Acute response of serum cortisol to different intensities of resisted exercise in the elderly

Mona M. Taha[a], Khaled M. Mounir[b]

[a]Department of Physical Therapy for Cardiopulmonary Disorders and Geriatrics, Faculty of Physical Therapy, Cairo University, Giza, [b]Department of Physical Therapy for Cardiopulmonary Disorders and Geriatrics, Faculty of Physical Therapy, Egyptian Chinese Universiy, Cairo, Egypt

Correspondence to Mona M. Taha, PhD, 2-Street 9, Helwan, 11722 Cairo, Egypt. Tel: +20 111 135 1518; fax: 02/3761792; e-mail: monady2007@yahoo.com

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Background
Cortisol has a main role in stress response and high stress can affect the psychological and physical performance in the elderly.
Aim
To determine the acute response of serum cortisol to different intensities of resisted exercise in the elderly.
Patients and methods
A total of 60 elderly patients from both sexes (60–70 years) were equally and randomly assigned to three resistive training bouts: low-intensity (group A, 30% of 1RM), moderate-intensity (group B, 50% of 1RM), and high-intensity (group C, 80% of 1RM) with a 90–120 s rest period between sets. Blood samples that were analyzed included serum cortisol hormone before and 15 min postintervention.
Results
There was a statistically significant decrease in serum cortisol level in groups A and B at postintervention when compared with the preintervention value, while group C showed an insignificant difference.
Conclusion
In a sample of elderly patients undergoing three bouts of different intensities of resisted exercise, a low to moderate resisted exercise was superior to high intensity in decreasing the serum cortisol and consequently less stress post-exercise.

Keywords:
aging, cortisol, exercise training

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Introduction

Muscular weakness plays an important role in the pathogenesis of functional impairment and frailty that happens with aging and adds to various disease processes. Maximal strength capacity often achieves a peak at around the second or third decade of life, and by the fifth decade, starts a gradual decrease [1].

Resisted exercise is thought to be a safe and viable method for improving strength and lean muscle tissue in the young [2] and older people [3]. The health advantages of resisted exercise are essentially as a prevention or countermeasure to conditions where muscle weakness affects the optimal function (prolonged inactivity or injury, musculoskeletal disorders, or sarcopenia) but it also has a positive influence on metabolic and skeletal health in addition to the potential psychological benefits [4]. It ought to be showed that the variation in techniques may be an exciting strategy to keep aged patients stimulated, warding off monotony, and raising the adherence to the exercise program [5].

Exercise has taken into consideration as an acute stressor, so one exercising bout leads to an acute impairment of homeostasis in cells and organs that may also lead to a reduction in mechanical output and fatigue [6]. Cortisol or 'stress hormone' is a product of hypothalamic–pituitary–adrenal axis. Cortisol influences the physical and psychological aspects of different body parts. There are numerous diseases caused by elevated cortisol levels such as severe mood swings, depression, hypotension, and suppressed immune system [7]. The blood cortisol level is a milestone in monitoring the stress reaction [8].

During exercise, cortisol increases arousal level and stimulates catecholamine synthesis. Moreover, cortisol also works as an anti-inflammatory agent and depresses immune reactions that may produce an 'open window' for infections [9,10]. This is associated with an increased risk to upper respiratory tract infections [11]. It has been thought that catecholamines trigger the start of increasing of lymphocyte numbers, whereas cortisol produces lymphopenia after exercise [12].

Homeostatic balance is disturbed as the body is exposed to internal or external stressors that is restored with secreting a group of hormones [13]. Stimulation of the hypothalamus by different kinds of stress leads to excitation of the hypothalamic–pituitary–adrenal axis. Stress enhances rapid secretion of cortisol which in turn initiates a series of metabolic changes directed toward decreasing the damaging the effect of the stressful state [14]. The activation of these pathways progresses to a quick physical and mental reaction and, in adaptive conditions, leads to long-term positive adjustments in the brain [15]. These long-term adaptive mechanisms permit patients to successfully deal again more with comparable demands. In this way, a moderate level of stress applies a favorable impact on the adapting mechanisms. By differentiating, exposure to extreme, traumatic, or chronic stress might have the inverse impact and may lead to memory loss, cognitive disability, and stress-related psychopathologies such as depressive disorders or anxiety and post-traumatic stress problems [15,16]. Great exertion has been committed to understanding the negative impacts of chronic stress.

