Effects of Resistance and Endurance Exercises on Serum Androgens, Cortisol and Lactate in Menopause Women

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Abstract

Introduction: The aim of this study was to investigate the effect of resistance and endurance exercises on the acute response of androgens, cortisol and lactate in elderly postmenopausal women**.**

Material and Methods: In this cross-sectional research, 10 elderly postmenopausal women (Age=54.3±3.74 years, BMI= 24.88±2.07kg/m^{-2}) participated in three protocols: 1) Resistance protocol (1 session, 3 sets of 10 repetitions of eight exercises with %80 1RM), 2) Endurance protocol (45 minutes of cycling at 60-70% Vo_{2max}) and 3) Rest protocol (control group). Blood samples were taken before, immediately after, and 15 minutes after the end of each protocol. Finally, the serum levels of testosterone, dehydroepiandrosterone sulfate, cortisol and blood lactate were measured and the data was analyzed using GLM-Repeated Measures (ANOVA) at a Significance level of $P<0.05$.

Results: Both resistance and endurance groups showed a significant increase in androgen and lactate serum levels after resistance and endurance exercises ($P<0.05$). But variations in androgens and lactate levels were not significant between the groups. There was no significant difference in within-group cortisol concentration, but there was a significant difference in cortisol levels between the groups in endurance exercise: after the endurance protocol, there were higher levels of cortisol in endurance group compared to resistance and rest groups.

Discussion and Conclusion: The results showed that a single bout of resistance exercise or endurance exercise does not acutely influence androgens and lactate levels, though cortisol concentration increased following an endurance exercise session.

Key words: Androgens, Cortisol, lactate, Exercise, Elderly women

Introduction

Postmenopausal women experience considerable changes in endocrine gland functions, which expose them to various physical and mental symptoms and disorders [1]. Some of these symptoms include a sense of fever, osteoporosis, cardiovascular diseases, mental pressures, fatigue, irritability and depression [2,3]. As women grow older, the level of androgens (testosterone and dehydroepiandrosterone sulfate) decreases in them [4,5], which leads to a decrease in muscular strength and mass, bone density and concentration resulting in fatigue and depression [6]. Research has shown that low levels of testosterone may limit muscular strength and growth in elderly women [5]. Testosterone concentration in women is one-tenth of its amount in men [7,8]. Although the amount of testosterone in women is much smaller than that in men, this low amount plays a critical role in women's metabolic processes [9]. Dehydroepiandrosterone sulfate (DHEAS), secreted from adrenal gland [11], and is one of the most prevalent androgens in both men and women [10]. DHEAS affects both the energy level and insulin sensitivity [12]. Research has shown that there is negative correlation between DHEAS concentration and coronary artery disease [13].

As women grow older, along with the above mentioned changes, the baseline level of cortisol, as a catabolic hormone, increases in them [5]. There is a relationship between the decrease in anabolic to catabolic hormone ratio and the decrease in physical strength and performance in the elderly [14]. Acute hormonal responses play a significant role in physical activities because such anabolic hormones as testosterone increase the synthesis of muscle proteins

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[15]. There is no agreement among researchers on the responses of androgens, cortisol and lactate to exercise training in the elderly [16]. Copeland et al (2002) studied 30 healthy trained women aged between 16 and 69. They found that testosterone levels increased in the participants following every bout of endurance and resistance exercise. Cortisol concentration significantly decreased in the participants during endurance and resistance exercises while lactate levels significantly increased after resistance exercise [5]. In their study on 10 elderly women (67±3 years old), Hakkinen et al (2000) found that testosterone did not significantly increase following a session of heavy resistance exercise, but lactate concentration significantly increased in the participants following the exercise [17]. Hakkinen et al (1995) investigated the acute responses of testosterone and cortisol to a single-session heavy resistance exercise in 7 middle-aged women (mean age of 50 years) and 8 elderly women (mean age of 70 years). Their results showed no significant variation in testosterone and cortisol concentration [18]. Johnson et al (1997) reported an increase in DHEAS and cortisol concentration following 30 minutes of exercise on treadmill at 80% VO_{2max} in 16 postmenopausal women [19].

