USATF Distance Initiative

Optimizing the Response to Altitude Training

2015 Summary Report

The USATF Distance Initiative is a scientific-based program within the USATF High Performance Plan, and is designed to help coaches and athletes optimize the positive physiological and performance outcomes from training at altitude. This report contains a brief explanation of the concept behind the Distance Initiative, the actions taken in 2015, the outcomes from this work, and plans for 2016.

<u>Distance Initiative actions taken in 2015</u>

- Equipment purchased for hemoglobin mass testing stations.
- Hb mass testing station set up in Flagstaff, Arizona in the Hypo2Sport facility. Equipment tested and validated for accuracy.
- Relationship developed with US Ski and Snowboard officials to be able to utilize existing Hb mass testing station in Park City, Utah for any USATF athletes training there.
- Offer extended to complete pre- and post-Hb mass testing (for free) on any sea level based US athletes completing a training camp in Flagstaff or Park City.
- Additional support funding sent to Hypo2Sport for services for USATF Tier athletes.
- USATF funded pacers for 5k and 10k events at Payton Jordan Invitational.
- Distance Initiative educational presentation at Payton Jordan.
- Altitude training grants offered to World Championships team athletes for completing an altitude training camp between USA Outdoor Championships and World Championships.
- Alternate altitude training site supported in Hida-Ontake, Japan for those interested in training at altitude (versus sea level in Narita) in the days prior to Worlds.

<u>Key Outcomes of 2015 Distance Initiative testing</u>

A total of 67 athletes completed total hemoglobin (Hb) mass testing and questionnaires in 2015 as part of the Distance Initiative. Nine athletes lived in an altitude tent while at sea level, while the remaining 58 athletes completed an altitude camp in either Flagstaff (48 athletes) or Park City (10 athletes).

The primary finding is that most athletes and coaches are not <u>optimizing</u> altitude training by following current scientific best-practice principles.

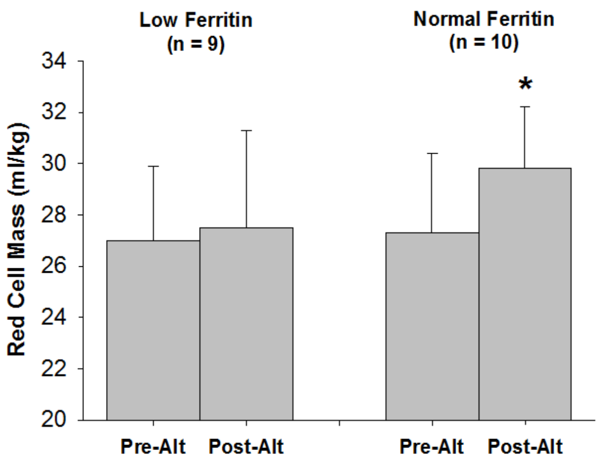
When training at altitude, there are a number of variables that the athlete and coach must select. Depending on those decisions, the degree of physiological and performance adaptations that happen as a result of training at altitude can be dramatically altered. The key variables that are known to affect the physiological and performance response to training at altitude:

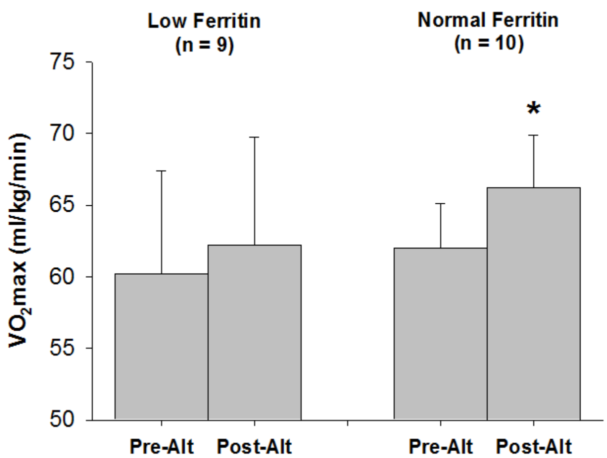
- Proper iron stores and iron supplementation
- Living at an appropriate altitude (high enough to maximize EPO and Hb mass production, but not too high as to add negative factors that affect acclimatization)
- Living at altitude long enough to produce additional red blood cells
- Completing higher intensity workouts at lower altitude, to maximize the training response
- Competing within an ideal window upon return to sea level

