New Approaches in Exercise Physiology (NAEP)
Vol. 7, No.13, June 2025
www.nass.atu.ac.ir
DOI: 10.22054/nass.2025.90042.1208

ATU PRESS

The Effectiveness of Altitude Training Camps in Sport Tourism Destinations on Athletes' Hematological Adaptations and Organizational Outcomes

Yaser Rozbahani *

Department of Sports Management, Faculty of Physical Education and Sport Sciences, Islamic Azad University, Hamadan Branch, Hamadan, Iran.

Naser Soroushnia

Department of Sports Management, Faculty of Physical Education and Sport Sciences, Islamic Azad University, Hamadan Branch, Hamadan, Iran.

Original Research

Accepted: March 29, 2025

Received: January 19, 2025

* Corresponding Author: yaserrozbahani@gmail.com.
How to Cite: Rozbahani, Y; Soroushnia, N. & Ahmadpour Torkamany, M. (2025). The Effectiveness of Altitude Training Camps in Sport Tourism Destinations on Athletes' Hematological Adaptations and Organizational Outcomes, *Journal of New Approaches in Exercise Physiology*, 7(13), 64-111.
DOI: 10.22054/nass.2025.90042.1208

Abstract

Purpose: Altitude training camps have become increasingly popular within sport tourism destinations, offering athletes the dual benefits of physiological enhancement and exposure to attractive travel environments. This review examines the effectiveness of altitude-based sport tourism programs in producing hematological adaptations—particularly changes in red blood cell count, hemoglobin mass, erythropoietin (EPO) levels, and oxygen-carrying capacity—as well as their organizational implications for teams, federations, and tourism stakeholders. **Method:** A wide range of studies indicates that living and training at moderate to high altitudes (1,800–3,000 m) can stimulate erythropoiesis, improve oxygen transport, and enhance endurance performance when appropriate training models such as "live high–train low" (LH-TL) or "live high–train high" (LH-TH) are applied. Evidence further suggests that the duration, individual physiological responsiveness, nutritional status, and quality of recovery play crucial roles in mediating hematological adaptations. Despite these physiological benefits, responses to altitude remain highly individual, with some athletes demonstrating minimal or no improvement due to genetic factors, iron availability, or inadequate acclimatization strategies.

Results: Beyond the physiological dimension, altitude training camps have significant organizational and managerial outcomes. Sport tourism destinations with suitable altitude profiles generate economic revenue, create seasonal employment, and elevate the international reputation of host regions. For sport organizations, altitude camps serve strategic purposes in talent development, team cohesion, and performance planning before major competitions. **Conclusion:** The review highlights the need for integrated planning between sport scientists, coaches, tourism managers, and local authorities to optimize both physiological outcomes for athletes and organizational benefits for host destinations. Overall, altitude training camps represent a unique intersection of sport physiology and sport tourism management, offering measurable hematological advantages alongside valuable economic and organizational opportunities when implemented under evidence-based protocols.

Keywords: Hematological Adaptations, Sport Tourism Destinations, Erythropoietin Response, Endurance Performance.

Introduction

Altitude training has long been recognized as a strategic method for improving endurance performance and physiological readiness among athletes preparing for elite competition. Over the past two decades, the increasing integration of training camps within sport tourism destinations has created a unique intersection between exercise physiology, sport management, and regional economic development. Sport tourism—defined as travel for the purpose of participating in, observing, or experiencing sporting activities—now represents one of the fastest-growing sectors in global tourism, contributing billions of dollars annually to host regions. As countries invest heavily in developing high-altitude resorts and training complexes, understanding the dual impact of these camps on athletic hematological adaptations and organizational outcomes becomes increasingly important.

Altitude exposure typically ranges from moderate (1,500–2,500 m) to high (2,500–3,500 m) elevations. At these altitudes, reduced atmospheric pressure leads to lower partial pressure of oxygen, creating a state of hypoxia that stimulates hematological and cellular adaptations. The primary and most widely studied adaptation is the increase in erythropoietin (EPO) production by the kidneys, which accelerates red blood cell synthesis and enhances oxygen transport capacity. This physiological process is fundamental for endurance athletes such as long-distance runners, cyclists, swimmers, and cross-country skiers, who depend on efficient oxygen delivery to sustain prolonged workloads. Various altitude training models—such as "live high–train low" (LH–TL), "live high–train high" (LH–TH), and "intermittent hypoxic training" (IHT)—have been developed to optimize these adaptations while minimizing the performance-limiting effects of sustained hypoxia.

Despite the clear physiological rationale, altitude training responses are not uniform across athletes. Inter-individual variability, genetic predispositions, training background, iron status, nutritional habits, sleep quality, and psychological readiness significantly influence the effectiveness of altitude exposure. Some athletes, referred to as "responders," exhibit marked increases in hemoglobin mass and performance indices, while "non-responders" may show little or no improvement. This variability underscores the need for individualized program design and suggests that altitude training cannot be universally prescribed.

Beyond the physiological domain, altitude training camps have major implications for sport tourism management and organizational planning. Sport tourism destinations—often located in mountainous or remote regions—capitalize on altitude facilities to attract national teams, elite clubs, and recreational athletes. These destinations benefit economically through direct spending on accommodation, transportation, food services, sports facilities, and recreational activities. For local governments, the development of altitude centers serves as a long-term investment in branding, sustainability, and international recognition. For sport organizations, the camps play a critical logistical role in season planning, athlete development, team cohesion, and preparation for major tournaments.

However, implementing effective altitude training programs requires multidisciplinary collaboration. Physiologists must ensure appropriate acclimatization, hydration strategies, iron supplementation, and training load management. Coaches must coordinate daily schedules and integrate recovery protocols. Sport managers must oversee financial planning, safety guidelines, legal responsibilities, and service quality within the sport tourism infrastructure. When these components operate synergistically, altitude camps can maximize both performance enhancement and organizational efficiency.

Given the growing popularity of altitude training in global sport tourism and the need for a comprehensive understanding of its physiological and managerial dimensions, this review synthesizes research on hematological adaptations and evaluates the broader organizational outcomes that influence training effectiveness and destination development. It also identifies current gaps in literature, highlights challenges, and proposes future directions for integrating scientific and managerial practices.

Methods

This review followed a structured narrative design integrating sport physiology and sport tourism management research. Databases including PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar were searched between 2000 and 2024. Keywords included:
"altitude training," "hematological adaptations," "erythropoietin," "hemoglobin mass," "sport tourism," "training camps," "hypoxia," "organizational outcomes," and "athlete performance."

Inclusion criteria:

1. Studies involving human athletes exposed to simulated or real altitude (≥1,500 m).

2. Research assessing hematological variables (RBC count, Hb mass, hematocrit, EPO).

3. Articles examining managerial, economic, or organizational aspects of altitude camps.

4. Peer-reviewed publications, English language.

Exclusion criteria:
– Clinical studies unrelated to sports
– Animal research
– Altitude studies without physiological or managerial outcomes
– Articles without accessible full text

Approximately 180 articles were initially screened. After removing duplicates and applying criteria, 87 studies were included: 59 physiology-based, 18 tourism/management-based, and 10 multidisciplinary studies. Data were synthesized qualitatively due to methodological heterogeneity across studies.