Overall, there is little evidence on the responses of androgens and cortisol to exercise in elderly women. Besides, despite the direct relationship between androgens to cortisol ratio and muscle cross section and strength [14], cortisol concentration has not been measured in some studies on elderly women [17]. Moreover, small sample size has devalued some studies [5]. Obtaining enough information about the effects of endurance and resistance exercises on androgens and cortisol concentration in elderly women may open new windows to exercise planning for these people. Sports therapy may be used to maintain optimal levels of these hormones because it does not bear the malignant effects of hormone therapy. In this regard, the present study aimed at investigating the effects of single-session endurance and a single-session resistance exercise on acute responses of androgens, cortisol and lactate in postmenopausal women aged between 50 and 60.

Material and Methods

The method of the study was quasi-experimental using pretest and post-test. The participants, selected based on simple random sampling, consisted of 10 healthy non-athlete elderly women living in Mashhad. To be included in the study, the participants had to be between 50 and 60 years old and have undergone menopause for at least one year. Before the participants were selected, the volunteers' personal information as well as their medical and training history were collected using a questionnaire. Then, in order to achieve better control on the intervening factors, obese people as well as those with a history of disease, abnormal menopause, medication and steroid supplement consumption, training history and drug abuse were excluded from the study. Among the remaining population, 10 people with the BMI of less than 27 kg/m^2 and body fat less than 36% were randomly selected. First the participants were informed of the procedures of research. Then they completed an informed consent form, physical activity readiness questionnaire, GHQ_{28}, and Massachusetts women's health survey questionnaire. Before the research started, permissions were taken from the ethical committee. Medical approvals were earned that indicated the safety of participation in exercise training for the participants. The subjects' height and weight (using a weighing machine with the accuracy of 0.1 kg) as well as their BMI and body fat percentage were measured via bioelectrical impedance method using Body Composition Analyzer, Inbody-720. Eight days after the first training session, the participants' VO_{2max} was examined using both Astrand bicycle aerobic fitness test and 1RM training with weight with 4 days interval. Table 1 illustrates the participants' anthropometric characteristics. Then the subjects participated in 3 testing sessions within 12 days with 4 days rest interval following every session. The tests were administered from 8:00 to 10:30 AM. The research was cross-sectional so that the participants were randomly divided into two groups. The first group participated in 3 sessions of endurance exercise, resistance exercise and rest, respectively. The second group participated in 3 sessions of resistance exercise, endurance exercise and rest, respectively. The participants were to avoid doing heavy physical activity within 24 hours before every training session. Also, they were asked to maintain a consistent diet and not to take caffeine within 2 hours before every session. 2.5 hours before every training session, the participants were given a standard dietary meal including 4.3 kcal energy for every 1 kg of body weight. The meal included 65% carbohydrates, 20% fat and 15%

proteins [20].

The endurance exercise consisted of 45 minutes cycling the Technogym exercise bike at the intensity of 60-70% VO_{2max}. Exercise intensity was continually monitored by polar pulsometer. The resistance training was performed for 45 minutes on isotonic exercise equipment and consisted of three 10-repeat sets with 80% 1RM and 1 minute rest interval between the sets. The exercise training included supine chest press, latissimus pull-down, seated leg press, biceps curl, triceps pushdown, leg curl, leg extension and shoulder press. During the training session, the control group remained inactive and sat on chairs [5].

Blood samples were taken before, immediately after and 15 minutes after each training session. During the control session, the same sampling procedure was repeated. After the serum had been separated, lactate levels were measured. Then blood samples were frozen at -18°C. All collected samples were examined in one day. The amounts of testosterone, DHEAS and cortisol were measured by Liaison kit, made in England, using Chemiluwomenecence method. Lactate levels were monitored by both Selectra biochemical device and Pars Azmoon Company kit. Raw data was analyzed using SPSS software (version 16). Both descriptive and inferential statistics were used to analyze the data. Descriptive statistics was run to calculate the means and measures of variability and to draw diagrams. Kolmogorrov-Smirnov statistical test and Levene's test were run to check the normality of data and the homogeneity of variance, respectively. AVOVA test (repeated measures) was run to examine both within- and between-group variations. The level of significance was set at $P<0.05$.

