

Erythrocytosis and Previous Deep Vein Thrombosis in Occupationally Active Adult Men Living at Moderate Altitude: A Retrospective Cross-Sectional Study

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Abstract

Objective: Deep vein thrombosis (DVT) is an important cause of venous thromboembolism-associated morbidity and mortality. Chronic exposure to moderate altitude may promote erythrocytosis through adaptive erythropoiesis, whereas elevated low-density lipoprotein (LDL) cholesterol may contribute to endothelial dysfunction and vascular inflammation. This study aimed to determine the frequency of previous DVT and to investigate the association of erythrocytosis and LDL cholesterol with previous DVT in occupationally active adult men living at moderate altitude.

Methods: This retrospective cross-sectional study included 200 occupationally active adult men residing at an altitude of approximately 1300–1400 m above sea level. Participants were classified according to the presence or absence of a documented history of previous DVT. Hemoglobin and hematocrit were evaluated as markers of erythrocytosis, whereas LDL cholesterol was evaluated as the principal metabolic variable. Age, smoking status, hypertension, platelet count, white blood cell (WBC) count, red blood cell (RBC) count, and C-reactive protein (CRP) were analyzed as secondary variables. Because of the small number of DVT events and complete separation for hematocrit, univariate Firth-penalized logistic regression was used to identify factors associated with previous DVT.

Results: Previous DVT was documented in 7 participants (3.5%). Participants with previous DVT were significantly younger than those without DVT (33.0 ± 5.1 vs. 39.1 ± 8.8 years, $p=0.018$) and had significantly higher hemoglobin levels (17.83 ± 0.86 vs. 16.88 ± 0.98 g/dL, $p=0.027$). In univariate Firth-penalized logistic regression, each 1-g/dL increase in hemoglobin was associated with higher odds of previous DVT (odds ratio [OR] 2.94, 95% confidence interval [CI] 1.32–6.71; $p=0.009$). Elevated hematocrit ($\geq 49\%$) was present in all participants with previous DVT (100.0% vs. 74.1%). Firth regression provided a finite but highly imprecise estimate for hematocrit $\geq 49\%$ (OR 5.28, 95% CI 0.62–689.64; $p=0.151$); the extremely wide CIs reflect sparse events and complete separation. Mean LDL cholesterol levels were similar between groups (122.0 ± 34.3 vs. 121.2 ± 29.6 mg/dL, $p=0.952$). Smoking, hypertension, platelet count, WBC count, RBC count, and CRP were not significantly associated with previous DVT (all $p > 0.05$).

Conclusion: A history of previous DVT was identified in 3.5% of this relatively young, homogeneous male population living at moderate altitude. Higher hemoglobin levels were associated with previous DVT in univariate analysis; however, an independent association could not be established because multivariable adjustment, including adjustment for age, was not feasible owing to the small number of events. These findings should therefore be considered exploratory and hypothesis-generating and require confirmation in larger prospective studies.

Keywords: Deep vein thrombosis; erythrocytosis; hemoglobin; lipoproteins; moderate altitude.

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Orta Rakımda Yaşayan Çalışan Erkeklerde Eritrositoz ile Önceki Derin Ven Trombozu Arasındaki İlişki: Retrospektif Kesitsel Bir Çalışma

Özet

Amaç: Derin ven trombozu (DVT), venöz tromboembolizme bağlı morbidite ve mortalitenin önemli nedenlerinden biridir. Orta rakımda kronik yaşam, adaptif eritropoez yoluyla eritrositozu teşvik edebilirken, yüksek düşük yoğunluklu lipoprotein (LDL) kolesterol düzeyleri endotelial disfonksiyon ve vasküler inflamasyona katkıda bulunabilir. Bu çalışmada, orta rakımda yaşayan çalışan erişkin erkeklerde önceki DVT sıklığının belirlenmesi ve eritrositoz ile LDL kolesterolün önceki DVT ile ilişkisinin araştırılması amaçlandı.

