SPORTS METABOLISM IN IMPROVING NATIONAL FITNESS

O METABOLISMO ESPORTIVO E A MELHORA NO PREPARO FÍSICO NACIONAL

EL METABOLISMO DEPORTIVO Y LA MEJORÍA EN EL PREPARO FÍSICO NACIONAL

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ABSTRACT

Introduction: Exercise can invigorate the body's metabolism. There are very few people who know how sports promote people's physical and mental health. How to lead people to participate in physical exercise through sports is a question worth considering. Objective: We explore the effects of sports on human metabolism. Methods: The article analyzes athletes' physical and chemical indicators before and after exercise and during the recovery period. The indicators cover blood routine, urine routine, and blood testosterone content. Results: The blood and urine routines of athletes before and after training are different (P<0.05). After an expressive number of exercises, the urine testosterone content will be different due to the difference in genders (P<0.05). Conclusions: Physical exercise has a very significant impact on human metabolism. The body's hormone levels and metabolism are related to the amount of exercise. ***Level of evidence II; Therapeutic studies - investigation of treatment results.***

Keywords: Sports Performance; Gonadal Steroid Hormones; Basal Metabolism; Exercise Test.

RESUMO

Introdução: o exercício pode fortalecer o metabolismo corporal. Poucas pessoas sabem o quanto o esporte promove a saúde física e mental de indivíduos. Como levar as pessoas a participar em exercícios físicos através dos esportes é uma questão que vale a pena considerar. Objetivo: Explorar os efeitos do esporte no metabolismo humano. Métodos: O artigo analisa indicadores físicos e químicos de atletas antes e depois do exercício e durante o período de recuperação. Os indicadores cobrem testes de sangue, de urina e conteúdo de testosterona no sangue. Resultados: Os resultados dos testes de sangue e urina dos atletas antes e depois de treinar são diferentes (P<0.05). Após muito exercício, o conteúdo de testosterona na urina será diferente devido a diferença entre os sexos (P<0.05). Conclusões: O exercício físico tem um impacto significativo no metabolismo humano. O nível hormonal e o metabolismo do corpo estão relacionados a quantidade de exercício. ***Nível de evidência II; Estudos terapêuticos – investigação de resultados de tratamento.***

Descriptores: *Desempenho Atlético; Hormônios Esteroides Gonadais; Metabolismo Basal; Teste de Esforço.*

RESUMEN

Introducción: El ejercicio puede fortalecer el metabolismo corporal. Pocas personas saben cuánto el deporte promueve la salud física y mental de individuos. Cómo llevar a las personas a participar en ejercicios físicos a través de los deportes es una cuestión que vale la pena considerar. Objetivo: Explorar los efectos del deporte en el metabolismo humano. Métodos: El artículo analiza indicadores físicos y químicos de atletas antes y después del ejercicio y durante el periodo de recuperación. Los indicadores abarcan análisis de sangre, urina y contenido de testosterona en la sangre. Resultados: Los resultados de los análisis de sangre antes y después de entrenar son distintos (P<0.05). Tras mucho ejercicio, el contenido de testosterona en la urina será diferente debido a la diferencia entre los sexos (P<0,05). Conclusiones: El ejercicio físico tiene un impacto significativo en el metabolismo humano. El nivel hormonal y el metabolismo del cuerpo están relacionados a la cantidad de ejercicio. ***Nivel de evidencia II; Estudios terapéuticos – investigación de resultados de tratamiento.***

Descriptores: *Rendimiento Atlético; Hormonas Esteroides Gonadales; Metabolismo Basal; Prueba de Esfuerzo.*

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INTRODUCTION

Studies have shown that testosterone, as the primary male hormone in the body, plays a vital role in sports training. It involves endurance training, strength training, and testosterone reaction at different stages of training, and athletes of different genders also have different reactions to testosterone. Some authors reported increased testosterone levels after strength training in athletes, while others detected a decrease in testosterone levels.[1] This article compares the changes of testosterone and its metabolites in serum and urine of different genders in different exercise levels and exercise. In this way, we hope to understand its outcome mechanism and influencing factors.

