

## ACUTE GH AND IGF-I RESPONSES TO SHORT VS. LONG REST PERIOD BETWEEN SETS DURING FORCED REPETITIONS RESISTANCE TRAINING SYSTEM

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### ABSTRACT

*In order to examine the effects of different rest intervals between the sets on acute growth hormone (GH) and insulin-like growth factor-1 (IGF-I) responses, ten recreationally resistance trained men served as subjects (Mean  $\pm$  SD, age=22  $\pm$  2 years, body mass= 84  $\pm$  8 kg). Subjects performed two heavy-resistance training protocols that were similar with regard to the total volume of work (sets  $\times$  reps  $\times$  loads), but differed with regard the length of rest between sets (1vs.3-minutes). Both protocols included 5 sets of 10 RM bench press and squat that performed on two randomized separate sessions. Blood samples were collected before, immediately after and 1-hour after the protocols for determination GH, IGF-I and blood lactate concentration. Postexercise values for lactate and GH were significantly ( $P \leq 0.05$ ) elevated above preexercise, but did not for IGF-I concentrations. However, IGF-I serum concentrations were significantly ( $P \leq 0.05$ ) increased during 1-hour post-exercise. Postexercise serum GH and blood lactate concentrations were significantly ( $P \leq 0.05$ ) higher in SR than LR protocol, but IGF-I did not change. These data suggest that the duration of the rest interval between sets of dynamic resistance exercise influence GH serum concentration, it must be noted that short rest period between sets induced greater acute GH responses than the long rest period. Given that GH concentration is an anabolic hormone, this finding may have implications regarding hypertrophy in resistance training.*

**Key words:** Growth hormone; Insulin-like growth factor-1; Resistance training; Rest between sets.

### INTRODUCTION

Resistance training (RT) is a powerful stimulus for acute increase in the concentration of anabolic hormone in young men. These responses are highly dependent on the resistance training variables such as number of set and repetition per set, rest interval between sets, training intensity and muscle mass involved (Hakkinen & Pakarinen 1993; Banes *et al.* 1995). In order to overload the muscle progressively, the training intensity should be increased periodically. In RT program the intensity can be modified by training variables and training systems. There are many training systems such as forced repetition system that defined by Fleck and Kraemer (1997). Forced repetitions are special RT systems, which strength athletes, especially bodybuilders, use to increase training intensity.

It means that, after a set has been performed to exhaustion, training partners will assist by lifting or pushing the load just enough to allow the trainee to complete three to four additional

repetitions. This system forces the muscle to continue to produce force when it is extremely fatigued. It is necessary to achieve the failure (momentary muscle fatigue) during resistance training sets to gain maximally muscle mass and strength (Baechele & Earle, 1994). In addition, length of rest between sets is another factor that can be modified to change intensity.

It has been well known that the stress of heavy-resistance exercise has a potent effect for both strength development and muscle fiber hypertrophy. This may be due, at least in part, to exercise induced acute increase in serum anabolic hormone (Kraemer *et al.*, 1999). According to the previous study by Ahtiainen *et al.* (2003) the acute growth hormone and cortisol response in heavy-resistance exercise was greater in forced repetitions system compared with maximum repetition system. In addition, Kraemer *et al.* (1999) found that the acute endocrine response to heavy RT was greater in 10RM sets with shorter compared with longer rest periods between sets (1 vs. 3-minute).

In addition, some of the effects of growth hormone are mediated through small polypeptide called insulin-like growth factor-1 (IGF-1) or somatomedins. IGF-I is a 70-amino acid polypeptide that plays an important role in tissue anabolism by causing cell hypertrophy (Banes *et al.*, 1995; Abrahamsson, 1997). IGF-I response to either acute or chronic physical activity remains unclear (Kraemer & Ratamess, 2005). Based on several studies done in healthy young adults, there is an increase in circulating IGF-I in response to different types of exercise, either aerobic, resistance or heavy ergometer cycling (Cappon, 1994; Kraemer *et al.*, 1991 & 2004; Rubin *et al.*, 2005). However, most studies dealing with the acute response of IGF-I to resistance exercise have shown no change in serum IGF-I level (Chandler *et al.*, 1994, Kraemer *et al.*, 1995).