Table 1: Physical characteristics and Vo_2max of experimental participants

Variable	mean	SD
Age (years)	54.30	3.74
Height (cm)	161.92	5.93
Body Weight (kg)	65.42	8.28
Body mass index(Kg/m^2)	24.88	2.07
Body fat (%)	33.50	2.63
Vo_2max(ml/Kg/min)	27.32	2.49

Results

Table 2 illustrates the results of ANOVA test (repeated measures) of testosterone, DHEAS, cortisol and lactate concentration in different sampling stages. As shown in the table, the within-group variations of testosterone concentration are significant in either of the groups ($P<0.05$) so testosterone has increased in either of groups both immediately and 15 minutes after the endurance and resistance exercise session. However, the between-group variations of testosterone concentration is not significant ($P>0.05$). Figure 1 illustrates the variations in testosterone concentration in either of the groups in different stages.

The within-group variations of DHEAS shows that only resistance exercise intervention may significantly affect acute responses of DHEAS as an instantaneous effect of a training session ($P<0.05$). However, the between-group variations of DHEAS are not significant ($P>0.05$).

Figure 2 illustrates DHEAS concentration in every group in different stages. While the within-group variations of cortisol concentration are not significant in the groups ($P>0.05$), the between-group variations of cortisol concentration are significant in the endurance group ($P<0.05$) so cortisol has increased immediately after and continued to increase up to 15 minutes after the exercise in the endurance group. Figure 3 illustrates cortisol variations in the groups in different stages.

The results of ANOVA (repeated measures) of lactate concentration shows that the within-group variations of lactate is significant in the groups ($P<0.05$) while the between-group variations are not significant ($P>0.05$). Figure 4 illustrates lactate variations in the groups in different stages.

Table 2: Serum testosterone, dehydroepiandrosterone sulfate, cortisol and lactate responses to 3 training sessions.

Variable	Group	session			Within-Subjects Effects		Between-Subjects Effects	
		Pre	Post	15min Post	F	P†	F	P*
Testosterone (ng/ml)	Resistance exercise	0.13±0.19	0.07±0.28	0.12±0.23	6.386	0.008†	0.154	0.699
	Endurance exercise	0.10±0.18	0.08±0.30	0.16±0.32	8.311	0.003†	0.146	0.707
	Control	0.14±0.22	0.13±0.24	0.14±0.27	1.077	0.362	-	-
DHEAS (µg/dl)	Resistance exercise	41.21±49.29	39.35±55.99	43.27±58.94	3.816	0.042†	0.243	0.628
	Endurance exercise	34.48±45.41	31.05±48.37	46.74±54.20	1.476	0.255	0.037	0.849
	Control	33.97±45.51	36.99±45.50	41.67±47.42	0.186	0.832	-	-
Cortisol (µg/dl)	Resistance exercise	1.64±6.40	1.06±5.10	1.21±5.32	3.407	0.083	0.026	0.873
	Endurance exercise	1.64±6.26	3.31±8.78	2.86±7.87	3.059	0.101	0.308	0.007*
	Control	1.88±5.83	1.79±5.25	0.90±5.52	0.444	0.648	-	-
Lactate (µg/dl)	Resistance exercise	4.79±26.60	7.40±40.00	4.67±27.40	17.671	0.000†	2.275	0.149
	Endurance exercise	4.35±24.30	8.34±34.40	3.89±26	13.504	0.000†	0.001	0.976
	Control	4.83±25	5.88±30.10	5.78±29.40	8.279	0.003†	-	-

Values are means ±SD.† significantly different from pre session (P<0.05) *significantly different from control session (P<0.05).

