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Effect of dynamic and static strength training on hormonal activity in elite boxers

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: The aim of this study was to determine hormonal responses to acute and chronic exposure to static and dynamic strength training programs using resistance bands in boxers.

Material and methods: 19 male national boxers participated in the study. Boxers were instructed to perform strength exercises with resistance bands for 3 days a week for 8 weeks involving either dynamic (n=10) or static (n=9) resistance exercises. Blood samples were taken before exercise, immediately after the initial exercise session, and 8 weeks later following the last exercise session. Cortisol, growth hormone, adrenocorticotropic hormone adrenaline and noradrenaline levels were measured. Statistical analyses involved non-parametric analysis with an alpha level of .05.

Results: Dynamic strength exercises were effective stimuli to growth hormone, adrenaline and noradrenaline, while static strength exercises provoked cortisol, growth hormone, adrenaline and noradrenaline responses both initially after exercise and after 8 weeks of chronic training. Neither dynamic nor static strength exercises were effective in prompting adrenocorticotropic changes after an exercise session or after 8 weeks of training.

Conclusions: We showed that dynamic and static strength exercise protocols using resistance bands both could provoke acute and chronic hormonal responses in boxers similar to more traditional modes of such exercise.

Abbreviations: ACTH – Adrenocorticotropic Hormone, GH – Growth Hormone, C – Cortisol.

Key words: dynamic strength, static strength, exercise, hormonee.

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INTRODUCTION

Strength training is a common component of sports and physical fitness programs for many performance athletes. It is clear that the maximization of muscular strength is a key element of such training programs, as this adaptation can result in an enhanced power development capacity [1]. Muscular force, dependent upon the ability of contracting muscles to generate and utilize energy, usually resulting in moving an object, increases with strength training [1]. Strength training programs may include the use of free weights, weight machines, elastic tubing, resistance bands or simply a participant's body weight. To that end, training with exercise resistance bands is considered a very effective, inexpensive, and practical way for strength development [2], and hence attractive for athletes and recreational exercisers alike.

Static and dynamic force-based exercises are different in sporting practice and application – i.e., joint angle and muscle length do not change during static muscle contractions, but they do change during a dynamic muscle contraction. A static muscular load is perceived as more tiring for the body (i.e., muscles) than dynamic muscular loads of the same relative intensity and duration, as static muscular loading does not include the phase of relaxation which allows recovery [3].

Boxing is a sport in which athletes require a combination of strength, power, speed, agility, and sport-specific skills. Boxing has a complex structure and physiologic demand due to its dynamic and static muscular contraction characteristics at a high level and is considered as a combative sport that requires a very high level of muscular power [4]. It would follow then that strength training helps boxers develop muscle power so that they can quickly and effectively execute their performance movements during competition.

With respect to the neuroendocrine system, strength trainings can provoke large and diverse changes in the concentration of some key hormones from resting, basal levels [5]. These hormonal changes with exercise occur for various physiological reasons: to induce cardiovascular adjustments, to activate energy production pathways and mobilize energy substrates, to facilitate maintenance of adequate hydration, and to some extent as part of stress reactivity [5].

There is, however, limited information regarding the effect of different types of (static and dynamic) strength training regimens involving resistance bands in eliciting hormonal changes in boxers. Therefore, the aim of the present study is to determine the acute and chronic effect of static and dynamic strength trainings on selected hormonal activity in boxers.

MATERIAL AND METHODS

ETHICAL CONSIDERATIONS

All subjects signed an informed consent form before starting the study protocol, in accordance with the Research Commission of the Department of Physical Education and Sports at the University of Erzincan (Turkey). All procedures met the requirements listed in the Declaration of Helsinki and are in accordance with the ethical standards of the Erzincan University Ethics Committee.

