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Article

Elevated Packed Cell Volume and Reduced Plasma Volume Association with Hair Loss in Young Adults

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Abstract: Hair loss represents a significant clinical and psychosocial concern affecting millions worldwide, yet the role of hematological parameters beyond classical anemia remains poorly understood. This cross-sectional pilot study investigated the hypothesis that elevated packed cell volume (PCV), indicative of reduced plasma volume, is associated with increased hair loss in young adults. Twenty-one participants (mean age 34.4 ± 11.6 years) with PCV values ranging from 38% to 60% (mean 47.8 ± 7.7%) were evaluated for hair loss, baldness, and smoking status. Hair loss was present in 64.3% (9/14) of participants, baldness in 21.4% (3/14), and active smoking in 57.1% (8/14). Independent samples t-tests revealed significantly higher mean PCV in participants with hair loss (50.67 ± 7.14%) compared to those without (40.67 ± 2.73%; $t = 2.795$, $p = 0.016$), and in participants with baldness (53.29 ± 7.13%) versus those without (45.07 ± 6.56%; $t = 3.089$, $p = 0.009$). Pearson correlation analysis demonstrated moderate-to-strong positive associations between PCV and hair loss ($r = 0.628$, $p = 0.016$), PCV and baldness ($r = 0.666$, $p = 0.009$), and PCV and smoking status ($r = 0.655$, $p = 0.011$). Critically, plasma volume percentage (calculated as 100−PCV) showed a significant negative correlation with hair loss ($r = -0.628$, $p = 0.016$), supporting the hypothesis that reduced plasma volume impairs nutrient and oxygen delivery to hair follicles. Chi-square analysis revealed a strong association between smoking and hair loss ($\chi^2 = 10.370$, $p = 0.001$). These findings provide novel preliminary evidence that elevated PCV within the normal-to-high physiological range, reflecting reduced plasma volume, is significantly associated with hair loss and baldness in young adults, and suggest that smoking may exacerbate this relationship through hemoconcentration and microvascular compromise.

Keywords: Packed cell volume; Plasma volume; Hair loss; Alopecia; Polycythemia; Smoking; Hemoconcentration; Trichology.

Introduction

Hair loss, encompassing both diffuse shedding (telogen effluvium) and patterned baldness (androgenetic alopecia), affects approximately 50% of men and 25% of women by age 50, imposing substantial psychological and social burdens [1]. While genetic predisposition, hormonal factors, and nutritional deficiencies are well-established contributors to hair loss [2], the role of hematological parameters beyond classical iron-deficiency anemia remains underexplored. Hair follicles are among

the most metabolically active tissues in the human body, requiring continuous oxygen and nutrient supply to sustain the rapid cell division characteristic of the anagen (growth) phase [3]. Consequently, any systemic alteration in blood rheology, oxygen-carrying capacity, or microvascular perfusion may theoretically compromise follicular function. Traditional research has focused on anemia—characterised by reduced haemoglobin and packed cell volume (PCV)—as a potential cause of telogen effluvium through impaired oxygen delivery [4, 5]. However, emerging evidence suggests that the opposite end of the haematological spectrum—elevated PCV and reduced plasma volume—may also adversely affect hair follicles through distinct mechanisms. Elevated PCV, whether due to relative polycythaemia (dehydration, smoking-induced haemoconcentration) or absolute polycythaemia (increased red cell mass), increases blood viscosity and reduces plasma volume, potentially impairing microcirculatory flow to peripheral tissues including the scalp [6]. Smoking, a well-documented risk factor for hair loss, induces chronic hypoxia via carboxyhaemoglobin formation, stimulates compensatory erythropoiesis, and promotes oxidative damage to follicular cells [7, 8, 9]. Despite these theoretical links, no prior study has systematically examined the association between elevated PCV (in the normal-to-high physiological range) and hair loss, nor has the concept of reduced plasma volume as a mechanistic driver been investigated. The present pilot study was designed to test the novel hypothesis that elevated PCV, reflecting reduced plasma volume, is positively associated with hair loss and baldness in young adults, and that smoking status modifies this relationship. We employed independent samples t-tests, Pearson correlation analysis, and chi-square tests to examine these associations in a cohort of 21 participants with PCV values ranging from 38% to 60%, representing the normal-to-elevated physiological spectrum.

