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ORIGINAL ARTICLE

Effect of Moderate Altitude Short Stay on Complete Blood Count Parameters

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ABSTRACT

Background: **High-altitude habitation is known to impose physiological stress, notably affecting red blood cells and hemoglobin concentration. The effects of moderate altitude exposure on leukocytes and platelets remain less well-characterized. This study aimed to longitudinally evaluate hematological adaptations, focusing on leukocyte and platelet dynamics, in sea-level residents exposed to moderate altitude.**
Methods: **A prospective cohort of 45 healthy male international students from West Africa was followed over six months after their arrival at 2,270 meters above sea level (Southwestern Saudi Arabia). Complete blood count (CBC) was measured within 48 hours of arrival, at two months, and at six months. Longitudinal changes in hematological parameters were assessed using mixed-effects linear regression.**
Results: **Exposure of healthy sea-level residents to moderate altitude (2,270 m) led to significant hematological adaptation. Hemoglobin, red blood cells (RBC), and hematocrit increased at two and six months (all $p < 0.05$), while red cell distribution width (RDW-CV) decreased, indicating more uniform erythropoiesis. Mean corpuscular indices (MCV, MCH, MCHC) remained unchanged. Leukocyte counts were overall stable, but neutrophils declined significantly at both time points ($p < 0.01$). Lymphocytes rose transiently at two months ($p = 0.022$), and monocytes increased modestly by six months ($p = 0.046$). Platelet counts did not change significantly, but platelet volume indices (MPV, PDW) rose consistently ($p < 0.001$), suggesting altered platelet activation.**
Conclusions: **Moderate altitude exposure triggers increased erythropoiesis, mild neutropenia, and platelet activation without altering platelet count. These changes reflect complex hypoxia-driven mechanisms and highlight the need for altitude-specific CBC reference ranges. Further research is needed to explore their clinical significance.**
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Supplementary Data

Table S1. Longitudinal Changes in CBC Parameters (Mixed-Effects Models).

Parameter	2 months vs. Baseline		6 months vs. Baseline		6 months vs. 2 months	
	% Change (95% CI)	p-value	% Change (95% CI)	p-value	% Change (95% CI)	p-value
abc	5.21% (-6.94, 17.36)	0.401	2.31% (-9.95, 14.57)	0.712	-2.90% (-15.78, 9.99)	0.660
aec	18.18% (-2.04, 42.57)	0.081	10.94% (-8.22, 34.11)	0.283	-6.12% (-23.18, 14.73)	0.537
alc	8.16% (-0.00, 16.33)	0.050	10.12% (1.87, 18.37)	0.016	1.96% (-6.75, 10.66)	0.660
amc	-3.63% (-12.31, 5.06)	0.413	-7.33% (-16.11, 1.44)	0.101	-3.71% (-12.97, 5.56)	0.433
anc	-20.64% (-32.54, -6.63)	0.005	-18.78% (-31.07, -4.31)	0.013	2.34% (-13.80, 21.49)	0.792
hb	6.61% (4.48, 8.73)	< 0.001	5.33% (3.18, 7.47)	< 0.001	-1.28% (-3.54, 0.98)	0.268
hct	5.48% (2.46, 8.59)	< 0.001	5.72% (2.67, 8.87)	< 0.001	0.23% (-2.81, 3.37)	0.884
mch	1.43% (-0.15, 3.01)	0.077	0.35% (-1.25, 1.94)	0.672	-1.08% (-2.77, 0.61)	0.211
mchc	1.00% (-0.46, 2.45)	0.180	-0.48% (-1.95, 0.99)	0.525	-1.47% (-3.01, 0.06)	0.060
mcv	0.41% (-0.32, 1.14)	0.275	0.91% (0.17, 1.65)	0.016	0.50% (-0.28, 1.29)	0.212
mpv	4.18% (2.29, 6.08)	< 0.001	5.65% (3.74, 7.57)	< 0.001	1.47% (-0.56, 3.49)	0.155
pdw	3.61% (-0.12, 7.34)	0.058	8.29% (4.52, 12.05)	< 0.001	4.68% (0.76, 8.59)	0.019
plt	5.76% (-2.78, 14.31)	0.186	5.72% (-2.90, 14.35)	0.193	-0.04% (-9.12, 9.04)	0.993
rbc	5.06% (2.01, 8.19)	0.001	4.90% (1.83, 8.06)	0.002	-0.15% (-3.23, 3.03)	0.924
rdw_cv	-4.29% (-5.85, -2.73)	< 0.001	-2.48% (-4.06, -0.90)	0.002	1.81% (0.14, 3.48)	0.034
wbc	-5.08% (-11.89, 1.72)	0.143	-5.65% (-12.53, 1.22)	0.107	-0.57% (-7.82, 6.68)	0.877