Research groups

19 male boxers were divided into two groups: 10 national champions (mean age: 17.6 ±3.8 years, height: 171.7 ±10.9 centimeters, and weight: 67.2 ±15.2 kilograms) were assigned to a dynamic training group, and 9 elite males boxers (mean age: 18.1 ±3.3 years, height: 173.8 ±5.4 centimeters, and weight: 69.8 ±19.7 kilograms) to a static training group. All participants were nonsmokers and did not use any nutritional supplements or medications known to affect their performance.

Resistance band exercise

A variety of elastic resistance bands were used in the study to provide for progressive overload of the subjects as they improved in their fitness level. These bands consisted of Thera-Band exercise bands: gold - with very high-level resistance, silver – with high level resistance, and black - with medium resistance.

Experimental design

The study involved two experiments treatments (i.e., groups), and the components of the utilized approach are depicted in Figure 1. Each treatment group underwent different strength training programs but comparable assessments to evaluate the impact of their treatment programs on cortisol, adrenocorticotropic hormone, growth hormone, adrenaline and noradrenaline during eight weeks of their respective exercise programs. Subject assignment to each of the experimental treatment groups was randomized.

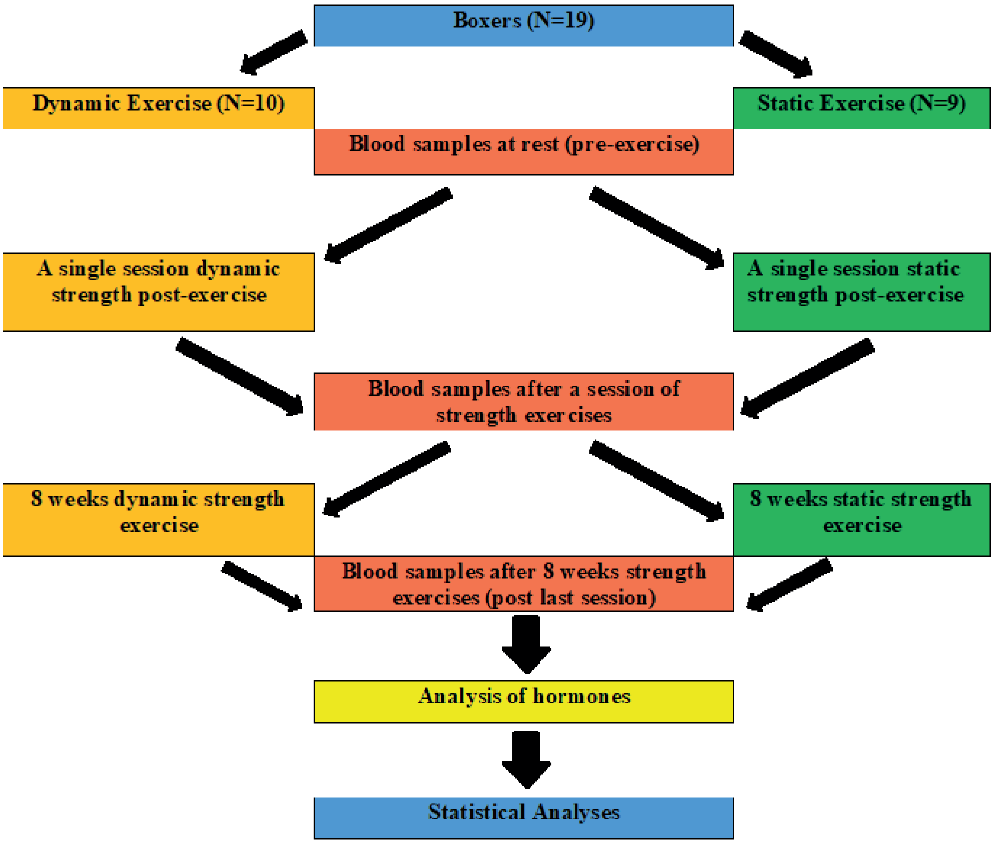

Fig. 1. Flow chart illustrating the design of the study

Training programs

Boxers were matched and grouped according to similar dynamic and static strength qualifications, were instructed to perform strength exercises with Thera-Band for 3 days a week for 8 weeks. Participants were instructed in how to do their exercises in the dynamic and static test positions. The static and dynamic procedures involved the same types of exercises being applied to each of the groups. All movements applied in the strength exercises were determined by considering the activities and muscle contraction positions utilized in the boxing. The chosen exercises and procedures were approved by expert boxing coaches. For the upper extremities, these were direct punch, hook punch, uppercut punch, elbow extension, elbow stretch, lateral lift, upward rowing, reverse wing, chest press, front lift, cross lift, cross back cut. For the lower extremities, these were leg press, squatting and standing, and attack movements.