Yöntem: Bu retrospektif kesitsel çalışmaya deniz seviyesinden yaklaşık 1300–1400 metre yükseklikte yaşayan 200 çalışan erişkin erkek dahil edildi. Katılımcılar, tıbbi kayıtlarda kompresyon venöz ultrasonografi ile doğrulanmış önceki DVT öyküsünün varlığına göre gruplandırıldı. Eritrositoz belirteçleri olarak hemoglobin ve hematokrit, temel metabolik değişkenler olarak LDL kolesterol değerlendirildi. Yaş, sigara kullanımı, hipertansiyon, trombosit sayısı, beyaz küre sayısı, eritrosit sayısı ve C-reaktif protein (CRP) ikincil değişkenler olarak incelendi. Düşük olay sayısı ve hematokritte tam ayrışma nedeniyle ilişkiler tek değişkenli Firth cezalandırılmış lojistik regresyon analizi ile değerlendirildi.

Bulgular: Önceki DVT yedi katılımcıda (%3,5) saptandı. Önceki DVT öyküsü olan katılımcılar, DVT öyküsü olmayanlara göre daha gençti ($33,0 \pm 5,1$ e karşı $39,1 \pm 8,8$ yıl; $p=0,018$) ve hemoglobin düzeyleri daha yüksekti ($17,83 \pm 0,86$ 'ya karşı $16,88 \pm 0,98$ g/dL; $p=0,027$). Tek değişkenli Firth lojistik regresyon analizinde hemoglobindeki her 1 g/dL artış, önceki DVT olasılığında artış ile ilişkili bulundu (OR 2,94; %95 GA 1,32–6,71; $p=0,009$). Önceki DVT öyküsü bulunan katılımcıların tamamında hematokrit ≥ 49 iken, DVT öyküsü olmayanlarda bu oran %74,1 idi. Firth regresyonu hematokrit ≥ 49 için sonlu ancak belirsiz bir tahmin sağladı (OR 5,28; %95 GA 0,62–689,64; $p=0,151$). Ortalama LDL kolesterol düzeyleri gruplar arasında benzerdi ($122,0 \pm 34,3$ 'e karşı $121,2 \pm 29,6$ mg/dL; $p=0,952$). Sigara kullanımı, hipertansiyon, trombosit sayısı, beyaz küre sayısı, eritrosit sayısı ve CRP ile önceki DVT arasında anlamlı ilişki saptanmadı (tüm $p>0,05$).

Sonuç: Orta rakımda yaşayan bu nispeten genç ve homojen erkek popülasyonun %3,5'inde önceki DVT öyküsü saptandı. Daha yüksek hemoglobin düzeyleri tek değişkenli analizde önceki DVT ile ilişkiliydi; ancak olay sayısının düşük olması nedeniyle yaş dahil çok değişkenli düzeltme yapılamadığından bağımsız bir ilişki gösterilemedi. Bu nedenle bulgular keşifsel ve hipotez oluşturucu olarak değerlendirilmelidir ve daha büyük prospektif çalışmalarla doğrulanmalıdır.

Anahtar sözcükler: Derin ven trombozu; eritrositoz; hemoglobin; lipoproteinler; orta rakım.

Introduction

Deep vein thrombosis (DVT) is a major manifestation of venous thromboembolism (VTE) and remains an important cause of morbidity and mortality worldwide. Although well-established risk factors such as advanced age, surgery, malignancy, trauma, and inherited thrombophilia have been extensively studied, the contribution of environmental and hematological factors to venous thrombosis remains incompletely understood.^[1–6]

Residence at moderate altitude may induce adaptive erythropoiesis, resulting in increased hemoglobin and hematocrit levels. These changes may increase blood viscosity and potentially contribute to venous thrombosis. In addition, elevated low-density lipoprotein (LDL) cholesterol has been associated with endothelial dysfunction and vascular inflammation and has recently been suggested as a possible contributor to VTE. However, the relationship between erythrocytosis, LDL cholesterol, and previous DVT remains controversial, particularly in relatively young and healthy populations.^[7–17]

