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Impacts of Androgen Abuse and Overtraining on Endocrine Profile in Bodybuilders

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Abstract

Abuse of androgens and overtraining expose bodybuilders to multifactorial stress influences related to endocrine activity. Endocrine responses in 23 bodybuilder athletes were investigated after a strength training period, during which they were taking high doses of androgenic-anabolic steroids. Serum concentrations of TSH, T3, and T4 were unchanged significantly. Serum LH and FSH concentrations decreased dramatically ($P<0.05$). In addition, low mean concentration of serum testosterone was recorded, with more substantial reduction in participants of elder ages. The multiple regression model used in this analysis supported this inference. On the other hand, a positive association was observed between levels of blood lipids (total cholesterol, triglyceride) and the outcome predictor (mean serum testosterone level). The results also suggested a negative correlation between testosterone level and each of age and HDL level. The current study shows that excessive bodybuilding exercise has an impact on the hypothalamic–pituitary–thyroid (HPT) axis in top-level athletes. Also, simultaneous usage of anabolic steroids induces extreme shifts in the hypothalamic-pituitary–gonadal (HPGA) axis, which is reflected as changes in testosterone level, development of the overtraining syndrome, and adverse influences on hormonal control.

Keywords: Androgens, Bodybuilders athletes, Testosterone hormones, Thyroid hormone, Follicle-stimulating hormone Luteinizing Hormone.

تأثير إساءة استخدام الأندروجينات والإفراط في التدريب على مستوى الغدد الصماء لدى لاعبي كمال الأجسام

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الخلاصة:

يؤثر تعاطي الأندروجينات والإفراط في التدريب على التعرض للإجهاد متعدد العوامل على نشاط الغدد الصماء لدى الرياضيين لاعبي كمال الأجسام. تم التحقيق في استجابات الغدد الصماء في 23 شخص يمارس رياضة كمال الأجسام بعد فترة تدريب القوة ، عندما كان لاعبو كمال الأجسام يأخذون جرعات عالية من المنشطات الأندروجين الابتدائية . تركيزات مصل TSH و T3 و T4 لم تتغير ($p>0.05$) بين مجموعة

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لاعبي كمال الاجسام من مجموعة السيطرة (غير الرياضيين) . بينما انخفضت تركيزات مصل كل من LH و FSH و بشكل كبير لدى لاعبي كمال الاجسام عند المقارنة مع مجموعة السيطرة بالإضافة الى فإن لاعبي كمال الأجسام لديهم تركيز منخفض من هرمون التستوستيرون في الدم ، بالإضافة إلى انخفاض كبير للغاية في مستويات هرمون التستوستيرون عند التقدم بالعمر. دعم نموذج الانحدار المتعدد المستخدم في هذا التحليل هذا الاستنتاج. من ناحية أخرى ، لوحظ ارتباط إيجابي بين (الكوليسترول الكلي ، الدهون الثلاثية) ومتنبئ النتائج (متوسط مستوى هرمون التستوستيرون في الدم) ، مما يشير إلى وجود علاقة سلبية بين كل (العمر ، HDL) ومستوى هرمون التستوستيرون في الدم. تظهر الدراسات الحالية أن التعرض المفرط لتمارين كمال الأجسام له تأثير على محور الغدة الدرقية – الغدة النخامية – الغدة الدرقية لدى الرياضيين من المستوى الأعلى (HPT). يؤدي الاستخدام المتزامن للستيرويد آت الابتدائية إلى تحولات شديدة في المحور الوطائي – النخامي – الغدد التناسلية (HPGA) ، مما يعكس هرمون التستوستيرون ومتلازمة الإفراط في التدريب ويؤثر سلبًا على التحكم في الهرمونات.

Introduction

Exercise has been found to affect the function of multiple glands as well as the development of their hormones [1]. Gonadotropes in the anterior pituitary gland manufacture and release hormones called follicle-stimulating hormone (FSH) and luteinizing hormone (LH) [2]. In addition, both triiodothyronine (T3) and thyroxine (T4) are thyroid hormones, with the former playing a number of essential functions in metabolism, heart rate, digestion, muscle control, brain function and development, and bone health [3]. Hormonal balance under stress has been shown to be affected by a variety of factors, including training load and dietary deficiencies [4-6]. The impact of long-term physical exercise on hormonal response in athletes has been well documented. Low testosterone, FSH , and LH levels, as well as elevated levels of thyroid hormone-binding proteins have been related to these symptoms in the HPGA and HPT axes [4,7]. Overtraining is well-known to be associated with testosterone deficiency [4]. Cortisol levels have been linked to low testosterone levels in over trained athletes. In addition, overtraining has been shown to suppress testosterone output in men [8]. Resistance exercise can temporarily increase testosterone and has an effect on fat distribution in women [9]. The regular exercise raises testosterone levels more than weight loss, according to Kumagai's survey on obese men [10].

