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RESTING HORMONE LEVEL RESPONSE TO A 16-WEEK DYNAMIC AND STATIC EXERCISE PROGRAMME

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ABSTRACT

The aim of the study was to evaluate hormonal responses of serum cortisol, growth hormone (GH), testesterone and insulin-like growth factor-1 (IGF-1) levels during dynamic and static stress exercises in 20 male volunteer student athletes. The serum fasting hormonal levels of the participants were measured after six weeks of general resistance exercise. Subsequently, nine of the participants performed static exercises and 11 participants performed dynamic exercises for an additional 16 weeks and the serum hormonal levels were measured again. The cortisol level significantly decreased in participants from the static group compared to participants from the dynamic group ($p<0.05$). However, the other parameters measured in the participants of the study group, as well as the cortisol level in the participants of the dynamic study group, did not change significantly.

Key words: Exercise; Cortisol; Testosterone; Growth hormone; IGF-1.

INTRODUCTION

Exercise performed against body weight, free weight and various weight systems is known as resistance exercise and this type of exercise causes specific changes in the body. These changes are mainly stress adaptations of the body that usually have general common findings, although they are affected by several factors such as age, gender, genetic predisposition, nutrition and circadian pattern. The most prominent adaptations are in the neuromuscular and endocrine systems. The hormones of the endocrine system are the regulators of metabolic functional changes of the body during restructuring of tissues by resistance exercise. The catabolic process causes tissue destruction within the body during resistance exercise, while the anabolic process predominates and leads to growth and tissue repair during the rest period (Viru & Viru, 2004; Kraemer & Ratamess, 2005).

The hormones that are related to exercise include glucocorticoids (cortisole and corticosterone), catecholamines, testosterone, growth hormone (GH), insulin and insuline-like growth hormone-1 (IGF-1). Among these hormones, testesterone, GH, insulin and IGF-1 have complex anabolic effects and are important regulators during reshaping of muscles. The glucocorticoids have a direct catabolic effect and trigger destruction of muscle proteins. Expression of catecholamines, glucocorticoids and glucagon, which are all stress hormones,

leads to muscle catabolism when they act together (Kraemer *et al*., 1998; Viru & Viru, 2004; Kraemer & Ratamess, 2005; Crewther *et al*., 2006).

The hormonal response to exercise is altered by many factors, such as the type and duration of exercise, age, gender and muscles used during the exercise (Gray *et al*., 1993; Viru & Viru 2004; Uchida *et al*., 2009; Widdowson *et al*., 2009; Wahl *et al*., 2010). In static exercise, the working muscles are not getting shorter, and lengthen by contraction opposing the dynamic exercises in which the muscles contract, changing their length during the exercise. The static exercise is based on tension and does not produce work, while the dynamic exercise is based on contraction of muscle fibres and produces work. The purpose of this study was to evaluate resting levels of cortisol, testesterone, GH and IGF-1 following dynamic and static exercises performed by a group of 20 male sport students enrolled at the school of physical education and sports.

METHODOLOGY

The aim of this study was to evaluate the effects of static and dynamic exercise on the levels of cortisol, testesterone, GH and IGF-1. Twenty-two (22) male volunteer student athletes with a mean age of 21.96±1.80 years, height of 177.09±6.22cm and body mass 72.83±9.37kg participated in this study. All study group members performed resistance and power exercises for 6 weeks, such as push-ups, sit-ups, jumping and step-by-step running, before being divided into 2 groups who would participate in static or dynamic stress exercises.

The purpose of the initial 6-week general resistance exercise regimen was to ensure the study group members adapt to resistance and to minimise the risk of injury. The participants performed the same exercises in terms of mobility, power, time, repetition, rest and number of sets. Following this general adaptation period, the study group was randomly divided into 2 groups: a dynamic; and a static exercise group. Dynamic exercise keeps joints and muscles moving. It usually involves active full range of motion movements. The dynamic stress exercise group consisted of 11 athletes at the beginning, but 2 were later excluded from the study due to injury. Static exercise, which is also known as isometric exercise, involves muscles at high intensities without movement of the joints. The static stress exercise group consisted of 11 participants for the duration of the study.