The discrepancies between these studies may in part result from differences in the volume and intensity of training, dependent variable selection, the pretraining physical fitness status, and muscle groups tested. Resistance training is characterized by exposing subjects to a very high degree of sudden strenuous all-out exercise. Little data are available on changes in the levels of IGF-I and GH following heavy RT in healthy young subjects. Furthermore, the effect of rest between sets on these responses has not been studied yet. We hypothesized that shorter rest would manifest greater alterations in serum IGF-I and GH levels following the forced repetitions RT system, than the longer rest intervals between sets. In addition, the majority of studies only evaluate GH as acute hormonal response to RT programs without considered IGF-I response. Therefore, the purpose of this study was to assess IGF-I and GH responses to different rest intervals between sets during resistance training in male athletes.

## METHOD

### The experimental approach to the problem

The acute hormonal responses of two resistance training protocols differing by rest periods between the sets (1 vs. 3-minutes) were studied with 10 recreationally strength-trained men. Both loading protocols were performed in forced repetitions system and expected to lead to large acute hormonal responses. According to the previous studies (Ahtiainen *et al.*, 2003:5), we hypothesized that when using short rest periods between the sets in forced repetitions system, the endocrine response should be larger along with a greater metabolic stress (i.e., lactic acid) than that of long rest periods between the sets.

## Subjects

Ten recreationally strength-trained men (Mean  $\pm$  SD, age=22  $\pm$  2 years, body mass=84  $\pm$  8 kg) volunteered as subjects. Each subject had at least two years recreational experience with resistance training but none were competitive strength athletes. No medication was taken by the subjects, which would have been expected to affect physical performance. Complete advice about possible risks and discomfort was given to the subjects, and all of them give their written informed consent to participate. The study was approved by the Ethics Committee for human experiments, department of physical education and sport science, University of Kurdistan.

## Strength testing

Lower and upper body maximal strength was assessed by using 10RM actions. Warm-up consisted of a set of five repetitions at the loads of 40-50 % of the perceived maximum. In the half squat (10 RM<sup>HS</sup>), the shoulders were in contact with a bar, and the starting knee angle was 90°. On command, the subject performed a concentric extension (as fast as possible) of the leg muscles starting from the flexed position to reach the full extension of 180° against the resistance. The trunk was kept as straight as possible. A security belt was used by all subjects. All of the tests were performed in a squatting apparatus in which the barbell was attached to both ends, with linear bearings on two vertical bars allowing only vertical movements. During the bench press test, the subject was instructed to perform from the starting position a purely concentric action maintaining the shoulders in a 90° abducted position to ensure consistency of the shoulder and elbow joints throughout the testing movement. During 10RM tests, if fewer than nine repetitions or more than 11 repetitions were completed, a second trial was performed with the load adjusted accordingly. 10RM was determined to serve as reference point in setting the load used in both protocols.

## Experimental Design

Familiarization session. The subjects were familiarized with the experimental testing procedures during a control day about one week before the actual measurements. Resistance-load verification for the experimental bench press and half squat exercises were also determined. During the control day, three blood samples were obtained from each subject. One blood sample was drawn in the morning after 12 hours of fasting and approximately eight hours of sleep for determination of basal serum hormone concentration. Two blood samples were also drawn within ½ hour without exercise at the same time of day that each subject would later undergo his heavy-resistance loading protocols of normal diurnal variation of serum hormone concentration. The experimental design comprised two forced repetitions resistance protocols within one week, (a) forced repetitions protocol with short rest (SR) period (1-minute) and (b) forced repetitions protocol with long rest (LR) period (3-min) (randomly assigned). SR protocol included 4 sets of 10RM bench press and squat with a 1-min recovery between the sets and 4-min recovery between the exercises. LR protocol was the same as in SR, but the rest period between the sets was 3-min. training load in both protocols was set approximately 15% higher than 10 repetition maximum so that the subjects could not perform 10 repetitions without assistance and would require assistance during the last three to four repetitions. The assistant was the same person in both protocols.

### **Blood collection and analysis**

During the loading session, blood samples were obtained via venipuncture from an antecubital vein by using a 20-gauge needle and Vacutainers for the determination of serum GH, IGF-I and blood lactate concentrations before, immediately after (post), and 1-hour after (1-h post) the training protocols. Concentrations of GH were measured using radioimmunoassay kits from Pharmacia Diagnostics (Uppsala, Sweden). The sensitivity of the GH assay was 0.2  $\mu\text{g/L}$ .