Occupationally active adult men living at moderate altitude represent a unique population in whom traditional cardiovascular risk factors are relatively uncommon, allowing a clearer evaluation of potential hematological and metabolic correlates of venous thrombosis. However, data regarding the frequency of previous DVT and its association with erythrocytosis and lipid profile in this population are limited.^[17]

Materials and Methods

Study Design and Population

This retrospective cross-sectional study included 200 occupationally active adult men residing at a moderate altitude (approximately 1300–1400 m above sea level) who underwent routine periodic health examinations between January 2025 and March 2026. Demographic characteristics, medical history, and laboratory measurements were retrospectively reviewed. Participants were categorized according to the presence or absence of a documented history of previous DVT.

Inclusion and Exclusion Criteria

Participants were excluded if they had chronic kidney disease, chronic liver disease, active infection or inflammatory disease, hematologic malignancy, secondary causes of erythrocytosis (including chronic pulmonary disease, cyanotic congenital heart disease, obstructive sleep apnea, testosterone therapy, or other conditions known to increase erythropoiesis), or incomplete clinical or laboratory data.

Only male participants were included. Female individuals were excluded to minimize the potential confounding effects of sex-related hormonal differences on hematological and lipid parameters, as well as the influence of estrogen exposure and hormonal contraceptive use on venous thrombotic risk. Restricting the study to men was intended to provide a more homogeneous study population and reduce biological variability (Fig. 1).