The 2 groups were taken to the sport hall at different times and days for the 16-week stress exercise regimen. Before the stress exercises were started during each session, the participants performed 20 minutes of warm-up exercises including 15 minutes of stretching, and 7 or 8 times of 30 to 50m running with increases in speed as the warm-up progressed. Hypertorphy and power training for the upper and lower extremity muscles, pylometric training for jump power, station training for general power increase, and circuit and interval training for increases in power sustainability were also performed.

The study protocol exercises were performed 5 days a week for a 16-week period consecutively. In the dynamic study group, maximum studies were performed at 85 to 100% loading, 8 to 1 repeats with 3 sets and 3 to 5 minutes rest intervals for the 5 weeks; optimal studies were performed as 15 repeats at 65% and 8 repeats at 85% loading with 3 sets and 3 to 5 minutes rest intervals for the 5 weeks. Strength endurance studies were performed as 20

repeats at 65% and 40 repeats at 40% loading with 3 sets and 3 to 5 minutes rest intervals for 6 weeks. In the static group, the exercises were performed with the same loading protocol except replacing the repeats with 1 to 10 seconds, 11 to 20 seconds, and 21 to 40 seconds loading times for the maximum, optimal and strength endurance studies consecutively.

Before starting the study protocol (following the adaptation exercise period), 5ml venous blood samples were obtained from the participants at 09h00 after at least 9 hours of fasting. The second blood samples were obtained following the 16-week exercise period at 09h00 with fasting. The blood samples were centrifuged at 400rpm for 10 minutes and then stored at –80°C until biochemically assessed. The GH, testesterone and cortisol levels were measured with a Roche Hitachi 170 hormone analyserusing, an immunocytochemical method. The IGF-1 levels were measured with Dynex-Dsx/Virion ELISA unitusing, an immuno-diagnostic systems study kit.

Statistical analyses were performed using the SPSS v15.0 software (SPSS, Chicago, IL, USA). The Wilcoxon test was used to evaluate significance in differences between the pre- and post-exercise intervention measurements of the hormone levels within the dynamic and the static exercise study groups. The Mann-Whitney-U test was used to evaluate significance in differences between the pre- and post-exercise intervention measurements of the hormone levels within each of the 2 groups. A p-value of <0.05 was considered to be statistically significant.

The University Human Research Ethics committee approved this study before it was initiated and informed consent was obtained from all participants.

RESULTS

The pre- and post-exercise intervention measurements of the hormone levels from participants in the dynamic study group are shown in Table 1. The GH levels were 0.17 and 0.11ng/ml; cortisol levels were 16.37 and 16.15µg/l; IGF-1 levels were 218.34 and 210.06µg/l; and testesterone levels were 628.24 and 657.68mg/dl, respectively. No statistically significant difference was found in any hormonal level between the pre- and post-exercise intervention measurements in the dynamic exercise group.

***TABLE 1*: PRE- AND POST-EXERCISE INTERVENTION MEASUREMENTS OF HORMONAL LEVELS IN DYNAMIC EXERCISE GROUP**

Variable	n	Mean Pre	Mean Post	p-Value
GH ng/ml	9	0.17	0.110	0.735
IGF-1 µg/l	9	218.35	210.065	0.678
Cortisol µg/dl	9	16.37	16.150	0.314
Testosterone mg/dl	9	628.24	657.640	0.767

Table 2 shows the pre- and post-exercise intervention measurements for the static exercise group. The GH levels were 0.21 and 0.16ng/ml; IGF-1 levels were 229.62 and 218.79µg/l; cortisol levels were 15.85 and 13.11µg/dl; and testesterone levels were 573.03 and 568.60mg/dl, respectively. No statistically significant difference was detected between the pre- and post-exercise intervention measurements of the static exercise group, with the exception of the cortisol levels, which decreased from 15.85 to 13.11µg/dl (p=0.026).

