The Influence of HiLo on Endocrine Indexes of Men's Speed Skaters During Non-Ice Age

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Abstract: Objective: this assay discusses the effect of High-training Low(HiLo)for speed skaters' endocrine index which includes Serum Testosterone(T),Serum Cortisol(C),and Ratio of Serum Testosterone to Cortisol(T/C).**Methods:**16 national master man of speed skaters was picked out and divided randomly into Experimental Group(EG) and Control Group(CG). Each Group had 8 people. Experimental Group lived in a simulated altitude of 2300 meters, while Control Group lived in normal oxygen environment. Both Experimental Group training and Control Group training was conducted in normal oxygen environment. The difference of HiLo and Low-training Low (LoLo) before,4 weeks during, and 3 weeks after are compared. **Results:**1) T of HiLo increased by 9% compared with before entering the cabin, increased by 5.94% compared with LoLo.2) C of HiLo decreased by 25.95% compared with before entering the cabin, decreased by 21.5%($p<0.01$) compared with LoLo. It decreased by 14.2%($p<0.05$) in leaving the cabin week 2 compared with before entering the cabin.3) T/C of HiLo increased by 46.1%, 23.07% in during the cabin week 4, leaving the cabin week 2 compared with before entering the cabin. It increased by 33.3%($p<0.01$) compared with LoLo. **Conclusion:** HiLo has little significant effects to T for men speed skaters. C is sensitive to low oxygen environment. The decrease of C result in the increase of T/C in week 4 in 4 weeks during. The effect of T and C caused by hypoxic environment disappeared in leaving the cabin week 3.

1 Introduction

Speed skating is a kind of periodic endurance event dominated by physical fitness. The physical function directly determines the outcome of the competition. Endocrine system affects athletes' body functions by regulating human anabolism and catabolism. Feng LS [1] concluded that the level of athletes' exercise and recovery after exercise are obviously related to the concentration of endocrine indexes such as serum testosterone and serum cortisol in blood. HiLo has been widely used in Europe and America as a mature training method. At present, HiLo has little research on the anabolism and catabolism of speed skaters. This study takes excellent speed skaters as the experimental object, and discusses the influence of HiLo on endocrine indexes T, C, T/C in 4 weeks of non-ice age so as to provide theoretical basis and data support for speed skaters preparing for Beijing 2022 Winter Olympics.

2 Materials and Methods

2.1 Research Objects and Methods

2.1.1 Research Object

Sixteen male speed skaters were selected, all of whom were national athletes. They were randomly divided into experimental group (8) and control group (8). There was no significant difference between the two groups before the experiment. The inclusion criteria were:1) no plateau training or HiLo for nearly half a year, and no heavy training or competition for nearly two weeks;2)

Medical physical examination showed no cardiopulmonary dysfunction and disease indications (no abnormality in blood lipid, viscosity, uric acid and major physiological organ functions);3) atmospheric low pressure oxygen pre-experiment: no altitude reaction was found after 2~3h of activity in the cabin (2,000 ~ 3,000 m). The exclusion criteria were:1) those who suffered from headache, tinnitus and vertigo were excluded;2) Eliminate dyspnea, inattention, and decreased judgment ability;3) For those who exclude gastrointestinal symptoms such as nausea, vomiting and abdominal pain, all subjects have signed informed consent forms, which have been approved by the School Ethics Committee. The research objects are shown in TABLE 1.

Table 1 Basic information list of research objects

Group	Hight（cm）	Weight（kg）	Age(years)	Years of exercise（years）
EG （HiLo）	178.86±5.51	65.64±5.72	19.85±4.35	8.71±2.05
CG (LoLo)	180.86±4.36	66.74±3.72	21.31±1.23	7.91±3.25

2.2 Research Methods

2.2.1 Training and Testing Arrangements

Sixteen men speed skaters were divided into experimental group (HiLo group) and control group (LoLo group) with no difference in height, weight and age ($p>0.05$). The experimental period was 7 weeks (49 days), divided into 4 weeks for HILO and 3 weeks for HILO. The collection time of test indexes in the control group and the experimental group was the same. In the experimental group, Hypoxic Tent System of Tianjin Cnro was selected as the atmospheric oxygen chamber system, and the oxygen concentration in the chamber was set at 15.9%, which is equivalent to 2300 meters above sea level, and hypoxic exposure was carried out for 8 hours at night every day for 4 weeks.