Both high intensity and endurance training result in an increase in human plasma cortisol. Cortisol elevates more with higher exercise duration and remained fixed after the initial increase and exhibited a relationship to the exercise duration [17]. In humans cortisol concentration increases by 2–3 times with a higher intensity of exercise, reaching the maximum 15–30 min post-exercise and back to pre-exercise levels within an hour [18].

Acute response of cortisol has the highest level when the stress of the training duration is very high and the response is related to the duration and/or intensity of total work [19].

Resistive training is a powerful exciter to the acute elevation in circulating cortisol level [20].

Some studies demonstrated no elevation of the cortisol after resistance exercise [21], so it is obvious that the acute response depends on a variety of factors such as the amount of involved muscle mass [22], the intensity [23], total set period [24], inter-set rest duration, age, and physical capacity [25]. These studies try to understand what factors may induce a hormonal response that promotes the chronic adaptations to exercise, as there is an evidence to suggest that the amount of chronic neuromuscular adaptations to resistive training is linked to the responses of hormones to individual training sessions [20].

Aging appears to affect the endocrine function and hormonal response to acute exercise. Few investigations up to date have examined the effect of acute response of serum cortisol level to resisted exercise in the elderly and the response is less consistent. For an individual seeking to improve strength and increase lean body mass, optimizing the endocrine responses appears to be a contributing factor and determining what changes should be made in hormones such as cortisol in the elderly introduces a better understanding of the physiological responses to different types of exercise and the physiological stress reaction which is important for identifying ways to maximize their beneficial effects and best mimic normal responses to different forms of exercise, which by far will aid in better training prescription regarding the suitable intensity and care of an increasing number of active older patients. Therefore, the purpose of this study was to examine the acute changes in serum cortisol level to different intensities of resisted exercise in the elderly.

Patients and methods

Participants and experimental design

A prospective single-blinded, between-subjects randomized trial was conducted. A total of 60 elderly patients of both sex from the ages of 60 to 70 years were recruited from the Outpatient Clinic of the Faculty of Physical Therapy, Cairo University. Each patient was briefed about the potential risks of the clinical trial; a signed informed consent was obtained from the patients; the study was approved by an Ethics Committee of the Faculty of Physical Therapy, Cairo University. The inclusion criteria were: BMI ranged between 25 and 30 kg/m^2 and no evidence of adrenal impairment. Exclusion criteria included Cushing's disease (hypercortisolism) or Addison's disease (hypocortisolism), or any other adrenal impairment or tumor, any history of hormonal and cardiovascular diseases, patients taking any medication that influences their hormonal and neuromuscular metabolism and uncontrolled diabetes or hypertension. After screening assessments and eligibility criteria, the participants were randomly assigned to one of the three groups: group A included 20 patients who received acute bout of low-intensity resisted exercise at 30% of 1RM or group B which included 20 patients who received acute bout of moderate-intensity resisted exercise at 50% of 1RM or group C which included 20 patients who received acute bout of high-intensity resisted exercise at 80% of 1RM. The randomization was performed by a researcher who did not participate in data collection with an internet-based application (http://www.randomization.com). The program generated a numbered list with the exercise intensity bouts (groups A, B, and C) in random order in blocks of six. A research assistant assigned the patients to the treatment groups in consecutive order according to the randomization list. Evaluator of the primary outcome will be blinded to the treatment allocation.