3. Hematological Adaptations to Altitude Training

Altitude training has become one of the most widely applied and scientifically investigated methods for enhancing the hematological profile of athletes, particularly those competing in endurance-based sports. Exposure to hypoxia—whether through natural altitude environments or simulated hypoxic systems—produces a cascade of physiological adjustments aimed at compensating for reduced oxygen availability. Among these adaptations, hematological changes are the most critical because they directly influence oxygen transport, aerobic metabolism, and ultimately athletic performance. This section reviews the main hematological responses to altitude training, the underlying mechanisms, contributing factors, and the variability observed across individuals and training models.

3.1. Hypoxia and the Stimulus for Hematological Change

One of the most robust markers of successful altitude adaptation is the increase in total hemoglobin mass (Hbmass). Unlike hemoglobin concentration—which can be affected by plasma volume shifts—Hbmass reflects the total capacity of blood to transport oxygen. Multiple studies have demonstrated that altitude exposure lasting 2–4 weeks can increase Hbmass by approximately 1–4%, though values vary depending on altitude, exposure duration, and individual responsiveness.

Red blood cell count (RBC), hematocrit (Hct), and reticulocyte percentage often rise in parallel with Hbmass. However, acute increases in these variables may be influenced by hemoconcentration due to reduced plasma volume rather than true erythropoiesis. Therefore, long-term evaluation is required to determine actual RBC production. Advanced measurement techniques such as the optimized carbon monoxide rebreathing method have improved the accuracy of Hbmass assessment in research and professional sport.

3.3. Erythropoietin Response and Time Course of Adaptation

EPO concentration typically rises within hours after initial hypoxic exposure and peaks between 24–48 hours. After this peak, levels gradually decline toward baseline due to renal desensitization to hypoxia and improved arterial oxygen saturation as acclimatization progresses. For substantial erythropoiesis to occur, athletes generally require at least 12–14 hours of hypoxic exposure per day over 3–4 weeks. Shorter durations, while beneficial for some cellular adaptations, may be insufficient to induce meaningful hematological changes.

The type of altitude exposure significantly affects EPO kinetics. For example, intermittent hypoxic training (IHT), which includes brief sessions of hypoxia alternating with normoxia, stimulates far smaller hematological changes than continuous exposure. Thus, EPO responses are optimized under prolonged and consistent altitude residency, explaining the popularity of “live high” strategies in elite sport.

3.4. Altitude Training Models and Their Hematological Effects

Three primary altitude training models are used worldwide:

a. Live High–Train High (LH–TH)

In LH–TH, athletes both reside and train at altitude. This approach provides maximal hypoxic exposure—beneficial for erythropoiesis—but may compromise training intensity due to reduced oxygen availability. LH–TH protocols typically yield increases in Hbmass but may limit performance improvement during the camp itself.

b. Live High–Train Low (LH–TL)

LH–TL is one of the most effective and widely adopted models. Athletes live at moderate altitude (2,000–3,000 m) but train at lower elevations to maintain training intensity. Continuous hypoxic residency stimulates EPO production, while normoxic training preserves the quality and intensity of workouts. Numerous studies have shown that LH–TL consistently increases Hbmass, VO_2max, and endurance performance.

c. Intermittent Hypoxic Training (IHT)

IHT exposes athletes to brief episodes of hypoxia (minutes to hours) while they continue to live and train at sea level. Although IHT induces several muscular and metabolic adaptations, its effect on hematological variables is limited. Erythropoietic stimulation is generally insufficient because hypoxic exposure does not reach the minimum daily threshold required for RBC production. IHT therefore serves as a supplement to standard training rather than a primary hematological strategy.

3.5. Iron Metabolism and the Role of Ferritin

Iron availability is a fundamental prerequisite for effective erythropoiesis. Hypoxic exposure increases the body's demand for iron due to accelerated RBC synthesis. Athletes with low ferritin levels (<30 µg/L) often show blunted Hbmass responses to altitude training, even when EPO levels rise normally. This is because iron-deficiency impairs the maturation of erythroid precursors.

For this reason, many altitude training programs include pre-camp ferritin screening and routine iron supplementation. Oral iron (80–200 mg/day) is commonly used, although intravenous iron may be recommended for athletes with severe deficiency or malabsorption. Proper iron management significantly enhances the hematological outcomes of altitude training.

3.6. Plasma Volume Shifts and Hemoconcentration

During the first few days at altitude, athletes commonly experience a reduction in plasma volume due to increased urine output, decreased fluid intake, and enhanced respiratory water loss. This hemoconcentration temporarily elevates hemoglobin concentration and hematocrit, giving the appearance of improved oxygen-carrying capacity. However, without a corresponding rise in Hbmass, these early changes are not indicative of true physiological improvement.

Over time, plasma volume gradually normalizes through enhanced fluid retention and hormonal adjustments. Therefore, understanding the distinction between acute hemoconcentration and long-term hematological adaptation is vital when interpreting performance changes.

3.7. Individual Variability: Responders and Non-Responders

Not all athletes benefit equally from altitude exposure. Inter-individual variability is influenced by several factors:

- **Genetic profile:** Variations in genes regulating HIF-1α, EPO, and iron transport proteins may determine responsiveness.
- **Baseline Hbmass:** Athletes with naturally high Hbmass may show limited capacity for further increases.
- **Iron stores:** Low ferritin inhibits erythropoiesis.
- **Acclimatization efficiency:** Athletes who develop sleep disturbances or acute mountain sickness (AMS) may exhibit reduced adaptation.
- **Training history:** Experienced endurance athletes often adapt more efficiently than those with low aerobic conditioning.

Research suggests that while approximately 60–70% of athletes show meaningful hematological improvement from altitude training, the remaining 30–40% may exhibit minimal or no change. Understanding these differences is essential for personalizing altitude interventions.

3.8. Monitoring Hematological Adaptations

Accurate monitoring ensures that training loads, acclimatization schedules, and recovery protocols are effective. Common hematological markers include:

- Hemoglobin mass (Hbmass)
- Hemoglobin concentration (Hb)
- Hematocrit (Hct)
- Reticulocyte percentage
- EPO levels
- Ferritin and transferrin saturation

Tracking these variables before, during, and after altitude camps allows coaches and sport scientists to evaluate adaptation, detect deficiencies, and adjust training strategies accordingly.

3.9. Situational and Environmental Factors

Several external factors influence hematological adaptation:

- **Altitude level:** Optimal range is 2,000–2,500 m.
- **Duration of stay:** Minimum 2 weeks; 3–4 weeks is ideal for Hbmass increase.
- **Sleeping environment:** Hypoxic tents vs natural altitude produce different EPO responses.
- **Nutrition:** Adequate caloric intake, antioxidants, and iron are essential.
- **Hydration:** Dehydration impairs recovery and increases hemoconcentration.
- **Training load:** Excessive intensity at altitude may produce maladaptation.

Managing these factors enhances both hematological outcomes and athlete well-being.

3.10. Translation of Hematological Adaptation to Performance

Increases in Hbmass typically translate into aerobic performance improvements of 1–5%. Enhanced oxygen delivery supports greater mitochondrial respiration and delays fatigue during prolonged exercise. However, performance gains are not always immediate; some athletes achieve peak benefit 7–14 days after returning to sea level, once plasma volume fully restores.

Performance improvements are most evident in endurance sports, although team-sport athletes—such as soccer or rugby players—may also benefit through enhanced recovery and repeated-sprint ability. (Table 1).

