Original Article

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Physiology Section

Acute Effect of Resistance Exercise on Serum Cortisol and its Correlation to Blood Glucose in Healthy Non Obese Adults: A Pilot Study

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ABSTRACT

Introduction: Different types and intensity of resistance training/ exercises lead to variable cortisol responses, which is essential for growth and homeostasis on short term and long term basis. But the variable responses are not accurately defined to be of any help in tailoring one's exercise program.

Aim: To study the effect of resistance exercise on serum cortisol and its correlation to blood glucose in healthy non obese subjects.

Materials and Methods: It was an experimental analytical pilot study extending from February 2017-July 2018 involving 48 healthy non obese subjects (24 males and 24 females) of age group 18-25 years, were enrolled in the study after the screening protocol. High volume exercise training regimen was used involving major muscle group of arms, legs and trunk. Regime involved five exercises with three sets. Between each set, subjects took 30 seconds rest and with each exercise, a rest period of one minute. Height, weight were measured to calculate Body Mass Index (BMI) and serum blood glucose was done along with serum cortisol.

Results: The serum cortisol levels in males in pre-exercise group was 145.47±33.67 μg/dL while postexercise group had 116.57±34.40 μg/dL reflecting moderately significant decrease ($p<0.01$). The serum cortisol levels in females in pre-exercise group were 141.83±38.38 μg/dL while in postexercise group 118.46±35.53 μg/dL with a moderately significant decrease ($p<0.01$). The Random Blood Sugar (RBS) levels in both males and females postexercise was significantly increased ($p<0.05$). There was decrease in serum cortisol levels in comparison to rise in RBS in both genders, a highly significant decrease ($p<0.001$) in males in comparison to moderately significant decrease ($p<0.05$) in females.

Conclusion: Resistance exercise induced decrease in cortisol hormone and its interplay with serum glucose can be better understood by multivariate/elaborate studies on a large sample size.

Keywords: Body mass index, Exercise program, Resistance training

INTRODUCTION

Exercise poses a physical stress challenging homeostasis. In response to this stressor, autonomic nervous system and the Hypothalamic-Pituitary-Adrenal (HPA) axis react to maintain homeostasis. This causes elevation of plasma cortisol and catecholamines. However, sustained physical conditioning in highly trained athletes is associated with a decreased HPA response to exercise. On the other hand, highly trained athletes exhibit a chronic mild hypercortisolism at baseline that may be an adaptive change to chronic exercise. Besides, the exercise stress inhibits the gonadal function, through the production of glucocorticoids and catecholamines, and through activation of the Corticotropin Releasing Hormone (CRH) neurons [1].

Several study results confirm the threshold phenomenon in adults and in late puberty adolescents indicating that the cortisol levels after acute bouts of exercise is intensity dependent. In contrast to these results, Budde H et al., found that postexercise levels of cortisol were significantly lower than the pre-exercise ones in both gender groups [2]. It was also seen that there were no significant differences in resting hormone levels or hormonal responses to exercise between training status groups and that hormonal responses to exercise differ between male and female older adults [3].

Collectively, the cortisol findings support the view that moderate to high intensity exercise provokes increase in circulating cortisol levels. In contrast, low intensity exercise (40%) did not result in significant increases in cortisol levels [4].

With so many variable responses as per the review literature, to gain still more insight into the exercise induced biochemical response in young healthy non obese subjects the authors planned the present study.

The more the authors understand, more would it be helpful to plan for better body growth via exercise induced stress in individual cases. So, the present study aimed to evaluate the acute effect of resistance exercise on serum cortisol and blood glucose in healthy non obese subjects.

MATERIALS AND METHODS

It was an experimental analytical pilot study of 1.5 years duration approximately, extending from February 2017-July 2018 involving 48 healthy subjects [5], of first year professional Bachelor of Medicine and Bachelor of Surgery (MBBS) comprising of 24 males and 24 females aged 18-25 years at Ganesh Shankar Vidyarthi Memorial (GSVM) Medical College, Kanpur, UP. All the study volunteers were screened via a comprehensive health questionnaire and physical examination. Ethical clearance duly taken from Institutional Ethics Committee and in accordance with the Helsinki Declaration of 1975 (revised 2013). Informed consent was duly taken.

Inclusion criteria: Those subjects who were sedentary or doing moderate activity and were not previously involved in any kind of weight training, athletic training or any sport activity for at least one year were involved in the study.