Below are data from USATF's Distance Initiative testing, describing how athletes chose to train at altitude and the resulting hematological response, as well as a set of global scientific recommendations to maximize the altitude training response

<u>Issue #1</u> – Proper iron storage and supplementation

It has been well documented that if an iron deficient athlete goes to altitude, even if they produce significant amounts of EPO, production of new red blood cells is significantly impaired. The graph below, *first published nearly 20 years ago* and confirmed in several recent studies, shows data of the increase in the mass of red blood cells after a four week altitude training camp at 8000ft. Note that athletes who had low serum ferritin levels did not make any additional red blood cells and had no significant change in VO_2max. Only the athletes with "normal" ferritin experienced a significant increase in red cells and VO_2max.





Of the 67 athletes who participated in the 2015 Distance Initiative testing, *only 27 (40%)* had their ferritin measured back home, before coming to altitude (or before utilizing an altitude tent). A total of 13 athletes had their ferritin measured within ~3 days of arrival at altitude, but 6 of the 13 had ferritin levels that were low or borderline low, and missed out on valuable time that could have been spent supplementing and getting iron stores normalized before coming to altitude.

Of the 40 athletes who had their ferritin measured, 11 had ferritin levels that were considered low or borderline low (women < 35 ng/ml; men < 50 ng/ml). A total of 29 athletes had normal ferritin levels (range 53 – 213 ng/ml). There was a significant difference between these two groups in the amount of new hemoglobin that was made over the course of the altitude camp. (Note that a typical increase in Hb mass for a normal ferritin athlete, living at 7000ft for 4 weeks is approximately 4%)

Athletes who had their ferritin measured (40 total athletes)	**Percent change in Hb mass from pre-altitude to post-altitude**
Athletes with **LOW** ferritin (11 athletes)	0.6 ± 2.0%
Athletes with **NORMAL** ferritin (29 athletes)	3.7 ± 3.0% *
	* = statistically significant increase ($P < 0.05$)

A total of 49 athletes lived at natural altitude (not in an altitude tent) and completed a questionnaire regarding iron supplementation as part of the Distance Initiative. Whether or not they supplemented with iron and the form of supplement used had a significant influence on the amount of new hemoglobin made over the course of the altitude camp.

Athletes who completed iron supplementation questionnaire (49 total athletes)	**Percent change in Hb mass from pre-altitude to post-altitude**
Athletes who did **not** supplement with iron while at altitude (3 athletes)	1.5 ± 0.5%
Athletes who supplemented with iron in **pill** form at altitude (19 athletes)	1.4 ± 2.7%
Athletes who supplemented with iron in **liquid** form at altitude (27 athletes)	4.2 ± 3.4% * #
	* = statistically significant increase # = statistically significant difference from no supplementation and pill form ($P < 0.05$)

Why liquid iron supplementation over pills?

The problematic piece about all oral iron supplementation is having as much as possible of the iron you ingest, be absorbed into the blood stream. An iron molecule forms a complex with Vitamin C and a substance called Intrinsic Factor, which is secreted from the stomach lining in an acidic environment and is found in the stomach only. That complex is absorbed into the blood in the first part of the small intestines (duodenum). So **only the iron that forms this complex in the stomach is absorbed** and the rest is just passes through the body and not absorbed.

So what can we do to maximize the formation of the complex and subsequent absorption?