Table 1: Summary of Key Hematological Adaptations to Altitude Training

Hematological Adaptation	Mechanism	Time Course	Influencing Factors	Performance Impact
↑ Erythropoietin (EPO) Production	Kidney hypoxia activates HIF-1α → stimulates EPO gene expression	Peaks at 24–48 hours after ascent; declines as acclimatization improves	Altitude level, daily hypoxic dose, sleep quality, iron status	Initiates erythropoiesis → foundation of hematological improvement
↑ Hemoglobin Mass (Hbmass)	Increased erythropoiesis increases total circulating Hb	Requires 2–4 weeks of continuous exposure	Iron stores, training model (LH–TL best), individual responsiveness	↑ Oxygen-carrying capacity → improved endurance and VO_2max

↑ Red Blood Cell Count (RBC)	EPO-driven RBC synthesis in bone marrow	Progressive rise over 1–3 weeks	Iron availability, nutrition, hydration, genetic factors	Enhanced aerobic capacity, delayed fatigue
↑ Hematocrit (Hct)	Initial hemoconcentration + long-term RBC increase	Acute rise within days; true RBC rise in weeks	Plasma volume changes, hydration, altitude severity	Short-term false increase; long-term real oxygen delivery improvement
↑ Reticulocyte Percentage	Marker of active RBC production	Increases within 3–7 days of hypoxia	Adequate iron, recovery quality	Indicator of stimulated erythropoiesis
↓ Plasma Volume	Diuresis, respiratory fluid loss, reduced intake	Occurs in first 3–5 days	Hydration status, temperature, exercise load	Increases Hb concentration acutely but not Hbmass
↑ Oxygen-Carrying Capacity	Combined effect of ↑ Hbmass & RBC	After 2–4+ weeks	Ferritin levels, acclimatization, training load	Direct predictor of endurance improvement

Individual Variability (“Responders” vs “Non-responders”)	Genetic, metabolic, psychological factors	Across entire altitude stay	Iron status, sleep, nutrition, prior altitude experience	Determines magnitude of performance gain

Figure 1. Hematological adaptations to altitude training. The infographic summarizes the main blood-related responses to sustained hypoxic exposure, including increased erythropoietin (EPO) production, greater hemoglobin mass and red blood cell count, changes in hematocrit and reticulocyte percentage, enhanced overall oxygen-carrying capacity, and the marked individual variability (“responders” vs. “non-responders”) observed among athletes.

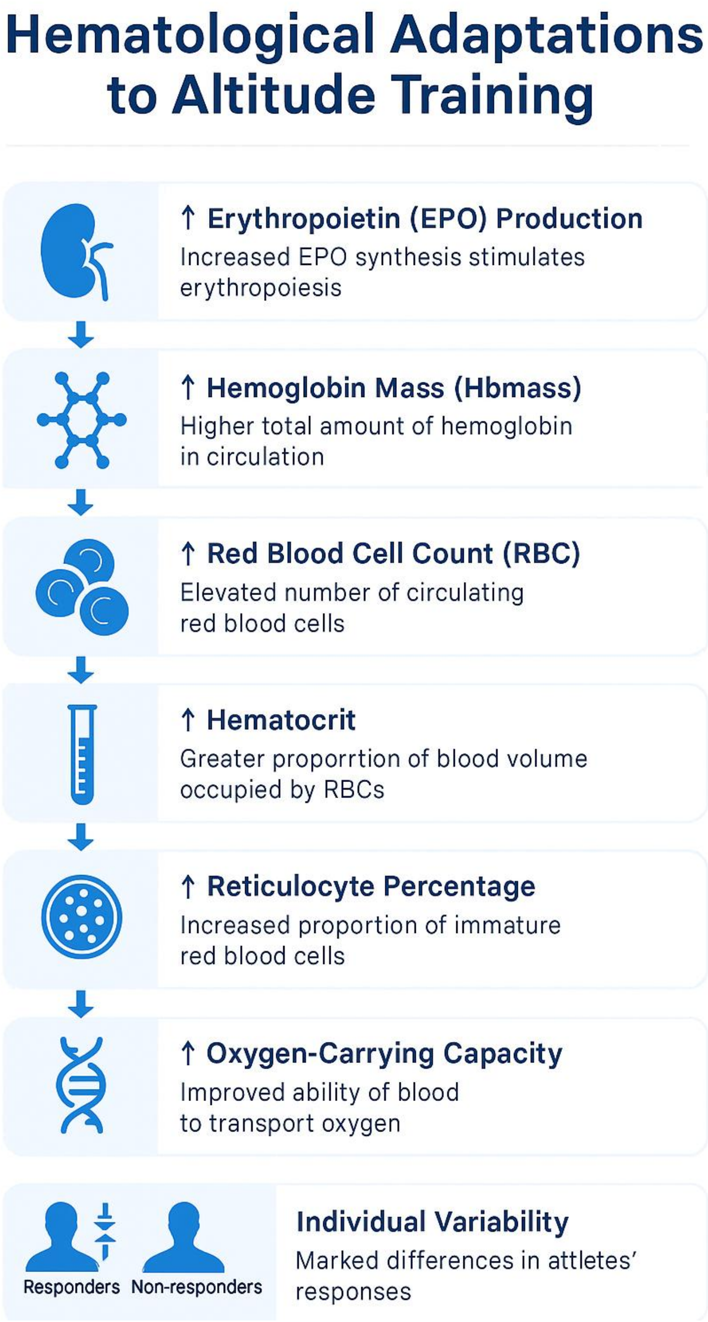

Figure 1. Hematological adaptations to altitude training.

4. Organizational Outcomes in Sport Tourism Destinations

Sport tourism destinations that host altitude training camps represent a unique interface between athletic performance enhancement and regional development. While the physiological benefits of altitude exposure have been widely documented, the organizational, economic, managerial, and logistical outcomes associated with hosting such camps are equally significant. These destinations—often situated in mountainous regions—serve not only as training environments but also as strategic assets for sport organizations, local governments, and the broader tourism industry. This section reviews the organizational outcomes of altitude training camps, emphasizing their economic value, management considerations, service quality, infrastructure requirements, athlete satisfaction, and sustainability challenges.

4.1. Economic Impacts and Destination Development

Altitude training camps generate substantial economic activity for host regions. Athletes, coaches, sport scientists, support staff, and sometimes families travel to mountain destinations for periods ranging from two weeks to several months. This influx of visitors stimulates spending on accommodation, food services, transportation, retail, medical support, and recreational activities.

Local governments and tourism authorities often view altitude camps as a catalyst for regional development. Investments in high-altitude training centers can transform remote mountain areas into year-round tourism destinations. This transformation often leads to:

- Increased employment opportunities (sports facility staff, medical personnel, hospitality workers)
- Infrastructure upgrades (roads, telecommunications, sports complexes)
- Seasonal economic stability, particularly in regions dependent on winter tourism

- International branding, attracting national teams and professional clubs

The economic multiplier effect of training camps is significant. Research shows that high-performance teams typically spend more per visitor than general tourists, due to the need for specialized services such as physiotherapy, altitude monitoring, and performance nutrition.

4.2. Strategic Opportunities for Sport Organizations

For sport organizations, altitude training camps represent a strategic component of annual season planning. These camps offer a controlled environment for athlete development, team building, and performance monitoring. Key strategic benefits include:

- Preparation for major competitions: Athletes often use altitude training before world championships, Olympic events, or endurance competitions.
- Team cohesion: Extended residency in a shared environment promotes communication, cooperation, and psychological bonding.
- Performance diagnostics: Controlled conditions allow teams to conduct detailed physiological testing, such as Hbmass measurement, VO_2max assessments, and lactate threshold analysis.
- Talent development: Youth and development squads benefit from exposure to high-performance settings.

