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Research Article

The Effects of Interval and Traditional Resistance Exercise on Hormonal Control of Adipose-tissue Lipolysis in Healthy Young Men

Minoo Bassami[1,2]*, Bahareh Taghipour[1], Rasul Eslami[1], Ali Nejatian Hoseinpour[1], Kallie Dawkins[3], Saiful Singar[3] and Bahram H Arjmandi[3]*

[1]Department of Exercise Physiology, Faculty of Physical Education and Sports Sciences, Allameh Tabataba'i University, Tehran, Iran

[2]Research institutes of Sport Science and Health, Allameh Tabataba'i University, Tehran, Iran

[3]Professor, Florida State University, Tallahassee, FL, USA

Abstract

Purpose: Lipolysis is regulated by lipolytic hormones, like insulin, cortisol, growth Hormone (GH), and catecholamines. Unregulated lipolysis results in the accumulation of free fatty acids (FFAs), leading to dysfunction of cells and death. Thus, the main aim of this study was to determine the effects of interval and traditional resistance exercise on hormonal control of adipose-tissue lipolysis in healthy young men.

Methods: Twelve healthy males (Mean ± SD; age, 25.5 ± 3.1 years; Body mass index, 24.2 ± 2.0 kg/m^2) performed tradition resistance exercise (TRE) at 80% of 1RM (3 sets of 6 repetitions) with 2 min passive recovery, and an interval resistance exercise (IRE) trial at 60% of 1RM (3 sets of 6 repetitions) followed by active recovery (1 set of 6 repetitions at 20% of 1RM). Three blood samples were taken before and immediately after exercise, and after one-hour recovery and were analyzed to measure epinephrine, norepinephrine, cortisol, and GH.

Results: Statistical analyses of the data revealed that concentrations of cortisol and GH increased in response to resistance exercise and significantly decreased ($p < 0.05$) during the recovery period. Although there were no significant differences between the two protocols for cortisol concentration, GH increases following IRE were profoundly higher than TRE protocol. Epinephrine and norepinephrine increased ($p < 0.05$) in response to both resistance exercise trials, though, no between-group differences were found for these variables.

Conclusion: The results of our study showed increases in GH, cortisol, epinephrine, and norepinephrine in two resistance exercise protocols which may lead to increases in fat oxidation.

More Information

***Address for Correspondences:**
Dr. Bahram H Arjmandi, Professor, Florida State University, 120 Convocation Way, Tallahassee, FL, USA, Email: Barjmandi@fsu.edu

Dr. Minoo Bassami, Department of Exercise Physiology, Faculty of Physical Education and Sports Sciences, Allameh Tabataba'i University, Opposite to Olympic Hotel, 9th Chougan Street, Tehran, Iran, Email: bassami@atu.ac.ir

Bassami M: https://orcid.org/0000-0001-8204-8355

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Keywords: Lipolysis; Hormonal control; Fat oxidation; Interval resistance exercise; Norepinephrine; Epinephrine

Abbreviations: GH: Growth Hormone; Camp: Controlling Intracellular Cyclic AMP; PKA: Protein Kinase A; FFAs: Free Fatty Acids; TRT: Traditional Resistance Training; HIIT: High-Intensity Interval Resistance Training

Introduction

In recent years, there has been a notable surge in interest within the realms of health, fitness, and lifestyle towards the exploration of effective exercise modalities aimed at optimizing metabolic outcomes. Adipose tissue lipolysis assumes a pivotal role in energy metabolism, with its regulation intricately guided by hormonal signals [1-3]. Lipolytic hormones, such as insulin, cortisol, Growth Hormone (GH), and catecholamines can influence lipolysis by controlling intracellular cyclic AMP (cAMP) and the activity of Protein Kinase A (PKA) [4-10]. Epinephrine and norepinephrine have the most important regulatory role in adipose tissue during metabolism and modulate lipolysis with increasing cAMP concentration and PKA activity [11,12]. FFAs accumulate in peripheral metabolic tissues, such as liver, muscle, and pancreatic islets due to unregulated lipolysis, and may lead to cell dysfunction and death [13].

The majority of research has studied the effects of aerobic exercise, finding that resistance exercise may improve overall body composition, and change lipid metabolism [14-16].