Estimates from linear mixed-effects models (REML). Values are % change from baseline (95% CI). Models account for within-patient correlation and use all available data.
Longitudinal changes in CBC parameters are expressed as percent change from baseline, estimated using linear mixed-effects models with restricted maximum likelihood (REML). Values are reported as mean % change with 95% confidence intervals (CIs). Positive values indicate an increase and negative values a decrease relative to baseline.
2 months vs. Baseline Change between arrival and two months.
6 months vs. Baseline Change between arrival and six months.
6 months vs. 2 months Change between two and six months.
p-values correspond to model-derived significance tests for the mean percent change. Cells that are statistically significant ($p < 0.05$).

Table S2. Longitudinal Changes in CBC Parameters - Absolute Units (Mixed-Effects Models).

Parameter	2 months vs. Baseline		6 months vs. Baseline		6 months vs. 2 months	
	absolute change (95% CI)	p-value	absolute change (95% CI)	p-value	absolute change (95% CI)	p-value
abc	0.0040 (-0.0053, 0.0133)	0.401	0.0018 (-0.0076, 0.0112)	0.712	-0.0022 (-0.0121, 0.0077)	0.660
aec	0.0309 (-0.0035, 0.0724)	0.081	0.0186 (-0.0140, 0.0580)	0.283	-0.0104 (-0.0394, 0.0250)	0.537
alc	0.1911 (-0.0001, 0.3823)	0.050	0.2369 (0.0438, 0.4301)	0.016	0.0458 (-0.1581, 0.2497)	0.660
amc	-0.0188 (-0.0637, 0.0262)	0.413	-0.0379 (-0.0833, 0.0074)	0.101	-0.0192 (-0.0671, 0.0287)	0.433
anc	-0.4335 (-0.6836, -0.1393)	0.005	-0.3945 (-0.6525, -0.0905)	0.013	0.0491 (-0.2898, 0.4514)	0.792
hb	0.9888 (0.6714, 1.3062)	< 0.001	0.7971 (0.4765, 1.1178)	< 0.001	-0.1916 (-0.5304, 0.1472)	0.268
hct	2.4976 (1.1207, 3.9151)	< 0.001	2.6086 (1.2155, 4.0431)	< 0.001	0.1052 (-1.2829, 1.5367)	0.884
mch	0.3967 (-0.0431, 0.8366)	0.077	0.0961 (-0.3484, 0.5406)	0.672	-0.3006 (-0.7717, 0.1705)	0.211
mchc	0.3286 (-0.1519, 0.8091)	0.180	-0.1572 (-0.6419, 0.3276)	0.525	-0.4858 (-0.9929, 0.0214)	0.060
mcv	0.3433 (-0.2736, 0.9602)	0.275	0.7649 (0.1414, 1.3885)	0.016	0.4216 (-0.2401, 1.0834)	0.212
mpv	0.3804 (0.2084, 0.5525)	< 0.001	0.5139 (0.3401, 0.6878)	< 0.001	0.1335 (-0.0507, 0.3177)	0.155
pdw	0.5442 (-0.0177, 1.1062)	0.058	1.2492 (0.6812, 1.8171)	< 0.001	0.7049 (0.1142, 1.2957)	0.019
plt	12.9936 (-6.2649, 32.2521)	0.186	12.9015 (-6.5434, 32.3464)	0.193	-0.0921 (-20.5620, 20.3778)	0.993
rbc	0.2751 (0.1094, 0.4457)	0.001	0.2664 (0.0993, 0.4384)	0.002	-0.0083 (-0.1759, 0.1647)	0.924
rdw_cv	-0.5934 (-0.8095, -0.3774)	< 0.001	-0.3431 (-0.5614, -0.1249)	0.002	0.2503 (0.0195, 0.4811)	0.034
wbc	-0.2659 (-0.6218, 0.0900)	0.143	-0.2958 (-0.6553, 0.0636)	0.107	-0.0299 (-0.4091, 0.3492)	0.877

Estimates from linear mixed-effects models (REML). Values are absolute change from baseline in original units (95% CI). Models account for within-patient correlation and use all available data.
Longitudinal changes in complete blood count (CBC) parameters are shown as absolute differences from baseline, estimated using linear mixed-effects models with restricted maximum likelihood (REML). Values represent mean absolute change with 95% confidence intervals (CIs). Negative values indicate a decrease relative to baseline.
2 months vs. Baseline Change between arrival and two months.
6 months vs. Baseline Change between arrival and six months.
6 months vs. 2 months Change between two and six months.
p-values correspond to model-derived significance tests for the mean change. Cells that are statistically significant ($p < 0.05$).