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Effects of tyrosine supplementation ration on anaerobic sports capacity and plasma catecholamine levels in soccer athletes.

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Abstract

Objective: Through laboratory test of anaerobic capacity and related biochemical indexes, the effect of exogenous tyrosine supplementation on human plasma catecholamines and anaerobic sports capacity during 2 w of training was observed.

Methods: 14 students from major of sports training (specialized project soccer) in Beijing Sport University were chosen as subjects and were randomly divided into 2 groups, after taking 2 w of tyrosine and placebo, anaerobic capacity and biochemical testing were conducted, then cleaning for 3 w, and the 2 groups were exchanged what they took and the test was repeated after two weeks.

Results: All peak power (t_{Tyr}=-1.82, P=0.0931; t_{Pla}=0.37, P=0.7173), power drop (t_{Tyr}=-1.87, P=0.0859; t_{Pla}=-1.18, P=0.2596), mean power (t_{Tyr}=-0.15, P=0.8840; t_{Pla}=0.91, P=0.3794) of the anaerobic sports capacity before and after experiment in Tyrosine group (Tyr) and Placebo group (Pla) were not changed; adrenaline (t_{Tyr}=5.46, P=0.0001) concentration after 2 w' intervention in tyrosine group decreased significantly compared with the concentration before taking tyrosine.

Conclusion: The intervention of tyrosine did not affect the anaerobic exercise ability of football players for 2 w, but the concentration of plasma epinephrine decreased significantly.

Keywords: Tyrosine, Catecholamine, Anaerobic sports.

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Introduction

Sports are the physiological stress of the body, so sports will have multiple effects on the body, of which the more important influence is the sports fatigue. Sports fatigue refers to a physiological process while functional ability or work efficiency in body declines so that it cannot maintain a certain level or predetermined sports intensity in the process of sports [1]. As precursor for the synthesis of catecholamine neurotransmitters, tyrosine has an influence on energy metabolism in sports and delaying sports fatigue, eliminating free radical and NO, NOS [2]. It has been shown in related animal experiment that the supplement of exogenous tyrosine increases plasma concentration ratio of tyrosine and tryptophan in rats, thereby increasing the concentration of dopamine in the brain, as well as raising the excitability of the central nervous system, moreover, delaying the occurrence of sports fatigue in the process of sports. During the past ten years, a series of military medical experiments has shown that [3] tyrosine supplementation in plateau environment can effectively improve the subjects' endurance and anti-fatigue ability, but so far, only two articles study about tyrosine supplementation in plain environment has good effect on the sports, and are the effect of taking tyrosine on endurance sports [4,5]. Previous studies focus only on the influence of disposable high dose of tyrosine supplementation ratio on the body of athlete, and study on the impact of taking tyrosine in short and medium term on sports is relatively rare. In this study, a certain dose of tyrosine was added during 2 w' training to observe the effects of tyrosine supplementation on human plasma catecholamine and anaerobic sports capacity through laboratory test of anaerobic sports capacity and other related physiological and biochemical indexes, so as to provide reference for scientific nutrition and monitoring of sport training.

Objects and Methods

Study subjects

14 students from 2010 soccer special class in College of competitive sports, Beijing Sport University were chosen as subjects, who were male and non-smokers with height 176.67 ± 1.26 cm, weight 67.73 ± 1.82 kg, age 19.53 ± 0.22 y old, sports years 4.87 ± 0.61 y, upon inquiry without history of metabolic disease, and were required to participate in the special training courses (1.5 h/time, 5 times/w) with promise of completing the sports test according to the experimental requirements. All the subjects volunteered to participate in the study and were in the full understanding of the experimental content and the process before the experiment with written

signature of informed consent book. Before the experiment began and throughout the experimental period, drugs affecting plasma catecholamines or nutritional supplements were avoided taking.