Exclusion criteria: Those subjects participating in outdoor sports/ Gymnasium (Gym) training, those with history of any musculoskeletal injury or disorder, steroid, or those with history of hormonal intake, history of oral contraceptive pill intake or hormonal therapy in females subjects and history of any major illness like diabetes mellitus, hypertension etc. were excluded from the study.

High volume exercise training regimen have previously shown to cause significant acute exercise induced hormone elevations was used. This training protocol was considered to provide the best prospects for evaluating potential adaptations in the acute exercise induced hormonal responses and the importance of hormonal factors on other training responses [4]. Subjects were instructed to fast overnight and exercise was performed in early morning.

Procedure

Intensity (i.e., load) has been shown to have a significant impact on muscle hypertrophy and is arguably the most important exercise variable for stimulating muscle growth. Intensity is generally expressed as a percentage of 1 Repetition Maximum (RM) and is proportional to the number of repetitions that can be performed as per the given weight. Repetitions are classified into three basic ranges: low (1-5), moderate (6-12), and high (15+). Each repetition range involves the use of different energy systems and taxes the neuromuscular system in varied ways, impacting the extent of the hypertrophic response [6].

Exercise training involved major muscle group of arms, legs and trunk. Free weights were used for all exercises. Regime involved five exercises with three sets. First set consist of 10 repetitions maximum with same weight. Then in the second set, load was increased as per the muscle group being stressed and subjects have to perform eight repetitions maximum and in the last set load was further increased and subject had to perform six RM, between each set subjects were rested for 30 seconds and with each exercise one minute. Similarly, this protocol was followed with other exercises. The exercise regime consisted of following exercises.

Dumbbell's biceps curl [7]: The alternating dumbbell biceps curls develop size and strength of the biceps and forearms. The alternating of each arm eliminates any muscular imbalances on each side.

1. With a pair of dumbbells; stand up straight allowing the dumbbells to hang at arm's length with palms facing forward.
2. Bend the elbows and curl the dumbbells close to the shoulders.
3. Pause for a second and slowly lower the weights to the starting position with arms fully extended.

Bench press [8]: The bench press strengthens the upper, by pressing a weight upwards from a supine position working the Pectoralis major, supporting chest, arm, and shoulder muscles- the anterior deltoids, Serratus anterior, Coraco brachialis, Scapulae fixers, Trapezii, and the Triceps. A barbell is used to hold the weight.

1. The person lies on his/her back on a bench with a weight grasped in both hands.
2. The weight is pushed upwards until arms are extended, not allowing the elbows to lock. Later the weight is lowered to the chest level.

Barbell bent over with dumbbells [9,10]: The bent over dumbbell row is considered as one of the best muscle building exercises for the back and the shoulders working both areas well thus improving overall strength of the muscle.

1. To perform the exercise with the left arm, right knee and lower leg, and right hand, are positioned on a bench.
2. Leave the left foot flat on the floor and bend forward to make the torso horizontal. Hold the dumbbell with palm facing the bench and arm extended straight down.
3. Lift the weight to the left side of the chest and then lower it slowly to the starting position. The exercise to be performed with both arms.

Seated front shoulder press [11]: This exercise increases strength and density throughout the core complex and upper back region, while increasing overall stability. This exercise is done with feet shoulder-width apart, which requires less core strength.

1. On a weight bench with an upright back support, grab a barbell using a double-overhand grip so the hands are slightly wider than shoulder-width apart.
2. Bending the arms slowly, lower the barbell to the collar bone, keeping the elbows by the sides.
3. Gripping the barbell firmly, press it overhead until the elbows are completely locked out.

Squats [12,13]: In strength training and fitness, the squat is a compound, full body exercise that trains primarily the muscles of the thighs, hips and buttocks, quadriceps femoris muscle, hamstrings, as well as strengthening the bones, ligaments and insertion of the tendons throughout the lower body.

1. Stand as tall as you can with feet shoulder-width apart, toes slightly pointed outward and arms in front at chest height to help maintain balance.
2. Dropping the hips, sit back to make the thighs parallel with the floor. Pause, then drive through the heels and lift body upwards back to the starting position, squeezing the gluteus maximus muscle at the top of the movement.

There were two different regimes as per the load, with each exercise the load was different for different muscle group which was shown in the tables [Table/Fig-1,2].

Blood Sampling

Blood samples were taken using a 2 mL syringe. Blood was withdrawn just before exercise and 10 minutes after exercise was collected in a plain glass vial with gel base. Serum was separated and stored at -17 to -20°C at our college blood bank. Random Blood Sugar (RBS) values were taken using strip digital glucometer before and 10 minutes after exercise. Other parameters like height and weight were taken at the time of screening. Measurements of the subjects were taken by the standard measuring scale and weight was taken by digital weighing machine and BMI duly calculated.