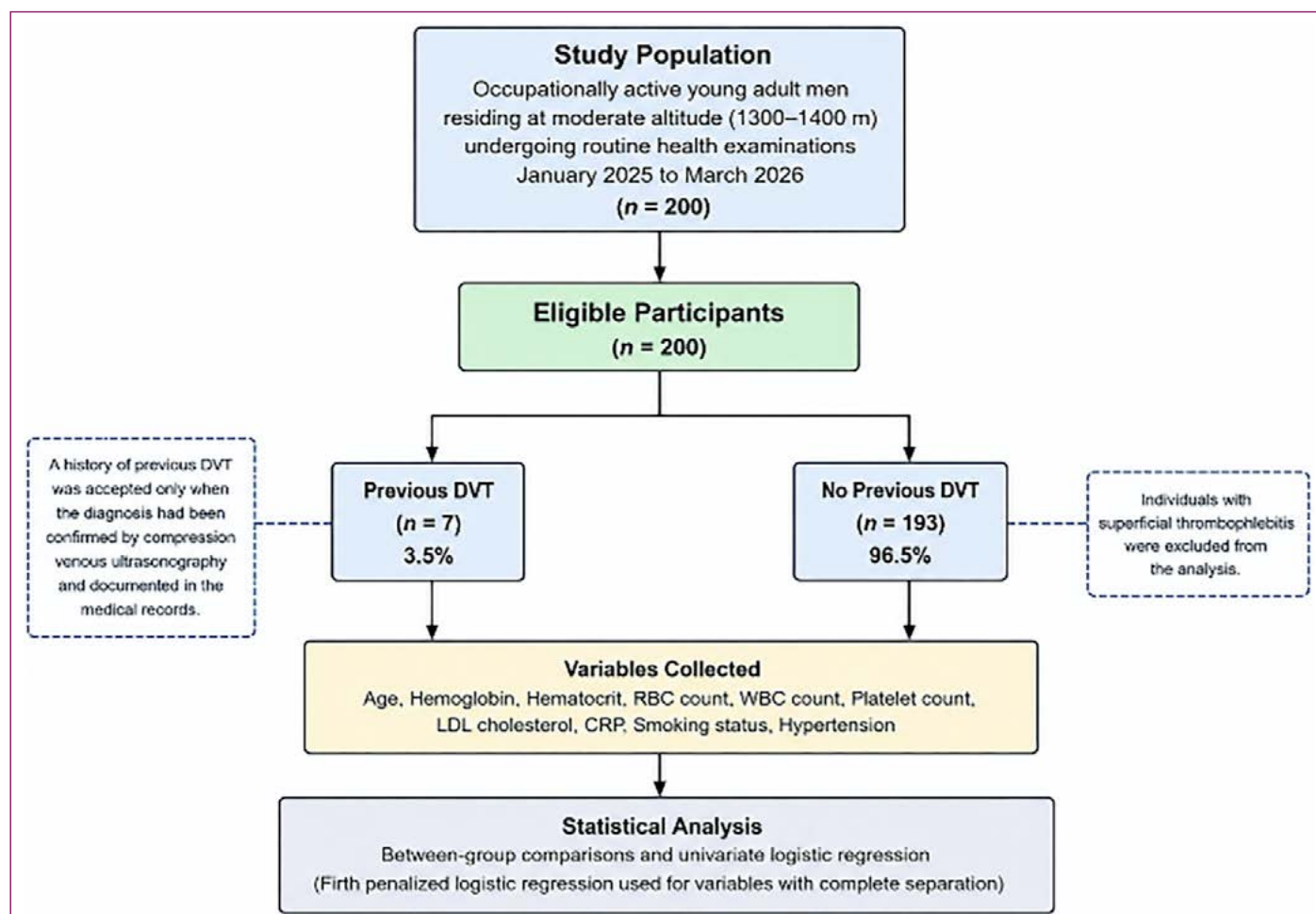


Figure 1. Study flow diagram. Selection of the study population and classification of participants according to the presence or absence of a documented history of previous deep vein thrombosis.

DVT: Deep vein thrombosis.

Data Collection

The following variables were extracted from medical records and routine laboratory evaluations: age, hemoglobin, hematocrit, red blood cell (RBC) count, white blood cell (WBC) count, platelet count, LDL cholesterol, C-reactive protein (CRP), smoking status, and hypertension. Blood samples were obtained after overnight fasting during routine occupational health examinations and analyzed in the hospital central laboratory using standardized automated analyzers.

Outcome Measure

Hemoglobin and hematocrit were evaluated as markers of erythrocytosis. Elevated hematocrit was defined as $\geq 49\%$, whereas elevated hemoglobin was defined as >16.5 g/dL. LDL cholesterol was evaluated as the principal metabolic variable. To minimize the influence of transient physiological fluctuations, hemoglobin and hematocrit values were reviewed together with available previous laboratory measurements obtained during the same annual occupational health surveillance period. When multiple measurements were available, persistent rather than isolated elevations were considered during data verification. The primary

outcome was a documented history of previous DVT. Previous DVT was defined only when confirmed by compression venous ultrasonography and documented in the medical record. Participants were categorized into DVT and non-DVT groups according to their medical records. Superficial thrombophlebitis was not considered a DVT event and was excluded.

Statistical Analysis

Continuous variables were expressed as mean $\pm$ standard deviation or median (interquartile range), according to data distribution. Normality was assessed using the Shapiro–Wilk test. Categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent-samples t-test or the Mann–Whitney U test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables, as appropriate.

Because only seven previous DVT events were observed and complete separation occurred for hematocrit $\geq 49\%$, univariate associations were estimated using Firth-penalized logistic regression. This bias-reduced likelihood approach provides finite estimates in sparse data and separation. Age, hemoglobin, he-

Table 1. Baseline demographic, clinical, and laboratory characteristics of participants according to previous deep vein thrombosis

Variable	Previous DVT (n=7)	No previous DVT (n=193)	p
Age (years)	33.0±5.1	39.1±8.8	0.018
Smoking, n (%)	3 (42.9)	58 (30.1)	0.438
Hypertension, n (%)	1 (14.3)	43 (22.3)	1.000
Hemoglobin (g/dL)	17.83±0.86	16.88±0.98	0.027
Hematocrit ≥49%, n (%)	7 (100.0)	143 (74.1)	0.196
RBC (×10 ⁶ /μL)	6.00±0.39	5.77±0.46	0.181
WBC (×10 ³ /μL)	8.79±1.91	8.65±2.08	0.854
Platelet (×10 ³ /μL)	243±83	233±61	0.753
LDL cholesterol (mg/dL)	122.0±34.3	121.2±29.6	0.952
CRP (mg/L)	3.67±2.89	3.14±3.22	0.652