Furthermore, it has been noted that resistance training promotes the breakdown of fat cells in obese individuals [17,18]. Additionally, engaging in regular physical activities outside of structured exercise has been found to have a beneficial effect on the body's composition and resting metabolic rate among older adults, as it increases muscle mass and daily energy expenditure while reducing fat mass [18,19]. The number of exercises, intensity, and number of repetitions, intervals, and sets are the parameters of a resistance training program, which may lead to different responses of regulatory hormones [20]. Epinephrine and norepinephrine increased significantly after three equal consecutive cycles of resistance training; a protocol designed to stress the major muscle groups and was performed by untrained young men [21]. Raymond, et al. [22] showed that resistance exercise may increase cortisol concentration with higher intensity. One study measured GH secretion for 12 hours after an acute heavy resistance exercise and demonstrated that resistance exercise elevated GH levels for 20 minutes after exercise immediately in young males [23]. Yet, several studies showed a greater GH response in both high repetition with 70% or more, and high total work with short intervals [24].

However, manipulating the intensity of an exercise, recovery type, and work-to-recovery ratio may lead to vastly different results in resistance exercise adaptations [25,26]. It has been suggested that resistance exercise with shorter rest intervals is more effective and useful for increasing lipolysis and oxidation [27]. A study measuring respiratory exchange ratio and energy consumption reported that 22 hours after Traditional Resistance Training (TRT) and High-Intensity Interval Resistance Training (HIIRT), there was a greater amount of energy expenditure after HIIRT than TRT. This study also demonstrated a decrease in the respiratory exchange ratio, showing that fat utilization was dominant in HIIRT. However, it is important to note that hormonal changes were not investigated [28]. In another study, after performing a 45-minute HIIRE session (including six repetitions with 80% 1RM with 20 seconds rest, three repetitions with 80% 1RM -with 20 seconds rest followed by two repetitions with 80% 1RM - with 20 seconds rest, which is performed twice) and a 65 minutes TRE session (including three sets of exercises with eight repetitions at 75% of 1RM, with 2 ′30″ of rest between the sets), no significant difference was shown between the two protocols. However, it is important to note that participants in this study were overweight young girls and other regulatory hormones were not investigated [29].

Therefore, to our knowledge, no study has focused on lipolytic hormonal responses following both a Traditional Resistance Exercise (TRE) and an Interval Resistance Exercise (IRE) session. Hence, our objective was to examine how these two exercise protocols affect the hormonal control of adipose tissue lipolysis in healthy young men. By investigating the impact of these exercise modalities on hormonal responses associated with adipose tissue lipolysis, our study aims to provide valuable insights for designing targeted and effective exercise strategies to improve metabolic health. The findings of this research have the potential to optimize exercise prescriptions and customize interventions to enhance the hormonal regulation of adipose tissue lipolysis. Ultimately, this research contributes to a deeper understanding of how exercise influences metabolic health in young, healthy males.

Methods

Participants

Following approval from the University's research degree and Ethics Committee (IR.SBU.RCE.1399.003), twelve healthy males were recruited to take part in the study (Table 1). Participants were excluded if they were active smokers or took medications/supplements known to affect substrate metabolism. Participants were required to refrain from consuming caffeine and performing exercise 24 hours before each laboratory visit. All participants were informed both verbally and in writing about the purpose, risks, and benefits of the research, and gave their written informed consent to participate in this investigation. All experimental procedures were performed by the Declaration of Helsinki.

Procedures

Determination of maximum strength (1RM): To minimize the risk of unnecessary musculoskeletal injury, all subjects performed a warm-up that consisted of two phases. The first phase was a 5-minute warm-up on a cycle ergometer (Monark ergometric 839E, Sweden) at a self-selected intensity. The participant's 1RM lifts for the exercises used during the strength testing period were determined using previously described procedures [30].

Experimental procedures: Subjects reported to the laboratory on four separate occasions. The first session was designed to familiarize the subjects with the procedures and to determine their anthropometric characteristics (stature, body mass, and percentage of body fat). The second session was to determine the one-repetition maximum (1RM), with the third and fourth sessions to perform the TRE and IRE protocols. Participants arrived at the laboratory under the same pretesting conditions for each visit (between 7 am - 8 am). Subjects completed a food diary on the day before their first test and repeated this diet before the second trial. Subjects were instructed to refrain from drinking alcohol and to not engage in any strenuous exercise 24 hours before all visits. Two exercise trials were allocated randomly in a counterbalanced manner and separated by at least 7 days.