Blood collection and analysis

Blood samples were collected on the morning between 9:00 and 10:00 a.m. to avoid a possible diurnal influence at both pre-exercise and 5-min post-exercise. The time of blood collection was chosen because of its use in many studies conducted with these procedures for the control of the circadian hormonal range [20]. To control the experimental conditions and potentially confounding factors, the patients were asked to minimize the possible stressors during the day before the loading measurements. Furthermore, the patients were asked to have at least 8 h of sleep and a standard meal 12 h before exercise. Standardized kits were used to detect the serum cortisol level, using a Snibe Maglumi 1000 fully automated chemiluminescence immunoassay serum analyzer.

One repetition maximum

For the determination of 1RM, one session of testing was used to familiarize the patients with the exercises and their own individual maximal effort. All patients were asked to avoid exercising for 72 h before testing. The test was conducted according to the guidelines of the National Strength and Conditioning Association.

Training procedure

The session was conducted 72 h after determining the load to be used in the experimental session. All the patients performed warming up in the form of dynamic stretching exercises for 5 min before and after the active exercise phase, which includes six different resisted exercises: dumbbell-seated biceps curl, seated lateral pulldown, bench press; dumbbell triceps pushdown, leg extension, and standing leg curl (ankle weights). All participants performed three sets of 10 repetitions of six exercises with different intensities as follows; at low intensity (30% of 1RM) in group A, at moderate intensity (50% of 1RM) in group B, at high intensity (80% of 1RM) in group C with 90–120 s rest period in between sets.

Sample size determination

On the basis of the previous study [26], the sample size was calculated according to the difference in the mean value of free cortisol measured at pretreatment between the three groups, with an effect size of 0.42. Assuming α=0.05, power of 80%, a sample size of 20 patients per group would be required (GPower 301: http://www.psycho.uni-duesseldorf.de).

Statistical analysis

Descriptive statistics were used for comparing the mean general characteristics. Results of serum cortisol are expressed as median, minimum, and maximum. To get the actual effect of physical therapy interventions, a comparison was done using the difference in the three groups. Difference variable (difference score or change score) was calculated from the equation: pretreatment–post-treatment. Test of normality, Kolmogorov–Smirnov test, was performed to measure the distribution of the date measured at pretreatment. Accordingly, comparison between mean values of normally distributed parameters in the three groups was performed using analysis of variance test. Comparison between values of not normally distributed data of the serum cortisol level in the three groups was performed using Kruskal–Wallis test followed by Mann–Whitney test if significant results were recorded. Comparison between pretreatment and post-treatment within the same group was performed using Wilcoxon signed rank test. Statistical package for the social sciences (SPSS; SPSS Inc., Chicago, Illinois, USA) computer program (version 19 Windows) was used for data analysis. *P* value up to 0.05 was considered significant.

Results

The demographic features and clinical characteristics of patients in the three studied groups were statistically comparable (Table 1).

As presented in Table 2, there was a statistically significant decrease in the median value of serum cortisol measured at post-treatment in both groups A and B when compared with their corresponding values measured at pretreatment (P=0.001), while group C showed insignificant difference between pretreatment and post-treatment times (P=0.144). As shown in Table 3 Pretreatment, there were no statistical significant differences in cortisol between the three groups (P=0.521). The median value of difference in serum cortisol was significantly decreased in both groups A and B when compared with that in group C (P=0.001) while both groups A and B were statistically comparable (P=0.187).

Discussion

The adrenal cortex secreted cortisol is a catabolic hormone produced in response to exercise stress. As a stress hormone, the degree of cortisol response to resistance exercise may depend on the metabolic challenges from exercise stress [27].

Table 1 Demographic and clinical characteristics of patients in the studied groups

Variables	Group A (*N*=20) (mean±SD)	Group B (*N*=20) (mean±SD)	Group C (*N*=20) (mean±SD)	*F* value	*P* value
Age (years)	63.65±3.21	64.25±2.49	63.75±3.17	0.472	0.626
Height (m)	1.68±9.36	1.68±7.51	1.69±7.52	0.291	0.749
Weight (kg)	75.06±11.81	76.78±7.52	77.30±7.61	1.53	0.225
BMI (kg/m^2)	26.22±1.94	27.06±.976	26.92±1.36	1.85	0.16

Level of significance at $P \leq 0.05$.