Values are presented as mean±SD or n (%), as appropriate. DVT: Deep vein thrombosis; SD, standard deviation; RBC: Red blood cell; WBC: White blood cell; LDL: Low-density lipoprotein; CRP: C-reactive protein.

matocrit, LDL cholesterol, smoking status, hypertension, platelet count, WBC count, RBC count, and CRP were assessed individually. Odds ratios (ORs), profile penalized-likelihood 95% confidence intervals (CIs), and penalized likelihood-ratio p-values were reported. Continuous predictors were modeled per 1-unit increase, except LDL cholesterol and platelet count, which were scaled per 10-unit increase.

Because of the limited number of DVT events, multivariable logistic regression was not performed to avoid overfitting and unstable parameter estimates. Consequently, adjustment for potential confounders, including age, was not feasible, and no independent associations can be inferred from the regression estimates. All regression analyses were therefore considered exploratory and hypothesis-generating.

A two-sided $p < 0.05$ was considered statistically significant. Statistical analyses were performed using IBM Statistical Package for the Social Sciences Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA) for descriptive and between-group analyses, and a Python-based implementation of Firth-penalized logistic regression for sparse-event modeling.

The study protocol was approved by the Koşuyolu High Specialty Training and Research Hospital Scientific Research Ethics Committee (Date: 28.07.2026, Decision no: 2026/13.1558) and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Owing to the retrospective observational design of the study and the use of anonymized data, the requirement for written informed consent was waived by the Ethics Committee. The study was reported in accordance with the STROBE Statement.^[18]

Results

A total of 200 occupationally active adult men were included in the analysis. Previous DVT, confirmed by compression venous ultrasonography, was documented in 7 participants (3.5%); the remaining 193 participants (96.5%) had no history of DVT.

Table 2. Univariate Firth-penalized logistic regression analysis of factors associated with previous deep vein thrombosis

Variable	OR	95% CI	p
Age (per 1-year increase)	0.86	0.72–0.99	0.041
Hemoglobin (per 1 g/dL increase)	2.94	1.32–6.71	0.009
Hematocrit ≥49%	5.28	0.62–689.64	0.151
LDL cholesterol (per 10 mg/dL increase)	1.01	0.78–1.30	0.922
Smoking	1.80	0.39–7.63	0.428
Hypertension	0.80	0.08–3.94	0.803
RBC (per 1 ×10 ⁶ /μL increase)	2.64	0.61–8.25	0.168
WBC (per 1 ×10 ³ /μL increase)	1.06	0.72–1.45	0.744
Platelet (per 10 ×10 ³ /μL increase)	1.03	0.91–1.15	0.601
CRP (per 1 mg/L increase)	1.07	0.85–1.26	0.483

Odds ratios are presented per unit increase unless otherwise specified. LDL cholesterol and platelet count are expressed per 10-unit increase. All analyses were performed using univariate Firth-penalized logistic regression. Odds ratios were estimated using Firth penalized likelihood. Profile penalized-likelihood 95% confidence intervals and penalized likelihood-ratio p values are reported. The very wide confidence interval for hematocrit ≥49% reflects sparse events and complete separation and should not be interpreted as a precise or independent effect estimate. DVT: Deep vein thrombosis; OR: Odds ratio; CI: Confidence interval; LDL: Low-density lipoprotein; RBC: Red blood cell; WBC: White blood cell; CRP: C-reactive protein.