Subjects reported to the physiology laboratory following an overnight fast, one hour before the main exercise protocol.

Table 1: Subjects' characteristics (mean ± SD).

Age (yrs)	Height (cm)	Body Mass (kg)	Body mass index (kg/m^2)	Body fat (%)
25.5 ± 3.1	174.1.5 ± 7.8	73.9 ± 1.0	24.2 ± 2.0	16.8 ± 4.6

They were given a light breakfast (two slices of toast with 150 g carrot jam and a 250 ml cup of orange juice), which contained approximately 650 kcal. One hour after consuming breakfast, resting blood pressure was measured (Omron M7, Omron Ltd, Kyoto, Japan), and a blood draw (11 ml) was taken. Like during the 1RM trial, all exercise was preceded by a two-phase warm-up.

The TRE protocol used in the present study was similar to that previously reported [30]. Briefly, it involved conducting 3 sets of 6 repetitions at 80% of 1RM of the six exercises stated previously, with 2 minutes of passive rest. The IRE protocol comprised 3 sets of 6 repetitions at 60% of 1RM with active recovery (one set of 6 repetitions at 20% of 1RM for the same exercises). Two exercise trials were performed in a counterbalance manner in two separate weeks and exercise volume (sets × reps × amount of weight) was kept equal for both protocols. The second and third blood draws were taken immediately after exercise and following one-hour recovery.

Data collection and laboratory methods

Venous blood samples were obtained from an antecubital vein at rest (before exercise), immediately after exercise, and after one-hour recovery. Plasma was obtained by collecting a blood sample into a pre-treated EDTA vacutainer. These samples were gently mixed before centrifugation (4 ºC for 15 minutes at 1900 g). After centrifugation, plasma was separated and stored at –70 ºC for the subsequent analysis of cortisol, epinephrine, norepinephrine, and GH. Catecholamines were analyzed using the Human 2CAT Epinephrin\Norepinephrine Elisa kit (96t-LDN, Germany); cortisol was analyzed by a German ZellBio Cortizol kit, and GH was analyzed by a Human GH Elisa kit (Monobind, Germany). All parameters were assayed by ELISA (Enzyme-linked immunosorbent assay) technique using a fully automated system (DRG instruments Gmbh, Germany).

Statistical analyses

All statistical analyses were performed using the software statistical package SPSS version 22. After confirming the normality of the data by the Shapiro-Wilk Test, a repeated measure of ANOVA (analysis of variance) (2 conditions × 3 times) was employed to evaluate the differences in the mean values of blood parameters between the two exercise protocols. When ANOVA indicated the presence of a significant difference, the Tukey post hoc test was used to identify which mean differences were statistically significant. Values are presented as mean (±SE), unless otherwise stated, with the level of significance set at $p \leq 0.05$.

Results

The statistical analyses of the data showed a main significant effect of exercise on cortisol ($p < 0.001$) and GH ($p < 0.001$). Post-hoc analyses indicated that concentrations of cortisol and GH were elevated ($p < 0.001$) after resistance exercise and significantly decreased during the recovery period (Figures 1,2). However, there was no significant difference in cortisol concentration between the two protocols ($F_{2, 22} = 1.7$, $p > 0.05$). On the other hand, the increase in GH following the IRE protocol was significantly higher compared to the TRE protocol ($F_{2, 22} = 8.07$, $p < 0.01$).

Epinephrine and norepinephrine levels increased significantly ($F_{2, 22} = 7.88$, $p < 0.01$; $F_{2, 22} = 7.3$, $p < 0.01$, respectively) in response to both resistance exercise trials (Figures 3 & 4), though, the differences between the two trials were non-significant.