METHOD

General information

The subjects of the study were 11 men and 11 women from the Sports Technology College. The male athlete is from a wrestling team [age is (20±1.8) years old, height is (1.6±0.71) m, weight is (62±7.3) kg]. Female athletes from the women's judo team [age: (18±2.8) years old, height

((1.56±0.63) m, weight (50±6.5) kg)]. The above test subjects are healthy and without any heart, liver, and kidney disease.[2] He did not take any hormone drugs or other contraindicated drugs 2 months before the test.

Test procedure

The subjects continued exercise training for 2 weeks. The first week is low-volume training, and the second week is heavy-volume training. High--volume training requires subjects to train for 4 hours a day. The training content includes confrontation, strength training, physical fitness training, etc. During the confrontation training, the subjects' heart rate on the training field is required to reach more than 180 times·min^{-1}. Low-volume training requires subjects to train for 2 to 3 hours a day.[3] In this study, the second training day of the two training weeks was selected as the study content, and the following day after training was used as the recovery period.

Specimen collection

Retention of blood samples

On the second day of the short exercise week, 5ml of venous blood was drawn from the subjects in the early morning, after training, and the following day (recovery period). The serum is naturally coagulated and separated at room temperature and stored at -20°C for later use.

Retention of urine specimens

We instructed the subjects to collect 30ml of urine samples from the early morning of the training day, after the training, and the following day on the second day of the short exercise week.[4] The subjects were asked to empty their bladder before training.

Specimen testing

The concentrations of serum testosterone (T), free testosterone (FT), and 17-OH progesterone (17-OHP) all use I125-labeled radioimmunoassay. We put it on the GC-911γ counter produced in Hefei for measurement. The determination of various hormones is completed at one time. The average inter-assay coefficient of variation was 10.47%. The average error response coefficient is 5.34%. The above kits all come with quality control serum. Urinary testosterone (T), epitestosterone (epit), Pancho androsterone (an), 11-hydroxy androsterone (11-Han), 11-hydroxy benzyl androsterone (11-Ohetio), 5α androstenediol (5α) and 5β androstenediol (5β) were all determined by GC-MS on HP5890 and HP5971GC-MS produced in the United States. The chromatographic column is the HP-1 (17m×0.22mm×0.11μm) column. The carrier gas is helium. The column flow rate is 1ml·min^{-1}. The total flow rate is 10ml·min^{-1}. The entire running time is 17 minutes. The paper uses the Sim method for testing. We integrate the measured characteristic ion peaks.[5]

Data processing

The obtained data is calculated, sorted, and counted using Excel spreadsheets on IBM-PC. All data is represented by $\bar{x} \pm s$. We used a t-test for significance analysis.

According to the directional characteristics in motion, we have established a dual-target data acquisition algorithm model. The coordinate system O_1 in the system model is the pole. The X_1 direction is the positive direction of the polar angle. Θ_1 and Θ_2 are the angles formed by the Y_1 and X_1 sides, respectively. O_2 is the pole. The X_2 direction is the positive direction of the polar angle. Θ_3 and Θ_4 are the angles formed by the Y_2 and X_2sides, respectively.[6] In this way, we can use the polar coordinate equation $f(r, \Theta)$ to establish the mathematical relationship of the two-object hoof of the motion system. Where r is the emotional distance between points O_1 and O_2 in the system function $f(r, \Theta)$. The constructor $f(x, r)$ is

$$\begin{cases} x = X_1 + r\cos(\theta k + \arctan(\frac{Y_2}{X_2}) + \theta_4) \\ y = Y_1 + r\sin(\theta k + \arctan(\frac{Y_2}{X_2}) + \theta_3) \end{cases} \quad \theta 1 \le \theta k \le \theta 2 \qquad (1)$$

We propose a DCT variation simulation of the direction. Since DCT is based on discrete points, we use a rounding function for equation (1).

$$\begin{cases} x = X_1 + r\cos\left|\theta k + \arctan(\frac{Y_2}{X_2}) + \theta_4\right| \\ y = Y_1 + r\sin\left|\theta k + \arctan(\frac{Y_2}{X_2}) + \theta_3\right| \end{cases} \quad \theta 1 \le \theta k \le \theta 2 \qquad (2)$$

In this way, we discretize the points on a particular ray into integer points. We assume that the total number of points after discretization is N, then we can use a linear function $g_1(r_k, \Theta)$ to represent these discrete points.[7] The subscript k represents the $k+1$ discrete point. We get the DCT of a particular ray $g_1(r_k, \Theta)$:

$$G_1(Rk,\theta) = Fr(g_1(r_k,\theta)) = Ck\sum_{k=0}^{N-1} g_1(r_k,\theta)\cos\frac{(2k+1)Rk\pi}{2N} \qquad (3)$$