Research grouping

The randomization, single blind, and crossover design were adopted in the experiment. Before the experiment, the subjects were randomly divided into two groups of A and B, group A was treated with tyrosine capsules (2 g/d) in the first 2 w, group B received placebo capsules (2 g/d) in the first 2 w, and there was no appearance difference between tyrosine capsules and placebo capsules. On the day of initiation of intervention and the ending morning of 2 w' intervention (7:00 AM), fasting venous blood of the subjects was extracted, subsequent anaerobic power test was conducted, and fingertip blood of subjects were collected to measure blood lactic acid, blood glucose, meanwhile, indexes of heart rate as well as cubital vein blood were collected. After 2 w, cleaning for 3 w, groups A and B were exchanged and repeated the previous experimental content, and the experiment lasted for 7 w.

Test indicators

Anaerobic capacity test, heart rate collection and blood indexes test were performed before and after intervention.

Anaerobic capacity test

The international general Wingate Test 30 s test method was adopted for anaerobic capacity test [6], and the Swedish Monark-894E power bicycle (BOSON Company, Lidingo, Swedish) and 7.5% of subject's weight on the same day were used as weight load equivalent. After 3 min of subjects' cycling warm-up without load, they rested quietly for 3 min, followed by a rapid ride to the maximum speed and immediately and manually putting down the load weight, as well as completion of 30 s test with the maximum ability. During the period, the staff constantly gave encouragement and time hints, as well as recorded data in online-computer.

Heart rate collection

SANTO TEAM PACK heart rate monitor (SANTO company, Holland) was used to collect the heart rate at four time points such as rest state (Pre), in post-sports immediate (post-0), post-sports 3 min (post-3 min) and post-sports 6 min (post-6 min) 4 heart rate. Average stable heart rate of 10 s when quiet was got as the heart rate in rest state.

Blood indexes

Fingertip blood was collected to test blood lactic acid and blood glucose indexes of subjects at the four time points of Pre, Post-0, Post-3 min and Post-6 min. The 1500 blood lactate analyzer (YSI Company, Ohio, USA) was used to test blood lactate, blood glucose was tested by using the JOHNSON One Touch Basic Plus portable blood glucose meter (JOHNSON company, New Jersey, USA). After cubital vein blood collected into anticoagulant tube, blood plasma was rapidly centrifuged, separated and placed at -80°C for cryopreservation. Within 2 w after the collection, ELISA kit (IBL Company, Hamburg, Germany) was used for determination of epinephrine, norepinephrine and catecholamine concentration.

Data statistics and analysis

The average number ± Standard Error (mean ± SE) was expressed as experimental data, and statistical software SPSS for Windows 17.0 was used for statistical analysis. The difference of data in the same groups at different time points was analysed by variance with repeated measures and design (GLM repeated measures) (Group X measurement time); multivariate variance analysis (GLM Multivariate) was used for the checkout of data differences in different groups between the same time points. For the differences of corresponding indexes between different groups, test of normality was first conducted for the data, and if the data of compared two groups accorded with the normal distribution, then paired sample t-test was used; if the data did not meet the normal distribution, paired sample signed rank test was adopted. $P<0.05$ was seen as statistical difference, and $P<0.01$ as the result had statistically significant difference.

Results

Test results of anaerobic capacity

As shown in Table 1, there were no differences in various indexes of Wingate Test (peak power, power drop, mean power) between the subjects in Pla group and the Tyr group before and after the intervention.

Table 1. *Changes of the indexes in Wingate test of subjects before and after taking tyrosine.*

Wingate Test	Before intervention		After intervention	
	Pla group	Tyr group	Pla group	Tyr group
Peak power (W)	854.67 ± 40.22	942.25 ± 35.79	911.52 ± 42.15	936.87 ± 42.55
Peak power (W/kg)	14.06 ± 0.40	14.00 ± 0.55	13.45 ± 0.40	13.89 ± 0.56
Power drop (W)	542.09 ± 31.30	695.33 ± 50.00	685.63 ± 43.96	703.71 ± 37.03

Power drop (W/kg)	8.56 ± 0.26	10.44 ± 0.95	10.12 ± 0.55	10.46 ± 0.55
Power drop (W/s)	22.56 ± 1.01	21.19 ± 0.93	22.58 ± 1.44	23.00 ± 1.18
Power drop (W/s/kg)	0.31 ± 0.02	0.31 ± 0.01	0.33 ± 0.02	0.34 ± 0.02
Mean power (W)	528.34 ± 16.61	547.21 ± 19.94	531.21 ± 17.46	533.61 ± 18.31
Mean power (W/kg)	7.86 ± 0.19	8.18 ± 0.45	7.88 ± 0.30	7.97 ± 0.41

*P<0.05, **P<0.01, compared with Pre within group.

