Effects of Resistance Training on Female Reproductive Hormones

Direnç Antrenmanlarının Kadın Üreme Hormonlarına Etkisi

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ABSTRACT Objective: The aim of this study was to determine the effects of resistance training on the reproductive hormone levels of female athletes. **Material and Methods:** Forty female athletes from university students have voluntarily participated in this study. At the beginning of the study blood samples were obtained from the control and the experimental groups to determine the hormone levels (n=40). Resistance training was performed by the experimental group (n=20) 3 times a week for 12 weeks. Resistance training exercise consists of 9 stations of exercise with fixed machines and free weights exercise. At the end of the study subjects' hormone profiles were measured and compared with those of control groups' and their pre-test results. Blood samples were tested according to Micro Eliza procedure for hormone levels. **Results:** There was a statistically significant increase in Prolactin levels of experimental group after a 12-week training (p=0.02). **Conclusion:** 12-week resistance training altered the hormonal profiles of active female Physical Education and Sports Department students. As a conclusion; considering the significant increase in prolactin levels, athletic amenorrhea may be explained by hyperprolactinemia together with other reasons like decrease in body fat, excessive energy expenditure and psychological stress.

Key Words: Weight training; athletic amenorea; female athletes; hormones

ÖZET Amaç: Bu çalışmanın amacı, on iki haftalık direnç antrenmanlarının kadın üreme hormonları üzerine etkisini belirlemekti. **Gereç ve Yöntemler:** Çalışmaya üniversite öğrencisi 40 kadın sporcu gönüllü olarak katıldı. Deney ve kontrol gruplarından çalışmanın başlangıcında hormon profillerini belirlemek amacı ile kan örnekleri alındı (n=40). Deney grubu (n=20) tarafından 12 hafta süre ile haftada üç kez olmak üzere direnç antrenmanları uygulandı. Direnç antrenmanları sabit makine ve serbest ağırlıklarla yapılan toplam 9 egzersizden oluşmaktaydı. Çalışmanın sonunda katılımcıların hormon değerleri tekrar ölçüldü ve sonuçlar her grubun test öncesi sonuçları ve kontrol grubunun değerleri ile karşılaştırıldı. Kan örnekleri Mikro Eliza yöntemi ile test edilerek hormon değerleri belirlendi. **Bulgular:** 12 haftalık direnç antrenmanı sonucunda prolaktin seviyesinde anlamlı bir değişiklik gözlenmiştir (p=0.02). **Sonuç:** 12 haftalık direnç antrenmanı kadın Beden Eğitimi ve Spor Yüksekokulu öğrencilerinin hormonlarında değişikliklere yol açmıştır. Sonuç olarak; prolactin seviyesindeki anlamlı artış gözönünde bulundurulduğunda, düşük yağ yüzdesi, yoğun enerji harcaması ve psikolojik sebepler ile beraber hiperprolaktinemi atletik amenore'nin sebeplerinden biri sayılabilir

Anahtar Kelimeler: Ağırlık antrenmanı; atletik amenore; kadın sporcu; hormon

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The effects of exercise on female organism have been examined in detail recently. As the number of female athletes increased, studies investigating their physiological response to acute and chronic exercise

diversified. These researches not only aim to develop the performance of athletes but also to help the preventions and treatments of some illnesses like osteoporosis and anorexia.[1] The effects of different types of exercises on female physiology are not restricted with physical appearance or cardio respiratory fitness, they also have some important influences on other parameters like hormones and reproductivety.[2,3]

Females are nowadays increasingly becoming active participants in competitive and recreational sports activities. As the number of women participating in heavy training programs increases, physicians have started to receive more complaints about menstrual disturbance and secondary amenorrhea which are considered as the indirect effects of exercise on endocrine system.[4-6]

There is no doubt that the indecent of menstrual irregularities among women athletes is much greater than general population.[7-9] Numbers of theories have been proposed to explain why these menstrual irregularities occur. The four most frequently cited theories are; decrease in body fat, excessive energy expenditure, and psychological stress, acute and chronic hormonal changes resulting from intense exercise.

The major system that regulates the most of the activities and reactions in human organism is the endocrine system.[10] The endocrine system is the control system which has mainly three functions: First, it helps to maintain homeostasis by regulating activities such as the concentrations of chemicals in body fluids, and the metabolism of proteins, lipids, and carbohydrates. Second, its secretion act is concerned with the nervous system to help body react to stress properly. Third, it is the major regulator of growth and development, including sexual development and reproduction.

