THE INFLUENCE OF VARIATION IN ALTITUDE ON ATHLETIC PERFORMANCE IN LONG-DISTANCE RUNNERS

INFLUÊNCIA DA VARIAÇÃO DE ALTITUDE NO DESEMPENHO ATLÉTICO EM CORREDORES DE LONGA DISTÂNCIA

INFLUENCIA DE LA VARIACIÓN DE LA ALTITUD EN EL RENDIMIENTO ATLÉTICO DE LOS CORREDORES DE LARGA DISTANCIA

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ABSTRACT

Introduction: The academic community has demonstrated the link of athletic performance in track and field with critical factors of sports training, including the psychology of competition. Recently, research has been verified that athletic performance is also related to altitude, weather, ambiance, and the timing of the competition. There are no studies to provide theoretical and practical training experience in the regional environment of Ganzhou. Objective: This paper analyzes the influence of altitude training in professional performance athletes. Concurrently, analysis of the physiological and biochemical indicators of the athletes is performed. Methods: Several long-distance runners had an 8-week altitude training. Analyzed the physiological and biochemical indicators of the athletes before and after the training. At the same time, perform mathematical-statistical analysis on the performance of long-distance runners before and after training. Results: After altitude training, hemoglobin and red blood cells showed a significant decrease (P<0.01). After training, athletes' performance improved considerably (P<0.01). Conclusion: Training at different altitudes may promote an ascending curve in the athletes' performance until a plateau in the fourth week of training. ***Evidence Level II; Therapeutic Studies - Investigating the result.***

Keywords: Altitude; Field and Track; High-Intensity Interval Training.

RESUMO

Introdução: A comunidade acadêmica tem demonstrado a ligação do desempenho em pistas e campo com os principais fatores de treinamento esportivo, incluindo a psicologia da competição. Em pesquisas recentes, foi verificado que o nível do desempenho atlético também está relacionado à altitude, ao clima, ao ambiente do local e ao cronograma da competição. Até o momento não existem estudos para proporcionar experiência teórica e prática de treinamento no ambiente regional de Ganzhou. Objetivo: Este artigo analisa a influência do treinamento em altitude sobre o desempenho dos profissionais de atletismo. Ao mesmo tempo, analisamos os indicadores fisiológicos e bioquímicos dos atletas. Métodos: Vários corredores de longa distância tiveram um treinamento de altitude de 8 semanas. Analisamos os indicadores fisiológicos e bioquímicos dos atletas antes e depois do treinamento. Ao mesmo tempo, realiza análises matemáticas-estatísticas sobre o desempenho dos corredores de longa distância, antes e depois do treinamento. Resultados: Após o treinamento de altitude, a hemoglobina e os glóbulos vermelhos apresentaram diminuição significativa (P<0,01). Após o treinamento, o desempenho dos atletas melhorou consideravelmente (P<0,01). Conclusão: O treinamento em diferentes altitudes pode promover uma curva ascendente no desempenho dos atletas até seu platô, na quarta semana de treino. ***Nível de evidência II; Estudos Terapêuticos - Investigação de Resultados.***

Descritores: *Altitude Competições Esportivas de Pista e Campo; Treinamento Intervalado de Alta Intensidade.*

RESUMEN

Introducción: La comunidad académica ha demostrado la relación del rendimiento deportivo en el atletismo con los principales factores del entrenamiento deportivo, incluida la psicología de la competición. En investigaciones recientes, se ha descubierto que el nivel de rendimiento deportivo también está relacionado con la altitud, el clima, el entorno del lugar y el horario de la competición. Hasta la fecha, no existen estudios que proporcionen una experiencia de formación teórica y práctica en el entorno regional de Ganzhou. Objetivo: Este trabajo analiza la influencia del entrenamiento en altitud en el rendimiento de los atletas profesionales de atletismo. Al mismo tiempo, analizamos los indicadores fisiológicos y bioquímicos de los atletas. Métodos: Varios corredores de larga distancia se sometieron a un entrenamiento en altitud de 8 semanas. Analizamos los indicadores fisiológicos y bioquímicos de los atletas antes y después del entrenamiento. Al mismo tiempo, realice un análisis matemático-estadístico sobre el rendimiento de los corredores de fondo antes y después del entrenamiento. Resultados: Tras el entrenamiento en altitud, la hemoglobina y los glóbulos rojos mostraron un descenso significativo (P<0,01). Tras el entrenamiento, el rendimiento de los atletas mejoró considerablemente (P<0,01). Conclusión: El entrenamiento en diferentes altitudes puede promover una curva ascendente en el rendimiento de los atletas hasta su meseta, en la cuarta semana de entrenamiento. ***Nivel de evidencia II; Estudios terapéuticos - Investigación de resultados.***