Heart rate

As shown in Table 2, there were very significant differences of post-0, post-3 min, post-6 min and pre heart rate before and after the intervention between Pla group and Tyr group, post-0 heart rate of two groups of subjects reached the maximum value, then the subjects' heart rate decreased along with the increasing recovery time, but the Post-3min and Post-6min heart rate was still obviously higher than pre heart rate. There was no difference of heart rate at each time points in Pla group and Tyr group before and after intervention.

Table 2. Changes in heart rate of subjects before and after taking tyrosine during anaerobic capacity test period.

Heart rate (b/min)	Before intervention		After intervention	
	Pla group	Tyr group	Pla group	Tyr group
Pre	76 ± 5	72 ± 4	70 ± 4	72 ± 2
Post-0	167 ± 5**	176 ± 6**	169 ± 5**	171 ± 4**
Post-3 min	115 ± 4**	115 ± 5**	117 ± 1**	115 ± 4**
Post-6 min	102 ± 4**	99 ± 4**	102 ± 1**	99 ± 1**

**P<0.01, compared with Pre within group.

Blood lactic acid

As shown in Table 3, blood lactate concentration at post-0, post-3 min, and post-6 min before and after intervention in Pla group and Tyr group was significantly higher than that at Pre, and blood lactate concentration went up with time increased, at post-6 min, the concentration reached the maximum value of test. But there was no difference in blood lactate concentration at different time points before and after the intervention between respective groups of Pla and Tyr.

Table 3. Changes in blood lactate of subjects before and after taking tyrosine during anaerobic capacity test.

Blood lactate (mmol/l)	Before intervention		After intervention	
	Pla group	Tyr group	Pla group	Tyr group
Pre	4.57 ± 0.64	5.20 ± 1.06	3.70 ± 0.59	3.60 ± 0.55
Post-0	8.07 ± 0.86*	7.47 ± 0.71*	9.19 ± 1.45**	9.70 ± 1.55**
Post-3 min	13.00 ± 1.49**	14.31 ± 1.21**	16.58 ± 1.98**	16.96 ± 1.89**
Post-6 min	17.09 ± 1.35**	16.69 ± 1.72**	17.64 ± 1.96**	17.66 ± 2.16**

Blood glucose

As shown in Table 4, there was no difference in blood glucose concentrations at pre, post-0, post-3 min, and post-6 min before and after intervention between the Pla group and the Tyr group.

Table 4. Changes in blood glucose of subjects before and after taking tyrosine during anaerobic capacity test.

Blood glucose (mmol/l)	Before intervention		After intervention	
	Pla group	Tyr group	Pla group	Tyr group
Pre	5.21 ± 0.20	5.12 ± 0.19	5.44 ± 0.25	5.47 ± 0.29
Post-0	4.92 ± 0.13	5.25 ± 0.24	5.23 ± 0.14	5.13 ± 0.20
Post-3 min	5.16 ± 0.22	5.24 ± 0.23	4.91 ± 0.15	5.01 ± 0.14
Post-6 min	5.18 ± 0.18	5.21 ± 0.25	4.99 ± 0.12	4.90 ± 0.19

Epinephrine

As shown in Table 5, plasma epinephrine concentrations before and after intervention in subjects of Pla group and Tyr group were not changed, and after disposable anaerobic sports, plasma epinephrine concentrations at post-0 in Pla group and Tyr group were significantly increased compared with that at Pre, but there was no difference between the two groups. However, epinephrine concentration at post-0 in Tyr group after the intervention had a significant difference compared with that before intervention.