It has been known that resistance training results in muscle tissue growth and strength development and it also provides stimulation that activate neuro-endocrine system.[11] Traditionally resistance training was performed by limited number of people such as bodybuilders. But in the last few decades, its popularity has grown for its contribution to the improvement of power, speed, muscular endurance, motor performance, balance and coordination.[12] Type and duration of training is related with its effect on the athlete metabolism. Meanwhile athletes' sex, age, exercise history, age of onset of training may alter effects and results.

The aim of this study was to investigate the effects of 12-week resistance training on female sex hormones. The results of this study will provide the broad information on hormonal alteration and athletic amenorrhea that may result due to resistance training.

MATERIAL AND METHODS

SUBJECTS

The study involved 40 female students from the School of Physical Education and Sports. Subjects were physically active females between the ages of 18-22 years. The average age of participants was 19.9±.98 years. The nature, the purpose and the possible risk of the study were explained to the subjects. Informed consent was obtained from all subjects prior to study the voluntary contest forms were signed by the subjects and the procedures applied during the tests were in accordance with the ethical standards of the revised 2008 Helsinki Declaration.

Subjects were randomly divided into two groups as experimental (n=20) and control (n=20) groups. All of the subjects had regular menstrual cycle and none of them used oral contraceptives or some ergogenic. Both control and experimental groups continued their daily activities and consumed regular diet throughout the study.

DATA ACQUISITION

At the beginning of the study weight, height, body mass index and body compositions of the participants were calculated. In order to determine the body compositions of the subjects, *suprailliac* skinfolds and *quadriceps* skinfolds were measured. Body fat ratio was determined using "Pollock Formula".[13] In this investigation, prior to the initiation of the training period, blood samples were obtained from all subjects in the follicular phase of their

menstrual cycle. Blood samples were obtained from the antecubital vein and serum were separated by centrifugation at 5000 rpm and stored in -80 C in a deep-freeze until testing.

Second blood samples were obtained during the first follicular phase following the end of the 12-week training program. The subjects kept on training until the first day of next follicular phase and blood samples were taken at 3rd to 5th days of the phase.

At the end of training period, anthropometric measurements were repeated.

TRAINING PROCEDURE

The experimental group practiced resistance training 3 times a week for 12 weeks. The training program started just after the blood samples were obtained for pre-test and continued for 12 weeks until the end of their menstruation period. Resistance training exercise consists of 9 stations of exercise with fixed machines and free weights exercise (Table 1).

At the preparation phase of the investigation the maximum load that subjects could lift was determined for each exercise. Medium weight was calculated and subjects started their training with this load (30% 1RM [14]). After every 4 weeks of training period, maximum loads were determined again and exercise weight was increased by subjects according to their progress.

This exercise aimed at improving the power under conditions of enhancing maximum strength as the numbers of repetitions for per set were 6-10.[14]Rest intervals between sets were 2 minutes and it was assumed that the heart rate would never drop under 120 beats per minute and rhythm of performance was explosive. Furthermore, the daily training methods were as follows;

30%10 + 40% 10 + 50% 10 + 40%10

First set was performed with 30% of maximum, second set was performed with 40% of maximum, third set was performed with 50% of maximum and fourth and the last set of training was performed with %40 of maximum.

TABLE 1: Daily training program of experimental group.

Types of Exercise	Number of Repetitions	Number of Sets
Squat	10	4
Leg-extension	10	4
Leg-curl	10	4
Bench press	10	4
Shoulder press	10	4
Lat-pull down	10	4
Arm curl	10	4
Triceps press	10	4
Sits-up	20	4

LABORATORY STUDIES

Blood samples were studied according to Micro Eliza test procedure. CERES 900 microeliza device was used for this study. This device has two main processors; a computer (PC/AT) and a spectrophometer. All the data collected from the sensors of the spectrophometer was evaluated and calculated via computer. Spectrophometer performs measurements by its optical sensor, and can read the endpoint and kinetic data at 405, 450, 490, 620 nm. Computer-based analysis of the results of the measurements are shown either by graphics with numerical results or positive or negative results

Blood samples obtained at the pre-test and post- test period were investigated and female reproductive (FSH, LH, Estrogen, progesterone and PRL) hormone levels were determined.