Bodybuilders use a variety of tools, including dietary supplements and anabolic-androgenic steroids (AASs), in addition to exercise and nutrition, to achieve their optimal body structure [11-13]. Androgenic hormones, such as testosterone derivatives, are known as AASs. Supraphysiological testosterone increases stimulate protein synthesis, which leads to increased muscle size, density, and strength [14]. However, it has been clinically proven that it leads them to elevated acne, fluid accumulation, and an increase in androgenic hormones, which increases breast size and the risk of breast cancer. It also leads to reduced testicle size and sperm count, as well as neurological problems in men and menstrual irregularities, clitoromegaly, and masculinization in women [15]. Very limited data on endocrine profiles in bodybuilders are published. The aim of the study is to examine these differences in endocrine profiles in more detail and to interpret some of the findings.

Materials and methods

Subjects

Twenty-three male bodybuilders (23.00 ±1.78 years old; 174.36 ± 6.24 cm height; 66.58 ± 5.76 kg weight) from Diyala province, east Iraq, were selected as a treatment group. They started to practice bodybuilding for approximately four years from the date of conducting the research, and the time elapsed for their use of androgens was approximately 2.5-3 years. Fifteen male healthy age-matched, non-smoker, non-drinker individuals (22.00 ±1.98 years; (176.36±4.21cm height; 68.50±4.56 kg weight) served as a control group.

Venipuncture with 5 ml plastic syringes was used to extract fasting blood samples in a resting state.The blood was allowed to to clot at room temperature and centrifuged for 15 minutes at 3000 rpm. All serum aliquots were arranged in duplicates for the estimation of cholesterol [16], triglyceride[17], and high density lipoprotein [18] by enzymatic methods. Friedewald's formula was used to calculated levels of low density lipoprotein and very low density lipoprotein [19]. In addition, levels of total testosterone [20], triiodo- thyronine, thyroxin, thyroid stimulating hormone[21], luteinizing hormone [22], and follicle stimulating hormone [23] were measured using the enzyme-linked immunosorbent assay (ELISA). All measurements within the experiments were made in the laboratories of the College of Science / University of Diyala.

Statistical analysis

Data were expressed as mean ± SE. The differences in groups were determined by performing Pearson chi-square statistic test and one-way analysis of variance (ANOVA). The differences with a *p-value* $\leq$ *0.05* were considered to be statistically significant. Multiple regression models were used to study the independent and net effects of a set of independent (explanatory) variables on the response (dependent or outcome) variable.

Results and Discussion

Table 1clearly shows non-significant differences in the serum levels of both T4 and TSH between the bodybuilder athletes (90.18±4.31 and 95.28±6.97, respectively) and the control group (2.06±.20 and 2.70±0.32, respectively).However, T3 level was significantly different ($p \leq 0.05$) between the bodybuilder athletes (1.70±0.06) and control group(2.54±0.15).

Table 1- Distribution of mean levels of thyroid hormones in bodybuilder athletes and control group

Parameter	Mean ± SE		*p-value*
	bodybuilder athletes	Control group	
T3(nmole/L)	1.70±0.06	2.54±0.15	0.0001
T4(nmole/L)	90.18±4.31	95.28±6.97	0.570
TSH(µIU/I)	2.06±.20	2.70±.32	0.367

Exercise is described as a form of physical stress that is accompanied by a series of physiological changes to counteract the impact on endocrine and metabolic processes [24]. The impact of exercise on thyroid function is debatable. However, this impact tends to depend on the intensity and length of the workout [25]. Our results are in agreement with those of Pakarinen *et al.* (1988) who observed no change in T3 after resistance exercise. On the other hand, the current results are not in harmony with another study that showed a substantial decrease in the levels of bound and free T4 [26]. During resistance exercise, Simsch *et al.* (2002) observed a drop in free T3 and TSH levels, but no substantial change in T4 [27]. Pakarinen *et al.* (1991) observed a substantial decline in T3, T4, and TSH in advanced weightlifters after a week of concentrated resistance exercise (two sessions per day) [28]. Similarly, after a week of intense strength training (two sessions per day), professional weightlifters showed a substantial drop in T3, T4, and TSH, according to Alen *et al.* (1993) [29]. Resistance exercise has been found to be pretentious to thyroid function [30].

Table 2 shows a significant decrease in the baseline FSH and testosterone levels in bodybuilder athletes when compared with the control group ($p < 0.0001$). At the same time, LH level was found to be significantly decreased in bodybuilder athletes than the control group.