World Health Organisation classification of obesity (2006) [14]:

Underweight <18.5 kg/m^2

Normal (healthy weight) 18.5-24.9 kg/m^2

Overweight 25-29.9 kg/m^2

Obese class 1 (moderately obese) 30-34.9 kg/m^2

Obese class 2 (severely obese) 35-39.9 kg/m^2

Obese class 3 (very severely obese) ≥40 kg/m^2.

STATISTICAL ANALYSIS

Continuous data were summarised as mean±SD and discrete data in number and percentages. For comparison on two different times, paired t-test was performed. Analysis was performed on Statistical

Exercise	Dumbbells			Bench press			Barbell bent over			Seated front press			Squats		
Repetitions	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6
Weights (kg)	5	7.5	10	15	20	30	7.5	15	20	7.5	15	20	15	20	30

[Table/Fig-1]: Males exercise regime.

Exercise	Dumbbells			Bench press			Barbell bent over			Seated front press			Squats		
Repetitions	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6
Weights (kg)	3	5	7.5	10	12	15	5	7.5	10	10	12	15	10	12	15

[Table/Fig-2]: Females exercise regime.

Package for Social Sciences (SPSS) software version 26.0. The p-value <0.001 was considered statistically highly significant while p-value >0.05 is considered non significant.

RESULTS

The demographic characterstics [Table/Fig-3] and the relevant findings for total 48 participants of the study were tabulated and analysed. It was found that, the serum cortisol was moderately significantly decreased (p<0.01) by 19.71%. The paired t-test showed weakly negative correlation (r=-0.03) between BMI and serum cortisol within the group (females) which was moderately significant with p-value <0.01 [Table/Fig-4].

Age (years)	BMI (kg/m²) Males Mean±SD	BMI (kg/m²) Females Mean±SD
18-25	23.22±3.12	20.40±4.49

[Table/Fig-3]: Demographic characterstics of the study participants.
BMI: Body Mass Index

Serum cortisol	Mean±SD (µg/dL)	BMI (kg/m²)	r-value	p-value
Pre-exercise	141.83±38.38	20.40±4.49	0.09	<0.01
Postexercise	118.46±1.06		0.05	
Difference	23.36±39.60		-0.03	

[Table/Fig-4]: Correlation of Serum cortisol in females with Body Mass Index (BMI).
Paired t-test

The pre-exercise RBS (fasting overnight) levels had 6.20 mg/dL increase which was significant (p<0.05). The paired t-test showed weakly negative correlation (-0.11) between rise in RBS and decrease in serum cortisol within the female group which was significant with p-value <0.05 [Table/Fig-5].

Serum cortisol	Mean±SD (µg/dL)	RBS (mg/dL)	r-value	p-value
Pre-exercise	141.83±38.38	90.41±11.41	0.23	<0.05
Postexercise	118.46±1.06	96.62±9.95	0.17	
Difference	-23.36±39.60	6.20±12.09	-0'11	

[Table/Fig-5]: Correlation of Serum cortisol in females with Random Blood Sugar (RBS).
Paired t-test

The serum cortisol levels showed a moderately significant decrease (p<0.01) of 24.79%. The paired t-test showed weakly negative correlation (r=-0.21) between BMI and serum cortisol within the group (females) which was moderately significant with p-value <0.01 [Table/Fig-6].

Serum cortisol	Mean±SD (µg/dL)	r-value	BMI (kg/m²)	p-value
Pre-exercise	145.47±33.67	0.16	23.22±3.13	<0.01
Postexercise	116.57±34.40	0.10		
Difference	-28.90±42.79	-0.21		

[Table/Fig-6]: Correlation of serum cortisol in males with Body Mass Index (BMI).
Paired t-test

The RBS (fasting overnight) levels in males showed a 7.16 mg/dL increase which was statistically significant (p<0.05). The paired t-test showed weakly negative correlation (-0.23) between rise in RBS and decrease in serum cortisol within the male group which was highly significant with p-value <0.001 [Table/Fig-7].