Prior to the study, a pilot investigation on six subjects with similar characteristic to the test groups was conducted to determine the maximum applicable workloads. In order to ensure the exercise load times were not different, the static group was asked to maintain the static contraction for 15 seconds by taking a measurement of the load duration of 15 seconds equal to the duration of 8 repetition of dynamic group. A total of 15 movements, 8 repetitions and 3 sets were used for the dynamic group; and 15 movements, 15 seconds and 3 sets for the static group. Subjects were externally motivated to exercise at a maximal resistance effort.

Blood samples

Blood samples were taken before any exercise training session (at rest, i.e., pre-exercise), after the first exercise session (post-exercise; acute), and after 8 weeks following the last exercise training session (post-exercise; chronic). A 3 mL blood sample was obtained and placed into the sterile tube without anticoagulant and then the blood samples were centrifuged at 3500 rpm for 10 minutes to obtain serum samples. An additional 2 mL of the blood was taken and placed in a tube with anticoagulant, and then the blood samples were centrifuged at 3500 rpm for 15 minutes to obtain plasma samples. All samples were stored at 80°C until subsequent later hormonal analysis.

Analysis of hormones

Serum levels of cortisol (C), growth hormone (GH) and adrenocorticotropic hormone (ACTH) were measured by use of an autoanalyzer involving the chemiluminescence method (Siemens Immulite 2000 from Japan). Plasma adrenaline and noradrenaline were measured by commercially available high-pressure liquid chromatography (HPLC) procedures (Chromsystems from Germany) using an Agilent modular system 1200 series HPLC device for measurements (Agilnet 1260 infinity quaternary LC, USA).

Statistical analyses

Statistical analyses were carried out using the SPSS (version 22 for Windows) software. Analysis was performed to determine whether the data were normally distributed by Kolmogorov-Smirnov test (data were found not to be distributed normally). Thus, non-parametric analysis was used. Specifically, the Friedman ANOVA procedure was subsequently applied for the analysis of repeated measurements and for the comparison of pre- and post-exercise data and chronic and acute response data. As a post-hoc test to the Friedman ANOVA, where appropriate, a Wilcoxon test was used in the evaluation of the groups as paired responses. In addition, the Mann-Whitney U test was used for between group comparisons. The results were evaluated using an alpha level of 0.05.

RESULTS

Table 1 shows there were no significant increases in the concentrations of C and ACTH after an exercise training session (post-exercise) and after 8 weeks' dynamic strength training exercises. GH, adrenaline and noradrenaline did increase in the dynamic exercise group after the first exercise training session (post-exercise; i.e., acute). Furthermore, GH and adrenaline decreased after 8 weeks' dynamic exercise (post-exercise; i.e., chronic effect), as was noradrenaline although this later change was not significant.

Table 1. Comparison of C, ACTH, GH, adrenaline and noradrenaline values within the dynamic exercise group (repeated measures), N=10