1. Take the supplement in liquid form to maximize forming the complex in the stomach. Note: pills take time to dissolve, and they do so unevenly and not as well as a liquid in the stomach.
2. Intrinsic Factor is secreted from cells in the stomach lining, so an empty stomach and a liquid supplement maximizes the chances of forming a complex.
3. Vitamin C is a necessary component of the complex, so provide some.
4. The complex forms best in an acidic environment. The stomach is normally acidic, but the additional acidity of the orange juice makes sure the mix in the stomach is proper.

Scientific best-practice recommendations

- Have ferritin measured ideally 2-4 weeks prior to departure for altitude (getting it measured on arrival at altitude is too late if iron stores are low)
- Supplement with iron before the altitude camp, to normalize iron stores before arrival
- Supplement with iron during the altitude camp, to keep iron stores adequate during a time of high iron turnover
- Take iron in a form (liquid) and volume that maximizes both absorption in the gut and red cell production in the bones (see attached document for why liquid forms of iron are recommended and recommended supplement dosages based on ferritin levels).

The best way to get ferritin measured is through an order placed by the athlete's physician. However, if this is not possible, USATF can advise / assist with blood testing. Contact Robert Chapman (Robert.Chapman@usatf.org) for assistance.

Issue #2 – Living at altitude long enough to make additional red blood cells

There are two schools of thought regarding the length of time necessary to make additional red blood cells while at altitude.

One school of thought is that athletes will typically see, a linear increase in Hb mass of an average of 0.7% for every 100 hours of residence at an altitude of 7000ft and higher. That means an athlete completing a 21 day altitude camp would see about a 3.5% increase in Hb mass, and staying an extra week to 28 days, would add about a 1.2% increase in Hb mass, to about 4.7% .

However, the process of growing a red blood cell, starting from a stem cell in the bone marrow to release as a mature red blood cell, takes as long as 15-18 days. Therefore, leaving altitude at (for example) day 21 and returning to sea level may terminate the growth of red blood cells in the middle of that 15 – 18 day production time. As a result, there are data that suggest that the increase in Hb mass over the first 3 weeks at altitude may be substantially less than the increase from week 3 to week 4. In fact, there are data that suggest that the number of red blood cells may nearly double from day 21 to 28 at altitude, with minimal increases after.

Therefore, if logistically possible, **it is strongly recommended that an altitude camp last at least 28 days**. Our data from 2015 athlete testing would support this recommendation. Of the athletes we tested, who had normal ferritin levels, there was a significant difference in hemoglobin produced as a function of how long the athlete stayed at altitude.

Athletes who had normal ferritin levels (29 total athletes)	Percent change in Hb mass from pre-altitude to post-altitude
Athletes who lived at altitude for **19 – 23 days** (9 athletes)	1.3 ± 1.7%.
Athletes who lived at altitude for **27 – 35 days** (20 athletes)	3.8 ± 2.6% * #
	* = statistically significant increase # = statistically significant difference from 19 – 23 days ($P < 0.05$)

Scientific best-practice recommendations

- Altitude camps should be at least 28 days in duration to maximize the red blood cell response.
- If 28 days is not possible, a minimum of 21 days is recommended.
- Choose an altitude training camp location where the athlete can live at an altitude between approximately 7000 and 8000 ft (plus or minus about 200 feet). Existing data suggests living lower is not adequate enough to enhance performance, while living higher increases adaptive responses which are negative to performance.

Issue #3 – Completing higher intensity workouts at a lower altitude

In a recent meta-analysis, looking at dozens of well controlled altitude training studies following the "**live high – train low**" model of altitude training (where all high quality sessions were completed at a lower altitude), the average change in maximal aerobic power was 4.0 ± 3.7%.

In the same meta-analysis, the change in maximal aerobic power when following the classic "live high – train high" model of altitude training, where all workouts were completed at altitude, was 1.6 ± 2.7%.