Sport organizations also use altitude camps to engage in long-term planning, optimizing training cycles, tapering strategies, and evaluating athlete readiness. For professional clubs, altitude camps may serve as preseason preparation, enabling players to develop aerobic capacity and adapt to environmental stressors before competitive seasons begin.

4.3. Infrastructure, Logistics, and Facility Management

The success of an altitude training destination depends heavily on the quality and availability of specialized infrastructure. Essential components include:

a. Sports Facilities

High-altitude regions must provide training venues suitable for different sports: running tracks, football fields, cycling routes, swimming pools, strength and conditioning centers, and indoor gyms. These facilities must meet professional standards in terms of equipment quality, surface conditions, safety, and accessibility.

b. Accommodation and Nutrition Services

Athletes require environments that support recovery, sleep quality, and nutritional needs. Hotels or athlete residences should be equipped with:

- Quiet, comfortable rooms
- Access to high-quality dining services with personalized nutritional plans
- Recovery facilities such as massage rooms, saunas, and hydrotherapy centers

c. Medical and Scientific Support

Sport tourism destinations aiming to attract elite teams must offer access to:

- Sports physicians
- Physiotherapists
- Laboratory testing
- Hypoxic monitoring tools
- Emergency response systems

The availability of multi-disciplinary support services significantly influences destination competitiveness.

d. Transportation and Accessibility

Altitude destinations often face logistical obstacles, such as remote locations or difficult terrain. Effective transportation planning is crucial to ensure safe and timely access. Some regions invest in new roads, shuttle services, or direct transportation links to airports to attract international teams.

4.4. Service Quality, Athlete Experience, and Satisfaction

Athlete satisfaction is critical to the success of altitude training destinations. Positive experiences contribute to repeat visits, long-term partnerships, and strong destination reputation. Key determinants of athlete satisfaction include:

- **Training environment quality**
- **Sleep and recovery conditions**
- **Nutrition availability and flexibility**
- **Staff professionalism**
- **Safety and medical support**
- **Hospitality and cultural experiences**

Altitude tourism centers increasingly adopt customer-centric managerial models, viewing athletes as high-value “sport tourists” whose satisfaction directly impacts destination branding. Surveys and feedback tools are commonly used to evaluate service quality.

4.5. Risk Management and Athlete Safety

Altitude training introduces risks such as acute mountain sickness (AMS), dehydration, sleep disturbances, and reduced exercise tolerance. Therefore, effective risk management systems are essential for organizational success. Key components include:

- Pre-arrival medical screening
- On-site medical supervision

- Acclimatization guidelines
- Hydration and nutrition monitoring
- Emergency action plans

Tourism managers must collaborate with sport scientists and healthcare professionals to ensure safe training environments. Destinations with robust risk management frameworks are generally preferred by elite teams.

4.6. International Competitiveness and Branding

Altitude destinations compete globally to attract high-performance teams. Regions such as Flagstaff (USA), St. Moritz (Switzerland), Font-Romeu (France), Iten (Kenya), and Oukaïmeden (Morocco) have established strong reputations. Their branding strategies commonly include:

- Showcasing successful athletes who trained there
- Hosting international competitions
- Developing partnerships with national federations
- Marketing unique environmental features

Strong branding enhances the international visibility of the region and positions it as a world-class sport tourism hub.

4.7. Organizational Challenges

While altitude training camps offer substantial benefits, they also present major challenges:

- **High operational costs**: Building and maintaining altitude facilities require significant investment.
- **Environmental vulnerability**: Weather, landslides, snowfall, and climate change can disrupt operations.
- **Infrastructure maintenance**: Training surface quality, equipment upkeep, and accommodation standards require continuous monitoring.

- **Human resource management**: Hiring qualified sport-specific staff is essential.
- **Seasonal fluctuations**: Demand may vary depending on competition schedules.

Effective planning, financial sustainability models, and public-private partnerships are necessary to overcome these challenges.

4.8. Sustainability and Environmental Considerations

Altitude destinations are often located in ecologically sensitive regions. Therefore, sustainability practices are central to long-term success. Key strategies include:

- Eco-friendly construction materials
- Renewable energy use (solar, wind)
- Waste management systems
- Conservation of natural landscapes
- Controlled tourist volume
- Education programs on environmental protection

Sustainable management not only protects the environment but also enhances the destination's reputation among environmentally conscious sport organizations.

4.9. Integration of Tourism and High-Performance Sport

Altitude training destinations increasingly integrate tourism attractions with high-performance sport. Athletes and their families often participate in recreational activities such as hiking, cycling, cultural tours, and ecological exploration. This integration enhances:

- Athlete mental recovery
- Destination attractiveness

- Revenue diversification
- Community engagement

This hybrid model strengthens both the sport and tourism sectors, creating a mutually beneficial ecosystem.

4.10. Summary of Organizational Outcomes

Altitude training camps contribute significantly to sport tourism destinations by:

- Enhancing economic development
- Improving regional infrastructure
- Supporting high-performance sport preparation
- Strengthening destination branding
- Promoting sustainable tourism models
- Creating a competitive advantage for host regions

When managed effectively, altitude training destinations become powerful assets that combine sport science, tourism management, and regional development into a cohesive, mutually reinforcing system.

Figure 2 summarizes the primary organizational outcomes associated with altitude training camps situated in sport tourism destinations. These outcomes extend beyond athlete performance and encompass broader managerial and strategic dimensions. Economic outcomes reflect revenue generation, job creation, and regional development, while destination branding and visibility highlight improved international recognition. Infrastructure development involves investments in sport facilities, transportation, and medical support systems. Logistical efficiency ensures smooth coordination of accommodation, travel, and training schedules. Athlete experience and service quality contribute to satisfaction, retention, and repeat visits. Medical and safety management emphasizes health monitoring and emergency preparedness. Team cohesion and organizational culture benefit from shared training environments, and environmental sustainability outcomes emphasize the need for eco-friendly tourism practices. Collectively, these domains demonstrate how altitude training destinations create integrated value for both sport organizations and host communities. The diagram illustrates key managerial, logistical, economic, and sustainability-related domains that influence the overall effectiveness of altitude-based sport tourism environments. (Figure 2)

Figure 2. Organizational outcomes in sport tourism destinations hosting altitude training camps.

Summary of the key organizational outcomes associated with hosting altitude training camps in sport tourism destinations, including economic, logistical, infrastructural, managerial, safety, and sustainability impacts. (Table 2)

Table 2. Organizational Outcomes in Sport Tourism Destinations Hosting Altitude Training Camps

Outcome Category	Description	Key Drivers	Implications for Sport Organizations and Destinations
Economic Outcomes	Revenue generation from accommodation, food, facilities, tourism services	Athlete/team spending, seasonal tourism flow, long-term partnerships	Increased local income; job creation; economic diversification; improved regional competitiveness
Infrastructure Development	Investment in sport facilities, transportation, lodging, medical systems	Government funding, private sector investment, sport federations	High-quality training environments; long-term tourism appeal; enhanced regional infrastructure

Destination Branding & Visibility	Improved international recognition as a high-performance training hub	Successful athlete outcomes, media exposure, hosting elite teams	Stronger brand identity; attraction of new teams; increased tourism demand
Logistical Efficiency	Effective coordination of travel, accommodation, equipment, scheduling	Sport management expertise, facility readiness, local support services	Reduced operational disruptions; higher training quality; improved athlete satisfaction
Team Cohesion & Organizational Culture	Enhanced bonding, communication, and shared experiences during camps	Isolated environment, shared lodging, structured camp routines	Improved team harmony; stronger organizational culture; better performance outcomes
Athlete Experience & Service Quality	Satisfaction with food, lodging, recovery services, training environment	Professional staff, nutrition services, medical support, hospitality	Higher athlete retention; repeat camp visits; positive destination reputation