The demographic, clinical, and laboratory characteristics of the groups are presented in Table 1. Participants with previous DVT were significantly younger than those without DVT (33.0±5.1 vs. 39.1±8.8 years, respectively; $p=0.018$). Smoking was numerically more frequent in the DVT group (42.9% vs. 30.1%; $p=0.438$), whereas hypertension prevalence was similar between groups (14.3% vs. 22.3%; $p=1.000$).

Regarding erythrocytosis-related markers, participants with previous DVT had significantly higher hemoglobin concentrations than those without DVT (17.83±0.86 vs. 16.88±0.98 g/dL; $p=0.027$). Elevated hematocrit (≥49%) was present in all participants with previous DVT, compared with 74.1% of those without DVT (100.0% vs. 74.1%; $p=0.196$). RBC counts were also numerically higher in the DVT group, although the difference was not statistically significant (6.00±0.39 vs. 5.77±0.46 ×10⁶/μL; $p=0.181$).

Mean LDL cholesterol levels were comparable between participants with and without previous DVT (122.0±34.3 vs. 121.2±29.6 mg/dL; $p=0.952$). No significant differences were observed in WBC count (8.79±1.91 vs. 8.65±2.08 ×10³/μL; $p=0.854$), platelet count (243±83 vs. 233±61 ×10³/μL; $p=0.753$), or CRP levels (3.67±2.89 vs. 3.14±3.22 mg/L; $p=0.652$).

Exploratory univariate Firth-penalized logistic regression findings are presented in Table 2. Each 1-year increase in age was associated with lower odds of previous DVT (OR 0.86, 95% CI 0.72–0.99; $p=0.041$). In exploratory univariate analysis, each 1-g/dL increase in hemoglobin was associated with approximately threefold higher odds of previous DVT (OR 2.94, 95% CI 1.32–6.71; $p=0.009$). RBC count showed a directionally positive but non-significant association (OR 2.64/1 ×10⁶/μL increase, 95% CI 0.61–8.25; $p=0.168$).

No significant associations were identified for LDL cholesterol (OR 1.01/10-mg/dL increase, 95% CI 0.78–1.30; $p=0.922$), smok-

ing (OR 1.80, 95% CI 0.39–7.63; $p=0.428$), hypertension (OR 0.80, 95% CI 0.08–3.94; $p=0.803$), WBC count (OR $1.06/1 \times 10^3/\mu\text{L}$ increase, 95% CI 0.72–1.45; $p=0.744$), platelet count (OR $1.03/10 \times 10^3/\mu\text{L}$ increase, 95% CI 0.91–1.15; $p=0.601$), or CRP (OR 1.07/1-mg/L increase, 95% CI 0.85–1.26; $p=0.483$).

Although all seven participants with previous DVT had hematocrit values $\geq 49\%$, Firth-penalized logistic regression produced a finite estimate (OR 5.28, 95% CI 0.62–689.64; $p=0.151$). The extremely wide CIs are an expected statistical consequence of the sparse event count and complete separation, reflecting the very limited information available for precise estimation. Therefore, this result should not be interpreted as evidence of an independent or precisely quantified effect.

Discussion

The present study investigated the frequency of previous DVT and its hematological and metabolic correlates in a homogeneous cohort of occupationally active young adult men residing at moderate altitude. The principal findings were as follows: First, previous DVT was identified in 3.5% of participants; second, participants with previous DVT were younger and had significantly higher hemoglobin concentrations; third, all participants with previous DVT had hematocrit values $\geq 49\%$, suggesting a possible relationship between erythrocytosis and venous thrombosis; and finally, LDL cholesterol, smoking, hypertension, CRP, platelet count, RBC count, and WBC count were not significantly associated with previous DVT. These findings should be interpreted as exploratory univariate associations rather than evidence of independent risk relationships, given the small number of DVT events and the inability to perform multivariable adjustment.