Table 2- Distribution of mean serum levels of gonadotropin hormones in bodybuilder athletes and control groups

Parameter	Mean± SE		*p-value*
	Bodybuilder athletes	**Control group**	
FSH(mIU/mL)	3.02±.34	5.85±.14	0.001
LH(mIU/mL)	5.96±.76	8.78±.57	0.007
Testosterone (ng/ml)	1.03±.10	5.48±.23	0.001

These results are similar to the observations of a number of other investigators. Mandal *et al.* (2010) showed that exercise, both acute and chronic, is linked to suppressed endocrine functions in the hypothalamus and testes, primarily the suppression of gonadotropin-releasing hormone (GnRH) and serum testosterone [31]. Walker and Cheng (2005) stated that exogenous hormones are also believed to suppress the synthesis of gonadotropin-releasing hormone, which in turn inhibits the release of luteinizing hormones and, as a result, testosterone development [32]. Parkinson and Evans (2006) also confirmed, by an animal model analysis conducted in India, the harmful effects on testes triggered by intraperitoneal injection of AAS. In addition, adverse improvements in the seminiferous epithelium of the testes and tubular diameter reduction were reported, resulting in lower pituitary gonadotropin (LH and FSH) and serum testosterone levels [33].

These symptoms are caused by the fact that elevated doses of AAS derivatives trigger negative feedback on the hypothalamic pituitary axis, lowering LH and FSH secretion. The activity of intratesticular testosterone and FSH on Sertoli cells is needed for spermatogenesis. Only Sertoli cells in the seminiferous tubules have FSH and testosterone receptors. When FSH binds to FSH receptors on these cells, it activates a cascade of signaling pathways that work in tandem with testosterone to boost spermatogenesis and fertility [34]. To show the net and independent effects of a set of explanatory variables on baseline serum testosterone level, multiple linear regression model was used [35]. The multiple linear regression equation used in this model is:

$$yi = \beta 0 + \beta 1xi1 + \beta 2xi2 + \ldots + \beta pxip + \epsilon$$

In the first step, all the possible explanatory variables were entered in the model and the resulting equation is shown in Table 3. A positive correlation was observed between the serum levels of FSH, total cholesterol, triglyceride and the outcome variable (testosterone). A negative correlation was observed between HDL level, age, and mean serum testosterone level. The resulting differences obtained from the equation were statistically significant ($P<0.05$) and explained 0.99% of the observed variation in the dependent variable.

To recover their athletic performance, some athletes take anabolic steroids, which are synthetic versions of testosterone [36]. Anabolic steroid use has been connected to a variety of negative consequences, including an elevated risk of cardiovascular disease [37]. Cross-sectional results support the hypothesis that anabolic steroids use in athletes lowers HDL-C and raises LDL-C levels in the blood [38], and this may be linked to acute myocardial infarction [39] or ischemic stroke [40]. There is, still, no long-term research on the effects of anabolic steroids on lipids.

Table 3-Multiple linear regression equation with testosterone level as the dependent variable and the studied independent variables

Model	Unstandardized Coefficients		Standardized Coefficients	Sig.	Correlations		
	B*	Std. Error	**β**		Zero-order	Partial	Part
Age (years)	-.007	0.007	-0.10	0.03	0.01	-0.72	-0.03
T3(nmole/L)	1.52	0.39	1.08	0.16	-0.01	0.96	0.14
T4(nmole/L)	0.004	0.002	0.18	0.28	0.38	0.90	0.07
TSH(µIU/I)	0.28	0.07	0.72	0.15	-0.26	0.97	0.14
FSH(mIU/mL)	0.53	0.07	2.25	0.05	0.35	0.99	0.25
LH(mIU/mL)	0.06	0.01	0.56	0.13	0.65	0.97	0.16
Cholesterol	0.013	0.002	1.00	0.01	0.27	0.98	0.20
Triglyceride	-0.009	0.001	1.04	0.05	0.43	0.98	0.19
HDL	0.04	0.009	-1.45	0.01	0.16	-0.99	-0.44
LDL	0.74	0.13	0.39	0.11	0.17	0.98	0.19
VLDL	0.02	0.01	0.55	0.31	-.53	0.87	0.06
HDL, High-density lipoprotein; LDL, Low-density lipoprotein, VLDL, Very-low density lipoprotein, Sig., significance.							

**β :Regression coefficients; P(model) <0.05;R^2 = 0.99;*

Conclusion

The current study shows that excessive bodybuilding exercise has an impact on the HPT axis in top-level athletes. Simultaneous application of anabolic steroids induces major changes in the HPGA axis which regulates testosterone.

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