GROUP	MEASUREMENT	Min	Max	Med	Mean Rank	X^2	p	Dif. Groups
Cortisol (µg/dL)	(a)	15.60	20.36	17.45	1.50	3.800	.150	-
	(b)	17.60	25.60	21.30	2.30			
	(c)	14.56	30.25	21.36	2.20			
ACTH (pg/mL)	(a)	30.14	55.32	36.90	1.75	4.667	.097	-
	(b)	38.54	61.20	54.32	2.55			
	(c)	27.69	48.45	35.66	1.70			
GH (ng/mL)	(a)	.95	2.09	1.09	1.85	14.308	.001*	a<b* c<b*
	(b)	3.78	5.36	4.21	2.90			
	(c)	.79	1.11	.87	1.25			
Adrenaline (ng/L)	(a)	88.65	188.74	144.21	2.00	9.800	.007*	a<b* c<b*
	(b)	133.58	221.36	188.65	2.70			
	(c)	78.90	178.21	124.79	1.30			
Noradrenalin (ng/L)	(a)	165.38	287.41	189.63	1.20	10.400	.006*	a<b*
	(b)	255.63	456.32	374.36	2.60			
	(c)	256.78	502.91	328.41	2.20			

(a) Pre-Exercise, (b) Post Exercise = acute response, (c) Post 8 weeks Exercise = chronic response; *p≤.05

Table 2 reveals there were significant increases in the concentrations of C, GH, adrenaline, and noradrenaline hormones after the first exercise training session (post-exercise; acute) within the static exercise group. Furthermore, there were significant decreases after 8 weeks' training for C, GH, adrenaline, and noradrenaline hormones at the post-exercise (chronic). There were no significant differences post-exercises (acute or chronic) in ACTH responses.

Table shows 3 that there were no significant differences between the groups over the measurement times (p>0.05) in the responses for either group for C or GH. However, ACTH and adrenaline values between the groups were significantly different at post-exercise (acute; i.e., lower in the static group). Finally, noradrenaline was also different between the groups, with the static one being greater than the dynamic group at pre-exercise and the relationship reversing at post-exercise (chronic).

Table 2. Comparison of C, ACTH, GH, adrenaline and noradrenaline values within the static exercise group (repeated measures), N=9

GROUP	MEASUREMENT	Min	Max	Med	Mean Rank	X^2	p	Dif. Groups
Cortisol (µg/dL)	(a)	11.36	23.65	18.77	1.22	10.889	.004*	a<b* c<b*
	(b)	18.65	31.50	28.22	2.78			
	(c)	16.32	31.24	20.31	2.00			
ACTH (pg/mL)	(a)	25.63	39.45	30.12	1.56	2.667	.264	-
	(b)	25.66	56.32	34.68	2.22			
	(c)	24.56	51.23	31.72	2.22			
GH (ng/mL)	(a)	.96	3.12	1.68	2.11	15.235	.000*	a<b* c<b*
	(b)	2.03	4.11	3.15	2.83			
	(c)	.56	1.02	.83	1.06			
Adrenaline (ng/L)	(a)	85.65	144.32	119.09	1.33	9.556	.008*	a<b* c<b*
	(b)	126.21	183.33	155.67	2.78			
	(c)	78.23	178.63	127.28	1.89			
Noradrenalin (ng/L)	(a)	155.32	355.63	300.56	2.00	10.889	.004*	a<b* c<b*
	(b)	299.63	445.36	353.52	2.78			
	(c)	144.90	398.37	227.21	1.22			

(a) Pre-Exercise, (b) Post Exercise = acute response, (c) Post 8 weeks Exercise = chronic response; *p≤.05

Table 3. Comparison of dynamic and static cortisol, ACTH, GH, adrenaline and noradrenaline values between groups at pre-post and post 8 weeks exercise