Descriptores: *Altitud; Competiciones Deportivas de Pista y Campo; Entrenamiento de Intervalos de Alta Intensidad.*

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INTRODUCTION

Improving the endurance and impressive speed of the middle and long-distance track and field athletes is the key means for China to prepare for the Olympic Games effectively. More athletes from high-altitude areas are engaged in such events.[1] Traditional altitude training refers to organizing athletes to areas with suitable altitudes for regular special sports training. Athletes train at higher altitudes. They live in lower elevations. This can effectively overcome the disadvantage that the traditional altitude training exercise load cannot be maintained. The article analyzes why long-distance runners have achieved excellent results in a plateau environment. At the same time, we asked athletes to perform a blood test and performance analysis after altitude training. The research purpose of the article is to summarize the experience to improve the athletic level of long-distance runners better.

Research objects and methods

Research object

We select 10 female middle and long-distance runners from the national team. Age 18.35±3.21 years old.[2] All subjects are non-native people living on the plateau. They have not participated in altitude training and volunteered to participate in this experimental study.

Research methods

We let 10 outstanding female middle and long-distance running athletes who do not live in the plateau have traditional altitude training and high-altitude living and low-altitude training, respectively.[3] Compare the changes of blood indicators in the two training modes through self-control.,

5-week altitude training in Gannan Plateau

From June 3rd to July 7th, 2019, the athletes of our national middle and long-distance running team, which we established for half a year, will conduct a five-week plateau training at the Gannan Plateau Base.[4] The purpose is to improve the athlete's athletic ability through basics. The running distance during the first plateau week is 92.13±3.21km. This exercise focuses on low-intensity aerobic training. After 1 week, the total amount of training increased to 149.15±7.29km. This exercise was significantly higher than the exercise at the first plateau. Aerobic training accounted for 78.78%±8.29%. Mixed oxygen accounts for 21.80%±7.28%. The following 4 weeks fluctuate according to this total amount of training. The amount of exercise was higher than the first week (P<0.05, Table 1). On July 8th, he went down to the Wuchuanya Plateau Training Base in Inner Mongolia.

3-week high-altitude living and low-altitude training

From October 29th to November 18th, 2019, 21-day high-altitude living and low-altitude training were carried out in the hypoxic laboratory. Living at a high altitude means living in a low-oxygen room equivalent to 2500m for more than 10 hours a day.[5] Low altitude training is carried out under normoxia. The average weekly running distance was 87.09±6.79km (Table 1). We arrange for athletes to carry out cycling training with 80% V·O2max intensity for 40 minutes three times a week under a low oxygen environment of 2000-2500m. The purpose of this is to increase hypoxia stimulation.

Table 1. Altitude training and simulated HiLo training volume km/week.

	Altitude training	Simulate HiLo
Week 1	92.13±3.21	102.75±24.51
Week 2	149.15±7.29	89.70±17.16
Week 3	148.88±71.73	81.00±15.12
Week 4	148.55±9.74	
Week 5	151.38±22.73	

Blood image determination

Take blood under fasting and peaceful state to determine blood indicators. The content includes red blood cell number (RBC), hemoglobin (Hb) content, red blood cell width (RDW), white blood cell number (WBC) and average red blood cell hemoglobin content (MCH=Hb/RBC), average red blood cell hemoglobin concentration (MCHC=Hb/Hct), etc.