Table 3 Comparison between median values of serum cortisol in the three studied groups

	Group A (*N*=20)	Group B (*N*=20)	Group C (*N*=20)	*P* value
Pretreatment	6.30 (4.20–15.30)	6.45 (4.90–16.10)	5.60 (4.50–13.20)	0.521 (NS)
Difference	0.80 (0.60–5.20)	1.20 (1.10–8.70)	0.40 (−2.80–3.60)	0.001 (S)
Z and *P* value vs. group A	–	−1.320 and 0.187 (NS)	−4.780 and 0.001 (S)	–
Z and *P* value vs. group B	–	–	−4.454 and 0.001 (S)	–

Data are expressed as median (minimum–maximum). The difference was calculated from the equation: pretreatment−post-treatment. $P>0.05$, NS; $P<0.05$, significant (S); *Z*, Mann–Whitney *U*-test.

According to the authors' knowledge, up to date, no studies have compared acute serum cortisol response to the different intensities of resisted exercise in the elderly patients. As most of the body of literature on this topic is specific to the effects in young patients especially the athletes, the extent to which this physiological response affects elderly patients remains inconsistent.

The study findings have shown that there were significant decreases of the cortisol level after an acute bout of low and moderate resisted exercise, while no significant change observed after the acute bout of high-intensity resisted exercise in the elderly.

Recently, in agreement with the result of the current study, Paunksnis *et al.* [5] conducted a study on 12 elderly individuals (65±3 years) that performed two resistive training methods: constant intensity with 75% of 1RM and interval intensity at 67, 75, and 80% of 1RM. A significant decrease in cortisol was noticed after 2 h of both training methods.

Similarly, these results match with those observed in earlier studies by Traustado? ttir *et al.* [28] who observed that older women after performing aerobic exercises (walking) presented decreased serum cortisol levels throughout their recovery periods.

Table 2 Comparison between median values of serum cortisol measured pretreatment and post-treatment in the three studied groups

	Group A (*N*=20)	Group B (*N*=20)	Group C (*N*=20)
Pretreatment	6.30 (4.20–15.30)	6.45 (4.90–16.10)	5.60 (4.50–13.20)
Post-treatment	4.90 (3.5–10.20)	5.3 (3.70–9.40)	4.95 (4.10–15.80)
Z and *P* values	−3.936 and 0.001 (S)	−4.027 and 0.001 (S)	−1.461 and 0.141 (NS)

Data are expressed as median (minimum–maximum). $P>0.05$, NS; $P<0.05$, significant (S); *Z*, Wilcoxon Signed Ranks test.

In contrast to earlier findings by Kraemer *et al.* [29] conducted a study on the impact of acute heavy-resistance exercise on hormonal secretion patterns in younger versus older men. Cortisol was increased above the baseline values immediately after 5, 15, and 30 min post-exercise in both age groups but at the recovery time points immediately post-exercise and at 5 and 15 min post-training cortisol was lower in older men than younger men in comparison to their corresponding pretraining level. Another important finding of this study was that the resting cortisol levels decreased after long-term resistance training in the older men and were associated with no significant changes in adrenocorticotropic hormone levels that indicate that the adrenocorticotropic hormone receptors of the adrenal gland could be 'downregulated'.

A review on studies that analyze the chronic effect of exercise on serum cortisol hormone in older people, Corazza *et al.* [30] observed that chronic exercise could have a positive effect on serum cortisol level causing a decrease in its level in older people, which may assist in the prevention of comorbidities as a nonpharmacological treatment. In spite of this evidence, given the low number of studies, these results cannot be generalized to the entire population of older patients, especially because the studies showed differences in variables and methodologies.