	MEASUREMENT	GROUP	N	Med	Mean Rank	Sum of ranks	Z	p
Cortisol (µg/dL)	Pre-Exercise	Dynamic	10	17.45	8.65	86.50	-1.103	.270
		Static	9	18.77	11.50	103.50		
	Post Exercise	Dynamic	10	21.30	8.00	80.00	-1.633	.102
		Static	9	28.22	12.22	110.00		
	Post 8 weeks Exercise	Dynamic	10	21.36	9.70	97.00	-.245	.806
		Static	9	20.31	10.33	93.00		
ACTH (pg/mL)	Pre-Exercise	Dynamic	10	36.90	12.00	120.00	-1.633	.102
		Static	9	30.12	7.78	70.00		
	Post Exercise	Dynamic	10	54.32	13.20	132.00	-2.613	**.009***
		Static	9	34.68	6.44	58.00		
	Post 8 weeks Exercise	Dynamic	10	35.66	11.00	110.00	-.816	.414
		Static	9	31.72	8.89	80.00		
GH (ng/mL)	Pre-Exercise	Dynamic	10	1.09	8.40	84.00	-1.307	.191
		Static	9	1.68	11.78	106.00		
	Post Exercise	Dynamic	10	4.21	11.70	117.00	-1.388	.165
		Static	9	3.15	8.11	73.00		
	Post 8 weeks Exercise	Dynamic	10	.87	10.45	104.50	-.368	.713
		Static	9	.83	9.50	85.50		
Adrenaline (ng/L)	Pre-Exercise		10	144.21	11.60	116.00	-1.306	.191
			9	119.09	8.22	74.00		
	Post Exercise		10	188.65	12.50	125.00	-2.041	**.041***
			9	155.67	7.22	65.00		
	Post 8 weeks Exercise		10	124.79	9.00	90.00	-.817	.414
			9	127.28	11.11	100.00		

	MEASUREMENT	GROUP	N	Med	Mean Rank	Sum of ranks	Z	p
Noradrenalin (ng/L)	Pre-Exercise	Dynamic	10	189.63	7.20	72.00	-2.290	.022*
		Static	9	300.56	13.11	118.00		
	Post Exercise	Dynamic	10	374.36	9.50	95.00	-.408	.683
		Static	9	353.52	10.56	95.00		
	Post 8 weeks Exercise	Dynamic	10	328.41	12.60	126.00	-2.123	**.034***
		Static	9	227.21	7.11	64.00		

*p≤.05

DISCUSSION

We were interested in determining the separate responses to dynamic and static strength trainings programs using resistance bands on hormonal activity in national champion level boxers. We hypothesized that dynamic and static strength training performed at comparable durations would produce different GH, C, ACTH, adrenaline and noradrenaline responses due to differences in metabolic stress from the dissimilar muscular contraction modes.

We pursued this research question because we felt revealing the separate physiological and hormonal effects of different muscle actions may lead to the development of new resistance exercise regimens tailored to different sporting populations [6]. Furthermore, it is well known that the type of exercise mode (i.e., dynamic vs. static exercise), muscular contraction positions, the amount of muscle mass engaged, and the intensity – duration of exercise strongly influences blood hormone levels [7, 8]. That said, the knowledge and specifics of such assumptions relative to the hormonal response in boxers are extremely limited.

CORTISOL AND STATIC-DYNAMIC EXERCISES

In the present study, there were no significant increases in the concentrations of C after the initial exercise session (post-exercise, acute) or at 8 weeks in the dynamic group (Table1). However, there were significant increases in C after the initial static session (post-exercise, acute), but there were decreases after 8 weeks of training in this group (Table 2). Although, when comparing the two groups, there were no significant differences (see Table 3).

Kraemer et al. reported that strength training experience (dynamic) of young athletes did not have an influence on the acute cortisol response [9]. Hakkinen et al. found similar responses for static resistance training and cortisol [10]. Conversely, Vega et al. found increased cortisol concentration acutely after short-term aerobic exercise and a following ramp incremental cycle ergometry to exhaustion [11]. Why our static exercise and training significantly impacted C is unclear but presents an interesting question for future researchers to determine if our findings are related to the methodology we used or if they are a physiological consequence.

ACTH AND STATIC-DYNAMIC EXERCISES

In this study, there were no significantly changes for ACTH post-exercise (acute), or at 8 weeks of dynamic and static strength exercise training. Some literature suggests that as exercise intensity is increased, there are approximately proportional increases in circulating concentrations of ACTH [5], but this finding is not universally reported [12, 13]. Interestingly, there were inter-group differences in ACTH, with the dynamic group values being greater than the static group (post-exercise, acute). However, this observed difference is difficult to interpret since the pre-exercise (acute) value was substantially higher in the dynamic group to begin with (i.e., this only approached statistical significance, see Table 3). It is important to note that ACTH can be a challenging hormone to assess due to its short half-life and the esoteric aspects of some assay detection procedures [5, 12]. These latter factors could account for the ambiguous results on this hormone in the literature, and our observed inter-group differences.