Serum cortisol	Mean±SD (µg/dL)	RBS (mg/dL)	r-value	p-value
Pre-exercise	145.47±33.67	86.79±10.03	0.34	<0.001
Postexercise	116.57±34.40	93.95±10.03	0.15	
Difference	-28.90±42.79	7.16±12.61	-0.23	

[Table/Fig-7]: Correlation of serum cortisol in males with Random Blood Sugar (RBS).
Paired t-test

The authors observed that males had more baseline serum cortisol level than females and there was a decrease in serum cortisol levels after exercise in both males and females. Collectively, there was a decrease in serum cortisol levels in comparison to the rise in RBS which was a highly significant decreased (p<0.001) in male group whereas less but still a significant decreased (p<0.05) in female group.

DISCUSSION

The authors investigated serum cortisol with response to maximal resistance exercise in young males and females within the group in comparison to BMI and RBS in untrained subjects and who have sedentary life at least for one year. There was a difference in loading weight between males and females as per their strength as it is known that males have more strength and muscular mass than the females along with a difference between the BMI, primarily due to hormonal differences and reflected in the present study also.

Kraemer WJ and Ratamess NA, have shown that resultant to metabolic buildup, moderate repetitions range training maximises the acute anabolic hormonal response of exercise [15]. Cortisolis generally related to catabolic processes, which leads to degradation of proteins from skeletal muscles. Also, the acute cortisol response meets the greater metabolic demands imposed by the resistance exercise. In previous studies, the acute cortisol response increase occurred when the overall stress of the exercise protocol was enormously high as in Ahtiainen JP et.al., [16] and the response was linked to the volume and/or intensity of total work of a given heavy-resistance exercise protocol as in McCall GE et.al. These increases seem to be due to simultaneous effects on haemoconcentration and HPA axis stimulus (ACTH) [4].

In contrast, low intensity exercise (40%) did not result in significant increase in circulating cortisol levels, but, after corrections for plasma volume reduction were and close monitoring of circadian factors, low intensity exercise resulted in a reduction in circulating cortisol levels [4] like what could be a part of the answer to what the present study results reflect regarding cortisol decrease post resistance exercise. Also, as per Ahtiainen JP et. al., long-term resistance training may cause an overall reduction of acute cortisol responses in males similar to a study conducted in both trained and untrained athletes where the acute exercise induced cortisol response decreased statistically significantly in both the groups [16]. The present study too reflected the same trend.

By observing the result, the authors can state that every individual needs a separate design of the resistance training program that will ultimately affect the extent of hormonal activity, strength improvement, and muscle hypertrophy. The degree of variance in physiological activity between the exercise protocol may be attributed to such factor as duration of training session, acid-base shifts, anaerobic work performance, circulation of associated sympathetic hormones, age, or muscle mass used etc. The variability between serum cortisol levels in males and females has been observed in the study with a difference in basal serum cortisol levels in males and females, males having high basal cortisol levels than females. This may be due to gender difference in cognitive understanding and psychological response with males reacting more, anticipating the psychological pre-exercise stress without actually performing the task.

In a study by Sofer Y et al., there was a gender difference in serum cortisol levels with males having higher Free Cortisol (FC) as they have comparatively lower cortisol binding protein levels. The higher FC in men relative to women was apparent across a wide age range (17 to 86 years) and persisted after adjustment for age and BMI [17]. There are also conflicting reports of increased vs decreased HPA activation in obesity; the most consistent finding is an inverse relationship between BMI and morning cortisol [18]. Similarly, a moderately significant inverse correlation between BMI and serum cortisol was observed in the both male and female group within the present study also, going with the consistent findings of the past studies. This suggests that lower the BMI more is the activation of HPA axis [18].

The study results also revealed a significant correlation between rise in RBS and decrease in serum cortisol in both the male and female group. The HPA axis is characterised by a marked circadian cycle with peaking phenomenon in the morning. This is in synchrony to awakening where the FC increases two to three-fold in the first 30-45 minutes called as the awakening cortisol response. Due to this activity, energy reserve mobilisation takes place, preparing the body for the metabolic demands of the day. Similar arguments are stated regarding the cortisol response to psychological challenge [19]. But in the present study, the author found it converse where a significant correlation of high glucose to, the decreased cortisol response was seen. This probably suggests that glucose is not a permissible substrate for positive cortisol response as suggested by Hucklebridge FH et al., [19]. They stated that there the cortisol response and awakening blood glucose levels were not related. Moreover, individuals with mean blood glucose at the bottom of the euglycaemic range, showed no deficit in cortisol response. Thus, drawing the inference that the awakening response physiology differs to that of a psychological stress response physiology posing a challenge to the view that an oxidisable substrate for energy metabolism is permissive for cortisol responses [19].

Limitation(s)

It was a small sample size study with few biochemical markers.