Optimization of starting image posture of long-distance runners

b'_{fh} represents the number of all pixels in the image. $I_c(i,j)$ represents the image frame of the starting posture of the current long-distance runner. $I_g(i,j)$ represents the reference frame. (s,t) represents the relative position of the pixel block in the current frame and the pixel block in the reference frame.[6] Use formula (1) to express

$$E'_{wer} = \frac{(s,t)}{e'_{sgpi}} + \frac{I_c(i,j)}{I_g(i,j)} * S'_{wey} + b'_{fh} \quad (1)$$

e'_{sgpi} represents the direction of the final motion vector of the pixel block in the reference frame. (s^*, t^*) represents the vector direction of a pair of pixel blocks with the smallest absolute difference.[7] Use formula (2) to give the reasonable matching threshold of the starting posture of long-distance runners

$$S'_{wep} = \frac{(s^*,t^*) \times A'_d}{g'_{sg}} \mp d_{lop} \quad (2)$$

A'_d represents the absolute difference between the pixel block to be matched in the current frame and the pixel block at the same position in the reference frame. d'_{lop} represents the number of starting positions of local athletes included in the window. s'_{sh} represents the average motion energy of any target pixel. K'_{ser} represents the average value of the motion energy of the background pixel block in each consecutive frame within T time.[8] Use formula (3) to complete the optimization and correction of the starting posture of long-distance runners

$$q'_{sg} = \frac{K'_{ser} \mp T}{s'_{sh} \times E_{wer}} S_{wep} \quad (3)$$

Data processing

SPSS11.0 statistically processes all data. One-way analysis of variance compares the changes of blood image indicators in different periods.[9] The significance level is 0.05.

RESULTS

The number of athletes' RBC, RDW, and WBC did not change much in the later stage of altitude training (the 5th week). Hb, MCH and MCHC were significantly reduced. The RDW increased significantly when the plateau was reached for 1 week, but the MCHC decreased significantly. At 2 weeks, Hb and MCHC decreased significantly, and RDW increased significantly. We compare the data before simulating high-altitude living and low-altitude training.[10] After high-altitude living and low-altitude training, the blood indicators of athletes do not change significantly. Only two weeks after leaving the hypoxic chamber, the MCHC decreased significantly (Tables 2 and 3).

DISCUSSION

In this experiment, RBC, Hb, MCH, and MCHC did not change during the first to third weeks of altitude training. High altitude hypoxia causes an

Table 2. Changes in blood image indexes during plateau training in Gannan Plateau (n=8).

		RCB / $10^{12}gL^{-1}$	Hb / gL^{-1}	MCH / pg
		4.36±1.23	45.63±6.68	33.44±2.16
In front of the plateau	1 week	4.33±1.24	143.11±5.93	33.16±1.96
	Two weeks	4.29±1.24	144.38±11.82	33.66±1.96
	3 weeks	4.59±1.21	139.51±3.59	31.48±1.64
	4 weeks	4.44±1.13	132.51±9.32	29.86±1.61
Shimokogen	5 weeks	4.42±1.16	134.11±3.46	31.38±1.66
	1 week	4.51±1.15	144.11±6.16	32.16±1.86
	Two weeks	4.33±1.15	132.16±5.68	31.61±2.14
		MCH / %	**RDW**	**WBC / $10^9 \pm L^{-1}$**
		396.16±8.16	11.11±1.53	4.64±1.26
In front of the plateau	1 week	391.11±11.62	1.46±1.56	5.83±1.94
	Two weeks	392.85±6.41	11.61±1.63	4.59±1.88
	3 weeks	346.91±6.11	13.61±1.11	5.68±1.91
	4 weeks	345.84±5.85	11.16±1.91	4.44±1.98
Shimokogen	5 weeks	349.12±11.41	11.18±1.65	4.68±1.62
	1 week	346.85±3.96	14.23±1.18	5.66±1.93
	Two weeks	356.84±9.62	14.42±1.81	4.63±1.23

Table 3. Changes in blood image indexes during simulated high-altitude living and low-altitude training (n=8).