STATISTICS

The statistical analysis was accomplished by using SPSS 16.0. Independent t- test was used determine whether the groups were statistically equal or not at the beginning of the study. Paired sample t-test was used to determine the differences of mean values in hormone levels in both experimental and control groups after 12 weeks. Independent t-test was used to determine the differences of mean values between experimental and control groups for post test results. The level of significance less than 0.05 were accepted as the p value for all instances.

RESULTS

At the beginning of the study the demographic and anthropometric factors and the hormone levels of

TABLE 2: Table of hormone levels of groups.

PRL	Pre-test(mIU/mL)	Post-test(mIU/mL)	p-values
Exercising Group	132.02±26.7	251.9±93.05	0,02
Control Group	153.50±35.6	135.7±26.4	0,40
P-values	0,30	0,01	
FSH	**Pre-test(mIU/mL)**	**Post-test(mIU/mL)**	**p-values**
Exercising Group	5.5±0.5	6.1±0.7	0.99
Control Group	5.3±1.06	5.7±0.1	0.1
P-values	0.731	0.611	
LH	**Pre-test(mIU/mL)**	**Post-test(mIU/mL)**	**p-values**
Exercising Group	6.8±1.09	9.1±3.01	0,1
Control Group	9.9±7.4	10.9±8.8	0,2
P-values	0,30	0,6	
E2	**Pre-test(mIU/mL)**	**Post-test(mIU/mL)**	**p-values**
Exercising Group	83.08±23.1	85.8±28.3	0.8
Control Group	78.2±15.1	94.4±24	0,2
P-values	0.7	0.6	
Progesterone	**Pre-test(mIU/mL)**	**Post-test(mIU/mL)**	**p-values**
Exercising Group	0.3±0.1	0.5±0.1	0,2
Control Group	0.4±0.3	0.6±0.4	0,5
P-values	0.5	0.5	

the exercise and control groups were similar. There are significant differences between the mean values of exercising group's pre-test (132,02±26.7) and post-test (153.5±35.6) levels of prolactin(p=0.02). Although there was no significant difference between mean values of the prolactin levels of control and exercising groups at the beginning of the study, a statistically significant increase in the prolactin levels of exercising group was observed after a 12 week resistance training program (Table 2).

The mean value of FSH (p=0, 99), LH (p=0.147), Progesterone (p=0.269) and estradiol (p=0.877) levels have not changed for those who exercised for 12 weeks.

Table 3 indicates changes in weight, body fat ratio and body mass indexes of subjects. There is a decrease in the mean value of the weight, body mass index and body fat ratio of the exercising group after a 12 week resistance training program.

TABLE 3: Table of body composition of groups.

Weight(kg)	Pre-test	Post-test	p-values
Exercising Group	56.1±1.7	54.6±1.8	0,0
Control Group	55.7±1.9	55.3±1.7	0,05
P-values	0,08	0,04	
BMI (kg/m2)			
Exercising Group	20.4±0.5	19.9±0.5	0.0
Control Group	20.0±0.4	19.9±0.3	0,05
p-values	0,5	0,6	
Fat Ratio (%)			
Exercising Group	21.6±1.5	20.09±1.9	0,1
Control Group	20.4±1.02	22.2±0.9	0,08
p-values	0,1	0,3	

DISCUSSION

The results of this study indicate that 12 week resistance training has resulted in the significant alteration of the prolactine levels of female students. The participants of this study were previously active and had their own physical training programs. The resistance training program caused additional load and increased their daily energy consumption. This physiological stress may cause high plasma levels of prolactin. Although it is found that resistance training increases the level of prolactin; estrogen progesterone, FSH and LH levels have not changed.

Early studies carried out on female athletes stated increased prolactin levels immediately after intense exercise reported that they returned to baseline within 24 hours after the exercise.[15,16.] Similar to earlier studies, it was also found in this study that the prolactin levels of female athletes were high even after a few days following the training.

Prolactin response to exercise cannot be underestimated because some studies indicate that high levels of prolactin may increase the risk of developing breast cancer and amenorrhea [17.] In order to understand whether exercise alters prolactin levels and whether high prolactin levels increase the risk of developing cancer, out of 96 women aged 40-75 years, 47 were randomized to a 12-month moderate-intensity physical activity. They performed 60 minute moderate aerobic exercise on treadmills or stationary cycles. Although there were some differences in the changes in serum concentrations of some subgroups, there was no difference in those of control and exercise groups'.[18.] Some of the earlier studies did not support the results obtained in this study. The results of previous studies change according to the type, intensity, time, volume and density of the applied exercise.