Table 5. Changes in plasma epinephrine concentrations of subjects before and after intervention.

	Cases (n)	Before intervention		After intervention	
		Pla group	Tyr group	Pla group	Tyr group
Pla group	14	1.77 ± 0.33	3.391 ± 0.27[a]	1.38 ± 0.21	3.48 ± 0.58[a]
Tyr group	14	1.51 ± 0.21	3.59 ± 0.27[a]	1.28 ± 0.17	2.59 ± 0.39[b*]

[a]P<0.01, compared with pre within group; [b]P<0.01, compared with pre within group; *P<0.05, compared with post-0 within group before intervention.

Noradrenaline

As shown in Table 6, there was no significant difference in plasma norepinephrine concentrations at Pre before and after the intervention in Pla group and Tyr group, and after the anaerobic sports capacity test, plasma norepinephrine concentrations at post-0 in Pla group and Tyr group were significantly increased compared with plasma norepinephrine concentrations at pre, but the two groups showed no difference.

Table 6. *Changes in plasma norepinephrine concentrations of subjects before and after intervention (ng/ml).*

	Cases (n)	Before intervention		After intervention	
		Pla group	Tyr group	Pla group	Tyr group
Pla group	14	8.12 ± 0.69	24.71 ± 2.65[a]	6.51 ± 0.51	28.42 ± 3.49[a]
Tyr group	14	8.41 ± 0.69	23.99 ± 2.35[b]	6.63 ± 0.72	19.79 ± 3.52[b]

[a]P<0.01, compared with pre within group; [b]P<0.01, compared with pre within group.

Dopamine

As shown in Table 7, there was no significant change in plasma dopamine concentrations at Pre before and after the intervention in Pla group and Tyr group, and after the anaerobic sports capacity test, plasma dopamine concentrations at post-0 in Pla group and Tyr group were significantly increased compared with that at pre, but the plasma dopamine concentrations between the two groups showed no significant difference after the anaerobic sports capacity test.

Table 7. *Changes in plasma dopamine concentrations of subjects before and after taking tyrosine (ng/ml).*

	Cases (n)	Before intervention		After intervention	
		Pla group	Tyr group	Pla group	Tyr group
Pla group	14	69.12 ± 12.79	107.42 ± 11.39[a]	89.44 ± 13.91	121.39 ± 9.31[a]
Tyr group	14	55.23 ± 5.23	106.21 ± 12.11	78.11 ± 14.97	110.04 ± 9.73[b]

[a]P<0.01, compared with pre within group; [b]P<0.01, compared with pre within group.

Discussion

Our research showed that 2 w of tyrosine intervention did not affect the anaerobic sports capacity of football players, and had no impact on plasma catecholamine concentration of football player at rest, as well as no effect on immediate plasma arterenol and dopamine concentration in football players after anaerobic sports, but plasma epinephrine concentrations decreased significantly.

Effects of tyrosine supplementation on anaerobic sports capacity

The effects of tyrosine supplementation on sports capacity is still controversial [7], and according to the differences in amount of tyrosine supplementation, oxygen demand in sports and temperature, and the results are not the same. Tumilty et al. [5] found that disposable and urgent dose of tyrosine supplementation can improve aerobic sports and cognitive ability of subjects, and after 1 year, however, similar experiment from Watson et al. [8] did not find the raise of aerobic sports and cognitive ability. These experimental results showed that 2 w' tyrosine intervention did not make the three indicators produce statistically significant changes, which was consistent with the experimental results from Sutton et al. [9].

