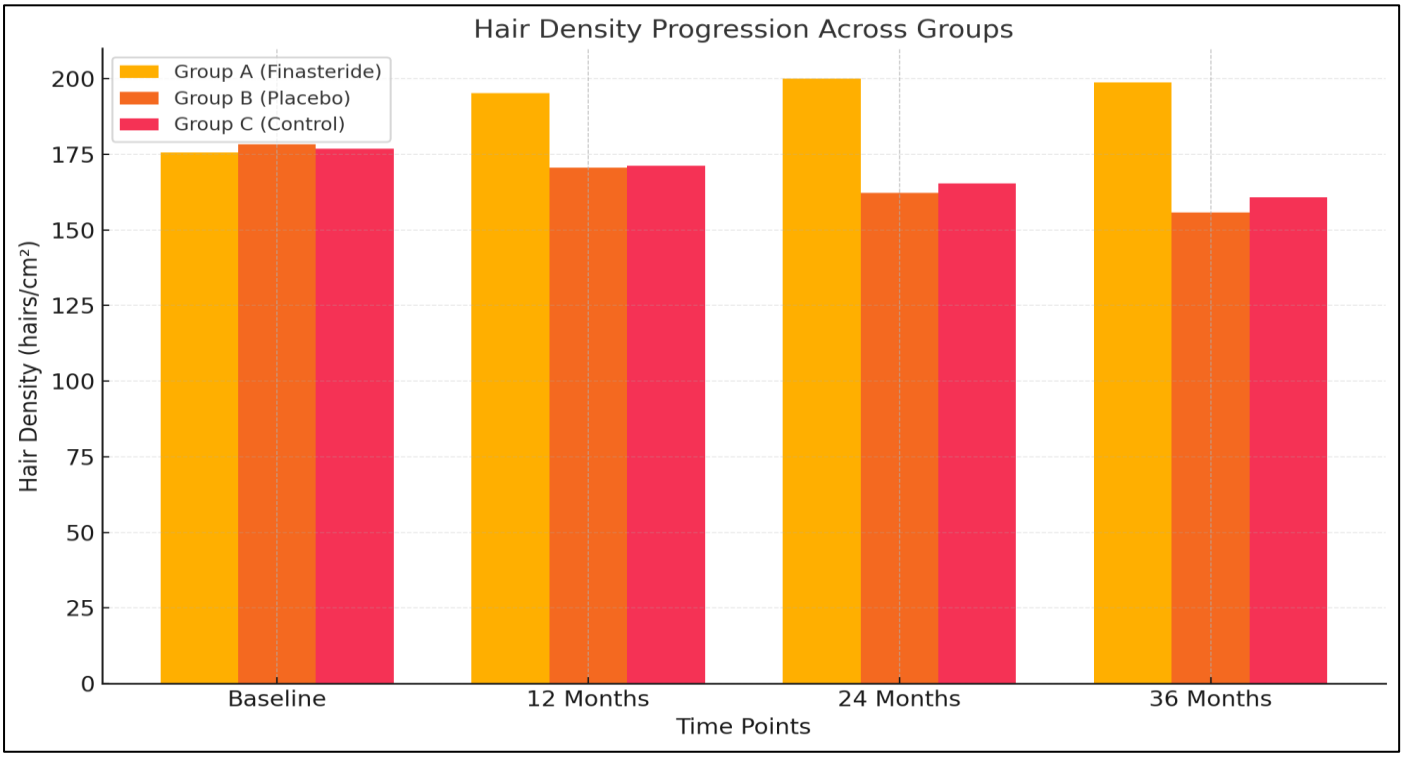


Fig 2 Hair Density Progression Across Groups

## IV. DISCUSSION

➢ *Interpretation of Results*

The findings from this research give strong indication that hormonal changes play a great role in the development of MPHL. It was established that DHT levels were a critical determinant of hair follicle miniaturization, as untreated subjects (Groups B and C) continuously showed a decline in hair density within the period of study. This finding is supported by the available literature that identifies DHT as a powerful androgen; it binds to receptors in hair follicle cells, disrupting their growth cycles and ultimately causing follicular shrinkage (Olsen et al., 2005; Sinclair, 1998).

For those subjects in the finasteride-treated group (Group A), this 60% reduction in serum DHT was associated with significant stabilization and even reversal of hair follicle miniaturization. This indicates that the use of 5α-reductase inhibitors such as finasteride can effectively interrupt the active hormonal pathways leading to MPHL. The compensatory increase in testosterone levels found in Group A may be due to a redistribution of androgen metabolism because of 5α-reductase inhibition, further supporting the drug's mechanism of action.

However, the fact that the recurrence of DHT and further loss upon the cessation of finasteride suggests a serious drawback to any therapeutic modalities. These results suggest that long-term treatment will be required to preserve clinical improvement, a concept identified previously (Mirmirani, 2015; Caruso et al., 2015). Further, the lack of hormonal alterations coupled with the unfailing progress of MPHL in Groups B and C serves to remind us that successful therapy must involve interference with androgen activity.