Scavo and co-workers observed acute changes in ACTH, beta-endorphin, cortisol and prolactin after a marathon and a half marathon.[19.] Moreover Dulac et al. revealed that the anaerobic exercise increases the prolactin levels of male subjects when they were tested after a 15 minute recovery.[20] The effects of intense training on menstrual cycle were reviewed by Arena et al and they also claimed that gonadotropins were significantly affected by exercise.[21] One study found that 12 month moderate–intensity exercise did not change the serum concentrations of prolactin.[22] Different results obtained from the earlier studies can be explained by different exercise types and amount of intensity. Although it is difficult to talk about a certain amount of intensity, most studies indicate that exercise above the anaerobic threshold elevates the circulating hormones levels.[23]

The results of this study indicate that estradiol (E2), progesterone (P4), follicle stimulating hormone (FSH), and luteinizing hormone (LH) levels have not changed after a 12 week resistance training program. In the study of Kraemer et al. E2 serum concentrations significantly elevated in both follicular and luteal phases after a low-volume resistive exercise.[24] On the other hand, the effects of a 30 minute bicycle ergonometric test on the responses of progesterone (P), estradiol (E_2), follicle stimulating hormone (FSH), and luteinizing hormone (LH) were investigated by Bonen et al. with 10 women. With such exercise a significant acute increase occurred in P and E_2 whereas no changes were observed in FSH and LH.[25] Nakamura et al. investigated the effects of acute resistance training on the ovarian and anabolic hormones of young women during the different phases of menstrual cycle and claimed that, serum estradiol and progesterone levels increased after acute resistance exercise in the mid-luteal phase of cycle.[26] Copeland has compared the acute effects of endurance exercise and resistance exercise and indicated a significant increase in estradiol, growth, cortisol and testosterone hormones after both types of exercise.[27] On the other hand, the study carried out by Smith et al. indicates that there is no exercise-induced estradiol change after a 16 week, low-intensity, 30 minute aerobic exercise like treadmill, stair-stepper, or elliptical machine, done 5 times a week.[28]

The findings from the current study support the hypothesis that physical activity affects the serum concentrations of hormones in the long

term. Acute hormonal alterations after each exercise session were not measured in this study . If they had been measured, acute changes in the other hormones might have been observed.

Based upon the result of this study, it can be said that long term resistance training may alter the hormonal profiles of college athletes. As a conclusion; considering the significant increase in prolactin levels, athletic amenorrhea may be explained by hyperprolactinemia together with other reasons like decrease in body fat, excessive energy expenditure and psychological stress.