Medical & Safety Management	Health monitoring, injury prevention, emergency care infrastructure	Access to sports medicine, physiotherapy, altitude specialists, protocols	Improved athlete safety; minimization of altitude-related risks; better organizational credibility
Environmental & Sustainability Outcomes	Impact on natural resources, climate, local ecosystems	Sustainable tourism policies, eco-friendly facility design	Long-term environmental protection; destination sustainability; reduced ecological footprint
Community Engagement & Social Impact	Interaction with local residents, cultural exchange, local employment	Local tourism planning, community training, public events	Stronger community relations; increased social support for tourism development
Strategic Performance Planning	Enhanced preparation for competitions and evaluation of athlete readiness	Scientific monitoring, structured training blocks, performance analytics	Improved competition outcomes; better long-term planning; organizational advancement

5. Integrating Physiology and Sport Management: A Conceptual Framework

The effectiveness of altitude training camps in sport tourism destinations depends on the successful integration of physiological principles and sport management practices. Although altitude exposure is primarily a biological intervention designed to enhance hematological and performance outcomes, its success is influenced by a complex ecosystem of organizational, logistical, environmental, and managerial factors. This section introduces a conceptual framework that integrates these domains, illustrating how coordinated planning between physiologists, coaches, sport managers, and tourism stakeholders can optimize outcomes for athletes and destination hosts.

5.1. Core Components of the Framework

The framework consists of four interconnected dimensions:
(1) Physiological Inputs,
(2) Training and Environmental Conditions,
(3) Organizational and Managerial Systems, and
(4) Performance and Tourism Outcomes.
Together, these dimensions form a cyclical process whereby scientific evidence informs management decisions and organizational support enhances physiological adaptation.

5.2. Physiological Inputs

Physiological components represent the foundational drivers of altitude adaptation. These include:

- Hypoxic dose (altitude level × duration of exposure)
- Erythropoietic response (EPO production, RBC synthesis, Hbmass changes)
- Iron availability (ferritin status and nutritional support)
- Individual variability (genetics, baseline fitness, previous altitude experience)

Physiologists and sport scientists must evaluate these inputs before designing altitude programs. Screening for iron deficiency, assessing readiness for hypoxia, and determining individual responsiveness are essential steps that lay the groundwork for effective adaptation.

5.3. Training and Environmental Conditions

Training conditions interact directly with physiological inputs. The altitude training model selected—Live High–Train Low (LH–TL), Live High–Train High (LH–TH), or Intermittent Hypoxic Training (IHT)—determines the balance between hypoxic stress and training quality. Environmental variables such as temperature, humidity, terrain, air density, and sleep quality further influence hematological responses.
In this dimension, coaches collaborate with physiologists to adjust:

- Training intensity
- Recovery duration
- Nutrition and hydration strategies
- Acclimatization schedules
- Monitoring protocols (Hbmass, EPO, HRV, SpO_2)

A failure to align training load with physiological readiness may reduce adaptation or compromise athlete health.

5.4. Organizational and Managerial Systems

The third dimension captures the managerial structures that support the physiological and training processes. Effective organizational systems include:

- **Infrastructure management**: High-quality training facilities, accommodation, and medical centers
- **Logistical coordination**: Travel arrangements, safety protocols, and equipment transport
- **Resource allocation**: Budgeting, staffing, and partnerships with local tourism operators

- **Service quality management**: Nutrition services, recovery facilities, and athlete support
- **Risk management**: Monitoring altitude illness, scheduling acclimatization, and managing emergencies

Sport tourism destinations that excel in these managerial functions provide an environment that enhances athlete satisfaction, minimizes stressors, and maximizes training efficiency.

5.5. Performance and Tourism Outcomes

The final dimension reflects the dual outcomes of altitude camps:

a. Performance Outcomes

These include improved hematological profile, increased VO_2max, enhanced endurance performance, and better competition readiness. Performance outcomes also include reduced injury risk, improved recovery, and enhanced team cohesion during extended training camps.

b. Tourism and Organizational Outcomes

Altitude destinations benefit through increased economic activity, improved branding, international visibility, and sustainable tourism development. Sport organizations gain strategic advantages in athlete development, performance planning, and professional credibility.

Importantly, successful outcomes reinforce the attractiveness of the destination, leading to repeat visits and long-term partnerships that strengthen both the sport and tourism sectors.

5.6. The Feedback Loop

A critical feature of the framework is its **feedback mechanism**. Performance outcomes provide insights for physiologists and coaches, allowing refinement of training protocols. Similarly, athlete satisfaction and organizational effectiveness inform tourism managers and policy-makers, encouraging continuous improvement of infrastructure and service quality. This loop ensures that altitude training destinations evolve through evidence-based practice and responsive management.

5.7. Summary

This conceptual framework highlights that altitude training is not merely a physiological intervention but a multidisciplinary system requiring tight coordination across scientific, managerial, and tourism sectors. When these components interact effectively, altitude camps deliver maximal hematological benefits for athletes while generating meaningful organizational and economic impacts for host regions.
Summary of the integrated physiological, environmental, and organizational factors that influence the overall effectiveness of altitude training camps in sport tourism destinations. (Table 3)

Table 3. Integrated Factors Influencing the Effectiveness of Altitude Training Camps

Domain	Key Components	Description	Impact on Outcomes
Physiological Inputs	Hypoxic dose, EPO response, iron stores, genetic variability	Determine hematological adaptation capacity	Strongly influence Hbmass, RBC count, endurance performance
Training & Environmental Conditions	Training load, altitude level, sleep, nutrition, recovery	Shape the athlete’s ability to adapt to hypoxia	Affects performance readiness, injury risk, and acclimatization
Organizational & Managerial Systems	Facility quality, logistics, medical care,	Provide the operational framework	Enhances athlete satisfaction, safety, and

	accommodation, sustainability policies	supporting training	program efficiency
Performance Outcomes	Improved oxygen transport, VO_2max, endurance, team cohesion	Direct physiological and psychological improvements in athletes	Determine competitive success and long-term athlete development
Tourism & Destination Outcomes	Branding, economic growth, environmental sustainability, community engagement	Benefits generated for host regions	Strengthen destination competitiveness and tourism value

Conceptual model illustrating the integration of physiological inputs, training and environmental conditions, and organizational management systems in altitude training camps. The diagram highlights how hypoxic dose, erythropoietin response, iron status, training load, recovery, infrastructure, logistics, and medical support interact to shape athletes' hematological and performance outcomes while simultaneously generating economic, branding, and sustainability benefits for sport tourism destinations. (Figure 3)