2.2.2 Test Instruments

Tianjin Cnro Hypoxic Tent System (FIG.1.) simulated an altitude of 2300 meters, a temperature of 18℃-23℃, and an air humidity of 30%-52%. Endocrine indexes were tested, and T and C were measured by the U.S. Beckman Access2.

Fig.1. Simulated plateau training atmospheric hypobaric chamber

2.2.3 Mathematical Statistics

According to the test results, Microsoft Excel 2019 software was used to collect data and draw graphs. SPSS 27.0 software was used to carry out statistical analysis on the experimental data. The data analysis was expressed by the mean value plus or minus standard deviation ($\bar{x} \pm s$).

3 Result

3.1 Comparative Changes of Serum Testosterone (T) Between Experimental Group and Control Group of Speed Skaters

Table 2 Serum (T) changes in the experimental group and the control group of the speed skater

	Before entering cabin	During cabin Week 1	During cabin Week 2	During cabin Week 3	Duringcabin Week 4	leaving cabin Week 1	leaving cabin week 2	During cabin week 3
EG (ng/dL)	632.28± 51.59	610.79± 71.59	618.82± 91.57	640.63± 95.36	689.56± 119.3	652.32± 89.65	673.04± 103.49	637.75± 105.21
CG (ng/dL)	644.65± 63.26	630.32± 86.69	636.24± 89.63	645.59± 92.32	650.87± 73.69	626.45± 69.36	660.74± 86.96	629.56± 72.56

Note: Comparison between the experimental group and before entering the cabin: a means (P<0.05), aa means (P<0.01); comparison between the control group and the basic value: d means (P<0.05), dd means (P<0.01) The experimental group was compared with the control group: e means(P<0.05), ee means (P<0.01).

As shown in Table 2, there is no significant difference in T before entering the cabin between the experimental group and the control group (P>0.05).Compare T of Experimental Group to before entering the cabin, HiLo decreased in week 1, week 2, and week 3, while it increased in week 3, week 4, and leaving the cabin week 1, week 2, week 3. HiLo increased by 9% in week 4 compared with before entering the cabin, and it increased by 5.94%compared with Control Group in week 4. There was no significant difference compared with before entering the cabin in week 4 (p>0.05), and there was no statistical significance compared with Control Group in week 4 (p>0.05).

3.2 Comparative Changes of Speed Skaters Experimental Group and Control Group C

Table 3 Serum (C) changes in the speed skater experimental group and control group

	Before entering cabin	During cabin Week 1	During cabin Week 2	During cabin Week 3	During cabin Week 4	leaving cabin Week 1	leavingcabin week 2	Leavingcabin week 3
EG (nmol/L)	420.43± 92.03	470.72± 121.63	455.86± 88.84	387.67± 70.07	311.31aaee± 97.36	389.97± 110.36	360.56a± 69.48	432.83± 118.60
CG (nmol/L)	418.35± 63.07	453.67± 69.58	448.39± 42.34	434.34± 59.69	396.59± 43.23	424.64± 96.54	389.4± 51.36	446.23± 95.89

Note: Comparison between the experimental group and before entering the cabin: a means (P<0.05), aa means (P<0.01); comparison between the control group and the basic value: d means (P<0.05), dd means (P<0.01) The experimental group was compared with the control group: e means(P<0.05), ee means (P<0.01).

As shown in Table 3, there was no significant difference between the experimental group and the control group before entering the cabin (P>0.05). Compared with before entering the cabin, the experimental group C has a very significant difference (p<0.01). In HiLo, it increased in week 1 during the cabin, week 2 during the cabin, and week 3 leaving the cabin, decreased in weeks 3 during during the cabin, week 4 during the cabin, week 1 leaving the cabin, and week 2 leaving the cabin. It decreased by 25.95%in week 4 during the cabin compared with before entering the cabin, decreased by 21.5% compared with CG, which had significant difference. It decreased by 14.2% in week 2 leaving the cabin compared with before entering the cabin, which had significant difference.