Serum IGF-I was measured by enzyme-linked immunosorbent assay kit (Diagnostic Systems Laboratories, Inc., Webster, TX) according to the manufacturer's procedures. All samples were assayed in duplicate and were decoded only after analyses were completed (i.e., blinded analysis procedure). The sensitivity of the IGF-I assay was 0.0013 nmol/l. Intrassay coefficients of variation for GH and IGF-I were 5% and 6%, respectively. A total two blood samples (before and after the protocols) were drawn and placed into a YSI lactate Analyzer (Yellow Springs, OH).

### **Statistical analyses**

Data are expressed as Mean  $\pm$  SD. Statistical evaluation was performed with SPSS 12.0 for windows and two ways analysis of variance (ANOVA) with Bonferroni's post hoc test were used to compare blood samples for the different programs. Statistical analysis compared the blood samples for each sequence against resting. The  $P \leq 0.05$  criterion was used for establishing statistical significance.

## **RESULTS**

Significant differences ( $P \leq 0.05$ ) were observed in mean blood lactate from pre- to post-exercise within and between each protocols (Table 1). No significant changes were observed in serum concentrations between the two control blood samples drawn within ½ hour without exercise during the control day. Serum GH concentrations increased after the SR and LR protocols from  $0.98 \pm 0.44 \mu\text{g/L}$  up to  $26.52 \pm 2.01 \mu\text{g/L}$  ( $P \leq 0.001$ ) and from  $1.06 \pm 0.44 \mu\text{g/L}$  up to  $22.91 \pm 1.64 \mu\text{g/L}$  ( $P \leq 0.001$ ), respectively (Table 1). Also, the relative changes in GH concentrations were greater ( $P \leq 0.01$ ) in SR than LR protocol. No significant changes in serum IGF-1 concentrations were observed from pre- to post-exercise. However, significant increases ( $P \leq 0.05$ ) were observed in serum IGF-1 concentrations from pre- to 1-hour post-exercise within each group but not between protocols (Table 1).

**TABLE 1. HORMONAL CONCENTRATIONS (MEAN  $\pm$  SD) IN PRE-, POST-, AND 1-HOUR POST-EXERCISE PROTOCOLS**

	Group	PRE	POST	1H- POST
IGF-I (nmol/l)	SR	25.12 $\pm$ 1.88	30.75 $\pm$ 3.91	48.25 $\pm$ 3.61*
	LR	25.75 $\pm$ 3.77	32.00 $\pm$ 3.45	42.37 $\pm$ 15.72*
GH ( $\mu$ g/l)	SR	0.98 $\pm$ 0.44	26.52 $\pm$ 2.01 <sup>*†</sup>	3.60 $\pm$ 0.12*
	LR	1.06 $\pm$ 0.44	22.91 $\pm$ 1.64 <sup>*†</sup>	2.15 $\pm$ 0.58*
Lactate (mmol/l)	SR	1.24 $\pm$ 0.34	14.5 $\pm$ 1.25 <sup>*†</sup>	
	LR	1.32 $\pm$ 0.5	9.70 $\pm$ 0.85 <sup>*†</sup>	

(SR: Short rest period between the set protocol, LR: Long rest period between the set protocol)

\* Significant differences to Pre-test

† Significant differences between Post-exercise in Short- and Long-rest protocol

## DISCUSSION

Exercise in humans is a well-known provocative stimulus for GH release, which is well known for its anabolic activity, and many researches (Ahtiainen *et al.*, 2003: 5; Hakkinen & Pakarinen, 1993; Kraemer *et al.*, 1987) have been shown that heavy RT-induced increased secretion of GH, which may be important for the process of training-induced muscle hypertrophy (Kraemer *et al.*, 1999). The present study was, to our knowledge, the first one to examine the exercise and recovery profiles on acute GH and IGF-I responses when the exercise regimen included different rest intervals between the sets in forced repetitions method of RT. *Forced repetitions* are a special RT system, which is used to increase the intensity of training; as well as rest intervals between sets is another factor that can be modified to change intensity of training (Ahtiainen *et al.*, 2003: 5; Kraemer *et al.*, 1999).

Although the actual effects of circulating GH on muscular adaptation are poorly understood, McCall *et al.* (1999) and Hakkinen *et al.* (2001) have reported that acute changes in GH are positively correlated with the muscle fiber cross sectional area and muscular strength after a prolonged training. These studies suggest that exercise induce-increase in blood GH concentration plays, in part, a role in muscular adaptation to resistance exercise. Although several studies (Ahtiainen *et al.*, 2003; Hakkinen & Pakarinen, 1993; Kraemer *et al.*, 1999) have defined reasonably well the relationship between intensity and or type of exercise and the concentrations of GH in circulation, relatively little is known about the effects of different rest intervals between the sets in forced repetitions resistance training system on GH and IGF-I.