***TABLE 2*: PRE- AND POST-EXERCISE INTERVENTION MEASUREMENTS OF HORMONAL LEVELS IN STATIC EXERCISE GROUP**

Variable	n	Mean Pre	Mean Post	p-Value
GH ng/ml	11	0.21	0.16	0.260
IGF-1 µg/l	11	229.62	218.74	0.424
Cortisol µg/dl	11	15.85	13.11	0.026
Testosterone mg/dl	11	573.03	568.60	0.657

***TABLE 3*: PRE-EXERCISE MEASUREMENT OF HORMONE LEVELS IN THE DYNAMIC AND STATIC EXERCISE GROUPS**

Varıable	Mean Dynamic	Mean Static	p-Value
GH ng/ml	0.17	0.21	0.400
IGF-1 µg/l	218.35	229.62	0.342
Cortisol µg/dl	16.37	15.85	0.761
Testosteron mg/dl	628.24	573.03	0.470

***TABLE 4*: POST-EXERCISE MEASUREMENT OF HORMONE LEVELS IN THE DYNAMIC AND STATIC EXERCISE GROUPS**

Varıable	Mean Dynamic	Mean Static	p-Value
GH ng/ml	0.11	0.16	0.503
IGF-1 µg/l	210.07	218.74	0.732
Cortisol µg/dl	16.15	13.11	0.270
Testosteron mg/dl	657.64	568.60	0.382

No significant differences were observed in hormone levels between the 2 exercise groups prior to the start of the regimen (Table 3). In addition, no significant differences were

observed in the hormone levels between the 2 exercise groups at the end of the study (Table 4).

DISCUSSION

It has been reported that exercise has a significant impact on the levels of several hormones, and can increase resistance and performance, as well as muscle mass. Hormone levels can change according to several parameters, including the type and length of exercise, the duration of time following exercise, the age and gender of the athletes, among others (Kraemer & Ratamess, 2005).

In the present study, blood hormone levels were measured prior to the start of the static or dynamic exercises in the 20 participants. The response of serum hormone levels to exercise and sport activities have been reported in other studies with different results. The reasons for the different results could be due to experimental design, composition of the study groups, type and length of the exercise, blood sampling time, and the time between the exercise and the sampling (Gray *et al*., 1993; Viru & Viru, 2004; Kraemer & Ratamess, 2005; Uchida *et al*., 2009; Widdowson *et al*., 2009; Wahl *et al*., 2010). Several studies have indicated that anabolic hormones, such as insulin, GH, testesterone and IGF-1, stimulate neural tissue and muscle development during resistance exercise (Karagiorgos *et al*., 1979; Kraemer & Ratamess, 2005; Crewther *et al*., 2006).

The serum concentration of anabolic hormones is elevated during and following resistance exercise compared to the level at rest, which leads to hypertrophy and remodelling of muscles (Widdowson *et al*., 2009). Different training intensities, such as high-intensity training and high volume, low-intensity training may have a different impact on hormone levels. Wahl *et al*. (2010) reported that cortisol levels are elevated at 10 and 60 minutes after high-intensity exercise compared to pre-exercise values. The cortisol concentration then decreases to a level that is lower than the pre-exercise level 240 minutes after the exercise period is complete. In addition, they reported that with high-volume and low-intensity exercise, the cortisol concentration decreases to a level that is lower than that of the pre-exercise level at 60 and 240 minutes after the exercise period is complete (Wahl *et al*. 2010). However, their study protocol was different from the present study's protocol, and they measured hormone levels during the early post-exercise period.

In the present study, the hormone levels were measured in the blood samples obtained at 09h00 following at least nine hours of fasting before and after the 16-week exercise period. The cortisol levels decreased significantly after static high-intensity exercise. However, the cortisol levels following dynamic exercise, as well as GH, IGF-1 and testosterone before and after the static and dynamic exercise periods had no significant changes. In contrast with these findings, several studies reporting increased hormonal levels with exercise found that elevation persists for a long period of time (Gray *et al*., 1993; Hakkinen & Pakarinen, 1993). Koziris *et al*. (1999) reported that increased hormonal response to exercise occurs for up to six months after the exercise. If the exercise intensity is above a certain threshold, then the blood level of cortisol increases with short-term exercise, which may be lower or may disappear with endurance training due to the threshold elevation.