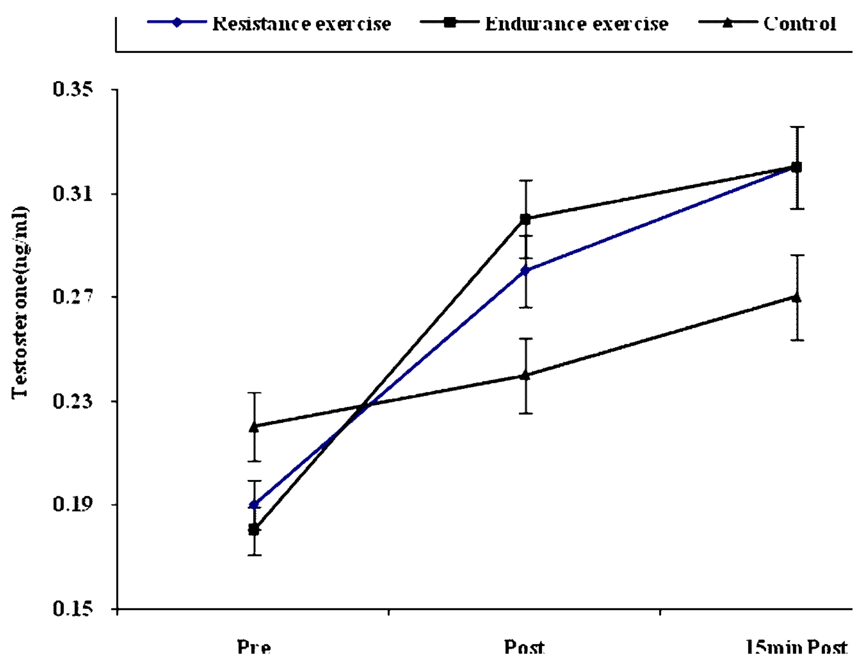

Figure 1: Variation in testosterone after endurance and resistance exercises and a control session.

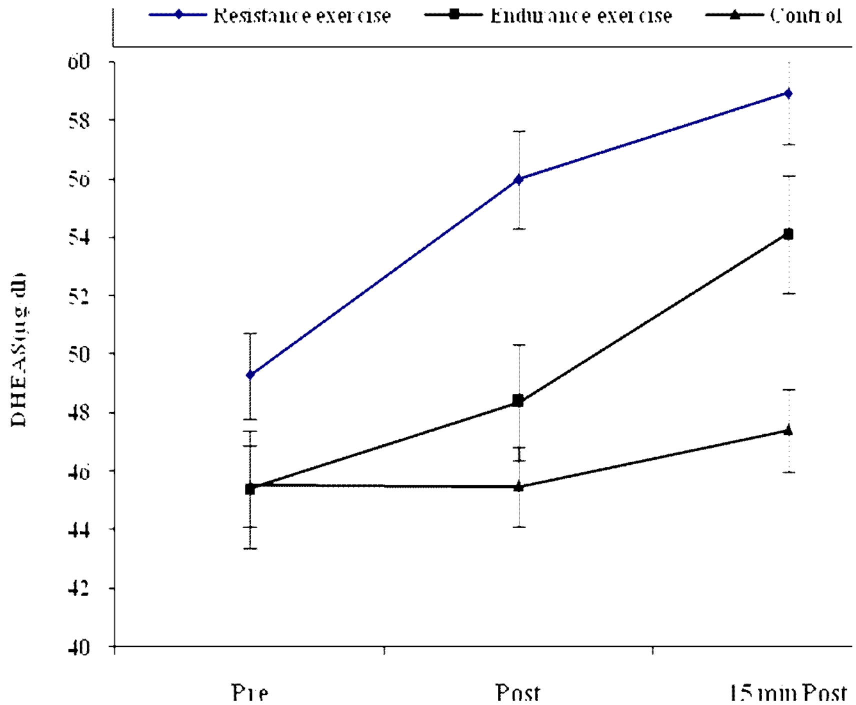

Figure 2: Variation in dehydroepiandrosterone sulfate (DHEAs) after Endurance and resistance exercises and a control session