3.3 Changes in Serum Testosterone and Cortisol Ratio (T / C) Of Experimental And Control Groups Of Speed Skaters

Table 4 Serum (T / C) changes of experimental and control groups of speed skaters (x ± S)

	Before entering cabin	During cabin Week 1	During cabin Week 2	During cabin Week 3	During cabin Week 4	leaving cabin Week 1	leaving cabin week 2	Leaving cabin week 3
EG (nmol/L)	0.052± 0.0194	0.045± 0.0204	0.047± 0.0357	0.057± 0.0472	0.076aaee± 0.0424	0.058± 0.0282	0.064aa± 0.0516	0.0511± 0.0306
CG (nmol/L)	0.053± 0.0348	0.048± 0.0432	0.049± 0.0734	0.051± 0.0536	0.057± 0.0591	0.051± 0.0249	0.059± 0.0587	0.0489± 0.0262

Note: Comparison between the experimental group and before entering the cabin: a means (P<0.05), aa means (P<0.01); comparison between the control group and the basic value: d means (P<0.05), dd means (P<0.01) The experimental group was compared with the control group: e means(P<0.05), ee means (P<0.01).

As shown in Table 4, there was no significant difference in serum T/C between the experimental group and the control group before entering the cabin (P>0.05). The T/C of the experimental group was lower than that of HiLo in the first and second weeks and before the departure of the cabin, and

HiLo increased in the third and fourth weeks and in the first and second weeks after leaving the cabin. The comparison between the second week and the pre-cabin cabin increased by 46.1% and 23.07%, respectively, and the comparison between the HiLo group at the fourth week increased by 33.3%, all with very significant differences ($P<0.01$).

4 Discussion

4.1 Effect of Hilo On Serum Testosterone (T) Of Male Speed Skaters

The study found that compared with before entering the cabin, the T of HiLo decreased in the 1st and 2nd weeks. The main reason was that during the athletes' first hypoxia, the body was under stress and testes secreted a large amount of T. After stress, testes were temporarily in a "depleted" state. Leydig cells' sensitivity to pituitary gonadotropin decreased, resulting in an increase in pituitary gonadotropin (GTH) and a decrease in T level [2]. Secondly, hypoxia can inhibit hypothalamic function, reduce gonadotropin-releasing hormone (GnRH) and luteinizing hormone (LH), thus inhibiting testosterone synthesis in testis [3]. Combined with the training arrangement, it was found that the dual stimulation of medium or low intensity aerobic endurance training and hypoxia reduced the athletes' anabolic ability, and led to the decrease of T. HiLo's T increased in the 3rd and 4th weeks. The reason may be that the body of speed skaters produced more 17α-hydroxyprogesterone after a week of hypoxia stimulation adaptation, which may have a positive stimulation effect on hypothalamus-pituitary-gonadal axis, resulting in an increase in T. Therefore, the stimulation of hypoxia on athletes' T is mainly affected by 17α- hydroxyprogesterone [4]. Another reason may be that hypoxia stimulation causes cerebral cortex excitation. Hypothalamus stimulates anterior pituitary to secrete luteinizing hormone (LH) and follicle-stimulating hormone releasing factor (FSH) by releasing luteinizing hormone releasing factor (LRF) and follicle-stimulating hormone releasing factor (FRF). It promotes testis to secrete and release testosterone [2], increases T concentration in blood, and is conducive to the body's adaptation to hypoxia environment. Some scholars believe that the stimulation generated by simulated hypoxia is different from that generated at high altitude. The stimulation generated by simulated hypoxia is short-lived and does not inhibit the balance between hypothalamus-pituitary-gonadal axis (GnRH), synthetic, and catabolic hormones. The hypoxia stimulation has stopped. Meanwhile, the excitability of cerebral cortex is continuously strengthened due to the decrease of intermittent hypoxia concentration week by week. The activity of pituitary gonadotropin (HPG) enhances the secretion of GnRH by hypothalamus. In addition, the compensatory effect caused by hypoxia has been formed. During the interval of hypoxia stimulation, the formed compensatory effect can be maintained or even strengthened continuously. Therefore, not only does it not cause the decline of body T, but also it promotes the secretion of T, strengthens the anabolism of the body, and improves the exercise ability of the body[5].Secondly, aerobic endurance training is mainly used during hypoxia with little training intensity and no deep stimulation to human body. Finally, athletes have a good diet structure during hypoxia. A good diet structure will stimulate tissue intake of amino acids, promote synthesis of nucleic acids and proteins, and have a positive impact on athletes' anabolism and recovery of body fatigue.