It has been reported that with supramaximal exercise, which is higher than the threshold intensity, the cortisol response can be more prominent in endurance-trained athletes. During prolonged exercise, the cortisol response is variable. An increase in the level of cortisol occurs in the beginning of exercise due to increased adrenocortical activation, which returns to normal levels as a result of feedback mechanisms, and increases again due to increased muscle mass at work if exercise is maintained for a long enough period of time (Viru & Viru, 2004).

In the present study, the participants performed six weeks of adaptation training and the blood samples were obtained as a prestudy measurement. The participants' basal level of hormones could be increased compared to the hormone levels of non-trained athletes. In addition, a 16-week study protocol may not have any further effects on the hormone levels of participants who had previously received six weeks of training. Obtaining blood samples prior to the adaptation training could have assessed this possibility; however, pre-adaptation blood samples were not obtained. Nevertheless, the present study can conclude that dynamic or static power exercises do not affect the hormonal response in trained athletes who receive a certain threshold adaptation period. Diurnal rhythm has specific effects on the release of cortisol and IGF-1 in the body, where the hormone levels are higher in the morning and lower in the afternoon (Hayes *et al*., 2010). The blood samples were obtained at 09h00 from all participants in order to minimise the effect of diurnal variations in the hormonal levels.

Increased, decreased or unchanged IGF-1and GH hormonal responses to exercise have been reported (Karagiorgos *et al*., 1979; Gray *et al*., 1993; Hakkinen & Pakarinen, 1993; Hakkinen *et al*., 1998; Zaccaria *et al*., 1999). However, the study protocols of these reports varied. Linnamo *et al*. (2005) reports that GH levels are increased in response to submaximal and maximal heavy resistance exercise. However, the prominent increase was detected just after the exercise session was completed, and the response returned to normal level two hours post-exercise. The hormonal response can also be affected by the age, gender, training experience and fitness level of the athletes (Kraemer *et al*., 1991; Kraemer & Ratamess, 2005; Linnamo *et al*., 2005; Kraemer *et al*., 2006).

Testesterone is an anabolic hormone that induces protein synthesis and decreases protein catabolism caused by heavy exercise (Karagiorgos *et al*., 1979; Tarpenning *et al*., 2001; Martinez *et al*., 2010; Vingren *et al*., 2010). The response is more prominent after puberty and decreases with age. A weaker response to exercise in middle-aged athletes has been reported (Cadore *et al*., 2008). The unchanged response of IGF-1, GH and testesterone levels after exercise in the two study sub-groups in the current study could be explained by the adaptation of the participants after the six-week adaptation training period or the relatively late measurement time point, which occurred at least 15 hours after the last exercise session.

Wahl *et al*. (2010) investigated different intensity exercises, including high-intensity and high-volume low-intensity exercises, with nearly the same total volume. The study detected increased cortisol levels 10 minutes after exercise in the athletes receiving high-intensity training. The cortisol levels decreased to a level that was lower than the pre-exercise level in the low-intensity group at 60 minutes. At 240 minutes post-exercise, they detected a lower level of cortisol than that of the pre-exercise measurement in both groups. In the present study, a similar process may explain a decreased level of cortisol in the static group on the

day following the last exercise. The measurement was performed after the 240-minute post-exercise resting period.

CONCLUSION

A decreased cortisol level was observed in response to static exercises. All of the other hormones tested in participants of the static and dynamic exercise groups, as well as the cortisol levels in the participants of the dynamic exercise group had no significant change after a 16-week exercise regimen. Importantly, the blood samples were obtained the day after the end of the exercise sessions, and therefore it is possible that some hormonal responses could occur in the acute period following the exercises.

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