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Effects of Altitude Acclimatization and Re-Acclimatization on Cardio-Respiratory Fitness in McPherson College Football Players

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ABSTRACT

It has been shown that high altitude training can provide physiological benefits for athletes competing at lower altitudes. However, the comparison of high altitude training compared to low altitude training for competition at the same altitude is relatively unexplored. Also, the rate at which athletes re-acclimatize to the altitude at which they will compete is often overlooked. The aim of this study is to determine which altitude training regimen, either high or low, will produce the best results for athletes (specifically football players) competing at McPherson, Kansas' altitude, and also to see how effectively the athletes from both altitude groups retain performance benefits. In this study, high and low altitude groups showed similar fitness score results after acclimatizing to their summer altitudes ($p=0.73$). Re-acclimatization for the first three weeks following return to McPherson, Kansas' altitude for both altitude groups were relatively similar ($p=0.27$). The low and high altitude groups showed mean fitness score increases of 6.18 ($p=0.30$) and 8.99 ($p=0.13$), a 6.0% and 8.9% increase, respectively. Confidence interval was set at 95% ($\alpha=0.05$) for all the tests performed. While both altitudes experienced an increase in cardio-respiratory fitness there was no statistical significance indicating that one altitude produced better results than the other. Further testing with a larger sample size and an intermediate altitude group would be beneficial in future studies determining the best training altitude at which McPherson College Football players should train.

Keywords: *Altitude Acclimatization, Fitness Testing, Altitude Training, Re-Acclimatization*

INTRODUCTION

It is well known that training in high altitudes is more beneficial than training in low altitude areas. At higher altitudes individuals are exposed to hypoxia, or decrease in the amount of oxygen reaching body tissues, which leads to a change in the regulation of metabolic pathways to favor greater dependence on glucose, rather than fatty acids. This is beneficial because it increases the energy yield per unit of O_2 (Braun et al. 2000). Hypoxic exercises may also increase the training stimulus, which would lead to greater endurance training effects (Levine et al. 1997).

During hypoxia there is also a decrease in arterial oxygen levels. This in turn causes an increase in heart rate in order to meet metabolic needs of the body (Lee et al. 1990). Individuals adapt to the high altitude by improved oxygen delivery or utilization (Levine et al. 1997). In the lungs, oxygen uptake is enhanced by increases in ventilation, lung compliance, and pulmonary diffusion. Highlanders, individuals born and raised in an elevation considered high, have shown to have an increase in lung and thorax volumes, as well as increased hemoglobin levels (De Meer et al. 1994).

Typically the depth chart for the McPherson college football team is set after the first weeks being back from summer break. Therefore it is crucial for the football players at McPherson College to be at their best early upon arrival from summer break. McPherson, Kansas is at an elevation of 1,496 feet (Google Earth), which is significantly different than the home altitudes of many players recruited for the McPherson College Football team. The main affect that altitude has on performance is physiological. This can have a profound impact on performance based sports such as football.

The purpose of this study is to examine the cardio-respiratory fitness of McPherson College football players when acclimatized to McPherson's altitude, before the beginning of the summer, and again when acclimatized to a different altitude, upon their return to McPherson College at the end of the summer. The other altitudes of the individuals will be determined by the addresses they will be staying at during the duration of the summer and will be found using Google Earth computer program. While there is a variety of tests that could be used to measure individual fitness, the Harvard Step Test will be used because it is commonly used to assess cardio-respiratory fitness (Watkins 1984), has minimal cost and required equipment, is a simple test to perform, (Top End Sports. 2011), and is commonly used in many studies to assess the health and cardiorespiratory fitness of individuals (Chien et al. 2000; Chen et al. 2005). Performance is based on the heart rate during the recovery period following exercise (Watkins 1984). Since the first two weeks upon return to college are important to the amount of playing time players receive, finding what altitude to train at during the summer based on their cardio-respiratory fitness when they return could be beneficial to athletes looking to gain an advantage

over their peers

MATERIALS AND METHODS

This study took place in McPherson, Kansas and involved 15 McPherson College football players between the ages 18-22. Of these 15 individuals many are from altitudes much different than McPherson, Kansas' altitude.

Each individual in this study was used as their own control subject. They will be measured for their cardiorespiratory fitness at several points during the year. The first point was done before they left for summer break while they were acclimatized to McPherson, Kansas altitude. They then went to their summer homes for about 3 months and then were tested again the first, second, and third week upon return to McPherson, Kansas using the Harvard Step Test.

Off-season training for football begins at the first of January and ends in May. This training includes weight lifting as well as condition running. The fitness regimen were the same for all subjects and since all individuals are participating in the same training, their levels of exercise were considered equal before their initial fitness test before they left for summer break.

At the end of the training and before departure for summer, the first fitness test was performed using the Harvard Step Test (Top End Sports). In this test individuals used a 20 inch high platform, stopwatch, and a metronome. The subjects were instructed to step up and down from the platform at a constant rate of 60 steps per minute for five minutes or exhaustion. Exhaustion is defined as "When the athlete cannot maintain the stepping rate for 15 seconds" (Top End Sports). They kept pace using a metronome. Following completion of the test the individual immediately sat down and took his pulse for 30 seconds at the 1, 2, and 3 minute marks following the test. They used the measured pulses to score their test using the following method.

Fitness Index = (100 x test duration in sec.) / (2 x sum the heartbeats in the 3 measured durations)
(Top End Sports). The results from each subject's first test were recorded and saved as a control value to be tested against their second post-summer testing.