We can prove that moderate and small intensity aerobic endurance training in HiLo environment can keep the male speed skater T at a higher level. Some literatures also concluded that simulating hypoxia environment can improve athletes' T level [4,6-7], but the improvement of athletes' T level through HiLo has not been confirmed from our data analysis.

4.2 Effect of Hilo On Serum Cortisol (C) Of Male Speed Skaters

The study found that compared with before entering the cabin, HiLo's c value increased in the first and second weeks, indicating that the athletes had just entered the hypoxia period. This is because the dual stimulation of hypoxia and training leads to insufficient anabolism and exuberant catabolism in athletes' bodies, which causes excitation of hypothalamus-pituitary-adrenal axis and increases adrenaline secretion of C hormone. The C value of HiLo decreased in the 3rd and 4th

weeks. the contrast between HiLo and before entering the cabin decreased by 25.95%(P<0.01) in the 4th week, and the contrast between groups decreased by 21.5%(P<0.01). The reason may be that the speed skaters adapted to the hypoxic environment and adjusted the nervous system, which inhibited the function of hypothalamus-pituitary-adrenal axis in the hypoxic environment and reduced the release of adrenergic hormone. This indicates that the athletes' functional state improved after hypoxic stimulation. Some studies believe that the effects of normal oxygen and hypoxia on C are different. Under normal oxygen conditions, the changes of C caused by exercise are closely related to the response of adrenocorticotropic hormone (ACTH), which is the main stimulus factor to enhance C secretion. However, under hypoxic conditions, plasma ACTH level will increase, plasma renin activity will increase, while aldosterone release will decrease, which indicates that hypoxic environment may damage adrenal cortex function, restrict adrenocortical enzyme activity, and cause decrease of adrenal blood flow. Adrenal blood flow can independently regulate the release of plasma ACTH and may prevent C secretion [8-12]. During the non-ice period, the coach adjusted the training plan according to the characteristics of the event and the actual situation of the athletes. Aerobic training was the main method, and the intensity of training was not high, which reduced the C of speed skaters.

HiLo and LoLo both went up in the first week after leaving the cabin. This is because the coach adjusted the training load according to the changes in the endocrine index in the fourth week to carry out high-load and high-intensity training. HiLo and LoLo both declined in the second week of departure. This is due to the coach's adjustment of the training plan this week. In the second week of HiLo's departure from the cabin, it decreased by 14.2% (P<0.05). According to some literature, C decreased It is suggested that the physical performance of athletes has been improved through altitude training [13]. The comparison between HiLo and LoLo in the third week of the group revealed that the C values of the two were not significantly different. Therefore, the study believes that HiLo can maintain athlete C for about 2 weeks, which shows that moderate and low-intensity aerobic endurance training in HiLo environment does not cause an imbalance of hormones in the body, but is conducive to the recovery of athletes' physical functions and can speed skaters. C remained for about 2 weeks.

4.3 Effect of Hilo On Serum Testosterone and Cortisol (T/C) Of Male Speed Skaters

Compared with before cabin entry, the T/C ratio of HiLo decreased in the first and second weeks. Firstly, due to hypoxic stimulation, athletes are not suitable for hypoxic environment, which leads to strong catabolism in the body, which makes the body's sugar, fat, and protein Decompose, inhibit the synthesis of protein and fat, and at the same time affected by training factors, athletes have recently undergone aerobic endurance training, resulting in athletes with lower T and higher C. Some studies suggest that [13] athletes need a week of training time during altitude training. Speed skaters in the HiLo environment, T/C is related to the intensity, load, and duration of the load, so it can be passed in training practice. T/C ratio to monitor athletes for overtraining. The T/C ratio of HiLo increased in the 3rd and 4th week. The main reason is that speed skaters have adapted to the hypoxic environment. Hypoxic stimulation has strengthened the protein synthesis ability in the body. The comparison between HiLo in the fourth week and the second week after departure was 46.1% and 23.07% (P <0.01), and the comparison between HiLo in the fourth week increased by 33.3% (P <0.01). The comparison between the groups in the third week of HiLo's departure showed that the T/C ratios were not much different, which indicates that moderate and low-intensity aerobic endurance training in the HiLo environment did not cause an imbalance in the body's synthesis and catabolism.

