"LIVING HIGH-TRAINING LOW" ALTITUDE TRAINING ON IMPROVEMENT OF SEA LEVEL HEMOGLOBIN/HEMATOCRIC IN MALE AND FEMALE ELITE SWIMMERS

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This study investigated the effect of "living high-training low" altitude on improvement of sea level hemoglobin and hematocric in male and female elite swimmers. A total of ten elite swimmers at the international and national level was recruited and randomly divided into two groups, altitude training group and control group. The athletes in altitude training group lived high condition while training at sea level for three weeks. The altitude was set at 2,800m. The all subjects in both groups accepted same training in the intensity, frequency and duration. Hemoglobin and hematocric were measured at sea level on seven occasions, the day before starting the experiment, during the period of experiment and the day completing the experiment. The results showed that the hemoglobin and hematocric in altitude training group increased 8.6% and had significant difference compared with those before the experiment. While the level of hemoglobin and hematocric in control group did not show any obvious change. "Living high-training low" altitude training can significantly improve the level of hemoglobin and hematocric.

KEY WORDS: altitude training, hemoglobin, hematocric, swimmer.

INTRODUCTION: "Living high-training low" altitude training is an approach recently applied in elite athletes training. In a lot of countries, such as Germany, American, Finland, Norway, Sweden, Japan, and Australian, altitude training has been widely applied (Rusko, Leppacuori,Makela, et al.,1995; Stray-Gundersen, Chapman & Levine, 2001). Therefore the adjustable pressure tank, sleep bag, hypothesis mask have been developed and applied in the training aiming to mimic altitude condition. The development and application of these facilities related to mimicking different altitude conditions were established on the basis of the studies in sports engineer and sports biomedicine. In 1998 Shandong Sports Science Center, China, developed the first mimicking altitude condition training tank that had been tested by both animal and human experiments and had been approved by Department of National Technique and Quality. The tank has been used for training purpose in a lot of elite athletes, such as track and fields athletes, and cyclists since 1999 (Hu, etal., 2001; Li, Wu, Zheng & Yu, 2000; Li, etal., 1999). But the impact of "living high-training low" altitude training has not been applied in elite swimmers. The objectives of this study were to investigate the effects of "living high-training low" altitude training on blood hemoglobin (Hb) and hematocric (Hct) in elite swimmers. It was expected that the results obtained from this study could provide the information in exploring altitude training to improve performance of athletes.

METHODS: Twelve elite athletes (6 males and 6 females) at national level were recruited. Of all swimmers, eight athletes (4 males and 4 females) served as altitude training group, and another four athletes (2 males and 2 females) served as control group. The athletes included two Asian champions in International champion game, and 4 athletes was ranked in the China top 10 for their event, and the others were ranked in the Shandong province top 5 for their event. Table 1 lists the details of subjects in the age, best record, and ranking of both groups of altitude training and control. *Protocol:* Athletes in altitude training group were required to live in CSDF-40 adjustable pressure tank for 12 hr (19:00 pm to 7:00 am) every day, for three weeks. The altitude of the pressure tank was set at 2,800 m. While the subjects in control group maintained the "living low-training low" training. During the experimental period, all subjects both in altitude training and control groups participated in the same training program at the same intensity,

duration and frequency at sea level. Individualized training plans were developed by the athlete and his or her coach. The experiment was conducted before National Game.

Table 1. The age, best record, and ranking of the subjects in two groups.

Group	Subject	Sex	Age	Best record
Altitude group	A	Male	22	Asia Champion
	B	Male	23	Asia Champion, Fifth International Champion game
	C	Male	22	Province Champion
	D	Male	19	Province Champion
	E	Female	14	Province Champion
	F	Female	14	Province Champion
	G	Female	14	Province Champion
	H	Female	14	Province Champion
Control	a	Male	15	Four in National game
	b	Male	15	Province Champion
	c	Female	15	Province Champion
	d	Female	15	Province Champion

Therefore, The training intensity was quite high. All measurements of Hb and Hct were conducted seven times at sea level. *Hematology and hematocric assessment.* COULer AC-10 blood analyzer was used to measure Hb and Hct. All measurements were conducted in the morning. Venous blood was collected on seven occasions: the day before "living high-training low" altitude training program, twice per week during living program, and the day completing training program. *Data analysis* Standard statistical methods were used to calculate mean±SD. One-way ANOVA and paired-sample t-test were applied to estimate statistical significance between and within the two groups for each variable. The significant difference level was set at 0.05.