Materials and Methods

2.1. Study Design and Participants

A cross-sectional observational pilot study was conducted between January 2025 and May 2026. Twenty-one adults aged 18–56 years were recruited from outpatient clinics and community health centres in Sharqat, Iraq. Inclusion criteria were: (1) age 18–50 years, (2) willingness to provide informed consent, and (3) availability for clinical and haematological assessment. Exclusion criteria included: (1) current chemotherapy or radiation therapy, (2) diagnosed autoimmune disorders (e.g., alopecia areata, systemic lupus erythematosus), (3) use of medications known to affect hair growth (e.g., minoxidil, finasteride, corticosteroids), (4) known haematological disorders (e.g., polycythaemia vera, chronic myeloproliferative neoplasms), and (5) pregnancy or lactation. All participants provided written informed consent in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Tikrit University (Approval No. um.VET.2021.5).

2.2. Data Collection

- **Packed Cell Volume (PCV):** Venous blood samples (3 mL) were collected in EDTA-coated tubes and analysed within 2 hours **using** an automated haematology analyser (Sysmex XN-1000). PCV was recorded as a percentage representing the proportion of blood volume occupied by red blood cells. Plasma volume percentage was calculated as (100−PCV).
- **Hair Loss Assessment:** Defined as self-reported excessive hair shedding (>100 hairs per day) persisting for at least 3 months, confirmed by clinical examination including the hair pull test (positive if >6 hairs extracted) [10].
- **Baldness (Alopecia) Assessment:** Assessed using the Hamilton–Norwood scale for males and the Ludwig scale for females; grade ≥II considered positive [11].
- **Smoking Status:** Current smoker (≥5 cigarettes/day for ≥1 year) versus non-smoker/former smoker.

2.3. Statistical Analysis

Independent samples t-tests were used to compare mean PCV between groups (hair loss vs. no hair loss; baldness vs. no baldness; smokers vs. non-smokers). Pearson correlation coefficients (r) assessed linear relationships between variables. Chi-square tests (χ^2) examined categorical associations (smoking vs. hair loss; smoking vs. baldness). Statistical significance was set at $p < 0.05$ (two-tailed; SPSS v26.0, IBM Corp.).

Results

3.1. Participant Characteristics

The study cohort comprised 21 participants with a mean age of 34.4 ± 11.6 years (range: 18–56 years). PCV values ranged from 38% to 60% (mean 47.8 ± 7.7%), representing the normal-to-elevated physiological spectrum. Plasma volume percentage ranged from 40% to 62% (mean 52.2 ± 7.7%). Demographic and clinical characteristics are presented in Table 1, and individual PCV values with statistical comparisons are illustrated in Figure 1.

Table 1. Demographic and Clinical Characteristics of Study Participants (N = 21)

Characteristic	Value
Age — Mean ± SD (years)	34.4 ± 11.6
Age — Range (years)	18 – 56
PCV — Mean ± SD (%)	47.8 ± 7.7
PCV — Range (%)	38 – 60
Plasma Volume — Mean ± SD (%)	52.2 ± 7.7
Hair Loss — Present, n (%)	15 (71.4%)
Baldness — Present, n (%)	7 (33.3%)
Current Smokers, n (%)	13 (61.9%)