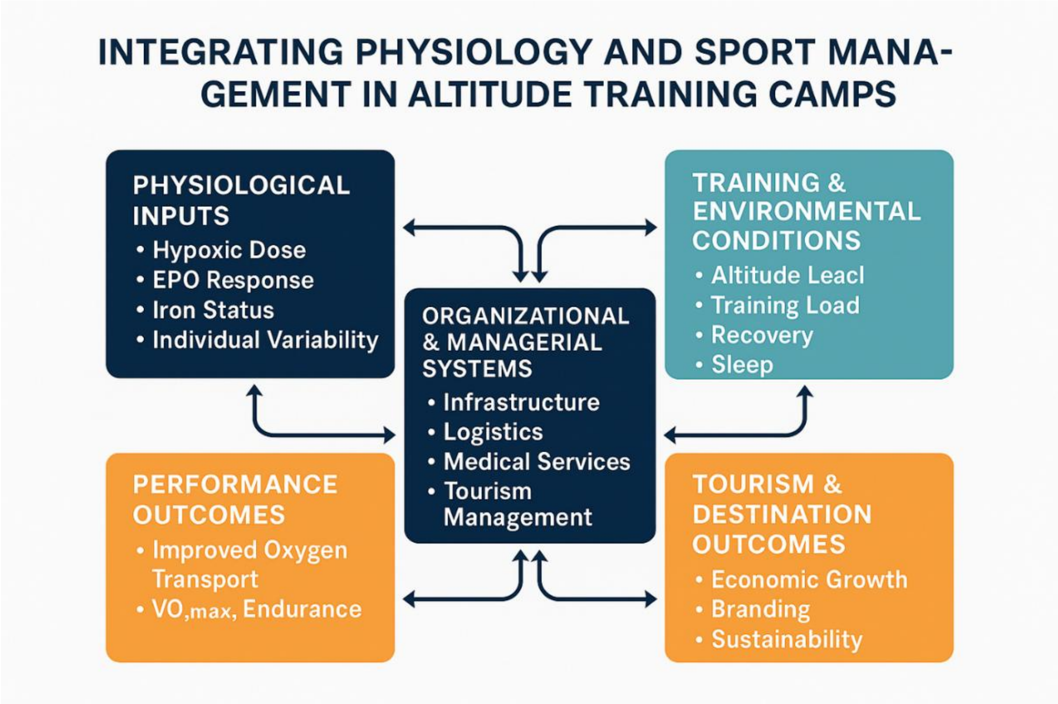

Figure 3. Integrated Physiological and Managerial Framework for Altitude Training Camps

6. Challenges and Limitations

Although altitude training camps in sport tourism destinations offer considerable physiological and organizational advantages, they also present a range of challenges and limitations that must be acknowledged when designing and implementing effective programs. These limitations arise from individual physiological variability, logistical constraints, financial burdens, environmental concerns, and gaps in scientific evidence. Understanding these challenges is essential for optimizing the utility of altitude exposure and ensuring safe, sustainable, and effective training environments.

6.1. Individual Variability and Physiological Constraints

One of the greatest challenges in altitude training is the marked inter-individual variability in hematological and performance responses. While some athletes display substantial increases in hemoglobin mass and endurance capacity, others experience minimal or no improvement. Factors such as genetics, baseline fitness, iron status, sleep quality, psychological readiness, and previous altitude experience contribute to this variability. Additionally, athletes with low ferritin levels may not respond adequately due to impaired erythropoiesis. These differences make standardized altitude prescriptions difficult and highlight the need for personalized training and monitoring strategies.

6.2. Risk of Maladaptation and Health Issues

Altitude exposure carries inherent physiological risks. Acute mountain sickness (AMS), dehydration, reduced appetite, sleep disturbances, and compromised immune function can occur in poorly acclimatized individuals. Overly aggressive training at altitude may exacerbate these symptoms and hinder adaptation. Hypoxic stress can also impair recovery, potentially increasing injury risk. Therefore, careful management of acclimatization phases, training load distribution, hydration, and monitoring of oxygen saturation is crucial.

6.3. Logistical and Organizational Challenges

Altitude destinations are often located in remote regions, making transportation, communication, and equipment management difficult. Maintaining high-quality sports facilities, medical support systems, and athlete accommodations requires significant organizational coordination. Unexpected weather changes—such as heavy snowfall, storms, or altitude-related hazards—can disrupt training schedules. Furthermore, the availability of specialized medical personnel, physiologists, and technology (e.g., Hbmass testing systems) may be limited in some locations, reducing the quality of scientific support.

6.4. Financial Limitations

Altitude training camps are expensive for both sport teams and destination managers. Costs include travel, accommodation, facility rental, staff support, and scientific monitoring. Smaller sport organizations, youth programs, and developing nations may find it difficult to afford prolonged stays at well-established altitude centers. This financial barrier can exacerbate inequalities in access to high-performance training environments.

6.5. Environmental and Sustainability Concerns

Most altitude training destinations are situated in ecologically fragile areas. Increased tourism and facility development can lead to habitat disturbance, waste production, water consumption, and carbon emissions. Without sustainable planning, the long-term environmental integrity of mountain regions may be compromised. Climate change also threatens snow-dependent locations, altering the availability and safety of altitude training sites.

6.6. Scientific Limitations and Research Gaps

Despite decades of research, several uncertainties remain. The optimal altitude level, exposure duration, timing relative to competition, and training model (LH–TL vs LH–TH) vary widely across studies. Additionally, long-term organizational outcomes—such as economic sustainability, destination branding, and athlete satisfaction—are under-researched. More longitudinal and multidisciplinary studies are needed to guide evidence-based practice in both physiology and sport tourism management.

6.7. Summary

Overall, while altitude training camps offer compelling benefits, their practical application is limited by physiological unpredictability, health risks, logistical complexity, financial burdens, environmental constraints, and incomplete scientific guidance. Effective planning, individualized monitoring, and sustainable management practices are essential to mitigate these challenges.

7. Future Directions

As altitude training camps continue to expand within sport tourism destinations, future research and practice must adopt more integrated and innovative approaches that address current limitations while enhancing both physiological and organizational outcomes. Several important directions can guide the evolution of altitude training and its role in sport tourism.

First, **personalized altitude prescriptions** represent a major future priority. Advances in genetic profiling, biomarker analysis, and wearable technologies can help identify “responders” and “non-responders,” allowing training programs to be tailored to individual physiological characteristics. Future studies should explore personalized hypoxic dose models that combine continuous altitude exposure, intermittent hypoxia, and normoxic training in optimized proportions.

Second, the integration of **smart monitoring technologies** will likely transform altitude training practices. Continuous tracking of hemoglobin mass, oxygen saturation, sleep metrics, hydration levels, and recovery indices using mobile sensors and artificial intelligence can provide real-time feedback for athletes and coaches. Machine learning models could assist in predicting optimal acclimatization timelines, performance readiness, and injury risk.

Third, **sustainable development of altitude tourism destinations** is essential. Future research should focus on ecological impact assessments, carbon-neutral infrastructure, renewable energy integration, and responsible visitor management. Collaboration between sport scientists, environmental planners, and tourism policymakers can ensure that altitude destinations remain viable long-term without degrading fragile mountain ecosystems.

Fourth, there is a strong need for **multidisciplinary organizational research**. Future studies should examine the economic, sociocultural, and managerial implications of altitude camps, including destination branding, athlete satisfaction, service quality, and community engagement. Such research will help optimize organizational strategies and enhance the competitive advantage of altitude tourism regions.

Finally, **longitudinal and comparative studies** comparing different altitude training models, seasons, and athlete populations are needed to establish clearer guidelines. Investigations into how altitude training interacts with travel stress, jet lag, and competition schedules will further improve evidence-based planning.

Overall, future progress requires a holistic approach that integrates physiology, technology, sustainability, and management to maximize the value of altitude training camps for athletes, sport organizations, and host destinations alike.