RESULTS AND DISCUSSION: Table 2 lists the measurements of Hb in the altitude training group and control group. All subjects underwent "living high-training low" altitude training got significantly improvement in their Hb level ($P<0.05$). On the average, the level of Hb was increased 8.7% in this group. Hb of four subjects increased for more than 10%, and reached the level of 15.9% than the level before the "living high-training low" program in one athlete. While, during the experiment, the Hb level in the control group showed a decrease compared with their Hb level before experiment and the average level of the altitude group at the same measurement point. The reason leading to reduced Hb in control group might be related to the training intensity. This experiment was conducted before the National game. The training intensity was relatively high. High intensity training is believed to reduce the level of blood Hb. However, the Hb level in altitude group did not show any decline, and even higher than those before attaining program. Because all athletes both in altitude training and control group accepted same training program, so the only possible explanation for the difference in Hb level is the effect of living-high condition. Living-high condition results in a relative low oxygen environment that stimulates the production of erythrocyte in human body, and subsequently induces Hb increasing. Hematocric is expressed as the percentage accounting for whole blood of one unit. Table 3 lists the changes in Hct in altitude training group and control group during experimental period. In the group of altitude training, the average hematocric increased for 8.6% compared with those before altitude training and higher than the level of average score in Chinese young people, but lower than the standard of China Olympic Committee (COC). The improvement of hematocric in female athletes was more obvious than those male athletes

(Figure1). The hematocric is one important factor affecting blood viscosity. A number of studies have demonstrated that altitude training could increase in both Hb level and hematocric in athletes, and subsequently increase blood viscosity. The Hct in Chinese young male and female is 46 ± 3% and 40 ± 3% respectively. COC has set the standard with which the athlete with Hct beyond 50% in male athlete and 48% in female athlete cannot be promised to participate in competition. This is because the high level of blood viscosity might be risky to the athlete during sport event. Thus, the measurement of Hct in the athletes who attend "living high-training low" altitude training is very important.

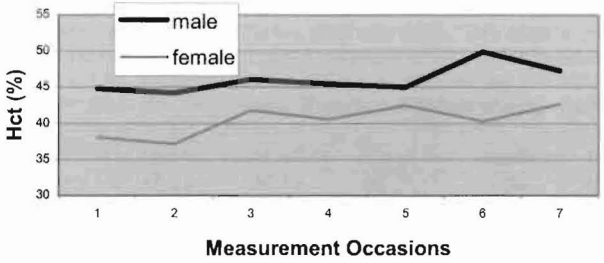

Figure 1. The changes of Hct of males and females in altitude group.

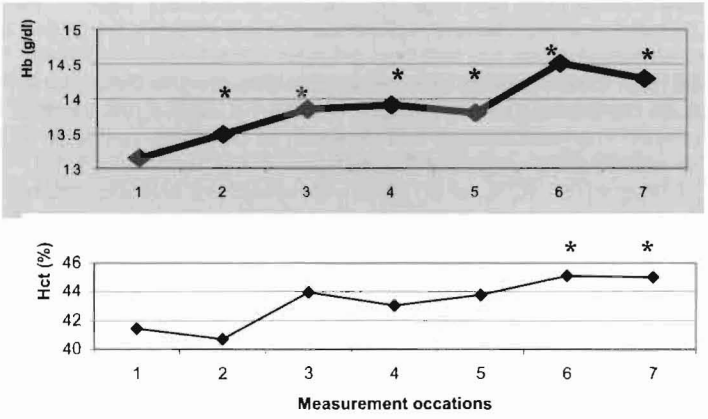

Figure 2. The change trend of HB and Hct in altitude group. * P<0.05 versus test1.

In addtion, The change trend of Hct in altitude group was similar with those of Hb, but not very consistent. The value of Hb was significant higher at the first test in pressure tank than that of before living programme. While the Hct didn't show this change, which just significantly increase at the sixth test (Figure 2). The underlying mechanism should be further explored.

CONCLUSION: The results of this study demonstrated that "living-high training low" altitude training increased the level of Hb and hematocric, while the hematocric level still maintained at

the level possible participating sport event in elite swimmers. The information from this study indicated that "living high-training low" might be applied to the elite training.

Table 2. The values of Hb in both groups durin g the whole experiment.

Hb (g/dl)	Test1	Test2	Test3	Test4	Test5	Test6	Test7
Altitude group	13.15	13.49*	13.85*	13.91*	13.80*	14.51*	14.28*
	(1.63)	(1.40)	(0.86)	(1.44)	(1.21)	(1.74)	(1.52)
Control group	13.00	12.88	13.05	13.00	12.60	13.23	12.58
	(1.13)	(0.43)	(1.43)	(0.72)	(0.51)	(0.15)	(0.25)

Values at test1and test7 were recorded before and after the altitute training, values at test2-6 were recorded during the period of the altitute training. * P<0.05 versus test1

Table 3. The values of Hct in both groups during the whole experiment.

Hct (%)	Test1	Test2	Test3	Test4	Test5	Test6	Test7
Altitude group	41.45	40.71	43.96	43.05	43.81	45.11*	45.00*
	(4.78)	(4.57)	(2.54)	(4.18)	(3.18)	(6.18)	(4.94)
Control group	40.80	40.95	41.35	41.77	40.00	39.27	42.73
	(4.03)	(2.96)	(5.29)	(1.97)	(1.66)	(1.59)	(1.21)

Values at test1and test7 were recorded before and after the altitute training, values at test2-6 were recorded during the period of the altitute training. * P<0.05 versus test1

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