The effect of tyrosine supplementation on heart rate, blood lactate and blood glucose of athletes

The result showed that the heart rate at Pre in Tyr group and Pla group had significant difference with that at post-0, post-3 min, post-6 min, which was consistent with heart rate change law in Wingate test. However, the heart rate at pre, post-0, post-3 min, post-6 min between groups of Pla and Tyr were not significantly different, indicating 2 w of tyrosine supplementation did not affect heart rate at Pre and in anaerobic exercise. There was significant (very significant) differences in blood lactate concentration at pre compared with that at post-0, post-3 min, post-6 min, however, there was no significant difference in blood lactate concentration at the 4 time points of pre, post-0, post-3 min, and post-6 min between the Tyr group and the Pla group. Changes in blood lactate at post-0, post-3 min and post-6 min were consistent with that in anaerobic capacity Wingate test [10], and there was no significant difference in value of blood lactate at the post-3 min and post-6 min. Jianhua et al. [11] reported 15 d' tyrosine intervention (3 g/d) had a reducing function for blood lactate concentrations in power cycling exhaustive exercise in plateau environment, and this experiment is in a plain environment and for the anaerobic exercise, thus the results differed. There was no significant difference in blood glucose values at pre, post-0, post-3 min and post-6 min between Tyr group and Pla group. The time for anaerobic capacity test (Wingate Test) was 30 s, during the experiment, the energy of human body is mainly supplied by anaerobic glycolysis, and thus blood glucose variation may be not large. In tyrosine supplementation endurance tests, blood glucose levels during exercise (0-60 min) showed a decreasing trend, but there was no significant difference before and after exercise. Though this experiment was anaerobic capacity test, the experimental results was consistent with the observation conclusion of long-time sports from Kindermann et al. [7] and Chinevere et al. [12].

Effect of tyrosine supplementation on plasma catecholamine concentration in athletes

The results showed that there was no significant difference in plasma epinephrine concentration and norepinephrine concentration in rest state (Pre) in athletes after 2 w of tyrosine supplementation. In this experiment, the tyrosine supplementation period was 2 w (14 d), 2 g daily, which was not a single acute supplement. And no change in the epinephrine and norepinephrine concentrations at Pre indicated that the added tyrosine did not improve the epinephrine and norepinephrine concentrations of subjects at pre, the possible reasons for which may be: (1) catecholamine has a short halflife, which is usually no more than 10 min [13], and in such a short period of time, epinephrine and norepinephrine in the blood were quickly decomposed into corresponding metabolites of 3-methoxy-4-hydroxy benzene ethylene glycol (MHPG), aromatic mandelic acid (VMA) and homovanillic acid (HVA) going into the urine or may be re ingested and utilized by sympathetic nerve; (2) due to limited conditions, this experiment did not measure concentration of plasma tyrosine, the effect of 2 w' tyrosine intervention on plasma tyrosine concentration is not clear, so far the reports on increase of plasma tyrosine concentration after tyrosine supplementation are mostly in an high altitude or high temperature environment, the report in the plain area and normal temperature is rare, and most reports are conducted with large dose intervention. Sutton et al. [9] reported that after a transient high dose (150 mg/kg BM) of intervention, plasma tyrosine concentration of subjects increased significantly, but plasma epinephrine and norepinephrine concentrations did not produce significant changes. Whether the plateau environment and temporary large dose of intervention are predispositions of rising plasma tyrosine after tyrosine supplementation for rising is inconclusive. The role of tyrosine in stress and its effects at different doses and time conditions should be further studied.

After anaerobic capacity test of athletes, immediate (post-0) plasma epinephrine, norepinephrine concentration increased significantly compared with that in rest state (pre). The previous studies showed that when sports time was the same, stress produced by exercise was proportional to its intensity of exercise; when the exercise forms were the same, the plasma catecholamine concentration was strongly correlated with exercise intensity. Compared to the long time and low intensity aerobic exercise, short time and high intensity anaerobic exercise can stimulate catecholamine neurotransmitter to change in the concentration [14]. However, 2 w of tyrosine intervention did not produce significant changes on plasma norepinephrine concentrations of subjects, and plasma epinephrine concentrations after 2 w' intervention of tyrosine was significantly lower than that before intervention, but there was no significant difference in post-0 plasma epinephrine concentrations between Tyr group and Pla group. Because of no difference in anaerobic exercise capacity before and after intervention between Tyr group and Pla group, therefore, we speculated that 2 w of tyrosine intervention might lead to the increased activity of the adrenergic associated receptor on the postsynaptic membrane, that meant a small concentration of epinephrine could make the postsynaptic membrane excitability and conduction of nerve signals after stress begun [15]. Many previous studies mostly focused on the plasma tyrosine concentration is increased after exogenous tyrosine supplementation, thereby increasing the plasma catecholamine concentration, but did not study the activity of related tyrosine neurotransmitter hormone receptor after intervention of tyrosine, and future research can explore the influence of tyrosine supplementation on the activity of neurotransmitter hormone receptor.