CONCLUSION(S)

Decrease in serum cortisol levels after exercise may be due to various factors which need to be investigated, but as cortisol has a catabolic effect on muscle tissue, it breaks muscle protein. A lower cortisol response in a way may help in the remodelling of the muscle tissue as it is synchronously secreted with the anabolic hormones and bring positive changes to rebuild the muscle tissue and help in physiological adaptation to the stress. An elaborate analysis on a large sample size, to further enhance the knowledge of variable observed effects and responses thus helping in tailoring specific exercise regime on individual basis is recommended in future.

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REFERENCES

[1] Mastorakos G, Pavlatou M, Diamanti-Kandarakis E, Chrousos GP. Exercise and the stress system. Hormones (Athens). 2005;4(2):73-89.
[2] Budde H, Machado S, Ribeiro P, Wegner M. The cortisol response to exercise in young adults. Front Behav Neurosci. 2015;9:13. Doi: 10.3389/fnbeh.2015.00013.
[3] Heaney JL, Carroll D, Phillips AC. DHEA, DHEA-S and cortisol responses to acute exercise in older adults in relation to exercise training status and sex. Age (Dordr). 2013;35(2):395-405.
[4] McCall GE, Byrnes WC, Fleck SJ, Dickinson A, Kraemer WJ. Acute and chronic hormonal responses to resistance training designed to promote muscle hypertrophy. Can J Appl Physiol. 1999;24(1):96-107.
[5] Julious SA. Sample size of 12 per group rule of thumb for a pilot study. Pharmaceut Stat. 2005;4(4):287-91.
[6] Schoenfeld, Brad J. The mechanisms of muscle hypertrophy and their application to resistance training. Journal of Strength and Conditioning Research. 2010;24(10):2857-72.
[7] Standing Dumbbell Biceps Curl: Biceps-MSN Health & Fitness Internet [Date unknown]. Available from: https://www.msn.com/en-my/health/exercise/strength/standing-dumbell-bicep-curls/ss-BBtOcxL.
[8] Graham JF. "Dumbbell bench press". Strength and Conditioning Journal. 2000;22(4):71. Retrieved 7 September 2014.
[9] Fenwick CM, Brown SH, Mcgill SM. Comparison of different rowing exercises: Trunk muscle activation and lumbar spine motion, load, and stiffness. J Strength Cond Res. 2009;23(2):350-58. Doi: 10.1519/JSC.0b013e3181942019.
[10] Livestrong Foundation. Internet Exercises and Workouts [Date unknown]. Available from: https://www.livestrong.com/sscat/exercises-and-workouts/.
[11] Seated Barbell Shoulder Press: Shoulders, Lats, Abs-MSN Health & Fitness. Internet [date unknown] Available from: https://www.msn.com/en-za/health/exercise/strength/seated-barbell-shoulder-press/ss-BBtO4Ya.
[12] Laura Sanchez Portfolio: Tweet- Squats (laurasanchezcames.blogspot.com). Available from: https://laurasanchezcames.blogspot.com/2018/05/tweet-squats.html.
[13] Squat: Glutes, Quads-MSN Health. Internet {date unknown}. Available from: https://www.msn.com/en-in/health/exercise/strength/squat/ss-BBtOa8W.
[14] Yumuk V, Tsigos C, Fried M, Schindler K, Busetto L, Micic D, Toplak H. European guidelines for obesity management in adults. Obes Facts. 2015;8:402-24. Doi: 10.1159/000442721.
[15] Kraemer WJ, Ratamess NA. Hormonal responses and adaptations to resistance exercise and training. Sports Med. 2005;35(4):339-61.
[16] Ahtiainen JP, Pakarinen A, Alen M, Kraemer WJ, Häkkinen K. Muscle hypertrophy, hormonal adaptations and strength development during strength training in strength-trained and untrained men. Eur J Appl Physiol. 2003;89:555-63. Doi: 10.1007/s00421-003-0833-3. Epub 2003 May 7.
[17] Sofer Y, Osher E, Limor R, Shefer G, Marcus Y, Shapira I, et al. Gender determines serum free cortisol: Higher levels in men. Endocrine Practice. 2016;22(12):1415-21.
[18] Schorr M, Lawson EA, Dichtel LE, Klibanski A, Miller KK. Cortisol measures across the weight spectrum. J Clin Endocrinol Metab. 2015;100(9):3313-21.
[19] Hucklebridge FH, Clow A, Abeyguneratne T, Huezo-Diaz P, Evans P. The awakening cortisol response and blood glucose levels. Life Sci. 1999;64(11):931-37.

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