According to the Kraemer *et al.* (1995), protocols using three sets of 10RM resistance with 1-minute recovery between sets significantly enhanced GH secretion and blood lactate concentrations. Our result showed that the GH and blood lactate were increased by both protocols, which was consistent with results of Kraemer *et al.* (1995).

In the present study, the concentration of GH was significantly increased by short rest (SR) protocol to long rest (LR) protocol. This suggest that short rest period between sets (1-minute) during forced repetitions resistance training system was practically important for enhancement

GH secretion, which was consistent with the results of Kraemer *et al.* (1990: 1), regimens using moderate exercise intensity, moderate repetitions and short rest periods between the sets (1-min) considerably enhanced GH secretion, whereas those using higher intensity, lower repetitions (5RM) and longer rest periods between the sets (3-min) do not. The reason for this was unclear, but this may be related to greater acidity that produced by SR protocol (1-min rest). Increasing muscle acidity stimulates mechanoreceptors and sends afferent feedback to the central nervous system and hypothalamus leading to an increased secretion of GH (Gosselink, 1998). This is supported by the present study showing that serum GH concentration correlated with blood lactate concentrations in both training protocols, which is in agreement with the findings of Ahtianin *et al.* (2003).

Growth factors, including IGF-I are known to be mediators of satellite cell activation, increased protein synthesis, decreased protein degradation, hyperplasia, and myofibril hypertrophy during muscle growth and development (Jennische, 1987). The response of IGF-I to acute RT is less clear. In the present study, although postexercise values of IGF-1 during two protocols increased but IGF-1 concentration changes immediately after protocols were not significant ( $P \geq 0.05$ ), which was consistent with the results of Kraemer *et al.* (1995).

However, IGF-1 concentrations increased significantly during 1-hour postexercise, but did not significantly differ between trials of different rest interval duration. Thus, these data demonstrated that a higher-intensity bout of heavy-resistance exercise that increases circulating GH appeared to affect IGF-1 concentrations over recovery period (1-hour post exercise) in recreationally strength-trained and healthy young men.

There are few limitations of this study that warrant discussion. First, these findings are related to few numbers of anabolic hormones. Further investigations are necessary to determine more anabolic hormones. Additionally, our findings are specific to healthy strength trained men. Further investigations are necessary to determine if these findings are generalizable to other populations.

In conclusion, our data suggest that the duration of the rest interval between sets of dynamic resistance exercise influence GH serum concentration, it must be noted that short rest period between sets induced greater acute GH responses than the long rest period. Given that GH concentration is an anabolic hormone, this finding may have implications regarding hypertrophy in resistance training.