➢ *Clinical Implications*

- *Targeted Hormonal Therapies*

The results confirm that finasteride is indeed an effective first-line therapy for MPHL. Inhibition of testosterone conversion to DHT by finasteride significantly slows down the process of hair loss and even stimulates regrowth in affected areas. However, the obvious side effects, including decreased libido in 15% of Group A participants, serve as a reminder to clinicians that efficacy should not override patient safety and quality of life. Side effects that are consistent, as in previous studies of Irwig & Kolukula (2011), will eventually discourage adherence to the therapy and perhaps further encourage a search for alternative therapies.

- *Comprehensive Hormonal Assessments*

Routine hormonal profiling offers a personalized approach to MPHL management. Monitoring DHT, testosterone, and cortisol levels enables clinicians to identify specific hormonal imbalances and tailor interventions accordingly. For instance, elevated cortisol levels in stressed individuals may exacerbate hair loss, suggesting the potential benefit of stress-reduction therapies as adjunctive treatments (Grymowicz et al., 2020). Integrating such assessments into standard practice can enhance therapeutic outcomes.

- *Preventive Strategies*

The timing of intervention is very important in cases of high genetic risk for MPHL. These could be identified well before significant hair loss occurs with the use of hormonal markers in combination with genetic screening. Early treatment might offer the best therapeutic efficacy by delaying the progression of MPHL. Patient education on the chronic nature of MPHL and the need for adherence to therapy will be important for sustained benefit.

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## V. LIMITATIONS OF THE STUDY

➢ *Notwithstanding the Robust Design of this Study, it Bears some Limitations that need Consideration:*

- *Sample Size and Diversity:*

The population under study in this research was composed essentially of middle-aged men coming from a limited area geographically, thus reducing the generalizability to other demographic groups. Thus, further studies should be performed to examine the variability of MPHL among different ethnic groups or genetic backgrounds.

- *Study Duration:*

Although three years of study gives much-needed information about the medium-term effects of hormonal changes, longer studies must be done to assess long-term therapeutic outcomes and treatment safety profiles, such as those provided by finasteride.

- *Subjective Measures:*

The self-reported nature of the outcomes, such as treatment satisfaction and psychosocial impacts, is naturally subjective and can lead to bias. Inclusion of validated psychological assessment tools or objective measures of quality of life could strengthen such findings.

## VI. FUTURE DIRECTIONS

➢ *To fill the gaps that this study has pointed out and to further the research in MPHL, future studies should be directed at the following aspects:*

- **Alternative Androgen Pathways** Emerging evidence suggests the existence of alternative pathways for androgen synthesis that bypass traditional intermediates. Exploring these pathways may uncover novel targets for therapeutic intervention, reducing reliance on broad-spectrum 5α-reductase inhibitors (Caruso et al., 2015).
- **Novel Therapy Development** Clearly, there is a need for the development of therapies that mitigate side effects associated with systemic hormonal modulation. Topical formulation of either 5α-reductase inhibitors or DHT blockers could have local benefits with less systemic exposure. Furthermore, gene-editing technologies, including CRISPR, may be developed to directly manipulate androgen receptor activity in hair follicle cells.
- **Contributions of Non-Androgenic Factors** While androgens play a major role in MPHL, other factors may lead to hair loss: namely, oxidative stress, inflammatory events, and nutritional deficiencies. The future perspective could be the study of interactions between these different causes in an attempt to find a very comprehensive therapeutic approach.
- **Population Studies** The future study must be expanded to include very diverse populations with different genetic, environmental, and lifestyle factors for better applicability of the results. Large-scale, multicenter studies are needed to elucidate the global burden of MPHL and tailor the interventions accordingly.

## VII. CONCLUSION

MPHL is a multifactorial disease, mainly driven by hormonal changes, and among these especially by dihydrotestosterone. The current longitudinal study evidences that increased DHT significantly leads to hair follicle miniaturization and progressive hair loss, whereas the treatment with finasteride, an inhibitor of 5α-reductase, decreases DHT levels, arrests the further development of hair loss, and leads to hair regrowth in many patients. However, the necessity of long-term treatment and potential drug side effects underlined the need for personalized therapeutic approaches.

Key findings of this research highlight the efficacy of hormonal therapies, the role of cortisol and stress-related factors in exacerbating MPHL, and the potential benefits of early intervention in at-risk individuals. Whereas finasteride remains a cornerstone of MPHL management, observed side effects and dependency on its continuous use are an urgent call for other therapeutic strategies.

This study also draws attention to significant knowledge gaps regarding the long-term effects of hormonal treatments for and the contribution of non-androgenic factors to MPHL. Future studies should be directed toward seeking more localized or other forms of therapy with minimum systemic side effects and the genetic and environmental epidemiology of baldness. Further, research on diverse populations and the integration of modern molecular approaches will provide further insight into the pathophysiology of MPHL.

Addressing these, clinicians and researchers will come closer to effective, sustainable, and patient-centered solutions that contribute to an improved quality of life of individuals affected by MPHL. This study serves as a foundation for future explorations into the complex hormonal dynamics underlying this prevalent condition.

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