Discussion

The main findings of the present study were that all variables were increased in response to both resistance exercise trials and that except for growth hormone changes in other variables were not different between the TRE and IRE protocols. These findings are consistent with previous studies that have reported increases in cortisol, GH, and catecholamines after an acute resistance exercise [29,31-34]. For instance, Allman, et al. [31] reported that acute resistance

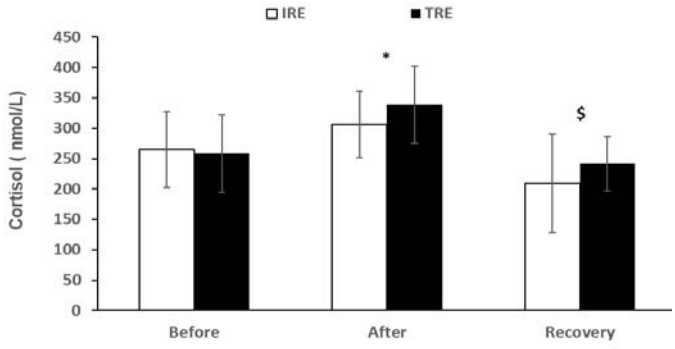

Figure 1: Cortisol values (means ± SD) before and after exercise, and after the recovery period for two exercise protocols. *indicates a significant ($p < 0.01$) exercise effect, and $ represents a significant ($p < 0.01$) recovery effect. IRE, interval resistance exercise. TRE is a traditional resistance exercise.

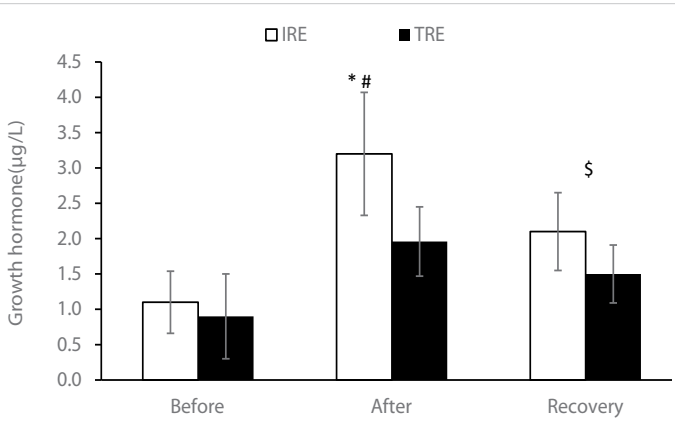

Figure 2: Growth hormone values (means ± SD) before and after exercise, and after the recovery period for two exercise protocols. * indicates a significant ($p < 0.001$) exercise effect, $ represents a significant ($p < 0.001$) recovery effect, and # indicates a significant ($p < 0.01$) difference between the protocols. IRE, interval resistance exercise. TRE is a traditional resistance exercise.

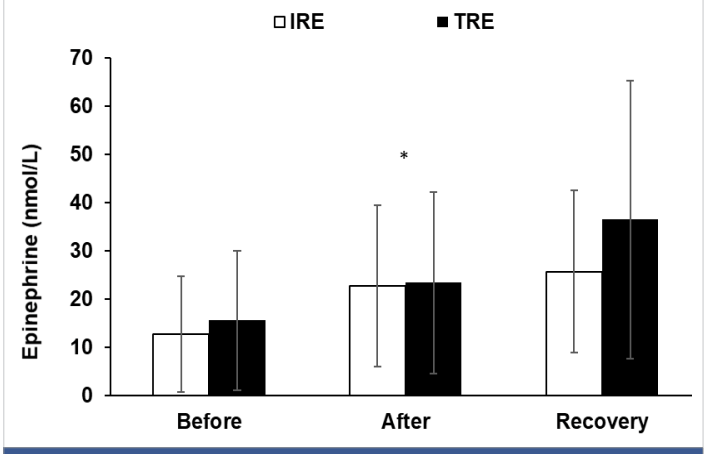

Figure 2: Epinephrine hormone values (means ± SD) before and after exercise, and after the recovery period for two exercise protocols.* indicates a significant ($p < 0.01$) exercise effect. IRE, interval resistance exercise. TRE is a traditional resistance exercise.