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## REFERENCES

- ABRAHAMSSON, S.O. (1997). Similar effects of recombinant human insulin-like growth factor-I and II on cellular activities in flexor tendons of young rabbits: experimental studies in vitro. *Journal Orthopedic Research*, 15: 256-262.
- AHTIAINEN, J.P.; PAKARINEN, A.; ALEN, M.; KRAEMER, W.J. & HAKKINEN, K. (2003). Acute hormonal and neuromuscular responses and recovery to forced vs. maximum repetitions multiple resistance exercises. *International Journal Sports Medicine*, 24: 410-418.
- AHTIAINEN, J.P.; PAKARINEN, A.; ALEN, M.; KRAEMER, W.J. & HAKKINEN, K. (2005). Short vs. long rest period between the sets in hypertrophic resistance training: Influence on muscle strength, size, and hormonal adaptations in trained men. *Journal of Strength and Conditioning Research*, 19(3): 572-582.
- BAECHLE, T.R. & EARLE, R. (1994). *Essentials of strength training and conditioning* (2<sup>nd</sup> ed.). Champaign, IL: Human Kinetics.
- BANES, A.J.; TSUZAKI, M.; HU, P.; BRIGMAN, B.; BROWN, T.; ALMEKINDER, L.; LAWRENCE, W.T. & FISHER, T. (1995). PDGF-BB, IGF-I and mechanical load stimulate DNA synthesis in avian tendon fibroblast in vitro. *Journal of Biogeochemistry*, 28: 1505-1513.
- CAPPON, J.; BRASEL, J.A.; MOHAN, S. & COOPER, D.M. (1994). Effect of brief exercise on circulating insulin-like growth factor-I. *Journal of Applied Physiology*, 76: 1418-1422.
- CHANDLER, R.M.; BYRNE, H.K.; PATTERSON, J.G. & IVY, J.L. (1994). Dietary supplements affect the anabolic hormones after weight-training exercise. *Journal Applied Physiology*, 76: 839-845.
- FLECK, S.J. & KRAEMER, W.J. (1997). *Designing resistance training programs* (2<sup>nd</sup> ed.). Champaign, IL: Human Kinetics.
- GOSSELINK, K.L.; GRINDELAND, R.E.; ROY, R.R.; ZHONG, H.; BIGBEE, A.J. & GROSSMAN, E.J. (1998). Growth hormone in the rat pituitary. *Journal of Applied Physiology* 84: 1425-1430.
- HAKKINEN, K. & PAKARINEN, A. (1993). Acute hormonal responses to two different fatiguing heavy-resistance protocols in male athletes. *Journal Applied Physiology*, 74: 882-887.
- HAKKINEN, K.; PAKARINEN, A.; KRAEMER, W.J.; HAKKINEN, A.; VALKEINEN, H. & ALEN, M. (2001). Selective muscle hypertrophy, changes in EMG and force, and serum hormones during strength training in older women. *Journal of Applied Physiology*, 91: 569-580.
- JENNISCHE, E. & HANSSON, H.A. (1987). Regenerating skeletal muscle cells express insulin-like growth factor I. *Acta Physiology Scandinavia*, 130: 327-332.
- KRAEMER, W.J.; NOBLE, B.J.; CLARK, M.J. & CULVER, B.W. (1987). Physiologic responses to heavy-resistance exercise with very short rest periods. *International Journal of Sports Medicine*, 8: 247-252.
- KRAEMER, W.J.; GORDON, S.E.; FLECK, S.J.; MARCHITELLI, L.J.; MELLO, R.; DZIADOS, J.E.; FRIEDL, K.; HARMAN, E.; MARESH, C. & FRY, A.C. (1991). Endogenous anabolic hormonal and growth factor responses to heavy resistance exercise in males and females. *International Journal of Sports Medicine*, 112: 228-235.
- KRAEMER, W.J.; AGUILERA, B.A.; TERADA, M.; NEWTON, R.U.; LYNCH, J.M.; ROSENDAAL, G.; McBRIDE, J.M.; GORDON, S.E. & HAKKINEN, K. (1995). Responses of IGF-I to endogenous increases in growth hormone after heavy-resistance exercise. *Journal of Applied Physiology*, 79: 1310-1311.
- KRAEMER, W.J.; HAKKINEN, K.; NEWTON, R.U.; NINDL, B.C.; VOLEK, J.S.; McCORMICK, M.; GOTSHALK, L.A.; GORDON, S.E.; FLECK, S.J.; CAMPBELL, W.W.; PUTUKIAN, M. & EVANS, W.J. (1999). Effects of heavy-resistance training on hormonal response patterns in younger vs. older men. *Journal of Applied Physiology*, 87: 982-992.

- KRAEMER, R.R.; DURAND, R.J.; ACEVEDO, E.O.; JOHNSON, L.G.; KRAEMER, G.R.; HEBERT, E.P. & CASTRACANE, V.D. (2004). Rigorous running increases growth hormone and insulin-like growth factor-I without altering ghrelin. *Experimental Biology and Medicine*, 229: 240-246.
- KRAEMER, W.J. & RATAMESS, N.A. (2005). Hormonal responses and adaptations to resistance exercise and training. *Sports Medicine*, 335: 339-361.
- McCALL, G.E.; BYRNES, W.C.; FLECK, S.J.; DICKINSON, A. & KRAEMER, W.J. (1999). Acute and chronic hormonal responses to resistance training designed to promote muscle hypertrophy. *Canadian Journal of Applied Physiology*, 24: 96-107.
- RUBIN, M.R.; KRAEMER, W.J.; MARESH, C.M.; VOLEK, J.S.; RATAMESS, N.A.; VANHEEST, J.L.; SILVESTRE, R.; FRENCH, D.N.; SHARMAN, M.J.; JUDELSON, D.A.; GOMEZ, A.L.; VESCOVI, J.D. & HYMER, W.C. (2005). High-affinity growth hormone binding protein and acute heavy resistance exercise. *Medicine Science in Sports and Exercise*, 337: 395-403.