This difference in maximal aerobic power of 2.4% between the two models converts to approximately a 0.7% difference in performance, or **about 5-8 seconds over a 5000m race**. The only difference between the two altitude training models is where the athlete completes high intensity sessions (usually defined as track sessions with reps longer than 300m or tempo runs that are faster than threshold pace).

A total of 47 athletes completed questionnaires which asked a) the total number of high quality workouts completed over the course of the altitude camp, and b) for how many of those high intensity workouts did they travel to a lower altitude.

Athletes who completed training questionnaires (47 total athletes)	**Number of workout sessions**
Number of workouts over the entire altitude camp classified as high intensity	8.5 ± 2.5%.
Number of high intensity workouts completed at a lower altitude (e.g. Sedona, Camp Verde, Salt Lake City)	3.6 ± 1.1% #
	# = statistically significant difference from total number of high intensity workouts ($P < 0.05$)

Note that *just 42%* of high quality sessions were completed at a lower altitude. In discussions after the altitude camp with several athletes, the choice not to go to low altitude for all high intensity sessions was mainly due to either a) thinking it was not important to go to low altitude, or b) not wanting to deal with the inconvenience of travel to Sedona / Camp Verde / Salt Lake City.

While it may be an inconvenience, the data suggest that athletes are giving up some fraction of 0.7% of the expected performance improvement from altitude training simply by not making the effort to drive down to a lower altitude for all quality sessions.

Scientific best-practice recommendations

- Workouts that include intervals of longer than 300m or workouts that are done faster than lactate threshold pace should be done at a lower altitude.
- Current data suggests that an altitude lower than 5000ft is adequate for these workouts, but the lower the altitude, the better the response.
- Even though it may be a hassle to drive down to lower altitude, the effort is well worth it in terms of added training response.

Issue #4 – Competing in an ideal window after return to sea level

Data on when is the ideal time to compete after return from altitude are lacking. What little data does exist suggest that the ideal times to compete are a) within 48-72 hours after return to sea level, and b) after approximately 15-18 days after return to sea level.

The physiological issues on timing competition after altitude training are related to the timing of:

- the gradual decline in red blood cells (hemoglobin mass)
- the gradual decline in added exercise ventilation
- regaining the sensation of having good "turnover" at fast speeds
- hormonal changes with return to sea level

When competing in the first 48-72 hours after return to sea level, the number of red blood cells are maximized, benefitting performance. After 15-18 days at sea level, even though the number of extra red blood cells added during altitude are starting to decline, the better sea level workouts during those 15-18 days appear to help maximize fitness to an even higher level. Competing between those two windows, anecdotally many athletes report feeling a little tired or "off." This is likely due to hormonal changes happening during this window, but has not been scientifically confirmed.

Current thinking is that distance athletes on the shorter side of race distances – 1500m, steeple, 5000m – may see better performances after 15 to 18 days at sea level, versus the first 48 to 72 hours after return. This is highly dependent on the quality and adaptation to the workouts done at sea level (when the athlete has a higher number of red blood cells) during that first 15-18 days after return. Distance athletes on the longer side of race distances – marathon, race walk, 10k – will generally see about the same performance gains competing in either the early or late window after altitude training.

In either case, targeting the early or late window, the logistics and burden of travel should not be discounted. The amount performance can be impaired by hurried travel and the time to recover from it can be greater than trying to hit a particular time window. However, the "flatness" that athletes tend to feel from about day 3 to day 18 appears to be a repeatable phenomenon and should be avoided, if possible, when scheduling an altitude camp relative to racing.

Scientific best-practice recommendations

- The best windows for peak performance after an altitude camp appear to be in the first 48-72 hours after arrival at sea level, or after approximately 15-18 days at sea level.
- Between those two windows, athletes tend to feel flatter – particularly in the legs.
- When deciding which window to compete, coaches should also consider the logistics and physical response to travel and how well the athlete recovers.

Should you have any questions about this information, please feel free to contact Robert Chapman at Robert.Chapman@usatf.org or 812 856 2452.

Special thanks to:

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