REFERENCES

1. Yeager KK, Agostini R, Nattiv A, Drinkwater B. The female athlete triad: disordered eating, amenorrhea, osteoporosis. Med Sci Sports Exerc 1993;25(7):775-7.
2. Burney MW, Brehm BA. The female athlete triad. JOPERD 1998;69(9):43-5.
3. Balcıoğlu İ, Savrun M. [Stress and hormones]. Turkiye Klinikleri J Psychiatry 2001;2(1):43-50.
4. De Crée C. Sex steroid metabolism and menstrual irregularities in the exercising female. A review. Sports Med 1998;25(6):369-406.
5. Hirschberg AL, Hagenfeldt K. [Athletic amenorrhea and its consequences. Hard physical training at an early age can cause serious bone damage]. Lakartidningen 1998;95(50): 5765-70.
6. Larsen HM, Hansen IL. [Effect of specific training on menstruation and bone strength]. Ugeskr Laeger 1998;160(33):4762-7.
7. Dusek T. Influence of high intensity training on menstrual cycle disorders in athletes. Croat Med J 2001;42(1):79-82.
8. Timmerman MG. Medical problems of adolescent female athletes. Wis Med J 1996;95(6): 351-4.
9. Şahin NF, Ağaoğlu SA. [Analysis of onset of training age, menarche age and reproductive hormone levels of girl athletes]. Turkiye Klinikleri J Sports Sci 2011;3(2):47-55.
10. Fox EL. Endocrin system and exercise. The Physiological Basis of Physical Education. 4th ed. New York: WB Saunders Company; 1988. p.405-6.
11. Gorostiaga EM, Izquierdo M, Iturralde P, Ruesta M, Ibáñez J. Effects of heavy resistance training on maximal and explosive force production, endurance and serum hormones in adolescent handball players. Eur J Appl Physiol Occup Physiol 1999;80(5):485-93.
12. Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. Med Sci Sports Exerc 2004; 36(4):674-88.
13. Tamer K. [Body composition]. Sporda Fiziksel-Fizyolojik Performansın Ölçülmesi ve Değerlendirilmesi. 2. Baskı. Ankara: Bağırgan Yayınevi; 2000. p.163-86.
14. Bompa TO, Jones D. Chapter 4: The components of training. Chapter 12: Biomotor abilities and the Methodology of Their Development. Theory and Methodology of Training: The Key to Athletic Performance. Iowa: Kendal-Hunt Pub; 1983. p.77-93, 287-8.
15. Boyden TW, Pamenter RW, Grosso D, Stanforth P, Rotkis T, Wilmore JH. Prolactin responses, menstrual cycles, and body composition of women runners. J Clin Endocrinol Metab 1982;54(4):711-4.
16. Baker ER, Mathur RS, Kirk RF, Landgrebe SC, Moody LO, Williamson HO. Plasma gonadotropins, prolactin, and steroid hormone concentrations in female runners immediately after a long-distance run. Fertil Steril 1982;38(1):38-41.
17. Tworoger SS, Eliassen AH, Sluss P, Hankinson SE. A prospective study of plasma prolactin concentrations and risk of premenopausal and postmenopausal breast cancer. J Clin Oncol 2007;25(12):1482-8.
18. Reding KW, Lampe JW, Wang CY, Stanczyk FZ, Ulrich CM, Xiao L, et al. A 12-month moderate-intensity exercise intervention does not alter serum prolactin concentrations. Cancer Epidemiol 2011;35(6):569-73.
19. Scavo D, Barletta C, Vagiri D, Letizia C. Adrenocorticotropic hormone, beta-endorphin, cortisol, growth hormone and prolactin circulating levels in nineteen athletes before and after half-marathon and marathon. J Sports Med Phys Fitness 1991;31(3):401-6.
20. Dulac S, Brisson GR, Péronnet F, DeCarufel D, Quirion A. [Hormonal responses to repeated lactic acid anaerobic exercise in male subjects]. Can J Appl Sport Sci 1986;11(4): 178-85.
21. Arena B, Maffulli N, Maffulli F, Morleo MA. Reproductive hormones and menstrual changes with exercise in female athletes. Sports Med 1995;19(4):278-87.
22. Reding KW, Lampe JW, Wang CY, Stanczyk FZ, Ulrich CM, Xiao L, et al. A 12-month moderate-intensity exercise intervention does not alter serum prolactin concentrations. Cancer Epidemiol 2011;35(6):569-73.
23. Galbo H. The hormonal response to exercise. Diabetes Metab Rev 1986;1(4):385-408.
24. Kraemer RR, Heleniak RJ, Tryniecki JL, Kraemer GR, Okazaki NJ, Castracane VD. Follicular and luteal phase hormonal responses to low-volume resistive exercise. Med Sci Sports Exerc 1995;27(6):809-17.
25. Bonen A, Ling WY, MacIntyre KP, Neil R, McGrail JC, Belcastro AN. Effects of exercise on the serum concentrations of FSH, LH, progesterone, and estradiol. Eur J Appl Physiol Occup Physiol 1979;42(1):15-23.
26. Nakamura Y, Aizawa K, Imai T, Kono I, Mesaki N. Hormonal responses to resistance exercise during different menstrual cycle states. Med Sci Sports Exerc 2011;43(6):967-73.
27. Copeland JL, Consitt LA, Tremblay MS. Hormonal responses to endurance and resistance exercise in females aged 19-69 years. J Gerontol A Biol Sci Med Sci 2002;57(4):B158-65.
28. Smith AJ, Phipps WR, Arikawa AY, O'-Dougherty M, Kaufman B, Thomas W, et al. Effects of aerobic exercise on premenopausal sex hormone levels: results of the WISER study, a randomized clinical trial in healthy, sedentary, eumenorrheic women. Cancer Epidemiol Biomarkers Prev 2011;20(6):1098-106.