

"Living high-training low": effect of moderate-altitude acclimatization with low-altitude training on performance.

Levine BD, Stray-Gundersen J. *J Appl Physiol.* 83(1):102-112, 1997

This is considered the definitive study on Live High Train Low, and provides sufficient evidence to support the theory.

Protocol:

- 27 days of living at 2,500 m (Park City)
- High-intensity training at 1,250 m (Salt Lake City)
- "Live High, Train High" & "Live Low Train Low" control groups

Results:

Change in VO₂ max

- Live High Train Low group...Increased 5%
- Live High Train High group...Increased 5%
- Sea-Level group...No change

Change in Red Blood Cell mass

- Live High Train Low group...Increased 5%
- Live High Train High group...Increased 5%
- Sea-Level group...No change

Change in 5000m running time

- Live High Train Low group...Faster by 13.4%
- Live High Train High group...No Improvement
- Sea-Level group...No improvement

Abstract: The principal objective of this study was to test the hypothesis that acclimatization to moderate altitude (2,500 m) plus training at low altitude (1,250 m), "living high-training low," improves sea-level performance in well-trained runners more than an equivalent sea-level or altitude control. Thirty-nine competitive runners (27 men, 12 women) completed 1) a 2-wk lead-in phase, followed by 2) 4 wk of supervised training at sea level; and 3) 4 wk of field training camp randomized to three groups: "high-low" (n = 13), living at moderate altitude (2,500 m) and training at low altitude (1,250 m); "high-high" (n = 13), living and training at moderate altitude (2,500 m); or "low-low" (n = 13), living and training in a mountain environment at sea level (150 m). A 5,000-m time trial was the primary measure of performance; laboratory outcomes included maximal O₂ uptake (VO₂ max), anaerobic capacity (accumulated O₂ deficit), maximal steady state (MSS; ventilatory threshold), running economy, velocity at VO₂ max, and blood compartment volumes. Both altitude groups significantly increased VO₂ max (5%) in direct proportion to an increase in red cell mass volume (9%; $r = 0.37$, $P < 0.05$), neither of which changed in the control. Five-kilometer time was improved by the field training camp only in the high-low group (13.4 +/- 10 s), in direct proportion to the increase in VO₂ max ($r = 0.65$, $P < 0.01$). Velocity at VO₂ max and MSS also improved only in the high-low group. Four weeks of living high-training low improves sea-level running performance in trained runners due to altitude acclimatization (increase in red cell mass volume and VO₂ max) and maintenance of sea-level training velocities, most likely accounting for the increase in velocity at VO₂ max and MSS.