One of the most noteworthy observations was the detection of previous DVT in 3.5% of a relatively young population with a mean age of approximately 39 years. Population-based studies have consistently demonstrated that the incidence of VTE increases markedly with advancing age and remains relatively low among younger adults.^[3,4,19]

Although our study evaluated the prevalence of previous DVT rather than incident events, the observed frequency appears noteworthy considering the young age and occupationally active nature of the study population. Direct comparison with population-based cohorts should nevertheless be interpreted cautiously because of differences in study design, outcome definition, and participant characteristics.

The association between erythrocytosis-related markers and previous DVT represents the most important biological finding of the present study. Chronic exposure to hypobaric hypoxia stimulates erythropoietin production and adaptive erythropoiesis, resulting in increased hemoglobin concentration and hematocrit.^[9,10,12,17] Increased red cell mass may increase whole-blood viscosity, impair venous blood flow, and promote thrombus formation through mechanisms consistent with Virchow's triad.^[8,16]

In our cohort, higher hemoglobin was associated with previous DVT in univariate analysis, whereas every participant with

previous DVT had hematocrit values $\geq 49\%$. However, because participants with previous DVT were significantly younger and the small number of events precluded multivariable adjustment, it cannot be determined whether the observed hemoglobin association is independent of age or other potential confounders. Although the limited number of events prevented robust estimation of the hematocrit effect, these findings are biologically plausible and consistent with the hypothesis that erythrocytosis may contribute to venous thrombosis in susceptible individuals.

Our observations are also supported by findings from the Tromsø Study. Brækkan and colleagues demonstrated that increasing hematocrit was associated with a higher long-term risk of VTE, particularly unprovoked events.^[7] More recently, Jakobsen et al.^[20] reported that elevated hemoglobin was independently associated with incident VTE and that the combination of high hemoglobin and obesity further increased thrombotic risk.

Although our study was cross-sectional and included considerably fewer thrombotic events, the direction of the univariate association between erythrocytosis-related markers and previous DVT was consistent with these prospective observations; however, our findings cannot establish an independent or causal relationship.

Residence at moderate altitude is accompanied by chronic exposure to mild hypobaric hypoxia, which activates hypoxia-inducible factor (HIF)1 α .^[10,12,17] Activation of HIF signaling stimulates erythropoietin synthesis, leading to adaptive erythropoiesis and progressive increases in hemoglobin concentration and hematocrit. Although these physiological adaptations improve oxygen transport, they may simultaneously increase whole-blood viscosity, impair venous flow, and promote blood stasis. Increased blood viscosity has long been recognized as a potential contributor to thrombus formation, particularly within the low-flow venous circulation.^[8,16]

Beyond erythrocytosis, chronic hypoxia may also contribute to a prothrombotic phenotype through endothelial activation.^[12,15] Experimental studies have demonstrated increased expression of tissue factor, von Willebrand factor, adhesion molecules, and inflammatory mediators under hypoxic conditions. These alterations may enhance platelet-endothelium interactions and facilitate activation of the coagulation cascade. Together with increased blood viscosity and potential reductions in venous blood flow, these mechanisms are compatible with Virchow's triad of thrombosis.^[8,16] Although the present study cannot establish causality, the observed association between higher hemoglobin levels and previous DVT is biologically plausible within this pathophysiological framework.

Unlike hemoglobin, LDL cholesterol was not associated with previous DVT in our cohort. Although LDL cholesterol is a well-established determinant of atherosclerotic cardiovascular disease through endothelial dysfunction, oxidative stress, and vascular inflammation,^[14] its role in venous thrombosis remains uncertain. Previous studies have reported inconsistent results,^[13,21] suggesting that lipid metabolism probably has a weaker influence on venous thrombosis than on arterial disease. Our findings

support this concept, as LDL cholesterol was not significantly associated with previous DVT in the present univariate analysis. Similarly, smoking status, hypertension, CRP, platelet count, RBC count, and WBC count were not significantly associated with previous DVT. The absence of an association between CRP and previous DVT is in agreement with findings from the Tromsø Study, in which high-sensitivity CRP was not identified as an independent predictor of future VTE.^[7] These exploratory findings raise the possibility that erythrocytosis-related parameters may warrant further investigation alongside conventional cardiovascular risk factors when evaluating venous thrombosis in similar populations.