5 Conclusion

HiLo has no obvious effect on male speed skater T, C is more sensitive to the hypoxic environment, the decline of C causes T/C to rise in the fourth week of hypoxia, the effect of T and C caused by hypoxic environment disappeared in leaving the cabin week 3.

Practical Applications

This study believes that HiLo is beneficial to maintain the stability of athletes' serum testosterone, and HiLo can be beneficial to the decline of athletes' serum cortisol.

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This research belongs to China's key R&D technology topic, and the topic name is "Study on the Impact of Specific Environment on the Biological Characteristics of Winter Event Athletes".

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References

[1] Feng L S,Feng MY, Feng WQ.Youxiu yundongyuan Shentijineng pingdingfangfa [Assessment method of physical function of outstanding athletes].Beijing:Renmin tiyu chubanshe. 2003;34-80.

[2] Qian FLi, Lu QZ, Zeng FH. [Gaoyuanxunlian dui youyongyundongyuan xuejiang gaotong pizhichun he cuxingxian jisu de yingxiang] Effects of altitude training on plasma testosterone cortisol and gonadotropin of swimmers [J]. Tiyukeyan .1993; (01):33-36,30.

[3] Nagel D, Seiler D, Franz H. Biochemical, hematological and endocrinological parameters during repeated intense short-term running in comparison to ultra-long-distance running[J]. International journal of sports medicine.1992; 13(04):337-343.

[4] Yao DW. [Wo guo you xiu su hua yundongyuan IHTde shengli sheng hua ji mianyi jia kong tixi yanjiu] Research on Physiological and Biochemical and Immune Monitoring System of IHT in Excellent Speed Skaters in China [D]. Dongbeishifandaxue. 2013.

[5] Luo RB, Liu WF, Tang CF. [Diyangxunlian dui xiaqiu nao -chuiti -shenshang xian pizhizhou neifenmi xiangguanjisu de yingxiang] Effect of Hypoxic Training on Endocrine Related Hormones in Hypothalamus-Pituitary-Adrenal Cortex Axis [J]. Zhongguozuzhigongchengyanjiuyulinchuangkangfu .2007; (52):10682-10686.

[6] Zhao ZK.Gaozhudixun dui Jilinsheng Suduhuabīng yundongyuan shentijineng zhibiao de yingxiang [Effect of Living High and Training Low on Physical Function Index of Speed Skating Athletes in Jilin Province].Tonghua shifanxueyuan xuebao. 2014;35 (02):130-132.

[7] Yi ZH, Wang G. Gaozhudixunfa duiduandaosuhua youxiuyundongyuan xueqinggaotong ji pizhichun de yingxiang [Effects of Living High and Training Low on Serum Testosterone and Cortisol in Excellent Short Track Speed Skating Athletes]. Bingxueyundong .2011;33 (04): 49-52.

Bouissou P, Peronnet F, Brisson G, et al. Fluid-electrolyte shift and renin-aldosterone responses to exercise under hypoxia[J]. Hormone and metabolic research.1987; 19(07):331-334.

[8] Milledge J S, Catley D M. Renin, aldosterone, and converting enzyme during exercise and acute hypoxia in humans[J]. Journal of applied physiology. 1982;52(2):320-323.

[9] Shigeoka J W, Colice G L, Ramirez G. Effect of normoxemic and hypoxemic exercise on renin and aldosterone[J]. Journal of Applied Physiology.1985;59(1):142-148.

[10] Raff H, Tzankoff S P, Fitzgerald R S. ACTH and cortisol responses to hypoxia in dogs[J]. Journal of Applied Physiology.1981; 51(5):1257-1260.

[11] Urquhart J. Adrenal blood flow and the adrenocortical response to corticotropin[J]. American Journal of Physiology-Legacy Content.1965;209(6):1162-1168.

[12] Bouissou P, Fiet J, Guezennec C Y, et al. Plasma adrenocorticotrophin and cortisol responses

to acute hypoxia at rest and during exercise[J]. European journal of applied physiology and occupational physiology.1988;57(1):110-113.

[13] Feng LS, Hong P, Zong YF, et al. [Gaoyuanxunlian dui nanzizhongzhangpaoyundongyuan xueqingjisu de yingxiang] Effects of Altitude Training on Serum Hormones of Male Middle and Long Distance Runners [J]. Tiyukexue.2000; (04): 49-52,66.