According to the experimental results, plasma dopamine concentration of athletes in rest state before and after taking tyrosine quiet state had no difference. Because the human body posture has a direct impact on catecholamine concentration, sitting position was used for immediate blood sampling in rest state and after exercise in this experiment, thus, effect of vertical position on plasma catecholamine concentration was excluded. For the spirit and emotion of subjects obviously influenced dopamine, ambient temperature and emotional control was strict in this experiment. During the experiment, noise and slapstick were forbidden, during anaerobic test, the entire human laboratory had less than 5 people, and the encouragement for subjects was very consistent. From the experimental results, before and after 2 w' intervention, pre plasma concentrations of dopamine in subjects had no significant changes, suggesting that 2 w' tyrosine intervention did not affect the change of pre concentration of dopamine in subjects. However, high concentrations of dopamine may be one of the causes of anxiety among athletes [16]. In this experiment after the tyrosine intervention, pre plasma epinephrine and norepinephrine concentration did not significantly change, and it was known by the tyrosine metabolism pathway, dopamine transformed into norepinephrine through the catalysis of dopamine β hydroxylase, and norepinephrine transformed into adrenalin through the catalysis of Phenethyl alcohol-N-methyl transferase. Therefore, the 2 w' tyrosine intervention did not alter pre plasma catecholamine concentration of subjects. In the future experiment, plasma catecholamine concentrations could be measured repeatedly during the period of intervention in order to find the peak value of plasma catecholamine changes after tyrosine intervention.

After disposable anaerobic sports capacity test of athletes, immediate plasma dopamine concentrations (post-0) were significantly increased compared with that at pre, but the post-0 concentrations between in Pla group and Tyr group showed no significant difference. The plasma dopamine concentration was closely related to exercise stress, and there was no significant difference in plasma dopamine concentration before and after taking tyrosine, which indicated athletes taking tyrosine did not have opposite effect on exercise stress. Chen [17] reported that before and after tyrosine supplementation, immediate plasma dopamine concentration after aerobic exercise had no difference, although the movement patterns were different, it could be explained that 2 w' tyrosine supplementation did not increase the plasma dopamine concentration, but also did not have a negative impact on exercise stress. Most studies suggested that release and decomposition of dopamine in the brain during exercise was related to exercise intensity, and there was a threshold corresponding to its intensity [18]. The increase or insufficient of synthesis and decomposition metabolism in the process of exercise can both lead to decreased exercise capacity, and the maintenance of metabolic balance contributes to body exercise. However, excessive dopamine release may be a protective response of the brain, and sustained dopamine release may cause the occurrence of brain chemical injury. But a comprehensive study of the previous results of epinephrine and norepinephrine was made and it's not difficult to find out after tyrosine supplementation, in the condition of the same exercise load, exercise stress of athletes was not diminished, the excitability of motor sympathetic nerve may be reduced, thus, in the future, the study on anaerobic load after tyrosine supplementation can be added up. In conclusion, (1) After 2 w' tyrosine supplementation, anaerobic sports capacity of soccer athletes does not change; (2) 2 w' tyrosine supplementation has no effect on Pre plasma catecholamine concentration; (3) 2 w' tyrosine supplementation has no influence on immediate plasma noradrenaline and dopamine concentrations of soccer athletes after anaerobic exercise, but after tyrosine intervention, plasma epinephrine concentration significantly decreased compared to that before intervention.

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