Growth hormone and static-dynamic exercises

It is well known that resistance exercise induces acute GH responses. For example, Ahtiainen et al. [8] demonstrated meaningful increases after acute heavy-resistance exercises in the blood GH concentrations of athletes. These findings of Ahtiainen et al. have been reported in numerous other studies in athletes as well as recreational exercisers [9, 12, 13].

One of the major findings in our study was that significant increases in GH after a session of either dynamic or static exercise occurred, and there were decreases after 8 weeks' training within both training programs, i.e., chronic strength training of either form attenuated the GH responses. Such hormonal attenuation with exercise training is a common finding in endocrine research [5,9,12,13]. Somewhat differently to our findings, Durand el al. [6] reported that concentric muscular exercises increased GH concentrations to a much greater extent than eccentric exercises at the same absolute load. Although these researchers stated it is likely that greater GH responses were related to the intensity of exercise rather than the mode of contraction [6].

Adrenaline – noradrenaline and static-dynamic exercises

A major result of our study was that there were significant increases in the concentration of adrenaline after the initial session (post-exercise) of both dynamic and static strength exercises, and decreases after 8 weeks of both strength exercises. Again, this supports an attenuation of hormonal responses when chronic exercise training occurs, which agrees with the literature [5, 9, 12, 13]. When comparing the adrenaline values of the static and dynamic groups, the values were significant higher with dynamic strength training than with static strength training at the initial post-exercise (acute) measurement. Again, these findings are somewhat difficult to interpret since the pre-exercise adrenaline tended to be higher in the dynamic group. Whether the dynamic exercise invoked a greater stimulus to the adrenal medulla, leading to higher circulating levels, remains to be seen. Epinephrine is associated with activation of both the alpha- and beta-adrenergic receptors and causing systemic vasoconstriction. Perhaps the dynamic exercise induced a great requirement for systemic action of such receptors to maintain aspects of mean arterial pressure and hence blood flow [14]. This is speculation on our part, and is in need of further investigation to access its legitimacy.

There were also significant increases in the concentrations of noradrenaline after the initial exercise session (post-exercise) both dynamic and static strength exercises, and decreases after 8 weeks' static strength exercises (the dynamic one was reduced but did not reach statistical significance).

The alterations in the plasma concentrations of noradrenaline described in the present research are in accordance with the well-documented results in the literature [15]. Interestingly, when trying to compare dynamic and static exercise equated on the duration of time to exhaustion, Lewis et al. showed a more significant increase in the noradrenaline concentrations during an exercise compared with a static one, whereas the adrenaline concentrations did not significantly differ [16]. Why our results do not agree with these of Lewis et al. may relate to procedural differences between the studies. While the magnitude of hormonal levels and changes showed varied levels between the groups (accounting for some of the inter-group differences), the trend in the response pattern within each group was highly comparable, specifically highlighting an adaptive training effect. This outcome agrees with the literature [12, 13].

CONCLUSIONS

We had hypothesized that dynamic and static strength training performed for the same duration and type would produce varying hormonal responses due to differences in metabolic stress from the dissimilar contraction modes. The study showed that dynamic and static strength exercise protocols using resistance bands both provoke acute and chronic hormonal responses, and the responses were more similar than dissimilar. However, the data suggest that the dynamic and static strength trainings may be slightly different in effect on the C hormonal activity of our boxer athletes, being more stimulatory. Future research needs to be conducted to elucidate the ramifications of these endocrine responses, and to determine the mechanisms involved. Nonetheless, we recommend that boxers train with either mode of resistance work, as neither invoked determinable hormonal responses.

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