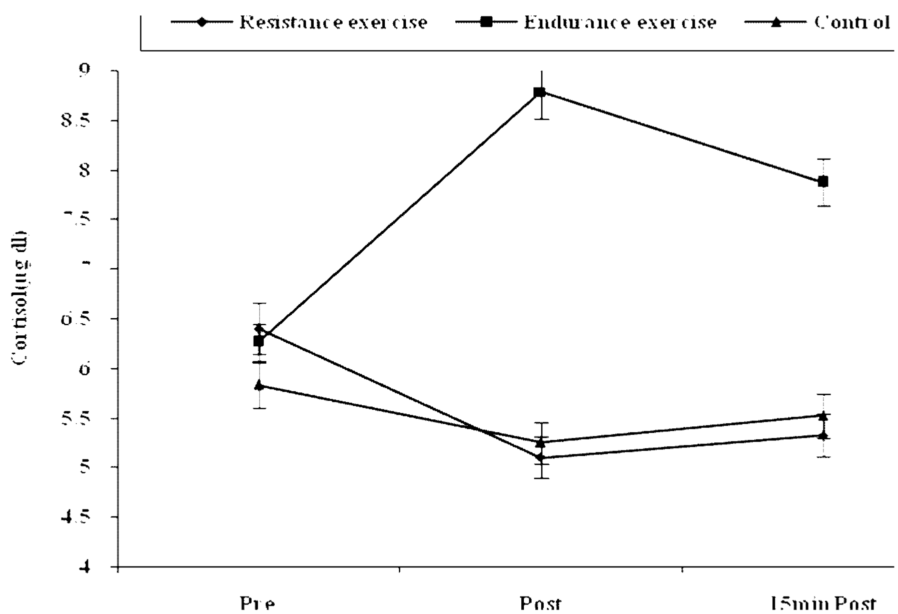

Figure 3: Variation in cortisol after endurance and resistance exercises and a control session

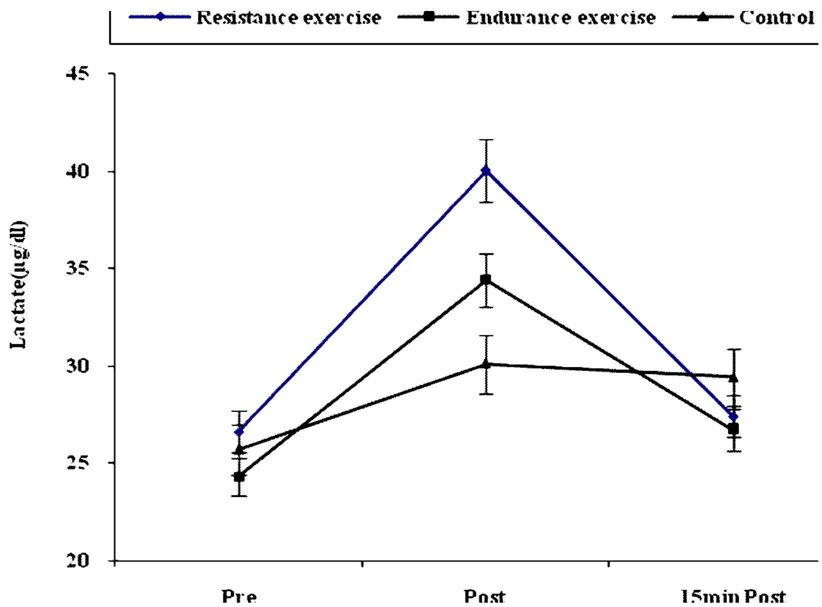

Figure 4: Variation in lactate after endurance and resistance exercises and a control session

Discussion and Conclusion

According to the findings of the present study, androgen levels increased immediately after and continued to increase up to 15 minutes after a session of resistance and endurance exercise, though the increase was not significant enough to affect the between-group variations. So far, few studies have investigated androgen responses in elderly women. Some studies have reported testosterone increases following endurance and resistance exercise [5] while some studies have found no variations in testosterone concentration [17,18]. With regard to DHEAS responses to physical activity, some studies have reported a significant increase in DHEAS in response to endurance exercise [19]. The present findings showed no significant variation in testosterone levels following a session of exercise training. This is consistent with the findings of Hakkinen et al (1995 and 2000) but inconsistent with the findings of Copeland et al (2002). DHEAS serum concentration showed no significant variation, which contradicts the findings of Johnson et al (1997).

The amount of muscular mass involved in the activity [21-23], exercise intensity [24-28], nutrition [29], age [30] and training experience are some of the factors affecting the rate of testosterone response [32]. Heavy exercise may stimulate testosterone responses. Research has shown that heavy training protocols which involve big muscles and multiple joints acutely increase testosterone concentration [33]. Hormonal responses will decrease in both males and females when the load of resistance exercise is reduced from 10 maximum repetitions to 10 repetitions with 70% 1RM [25]. Therefore, it is likely that exercise intensity in the present study, has not been fierce enough or the activity has not involved big muscular mass to stimulate significant variations in the between-group androgen concentration.