Once the individuals left to their summer homes, which are at different altitudes other than McPherson and were found using Google Earth, they all followed a fitness program assigned by the football coaches. Contact was made with each individual on a weekly basis to confirm that each subject was following the fitness regimen. The level of exercise received by each individual over the summer period was also considered equal since individuals were required to follow the same regimen.

Individual's scores were recorded and compared to their control test and each of their three tests following return was compared with one another. This tested not only their cardiorespiratory fitness of the individuals as they are acclimatized to their "summer homes" but also their fitness as they become acclimatized to McPherson, Kansas' altitude. I tested each of the three weeks after because full acclimatization does not occur until 3 weeks (Lundby et al. 2002). Data collection was complete by the end of the 3rd week upon return to McPherson.

I ran a repeated-measures ANOVA test for the two groups and tested for significance between not only their initial fitness test before they left and their first test upon return, but each subsequent test will be measured against all the other fitness tests. This enabled me to not only to check for altitude acclimatization between the two altitude groups, but also the rate of re-acclimatization within the groups.

RESULTS

Once data was collected, individuals were split into two groups, low altitude (<1500 Feet) and high altitude (>1500 Feet), which had nine and six participants respectively. These altitudes were used because of the large disparity between altitudes of the subjects. A paired T-test was done within 1 week before leaving McPherson, Kansas and within 1 week after return to McPherson, Kansas' altitude. The confidence interval was set at 95% (α=0.05) for the following tests. It was shown that the fitness scores between groups were relatively similar (p=0.73).

Next, a repeated-measures ANOVA test was done for fitness scores collected for each group within three successive weeks. Again the test was conducted using a 95% confidence interval (α=0.05). There was similar result of fitness scores over time with regard to the two altitude groups (p=0.27). Results for the repeated-measures ANOVA test can be seen in Table 1.

Table 1. Results of Repeated-Measures ANOVA for the 3 successive weeks following return to McPherson, Kansas

Interactions	F-Value	Exact F	Probability
Time	0.43	1.51	0.20
Altitude	0.07	0.66	0.44
Time *Altitude	0.34	1.51	0.27

Lastly, the means of each test were compared for both the groups. A paired t-test at a 95% confidence interval (α=.05) was done between the initial fitness scores and the first, second, and third successive tests for both low and high altitude groups. No significant difference was found between the tests. A

figure representing the mean fitness scores for both groups for each of the tests is shown (Figure 1).

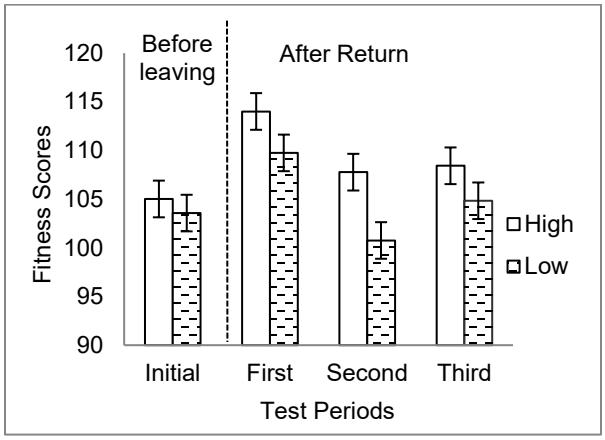

Figure 1. Mean Fitness Scores of McPherson College Football Players for Initial testing Before Summer and Testing 3 successive Weeks Upon Return. Error bars at 95% confidence intervals

DISCUSSION

The first question this study seeks to answer is whether acclimatizing to high or low altitude would give an athlete a cardiorespiratory advantage at McPherson, Kansas' altitude. The paired T-test comparing the high and low altitude groups showed that there was no statistical significance that altitude affected cardiorespiratory fitness of the athletes. This accepts the null hypothesis that individuals fitness will be unaffected by changes in altitude.

The second question this study seeks to answer was whether training at either low or high altitudes effects athlete's cardiorespiratory fitness during re-acclimatizing to McPherson, Kansas' altitude. This was measured in a three week period of re-acclimatization. The data received from the repeated-measures ANOVA shows that there was not statistical significance in cardiorespiratory fitness during re-acclimatization between groups overtime.

Taking a closer look at the data, I ran paired T-tests for each altitude against its successive tests in order to see any underlying trends. Both groups showed an increase mean fitness score from initial testing to the first test upon return. This is somewhat expected as both groups underwent an off season training regimen designed to increase strength and cardiorespiratory fitness. However, the high altitude group showed a higher mean fitness score increase of $\bar{x}$ = 2.81 over the low altitude group between the initial test and the first test upon return. This represents a trend that the high altitude increased cardiorespiratory fitness slightly better than the low altitude group. Also, the high altitude group experienced a larger decrease ($\Delta\bar{x}$ = -11.7 ± 0.48) (p=0.31) than the low altitude group ($\Delta\bar{x}$ = -8.93 ± 0.72) from their first test after return to the second test after return. This indicates that the high altitude group possibly lost the benefits of altitude acclimatization more drastically than that of the low altitude group. Both of these differences show a slight trend against the null hypothesis.

Using the power of the initial paired T-test between groups it was found that a sample size of 852 would be necessary to find significance. Clearly, a larger sample size is necessary, but there are several possible reasons for this large disparity. By limiting participants within certain altitude parameters of McPherson's altitude could help decrease dilution of data from participants living near McPherson's altitude. Also, a third group staying at McPherson's altitude could be used as a control/comparison group for the high and low altitude groups. This could help show significance that was found in s similar studies who used 12 participants (Williams 2010) and as few as eight (Lundby 2002). It is clear that more testing is needed to be done to identify and explain more clearly the effect of acclimatization at different altitudes on cardiorespiratory fitness and re-acclimatization on McPherson College athletes.

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