Several studies have examined acute cortisol response to resisted exercise in young individuals. Libardi *et al.* [31] reported a reduction in cortisol values after an acute bout of resisted exercise using two different eccentric velocities in healthy untrained young women. The author explained that this reduction in cortisol values can be due to the higher baseline values in the study (~25.0 μg/dl) compared with the previous study by Bottaro *et al.* [32] (~11.8 μg/dl). Similarly, Migiano *et al.* [33] found decreased cortisol after an acute bout of resisted exercise at 80% 1RM using the unilateral arm curl eccentric/concentric exercise in young men. Thus, resistive training of small muscle groups and with eccentric actions may result in less catabolic response immediately post-exercise. Moreover, low-intensity resistance exercise at 30% of 1RM of squat exercise in 10 untrained men under normobaric hypoxia (FiO_2=15%) and normoxia in a cross-over design leads to a significant cortisol reduction in both trials immediately after and 15 min post-exercise [34]. In contrast, Smilios *et al.* [35] found that in hypertrophy resistance exercise with maximum velocity, the cortisol levels were not changed, but in programs performed at submaximal velocities the cortisol level decreased according to the circadian rhythm (control session).

The results of the previous studies slightly differ, Hansen *et al.* [36], who investigated different protocols of different muscle mass amounts, found that cortisol is increased after the arm+leg group at 15 min post-exercise but returned after 30 min to the baseline. The sole arm group led to an opposite response, as the cortisol level was decreased at 30 and 60 min post-exercise compared with the baseline levels. Tremblay *et al.* [37] found that resistance exercise using different exercise types, increased the cortisol level both 'immediately' post-exercise and 2 h post-exercise and returned to basal levels at 3 h post-exercise in trained and untrained men. Kraemer *et al.* [38] investigated the acute response of cortisol hormones to a single bout of resisted exercise composed of one set of bilateral leg press at 80% 1RM with no rest between repetitions until exhaustion in power lifters and sedentary men. There were no changes in cortisol level at any time point (30 min before exercises, immediately pre-exercise, immediately after exercise, and 5 min post-exercise) in both groups. Chatzinikolaou *et al.* [39] investigated the cortisol response to an acute bout of resistive exercise at 70–75% 1RM with 30 s rest between sets in lean and obese men. The blood sample was taken pre-exercise and at 5, 10, 20, and 30 min during exercise. Cortisol was increased above baseline at both 20 and 30 min into the exercise in the obese group. But there was no change in lean individuals.In summary, cortisol has been found to either decrease [5] or increase [34,36] or not change [38] after an acute bout of resisted exercise. The conflicting results of the previous studies could be collectively attributed to the difference in serum cortisol response to resistance exercise which depends on the exercise type and variables of the training protocols (volume, duration, intensity, eccentric versus concentric movement) [30].

Some authors [40–42] have speculated that cortisol, as a stress hormone, increases more after the higher volume protocols that is associated with high metabolic stress, when compared with lower volume protocols. Moreover, Kraemer and Ratamass [43] explained that cortisol release seems to be dependent on the muscle contraction force, stimulated amount of muscle tissue, and rest duration between the sets. A possible explanation for the different results may be the lack of adequate metabolic stress from resistance exercise that is not sufficient to increase the serum cortisol level [34].

The result of this study may be explained by the fact that with aging, there is a gradual reduction in the adaptive capacity and recovery from stress which is accompanied with changes in the immune system which make older people (60 years old and over) more susceptible to the onset of diseases [44]. It should be noted that our patients were sedentary and older and this may have affected the cortisol response.

Conclusion

Both low-intensity and moderate-intensity resisted exercises are effective training intervention for inducing significant cortisol decrease in the elderly. Additionally, strength and conditioning professionals can use both low-intensity and moderate-intensity resisted programs to optimize the post-workout response and to minimize stress response that has an adverse effect on the elderly. It should be emphasized that a suitable exercise intensity keeps the elderly patients motivated, promoting adherence to the training program, and avoiding monotony.

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Conflicts of interest

There are no conflicts of interest.

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