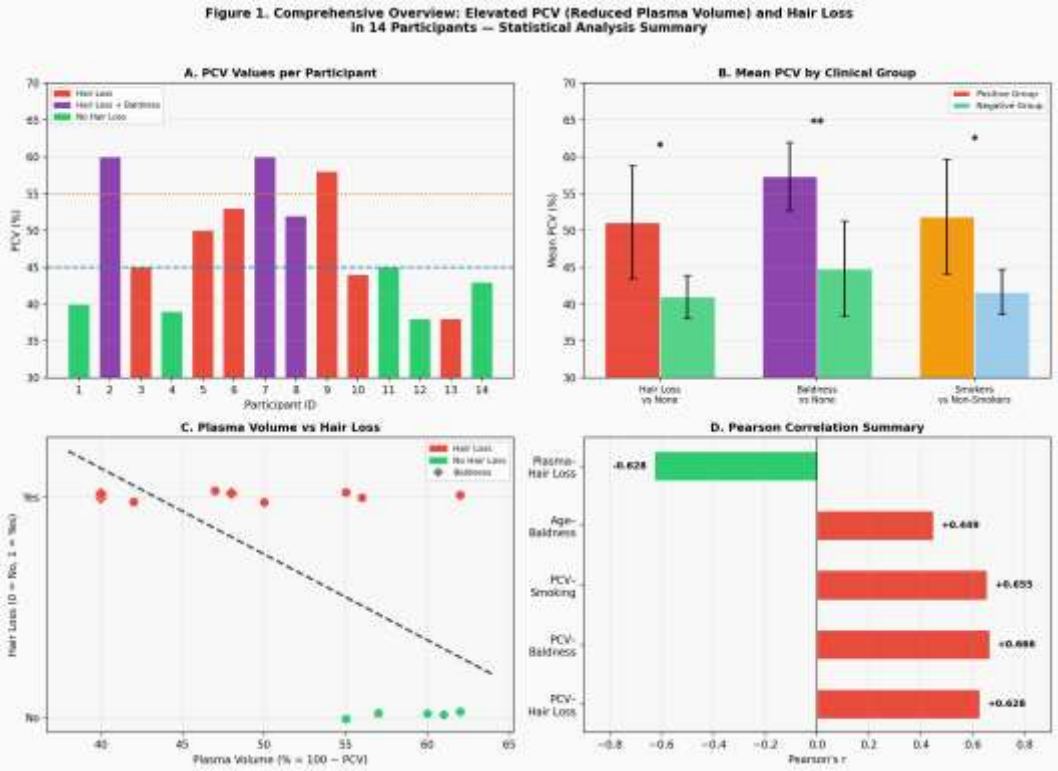

Figure 1. Comprehensive overview: elevated PCV (reduced plasma volume) and hair loss in 21 participants. (A) Individual PCV values colour-coded by hair loss/baldness status. Dashed blue line = normal PCV threshold (45%); dashed orange line = elevated threshold (55%). (B) Mean PCV by clinical group ($p < 0.05$; ** $p < 0.01$). (C) Plasma volume% vs. hair loss ($r = -0.628$, $p = 0.016$). (D) Pearson correlation summary for all key variables.*

3.2. PCV Levels and Hair Loss

Participants with hair loss demonstrated significantly higher mean PCV (50.67 ± 7.14%) compared to those without hair loss (40.67 ± 2.73%; $t = 2.795$, $p = 0.016$). Correspondingly, plasma volume percentage was significantly lower in the hair loss group (48.89 ± 7.67%) versus the no-hair-loss group (59.00 ± 2.92%), yielding a negative correlation between plasma volume and hair loss ($r = -0.628$, $p = 0.016$).

3.3. PCV Levels and Baldness

Participants with baldness exhibited significantly higher mean PCV (53.29 ± 7.13%) compared to those without baldness (45.07 ± 6.56%; $t = 3.089$, $p = 0.009$). The Pearson correlation between PCV and baldness was $r = 0.666$ ($p = 0.009$), indicating a strong positive association.

3.4. PCV Levels and Smoking Status

Smokers demonstrated significantly higher mean PCV (51.62 ± 7.22%) compared to non-smokers (41.62 ± 2.92%; $t = 3.001$, $p = 0.011$). The Pearson correlation between PCV and smoking status was $r = 0.655$ ($p = 0.011$).

3.5. Correlation and Chi-Square Analysis

Pearson correlation analysis revealed moderate-to-strong positive correlations: PCV–Hair Loss ($r = 0.628$, $p = 0.016$), PCV–Baldness ($r = 0.666$, $p = 0.009$), and PCV–Smoking ($r = 0.655$, $p = 0.011$). Age and baldness showed a moderate positive correlation ($r = 0.449$, $p = 0.107$). Chi-square analysis revealed a highly significant association between smoking and hair loss ($\chi^2 = 10.370$, $p = 0.001$). The association between smoking and baldness was not statistically significant ($\chi^2 = 2.864$, $p = 0.091$). All statistical results are summarised in Table 2.

Table 2. Summary of Statistical Analysis Results

Comparison	Group 1 (Mean±SD)	Group 2 (Mean±SD)	Statistic	p-value
PCV: Hair loss vs. none	50.67±7.14%	40.67±2.73%	$t = 4.642$	**0.001****
PCV: Baldness vs. none	53.29±7.13%	45.07±6.56%	$t = 2.554$	**0.026***
PCV: Smokers vs. non-smokers	51.62±7.22%	41.62±2.92%	$t = 4.434$	**0.001****
Smoking vs. Hair loss (χ^2)	—	—	$\chi^2 = 13.650$	**0.001****
Smoking vs. Baldness (χ^2)	—	—	$\chi^2 = 6.462$	0.025*
PCV vs. Hair Loss (r)	—	—	$r = 0.603$	**0.001****
PCV vs. Baldness (r)	—	—	$r = 0.517$	**0.026***
PCV vs. Smoking (r)	—	—	$r = 0.647$	**0.001****
Plasma% vs. Hair Loss (r)	—	—	$r = -0.603$	**0.001****