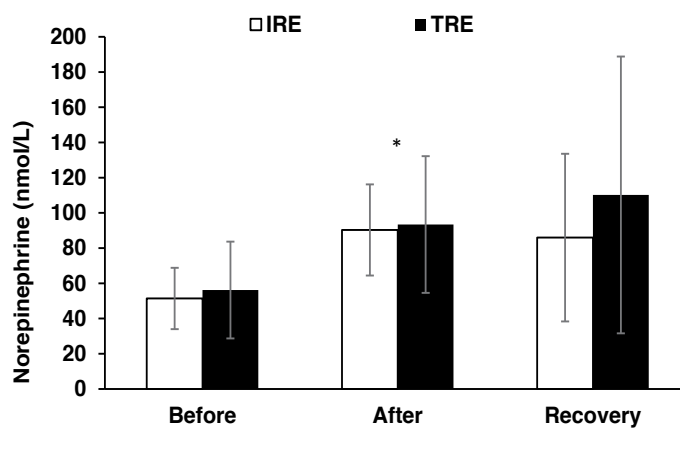

Figure 4: Norepinephrine hormone values (means±SD) before and after exercise, and after the recovery period for two exercise protocols. * indicates a significant ($p < 0.01$) exercise effect. IRE, interval resistance exercise. TRE is a traditional resistance exercise.

exercise with 65% 1RM with 90 seconds of rest resulted in elevated concentration GH, epinephrine, and norepinephrine concentration. These hormonal changes were associated with increased lipolysis during and after the exercise. The elevation of GH and catecholamines induced by resistance exercise may contribute to the stimulation of lipolysis [31]. Catecholamines regulate the lipolysis pathway by activating adenylyl cyclase through β-adrenoceptors (β-AR), specifically β-AR1-3, while α2-AR subtypes inhibit lipolysis. This signaling pathway increases the concentration of cyclic adenosine monophosphate (cAMP) and activates Protein Kinase A (PKA), which in turn phosphorylates specific serine residues of various proteins to enhance lipolysis [11]. Leite, et al. [34] reported that a single session of resistance exercise with 80% of 1RM and 2 minutes of rest increased cortisol and GH levels. These findings are consistent with those of Kramer, et al. [35], who demonstrated elevated cortisol and GH following four sets of ten repetitions at 1RM with 90 seconds of rest. Cortisol has been shown to stimulate leptin production, which in turn increases the activity of sympathetic nerves and promotes lipolysis [36,37]. Moreover, cortisol may influence the phosphorylation of perilipin, a protein involved in the regulation of lipolysis [38].

In addition to cortisol, GH stimulates lipolysis through several mechanisms: 1) GH increases the sensitivity of adipocyte β-receptor to catecholamines 2) GH stimulates lipolytic enzymes such as hormone-sensitive lipase 3) GH inhibits triglyceride-storing enzymes like lipoprotein lipase, fatty acid synthase, or acetyl-CoA carboxylase [39,40]. Furthermore, Peake, et al. [41] reported increased levels of epinephrine, norepinephrine, cortisol, and GH following a HIIT session. The HIIT session consisted of 10 × 4-minute intervals at 81.6 ± 3.7% of VO2max and 72.0 ± 3.2% of peak power output, with 2 minutes of rest (11.4 ± 0.9% of peak power output) between intervals.

Dote-Montero, et al. [42] emphasized several studies indicating an increase in cortisol levels following an acute HIIT session. The activation of the hypothalamic-pituitary-adrenal axis by stressors like exercise can impact cortisol synthesis [42]. However, our study did not find any significant differences in epinephrine, norepinephrine, and cortisol levels after exercise between the two resistance protocols. These findings align with those of Zarei, et al. [29], who reported non-significant differences in epinephrine response to TRE and HIIRE protocols, possibly attributable to variations in exercise duration or intensity. Nevertheless, our study demonstrated that GH concentration was significantly higher in the HIRE protocol compared to the TRE protocol. Hence, our results are consistent with previous literature indicating that GH response is greater in resistance exercises involving high total work and short rest intervals [24]. Previous research has shown that the most pronounced GH responses occur when resistance exercises are combined with minimal recovery periods. This evidence underscores the undeniable influence of various factors, such as exercise load type, exercise repetitions and rounds, and work-recovery intervals, on GH response [24].

Conclusion

To conclude, the present study found that the recovery type of resistance exercise does not have an impact on lipolytic hormones, except GH. Our results demonstrated that cortisol, epinephrine, and norepinephrine increased following resistance exercise, regardless of the protocols used. These findings suggest that the elevation of lipolytic hormones may contribute to enhanced fat oxidation and lipolysis, given their significant involvement in these processes during and after exercise. Notably, GH exhibited a more pronounced increase in response to active recovery following exercise and may play a substantial role in promoting lipolysis.

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Data availability statement

Data generated or analyzed during this study are not publicly available due to confidentiality agreements with research collaborators but are available from the corresponding author upon reasonable request.

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