Conclusion

Altitude training camps positioned within sport tourism destinations represent a powerful intersection of physiological enhancement and organizational development. This review demonstrates that altitude exposure—whether through natural or simulated environments—can induce significant hematological adaptations, particularly increases in hemoglobin mass, red blood cell count, and erythropoietin production. These changes directly enhance oxygen transport capacity and support improved endurance performance when training models such as Live High–Train Low or Live High–Train High are properly applied. However, the effectiveness of these adaptations is influenced by factors such as individual variability, iron status, acclimatization quality, and the careful balancing of training load with hypoxic stress.

Beyond physiological considerations, altitude training camps offer substantial organizational, economic, and managerial benefits for sport tourism destinations. Host regions gain from increased revenue, enhanced infrastructure, job creation, and global visibility, while sport organizations leverage these settings to improve athlete development, team cohesion, and competition preparation. The success of these camps relies heavily on high-quality facilities, comprehensive medical and scientific support, effective logistical planning, and positive athlete experiences. When these organizational systems operate efficiently, altitude destinations become attractive hubs for high-performance sport and sustainable tourism development.

Nevertheless, important challenges remain. Individual variability in physiological responsiveness, logistical barriers, financial constraints, environmental vulnerability, and gaps in scientific evidence highlight the need for cautious implementation and continuous improvement. As mountain ecosystems face increasing pressure, sustainable management of altitude tourism infrastructure is essential to ensure long-term ecological and community well-being.

Looking ahead, integrating personalized altitude prescriptions, smart monitoring technologies, and environmentally responsible practices will be essential for maximizing the dual benefits of altitude training. Further multidisciplinary research is needed to refine optimal hypoxic dose strategies, evaluate long-term organizational outcomes, and enhance cooperation between sport scientists, coaches, tourism managers, and policymakers.

In conclusion, altitude training camps—when implemented with scientific precision and strategic management—offer unique advantages that extend far beyond physiological adaptation. They create dynamic environments where high-performance sport, tourism development, and regional prosperity reinforce one another, establishing altitude destinations as vital components of modern athletic preparation and global sport tourism systems.

Funding:

This research received no external funding.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Acknowledgments:

We are grateful to all those who helped us in conducting this research.

Conflicts of Interest:

The author declares no conflict of interest.

ORCID

Yaser Rozbahani	**https://orcid.org/**
Naser Soroushnia	**https://orcid.org/**
Mahdi Ahmadpour Torkamany	**https://orcid.org/**

References

Ainslie, P. N., & Subudhi, A. W. (2014). Cerebral blood flow at high altitude. *High Altitude Medicine & Biology*, *15*(2), 133–140.

Bailey, D. M., & Davies, B. (1997). Physiological implications of altitude training for endurance performance. *Sports Medicine, 24*(2), 97–115.

Bärtsch, P., & Saltin, B. (2008). General introduction to altitude adaptation and mountain sickness. *Scandinavian Journal of Medicine & Science in Sports, 18*(1), 1–10.

Brugniaux, J. V., et al. (2006). Erythropoietic effect of altitude training. *Journal of Applied Physiology*, *100*(3), 941–947.

Chapman, R. F. (2013). The individual response to training and competition at altitude. *British Journal of Sports Medicine, 47*(1), i40–i44.

Chapman, R. F., Levin, J., & Snyder, E. M. (2014). Genetic factors in altitude adaptation. *Sports Medicine, 44*(2), 159–170.

Dick, F. W. (1992). *Training at altitude in practice*. British Olympic Association.

Friedmann, B., Frese, F., & Menold, E. (2005). Individual variation in the erythropoietic response to altitude training. *International Journal of Sports Medicine, 26*(7), 538–543.

Garvican-Lewis, L. A., Clark, S. A., & Gore, C. J. (2016). Live high–train low: A review. *Sports Medicine, 46*(2), 201–216.

Gore, C. J., Hahn, A. G., & Rice, A. (1998). Altitude training regimes. *Journal of Sports Sciences, 16*(1), 37–47.

Gore, C. J., et al. (2013). Altitude training and haemoglobin mass. *British Journal of Sports Medicine*, *47*(1), i65–i69.

Greenleaf, C. A., & Gould, D. (2009). Sport psychology and team cohesion in training camps. *Journal of Applied Sport Psychology, 21*(3), 251–268.

Hall, D. M., & Brenner, I. (2016). Altitude, hydration, and plasma volume. *Medicine & Science in Sports & Exercise, 48*(4), 859–867.

Hamlin, M. J., & Hellemans, J. (2007). Intermittent hypoxic training and its effects. *Sports Medicine*, *37*(4–5), 339–349.

Higham, D. G., et al. (2016). Cold, heat, and altitude training in endurance athletes. *Frontiers in Physiology, 7*, 447.

Jeong, T. S., et al. (2021). Hematological responses to altitude exposure. *European Journal of Applied Physiology, 121*(5), 1369–1382.

Karkoulias, K., et al. (2017). Altitude hypoxia and sleep disorders. *Sleep Medicine Reviews, 32*, 41–48.

Gharakhanlou, R., & Fasihi, L. (2023). The role of neurotransmitters (serotonin and dopamine) in central nervous system fatigue during prolonged exercise. *New Approaches in Exercise Physiology*, *5*(9), 138-160.

Fasihi, L., Shahrbanian, S., & Jahangiri, M. (2025). Effects of combined training on fatigue in multiple sclerosis: a systematic review and meta-analysis of randomized controlled trials.

Physical Treatments-Specific Physical Therapy Journal, 15(1), 1-14.

Levine, B. D., & Stray-Gundersen, J. (1997). "Living high–training low" improves performance. *Journal of Applied Physiology, 83*(1), 102–112.

Mazzeo, R. S. (2008). Physiological responses to exercise at altitude. *Sports Medicine, 38*(1), 1–8.

McLean, B. D., et al. (2014). Physiological strain at altitude. *International Journal of Sports Physiology and Performance, 9*(2), 287–291.

Muza, S. R. (2007). Acclimatization to high altitude. *Comprehensive Physiology*, 1–37.

Naughton, L., & Shilbury, D. (2020). Sport tourism destinations: Management and development. *Journal of Sport Management, 34*(5), 379–393.

Perret, C., et al. (2012). Hypoxic training in elite sport. *European Journal of Sport Science, 12*(4), 309–321.

Richardson, A., et al. (2020). Iron metabolism and altitude training. *Frontiers in Sports and Active Living, 2*, 41.

Ritchie, B., & Adair, D. (2004). The growing role of sport tourism. *Tourism Management, 25*(4), 501–515.

Semenza, G. L. (2012). Hypoxia-inducible factors in physiology and medicine. *Cell, 148*(3), 399–408.

Smith, T., et al. (2019). Economic impact of sports tourism. *Journal of Destination Marketing & Management, 11*, 106–113.

Stray-Gundersen, J., Chapman, R., & Levine, B. D. (2001). Altitude training revisited. *Medicine & Science in Sports & Exercise, 33*(1), 103–107.

Wilber, R. L. (2007). *Altitude training and sport performance*. Human Kinetics.

Wilson, M. A., et al. (2021). Environment, altitude, and athletic adaptation. *Sports Medicine, 51*, 1–15

Ashenden, M. J., Gore, C. J., Dobson, G. P., & Hahn, A. G. (2000). "Live high–train low" does not change the total hemoglobin mass of male endurance athletes. *European Journal of Applied Physiology*, *80*(5), 479–484.

Bailey, D. M., Rimoldi, S. F., Rexhaj, E., et al. (2013). Oxidative stress during hypoxic exercise in humans. *Journal of Physiology, 591*(1), 93–104.