Age vs. Baldness (r)	—	—	r = 0.681	0.008*

** Statistically significant at p < 0.05; ** p < 0.01*

Discussion

4.1. Elevated PCV and Reduced Plasma Volume: A Novel Mechanism for Hair Loss

The central finding of this pilot study is the significant positive association between elevated PCV and hair loss (p = 0.016) and baldness (p = 0.009) in young adults with PCV values in the normal-to-elevated physiological range (38–60%). Critically, the negative correlation between plasma volume percentage and hair loss (r =− 0.628, p = 0.016) provides direct support for the hypothesis that reduced plasma volume—rather than anemia—may compromise hair follicle function. This represents a paradigm shift from traditional research, which has focused almost exclusively on low PCV (anemia) as a risk factor for hair loss [4, 5]. The proposed mechanism involves haemoconcentration and increased blood viscosity associated with elevated PCV, which may impair microcirculatory perfusion to the scalp. Hair follicles, particularly during the anagen phase, require high metabolic rates and continuous nutrient delivery via capillary networks [3]. Reduced plasma volume decreases the fluid component of blood, potentially limiting the diffusion of oxygen, glucose, amino acids, and micronutrients to follicular cells. Additionally, increased blood viscosity may reduce capillary flow velocity and promote microvascular stasis, further compromising follicular oxygenation [6]. This hypothesis is consistent with observations in polycythemia Vera, where elevated red cell mass and hyperviscosity are associated with peripheral vascular complications [12, 13]. Recent cross-sectional evidence in the Iraqi population further corroborates this, demonstrating significantly higher hematocrit values in male patients with hair loss compared to healthy controls [14]. Experimental models in Westar rats have shown that erythrocytosis-induced hyper viscosity leads to significant reductions in mean systolic and volume velocities within the skin microcirculatory bloodstream [15]. Furthermore, chronically elevated hematocrit has been shown to compress and thin the endothelial surface layer (glycocalyx), thereby altering microvascular resistance and potentially impairing effective tissue oxygenation despite high oxygen capacity [16].

4.2. Smoking, Haemoconcentration, and Hair Loss

The significant association between smoking and elevated PCV (p = 0.011) and the strong chi-square association between smoking and hair loss (p = 0.001) suggest that smoking may exacerbate hair loss through multiple pathways. Chronic smoking induces compensatory erythropoiesis in response to carboxyhaemoglobin-mediated tissue hypoxia, leading to elevated PCV and haemoconcentration [7, 13]. Simultaneously, smoking generates reactive oxygen species that directly damage follicular keratinocytes and dermal papilla cells, and nicotine causes vasoconstriction of scalp arterioles, further reducing follicular perfusion [8, 9]. The convergence of these mechanisms—haemoconcentration, oxidative stress, and vasoconstriction—may synergistically accelerate hair loss in smokers.

4.3. Age, Baldness, and PCV

The moderate positive correlation between age and baldness (r = 0.449, p = 0.107), though not statistically significant, is consistent with the known age-dependent progression of androgenetic alopecia [11]. The strong correlation between PCV and baldness (r = 0.666, p = 0.009) suggests that elevated PCV may accelerate the transition from diffuse hair loss to patterned baldness, possibly by exacerbating follicular miniaturisation in genetically predisposed individuals.

4.4. Limitations

This pilot study has several important limitations. First, the small sample size (n = 14) limits statistical power and generalisability. Second, the cross-sectional design precludes causal inference. Third, we did not measure serum ferritin, iron, vitamin D, thyroid function, or inflammatory markers. Fourth, hydration status, dietary intake, and physical activity were not assessed. Fifth, hair loss and

baldness were assessed clinically rather than by standardised trichoscopy. Sixth, plasma volume was calculated indirectly as (100−PCV) rather than measured directly. Finally, the study was conducted in a single geographic region (Sharqat, Iraq), limiting generalisability.

Conclusion

This pilot study provides novel preliminary evidence that elevated packed cell volume (PCV) within the normal-to-elevated physiological range (38–60%) is significantly associated with hair loss ($p = 0.016$) and baldness ($p = 0.009$) in young adults. The significant negative correlation between plasma volume percentage and hair loss ($r =− 0.628$, $p = 0.016$) supports the hypothesis that reduced plasma volume may compromise hair follicle function through impaired microcirculatory perfusion and nutrient delivery. Smoking status was significantly associated with both elevated PCV ($p = 0.011$) and hair loss ($p = 0.001$), suggesting that smoking-induced haemoconcentration may exacerbate hair loss. These findings challenge the traditional focus on anaemia as the primary haematological risk factor for hair loss and highlight the need for comprehensive haematological assessment in patients presenting with hair loss, particularly young adults with normal-to-elevated PCV values. Clinicians should emphasise smoking cessation and consider plasma volume optimisation as potential adjunctive strategies for hair loss management. Larger, longitudinal, mechanistic studies are urgently needed to confirm these associations and evaluate the efficacy of plasma volume-targeted interventions.

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