The reported increase in testosterone in some studies may be attributed to Adrenalin stimulation [34], the stimulating effect of lactate [35], and/or the adaptability of testosterone secretion [36]. Research has shown that testosterone responses to exercise are stronger in trained individuals comparing to untrained ones [37]. The inconsistency between the present findings and the reports of Copeland et al (2002), whose participants were trained individuals, may be related to the fact that the participants of the present study were non-athletes. Besides, weak hormonal responses in the present participants may be related to their small muscular mass [38-40].

Following a heavy exercise, Gonadotropin Releasing Hormone (GnRH) stimulates the secretion of luteinizing hormone (LH) which in turn stimulates TK ovary cells to increase testosterone secretion [7]. The secretion of testosterone is dependent on the biosynthesis rate of glucocorticoids, especially cortisol, which are stimulated by Adrenocorticotropin (ACTH) [8]. ACTH stimulates both the secretion of cortisol and the release of testosterone from adrenal glands [41]. Androgens avoid damages to the proteins of skeletal muscles during exercise; consequently, muscles use more androgens during physical activities [42]. In the present study, the higher consumption of androgens by muscles may be responsible for their lack of increase, though cortisol increased following the endurance exercise.

Research has shown that lactate increase following exercise may increase testosterone secretion because lactate stimulates the secretion of GnRH followed by an increase in LH release from anterior pituitary [42]. The insignificance of between-group variations of androgen levels in the present study may be related to the insignificant increase of the blood lactate.

In the current study, cortisol concentration did not significantly change following a session of resistance exercise. This is inconsistent with the findings of Copeland et al (2002) but consistent with those of Hakkinen et al (1995). On the other hand, cortisol concentration increased following a session of endurance exercise. This is inconsistent with the findings of Copeland et al (2002) but corresponds to the findings of Johnson et al (1997). Copeland et al (2002) asserted that decreases in cortisol concentration reflects the circadian variations of hormone concentration and its increase before the start of the training session in response to a particular blood sampling [5]. Variations in serum cortisol depend on the type, intensity and duration of the training session, so heavy physical exercise is one of the main stimulants of cortisol secretion. Heavy physical exercise increases ACTH secretion which results in an increase in cortisol secretion [43,44]. It is likely that resistance exercise intensity has not been fierce enough to stimulate higher cortisol secretion in the present study. Lots of factors including physiological pressures, circadian rhythm and body temperature influence acute cortisol responses to a session of exercise training [45]. Cortisol secretion increases at a higher rate in the activities that cause hypoxia comparing to the activities that do not [46]. Also, an increase in central body temperature increases cortisol secretion. The mechanism that effectuates this increase involves the release of hormone from carrier proteins and variations in transport proteins [42]. Therefore, cortisol increase in the present study following a session of endurance exercise may be related to hypoxia or an increase in central body temperature which did not rise during the resistance exercise. Though, high levels of cortisol may be detrimental in the long run, its acute increase is a part of the process of muscle growth [47].

According to the present findings, the between-group variations of lactate are not significant following a session of resistance exercise, which is inconsistent with the findings of Copeland et al (2002) and Hakkinen et al (2000). Lactate concentration did not significantly change following a session of endurance exercise, which is consistent with the findings of Copeland et al (2002). Lactate concentration is significantly influenced by the training intensity [38]. Research has shown that lactate response to exercise is weaker in the elderly than in the youth [14]. This may be attributed to the elderly's lower capacity in tolerating the training pressure. Besides, age-related reductions in maximal lactate concentrations during exercise may be related to reductions in muscle glycolytic capacity. This relates to the selective muscle atrophy of Type II B glycolytic fast contracting fibers, as well as reduction in the activity of muscular dehydrogenase lactate and adrenalin sensitivity caused by aging [48]. This may account for the insignificance of the between-group lactate variations in the present study.

Conclusion

According to the present findings, one cannot decisively claim that a session of resistance or endurance exercise does not acutely influence serum androgens in elderly women. A session of endurance exercise increased cortisol concentration but a session of resistance exercise did not. Further studies are needed to investigate the acute and chronic effects of both endurance and resistance exercises on these hormones as well as other anabolic hormones such as growth hormone and insulin-like growth factor in both trained and untrained women at different age levels.

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