Among them,

$$Ck = \begin{cases} \frac{1}{\sqrt{N}} & k = 0 \\ \sqrt{\frac{2}{N}} & k \ne 0 \end{cases} \qquad (4)$$

Similarly, we can get the formula for the inverse transformation as

$$g_1(r_k,\theta) = Fr^{-1}(G_1(Rk,\theta) = \frac{1}{\sqrt{N}}G_1(r0,\theta) + \sqrt{\frac{2}{N}}\sum_{k=1}^{N-1} G_1(Rk,\theta)\cos\frac{(2k+1)Rk\pi}{2N} \qquad (5)$$

According to the arc of motion direction, we propose the direction DCT along the direction of the arc.[8] Similarly, we establish a system for the coordinate system and use the rounding function:

$$\begin{cases} x_2 = X_2 + \left|r\cos\theta k\right| \\ y_2 = Y_2 + \left|r\sin\theta k\right| \end{cases} \theta_3 \le \theta k \le \theta_4 \qquad (6)$$

RESULTS

Changes in blood hormone concentration of male and female athletes

As shown in Table 1 and Table 2, the 17OHP of female athletes increased significantly after training in the week of small exercise (P<0.05), while the level of the three hormones decreased in the week of extensive exercise (P<0.01). Interestingly, the hormone levels on the second day after exercise during the recovery period change in the opposite

Table 1. Changes in blood hormone levels of male athletes before, after, and during the recovery period of different amounts of exercise.

	T(ng·dl^{-1})	FT (ng·mm^{-1})	17OHP (ng·mm^{-1})
Small exercise			
Before training	474.99±203.35	13.90±4.90	0.81±0.50
After training	434.73±152.43	17.26±8.82	1.02±1.08
Recovery period	453.61±219.55	15.81±7.16	1.11±0.84
Heavy exercise			
Before training	465.42±138.23	16.35±4.68	1.04±0.74
After training	485.07±173.97	16.12±6.31	1.02±0.86
Recovery period	475.50±124.06	16.83±2.93	0.98±0.86

direction.[9] In male athletes, the level of hormones during the week of heavy exercise does not change significantly, while hormones of the week of small exercise show an upward trend.

The impact of exercise on the level of hormones in the urine of male and female athletes

As shown in Table 3 and Table 4, the changes of endogenous hormone excretion in the urine of male and female athletes do not respond to the amount of exercise. Female athletes have different responses to hormones in the urine after training for large and small exercises. Small exercise training can significantly reduce the excretion of etio, 5α, 5β, epit, T, and 11-OHetio in the urine.[10] However, high-volume training can cause a significant increase in urine excretion of an, 5α, 5β, and 11-OHan (all $P<0.05$). Male athletes have the same response to the amount of exercise. Small exercise training can significantly increase the urine's excretion of an, 5α, 5β, T11-OHan and 11-OHetio. However, high-volume training can cause a significant increase in urine excretion of an, etio, epit, 11-OHan, and 11-OHetio (all $P<0.05$).

Table 2. Changes in blood hormone levels of female athletes before, after, and during the recovery period of different amounts of exercise.

	T(ng·dl^{-1})	FT (ng·mm^{-1})	17OHP (ng·mm^{-1})
Small exercise			
Before training	30.22±14.36	1.47±0.85	0.65±0.48
After training	36.39±14.01	1.57±0.72	1.19±0.89
Recovery period	28.93±14.82	1.27±0.72	0.89±1.12
Heavy exercise			
Before training	40.88±30.60	1.27±0.84	1.89±2.56
After training	26.60±11.62	1.11±0.63	0.86±1.06
Recovery period	49.92±30.23	1.67±0.82	1.33±1.21

Table 3. Changes in urine hormone excretion of female athletes before, after and during the recovery period of different amounts of exercise.