Billaut, F., & Buchheit, M. (2013). Repeated-sprint performance and hypoxia. *Sports Medicine, 43*(12), 113–130.

Böning, D. (1997). Altitude and training. *Journal of Sports Medicine and Physical Fitness*, *37*(1), 1–9.

Brugniaux, J. V., Schmitt, L., Robach, P., et al. (2008). Eighteen days of "living high–training low" stimulate erythropoiesis. *European Journal of Applied Physiology, 102*(2), 143–152.

Chapman, R. F., Stickford, J. L., & Levine, B. D. (2010). Altitude training considerations for elite athletes. *Sports Health*, *2*(6), 429–436.

Clark, S. A., Quod, M. J., & Gore, C. J. (2012). Time course of hemoglobin mass during altitude training. *Journal of Science and Medicine in Sport, 15*(6), 451–456.

De Pauw, K., Roelands, B., Cheung, S. S., et al. (2013). Guidelines for environmental physiology and exercise. *European Journal of Applied Physiology, 113*(12), 3583–3593.

Dill, D. B., & Adams, W. C. (1971). Influence of altitude on training. *Exercise and Sport Sciences Reviews, 1*(1), 105–122.

Faiss, R., Girard, O., & Millet, G. P. (2013). Intermittent hypoxic training. *Sports Medicine, 43*(7), 617–633.

Flueck, J. L. (2018). Hematological adaptations in athletes to altitude. *Frontiers in Physiology, 9*, 1091.

Foster, C., & Lucia, A. (2007). Running economy and performance. *Sports Medicine, 37*(4–5), 316–319.

Fulco, C. S., Rock, P. B., & Cymerman, A. (1998). Maximal performance at altitude. *Journal of Applied Physiology, 84*(5), 1847–1851.

Gore, C. J., & Hopkins, W. G. (2005). Counterpoint: Positive effects of hypoxia. *Journal of Applied Physiology, 99*(5), 2055–2057.

Hahn, A. G., Gore, C. J., & Martin, D. T. (2001). Altitude training selection. *Sports Coach, 23*(3), 22–25.

Hamlin, M. J., Marshall, H. C., Hellemans, J., et al. (2010). Simulated altitude training. *Journal of Strength and Conditioning Research, 24*(1), 128–135.

Haymes, E. M., & Buskirk, E. R. (1968). Effects of altitude acclimatization. *Journal of Applied Physiology, 25*(6), 805–807.

Julian, C. G., & Moore, L. G. (2019). Human genetic adaptation to high altitude. *Journal of Applied Physiology, 127*(4), 1155–1166.

Kammerer, E., & Ringham, D. (2008). Physiological demands of altitude. *Wilderness & Environmental Medicine, 19*(3), 157–164.

Kayser, B. (2005). Altitude training and aquatic sports. *Scandinavian Journal of Medicine & Science in Sports, 15*(1), 1–9.

Koistinen, P. (2000). Erythropoiesis at altitude. *International Journal of Sports Medicine, 21*(4), 279–283.

Lawler, J., Powers, S. K., & Thompson, D. (1988). Linear relationship between VO2max and Hb. *Journal of Applied Physiology, 64*(4), 1486–1492.

Levine, B. D. (2002). VO2max: What do we know? *British Journal of Sports Medicine, 36*(6), 395–399.

Levitt, D. G. (2010). Oxygen delivery bottleneck. *PLoS One, 5*(10), e13963.

Lundby, C., Calbet, J. A., & Robach, P. (2018). The response of human Hbmass. *Comprehensive Physiology, 8*(1), 41–63.

Lundby, C., & Robach, P. (2016). EPO, RBCs, and endurance. *Journal of Physiology, 594*(18), 5075–5084.

Mazzeo, R. S., & Reeves, J. T. (2003). High-altitude research. *Journal of Physiology, 551*(Pt 1), 1–2.

Millet, G. P., Roels, B., Schmitt, L., et al. (2010). Specificity of altitude training. *European Journal of Applied Physiology, 110*(2), 281–292.

Mounier, R., & Brugniaux, J. V. (2012). Physiological responses to hypoxia. *Frontiers in Physiology, 3*, 289.

O'Halloran, K. D. (2006). Hypoxia and ventilation. *Respiratory Physiology & Neurobiology, 151*(2–3), 266–283.

Park, H. Y., et al. (2016). Hematological changes after altitude exposure. *High Altitude Medicine & Biology*, *17*(3), 207–214.

Peacock, A. J. (1998). High altitude medicine. *BMJ, 316*(7147), 877–880.

Peltonen, J. E., et al. (2001). Training at moderate altitude. *European Journal of Applied Physiology*, *85*(1–2), 62–67.

Prommer, N., & Wehrlin, J. P. (2011). Sea-level Hbmass after altitude training. *European Journal of Applied Physiology, 111*(5), 869–874.

Robach, P., et al. (2006). Time course of EPO after altitude. *Journal of Applied Physiology, 100*(1), 123–130.

Rodriguez, F. A., Ventura, J. L., & Casas, H. (2003). Intermittent hypoxia training. *Medicine & Science in Sports & Exercise, 35*(6), 1115–1121.

Rusko, H. (1996). New aspects of altitude training. *Medicine & Science in Sports & Exercise, 28*(Suppl 1), S118–S124.

Saunders, P. U., Pyne, D. B., & Gore, C. J. (2009). Endurance training at altitude. *Sports Medicine*, *39*(5), 341–356.

Schmidt, W., & Prommer, N. (2010). Hbmass and performance. *Sports Medicine, 40*(5), 433–455.

Seiler, S. (2010). What is best practice for altitude training? *International Journal of Sports Physiology and Performance, 5*(4), 450–455.

Shephard, R. J. (1984). Outdoor adventure training. *Sports Medicine, 1*(3), 176–189.

Steiner, T., Wehrlin, J. P. (2011). Hbmass increase after altitude. *Medicine & Science in Sports & Exercise*, *43*(1), 74–79.

Strobel, P., et al. (2020). RBC changes during hypoxia. *Scientific Reports, 10*, 7232.

Terrados, N. (1992). Altitude training and acclimatization. *International Journal of Sports Medicine*, *13*(S1), S206–S209.

Thompson, K. G., & Cooper, C. E. (2019). O2 kinetics in endurance. *Sports Medicine, 49*(6), 911–926.

Townsend, N. E., et al. (2016). Living high–training low for team sports. *International Journal of Sports Physiology and Performance, 11*(7), 885–892.

Vogt, M., et al. (2002). Hypoxia and muscle metabolism. *Journal of Applied Physiology, 93*(2), 873–880.

Wehrlin, J. P., & Zurbuchen, A. (2010). Hbmass changes at altitude. *International Journal of Sports Medicine*, *31*(6), 350–355.

Wilber, R. L. (2011). Application of altitude training. *Current Sports Medicine Reports, 10*(3), 132–139.

Young, A. J., et al. (2001). Hypoxia, blood volume, and adaptation. *Medicine & Science in Sports & Exercise, 33*(5), 865–868.

*Corresponding Author: yaserrozbahani@gmail.com.

How to Cite: Rozbahani, Y; Soroushnia, N. & Ahmadpour Torkamany, M. (2025). The Effectiveness of Altitude Training Camps in Sport Tourism Destinations on Athletes' Hematological Adaptations and Organizational Outcomes, Journal of New Approaches in Exercise Physiology, 7(13), 64-111 .

DOI: 10.22054/nass.2025.90042.1208