		RCB / $10^{12}gL^{-1}$	Hb / gL^{-1}	MCH / pg
		4.44±4.31	44.13±11.87	34.45±1.44
In front of Hilo	1 week	4.35±4.34	146.38±7.67	33.78±1.36
	Two weeks	4.51±4.45	154.54±7.47	33.44±1.65
After HiLo	3 weeks	4.44±4.41	45.44±8.86	34.68±1.54
	Two weeks	4.55±4.38	41.44±11.14	31.46±1.77
		MCH / %	**RDW**	**WBC / $10^9 \pm L^{-1}$**
		373.75±6.8838	3.21±2.45	6.65±1.43
In front of Hilo	1 week	1.22±8.21	12.81±2.32	7.35±1.48
	Two weeks	396.39±12.62	12.99±2.59	9.24±1.22
After HiLo	3 weeks	376.39±4.2736	13.23±2.45	7.19±1.39
	Two weeks	1.25±5.85	12.38±2.82	5.38±1.12

increase in EPO secreted by the kidneys. EPO promotes the differentiation of bone marrow stem cells into primitive red blood cells to accelerate the evolution of primitive red blood cells into RBC. It can promote the rapid release of reticulocytes. RBC has enhanced oxygen-carrying capacity.[11] In this study, the indexes of RBC, Hb, etc., did not increase during altitude training for 1 to 3 weeks because the experimental subjects were young athletes who participated in altitude training for the first time. Although the amount of exercise taken in the first week of the plateau is not large, the amount of exercise is still slightly larger for those players who have no experience in altitude training. Large exercise load causes increased physical consumption. This results in little difference between the rate of destruction and generation of blood cells.

The body gradually adapts to altitude hypoxia in the first 2-3 weeks of altitude training, and the amount of exercise scheduled is significantly higher than that in the first week.[12] The number of athletes' RBC in the third week of altitude training was 5.1% higher than that before altitude. Hb is slightly reduced but not significant. It shows that the athlete has fully adapted to the hypoxic environment.

It is quite controversial whether blood indicators such as RBC and Hb can be maintained at a high level after going down to the plateau. We consider many factors such as climate, training conditions, and gradual changes in altitude. After training on Gannan Plateau, the team arrived in Wuchuan, Inner Mongolia, located in the sub-plateau.[13] In the first week after going down to the plateau, small and medium-intensity adjustment training was arranged. The overall training volume is small, so the Hb increases significantly in the first week after altitude training. This is the same as the highest level during the plateau period. The RBC level is also similar to the highest level during the plateau. MCH and MCHC are the same as those after altitude training. Sudden changes in the environment cause the neuroendocrine system to stimulate the kidneys to secrete EPO. However, the subsequent loss of altitude training effect and the alleviation of hypoxia will cause an increase in EPO secretion for a short period.[14] Therefore, Hb decreased significantly in the second week from the plateau to the sub-plateau ($P<0.05$). Of course, we do not rule out that the low Hb in the second week of reaching the sub-plateau is related to the increased amount of exercise performed.

This study used 3 weeks of HiLo training. Except for the obvious fluctuation of MCHC, other blood indicators changed a little before and after training.[15] However, the indicators remain at a relatively high level. Two weeks after leaving the hypoxic chamber, Hb decreased somewhat but not significantly.

Altitude training is a complicated issue. It involves the athlete's training level, functional level, training environment, geographical location, natural conditions, and other internal factors.

CONCLUSION

The implementation of classic altitude training programs for elite female athletes without altitude training experience has not achieved the expected effect of improving the number of red blood cells and hemoglobin content. After the altitude training, the simulated HiLo training was performed for 21 days, and the RBC and Hb indexes did not change significantly. Simulated HiLo training RBC, Hb, and other indicators are always at a relatively high level, and the effect of HiLo training can last about 2 weeks.

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