The present study has several limitations. First, only seven thrombotic events were observed, and the duration of residence at moderate altitude was unavailable; therefore, cumulative altitude exposure could not be evaluated. Firth-penalized logistic regression was used to reduce small-sample bias and obtain a finite estimate in the presence of complete separation; however, it does not restore information that is absent because of the low event count. Accordingly, the extremely wide confidence interval for hematocrit $\geq 49\%$ is an expected statistical consequence of sparse events and complete separation and indicates substantial uncertainty regarding the magnitude of the association. Multivariable regression was intentionally not performed to avoid overfitting and unstable parameter estimates. Consequently, adjustment for potential confounders was not feasible. This is particularly relevant for age, because participants with previous DVT were significantly younger than those without previous DVT. Therefore, the observed association between higher hemoglobin and previous DVT cannot be interpreted as an independent association, and all regression findings should be considered exploratory and hypothesis-generating rather than confirmatory. Second, the retrospective cross-sectional design precludes any causal inference between erythrocytosis, LDL cholesterol, and previous DVT. Third, this was a single-center study, which may limit the generalizability of the findings. Fourth, only occupationally active adult men were included; therefore, the results cannot be extrapolated to women, older individuals, or populations with different demographic characteristics. Fifth, thrombophilia screening and detailed coagulation profiles were not available; therefore, inherited or acquired thrombophilic disorders could not be excluded as potential confounders. Sixth, body mass index, physical activity level, hydration status, and other lifestyle-related factors were not systematically recorded and therefore could not be evaluated. Seventh, no sea-level comparison group was available, preventing assessment of whether residence at moderate altitude independently influenced thrombotic risk. Finally, the study evaluated a documented history of previous DVT rather than incident thrombotic events; therefore, temporal relationships between hematological parameters and thrombosis could not be established. Residual confounding cannot be excluded because several potentially relevant variables, including inherited thrombophilia and unmeasured lifestyle factors, were unavailable. In addition, selection bias is possible because

all participants were occupationally active individuals undergoing routine health examinations, and therefore the findings may not be generalizable to the broader population.

The present study has several important strengths. First, the study population consisted of a relatively homogeneous cohort of occupationally active adult men, minimizing variability related to chronic comorbidities and sex-specific hormonal influences. Second, all laboratory measurements were obtained during standardized routine occupational health examinations, reducing measurement variability. Third, all previous DVT diagnoses were objectively confirmed by compression venous ultrasonography and documented in the medical records, minimizing diagnostic misclassification. Finally, to our knowledge, this is among the first studies evaluating ultrasonography-confirmed previous DVT together with erythrocytosis-related markers in a homogeneous population permanently residing at moderate altitude. In addition, available serial hemoglobin and hematocrit measurements obtained during the same annual surveillance period were reviewed to verify the persistence of erythrocytosis, thereby reducing the likelihood that isolated laboratory fluctuations influenced the findings.

From a clinical perspective, these exploratory findings suggest that persistent erythrocytosis may warrant further investigation as a potential marker associated with previous venous thrombosis among individuals residing at moderate altitude. However, the present data are insufficient to support risk prediction, routine screening, or changes in clinical management.

Conclusion

Higher hemoglobin concentrations were associated with previous DVT in occupationally active men living at moderate altitude. However, because the small number of DVT events precluded multivariable adjustment, including for age, these findings should be considered exploratory and hypothesis-generating rather than evidence of an independent association. Larger prospective studies are needed to confirm these findings.

Disclosures

Ethics Committee Approval: The study was approved by the Koşuyolu High Specialty Training and Research Hospital Scientific Research Ethics Committee (no: 2026/13.1558, date: 28/07/2026).

Informed Consent: Owing to the retrospective observational design of the study and the use of anonymized data, the requirement for written informed consent was waived by the Ethics Committee.

Conflict of Interest Statement: None declared.

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