	an	etio	5α	5β
Small exercise				
Before training	1598.78±1512.07	2208.6±1945.6	61.99±61.15	137.45±154.12
After training	1634.36±980.46	1574.55±1132.3	39.25±12.61	71.26±52.25
Recovery period	1202.44±766.25	1667.55±1156.5	49.15±42.14	104.11±96.21
Heavy exercise				
Before training	809.05±754.21	3884.65±1534.12	26.45±22.92	26.42±23.21
After training	1072.24±651.2	1134.10±692.24	36.36±15.21	43.94±38.12
Recovery period	1217.38±749.4	1342.00±854.32	42.46±27.85	99.26±117.12
Small exercise	epit	T	11-OHan	11-OHetio
Before training				
After training	15.81±12.54	4.71±2.54	1266.40±1082.99	535.64±500.06
Recovery period	10.24±5.26	2.75±3.45	1415.12±814.99	404.84±252.26
Heavy exercise	10.15±5.11	4.06±3.12	915.98±615.11	471.15±305.14
Before training				
After training	8.12±10.64	1.42±1.82	633.24±356.25	245.15±220.21
Recovery period	6.35±4.92	1.21±1.06	993.25±662.12	282.54±214.56
	7.25±5.33	1.62±1.11	935.92±851.14	154.15±854.12

DISCUSSION

Testosterone is very closely related to sports training. Exercise on blood hormones is related to exercise intensity, exercise volume, and the muscles involved in exercise.[11] This result shows that low-volume training mainly improves testosterone in the body. In the heavy exercise week, female athletes showed a downward trend in the levels of three hormones, especially 17-OHP ($P<0.001$). The levels of the three hormones in male athletes did not decrease significantly. This shows that male and female athletes have different responses to considerable sports training. Female athletes have more intense reactions. This article discusses the changing law of FT and T affected by exercise. There are inevitable fluctuations in FT/T before, after, and during the recovery period of different exercises. But there was no statistical difference. This shows that there is a dynamic balance between FT and T in sports training. Exercise has a particular effect on T and FT but has no pronounced effect on the FT/T ratio.

Table 4. Changes in urine hormone excretion of male athletes before, after and during the recovery period of different exercise amounts.

	an	etio	5α	5β
Small exercise				
Before training	1566.76±1512.27	2226.6±1645.6	61.66±61.15	137.45±154.12
After training	1634.36±662.46	1574.55±1132.3	36.25±12.61	71.26±52.25
Recovery period	1222.44±766.25	1667.55±1156.5	46.15±42.14	124.11±66.21
Heavy exercise				
Before training	626.25±754.21	3664.65±1534.12	26.45±22.62	26.42±23.21
After training	1272.24±651.2	1134.12±662.24	36.36±15.21	43.64±36.12
Recovery period	1217.36±746.4	1342.22±654.32	42.46±27.65	66.26±117.12
Small exercise	epit	T	11-OHan	11-OHetio
Before training				
After training	15.61±12.54	4.71±2.54	1266.42±1262.66	535.64±522.26
Recovery period	12.24±5.26	2.75±3.45	1415.12±614.66	424.64±252.26
Heavy exercise	12.15±5.11	4.26±3.12	615.66±615.11	471.15±325.14
Before training				
After training	6.12±12.64	1.42±1.62	633.24±356.25	245.15±222.21
Recovery period	6.35±4.62	1.21±1.26	663.25±662.12	262.54±214.56
	7.25±5.33	1.62±1.11	635.62±651.14	154.15±654.12

The effects of exercise on the metabolism and metabolites of testosterone in urine are rarely reported at home and abroad. Some scholars have found that with the growth of puberty, T and Epit in urine increase. Some scholars have found that long-term treatment with larger doses of exogenous testosterone will cause urine testosterone and metabolites (an, etio, 5α, and 5β, etc.) to increase, and urine epitestosterone to decrease. This study found that the level of urinary hormones varies significantly among individual male athletes. After exercise, the hormones increase, and the recovery period decreases.[12] The changes in blood and urine hormone levels of female athletes after sports training are different from that of male athletes. In the former, the metabolites of testosterone in the urine decreased after low-volume training, but most of the metabolites in the urine increased after heavy-volume training.[13] This may be because the tissues take up more and then undergo catabolism in the tissues. Therefore, it is believed that the testosterone excreted directly from the urine is not the main one.

CONCLUSION

In short, the mechanism of how exercise affects the body's male hormones is restricted by many factors. The results show that different exercise levels may cause different response levels in the body's endocrine system. High-volume training has a more robust response to the body. At the same time, there are apparent differences between male and female athletes.

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