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Improvement of serum cortisol levels in obese female college students after moderate-intensity acute exercise

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Abstract

Obesity is a condition that can cause metabolic stress by activating the hypothalamic pituitary adrenal (HPA axis), which impacts increasing stress levels characterized by increased cortisol secretion. The present research aims to investigate the impact of moderate-intensity acute exercise on decreasing cortisol levels among obese female students. A true-experimental method with a pretest-posttest control group design was utilized to conduct the study. A total of 20 female students between the ages of 20 and 23, with a body mass index (BMI) ranging from 25-28 kg/m2, voluntarily participated in the research. The participants were divided into two groups: control (n=10) and exercise (n=10) - the latter group being exposed to moderate-intensity acute exercise once as an intervention, with 40-minute sessions and an intensity level of 60-70% HRmax using the Treadmill Life Fitness equipment. The serum cortisol levels were measured through the ELISA 30 minutes pre-exercise and 6 hours post-exercise. The collected data were analyzed using an independent sample t-test with a 5% significance level. The study's findings will help compare the mean serum cortisol levels between the control and exercise groups. Showed the result that data before the exercise intervention (225.33 ± 55.22 vs 223.28 ± 58.84 ng/mL, (p = 0.937)), post-exercise (241.87 ± 76.07 vs 131.85 ± 18.52 ng/mL, (p=0.001)), and delta (16.53±40.67 vs -91.42±51.17 ng/mL, (p=0.001)). Based on the results of the study, it was found it can be concluded that moderate-intensity acute exercise carried out for 40 minutes/exercise session was effective in reducing serum cortisol levels in obese female students. We recommend exercise to overcome stress-related metabolic health problems in individuals with obesity.

Keywords: Acute exercise, cortisol levels, obesity, stress response.

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INTRODUCTION

Globally, the prevalence of obesity among us ≥18 years has increased almost threefold since 1975, reaching 4.7% until 2016, reaching 13% of the world's population (11% of men and 15% of women) (WHO, 2021). Early adolescence provides an opportunity to develop and encourage positive health and behavioral practices, yet it is an understudied age group with limited information to guide and inform appropriate interventions (Drysdale et al., 2023). Adolescence is a critical transitional period of critical physical and mental development that occurs in adolescence, including emotional skills, physical abilities, and mental (Zietz et al., 2018). Adolescence is a critical transition period from child to adult health care, but readiness for this transition has been described as low in the general adolescent population (Mulkey et al., 2023). Obesity is the deposition of excessive fat in the body (Basu et al., 2023). Several factors, such as lack of physical activity, sedentary lifestyle, and eating patterns, can cause weight gain or obesity (Kazmi et al., 2022). Adipose tissue is a major endocrine organ in the human body, with composite cells producing and secreting hormones, cytokines, and non-coding RNAs into the circulation to alter the phenotype of multiple organs (Lodewijks et al., 2023).

Obesity is a condition that can affect metabolic health, which is characterized by abnormal hormone levels in the body (Velasco-Orjuela et al., 2018). One of them is characterized by increased levels of the hormone cortisol in individuals with obesity (Sugiharto et al., 2023; Hewagalamulage et al., 2016). An alternative to dealing with obesity is exercise. Exercise is a common measure used to treat obesity (Park et al., 2019). Exercise for the treatment of obesity can lead to improvements in hormonal changes (Irandoust & Taheri, 2018). These hormonal changes are due to the intensity of exercise affecting the stress response of the hypothalamus-pituitary-adrenal (HPA) axis, which depends on the dose of exercise performed (Caplin et al., 2021). The HPA axis is highly responsive to stress and exhibits a strong diurnal pattern with the glucocorticoid cortisol as the end product (Wegner et al., 2019). Therefore, HPA axis activation is characterized by cortisol secretion (Drogos et al., 2019), which has a strong reciprocal relationship with energy homeostasis (Rosa & Nodari-Junior, 2012; McLaughlin et al., 2022).

Poor diet during adolescence and early adulthood contributes towards the rapid increases in weight gain seen during this period (Winpenny et al., 2018; Ng et al., 2014; Malik et al., 2013). Adolescence represents a critical period of transition from child to adult health care, but readiness for this transition has been described as low in the general adolescent population (Mulkey et al., 2023). The increase in obesity is known to become the highest rate in early adulthood (Ghosh et al., 2023; GBD 2015 Obesity Collaborators, 2017). Globally, the prevalence of obesity aged ≥18 years has increased almost threefold since 1975 reaching 4.7% until 2016 reaching 13% of the world's population (11% of men and 15% of women) (WHO, 2021). Recent studies have shown that South Asian populations have a higher tendency to develop obesity-related non-communicable diseases compared to Caucasians (Ghosh et al., 2023). Obesity and overweight in adolescence are associated with a range of short- and long-term consequences, including adverse direct effects on physical and psychological health and a significantly increased risk of obesity and adverse health outcomes in adulthood (Moore Heslin et al., 2023). Some many policies and programs aim to enhance healthy growth and development in school ages focusing narrowly and generically on specific features of nutrition or the environment in either cities or rural areas (NCD-RisC, 2023). Other programs are needed to be implemented in a way to prevent and reduce obesity complications, particularly obesity-related metabolic stress that is influenced by cortisol levels (Verbiest et al., 2023). In light of the recommendation that children and adolescents need at least one hour of physical activity of varying intensity most days of the week to promote health and well-being (Bozzola et al., 2023).

Cortisol is responsible for various catabolic processes released as stress hormones in the bloodstream (Barros Dos Santos et al., 2020).

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Additionally, cortisol related to exercise has a major influence on skeletal muscle. Cortisol is critical in regulating energy homeostasis and metabolism in skeletal muscle. When engaging in physical exercise, cortisol boosts the availability of metabolic substrates, safeguards against immune cell activity, and preserves vascular integrity. The acute cortisol response to exercise is most pronounced when stress occurs during periods of intense physical activity (Kraemer et al., 2020).

Acute intense exercise for 40 minutes causes a decrease in cortisol response in overweight female adolescents (Setiakarnawijaya et al., 2022). Moderate-intensity acute physical activity of 60-70% HRmax for 30 minutes significantly lowers cortisol (Coli et al., 2021). The research found that swimming training affected cortisol levels in people with asthma (Nova Handayani et al., 2014). A study by Nova Handayani et al. (2014) found that swimming training affected cortisol levels in asthmatics. Previous research showed that acute aerobic exercise showed no statistically significant difference was found between the pre-test and post-test values of cortisol (Koc, 2018). Aerobic acute exercise combined with resistance exercise for 30 minutes increases cortisol in saliva (Wang et al., 2019). These results reap controversy regarding cortisol levels in the body. However, a study by Caplin et al. (2023) that conducted an aerobic exercise with moderate intensity revealed that exercise intensity dampens the HPA-axis stress response in a dose-dependent manner, with evidence that the cortisol released from exercising intensely suppresses the subsequent cortisol response to a psychosocial stressor.

The combination of HIIT and resistance acute exercise does not change serum cortisol, whereas acute HIIT exercise can cause reduced serum cortisol in overweight men (Velasco-Orjuela et al., 2018). Cortisol can be used to examine the neuroendocrinological response to acute exercise (Wang et al., 2019). Therefore, the main objective of this research is to demonstrate the impact of a moderate-intensity acute exercise routine on the reduction of cortisol levels in female students who are classified as obese.

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METHOD

The research employed the true-experimental approach, utilizing a pretest-posttest control group design. The participants in this study were obese students who were filtered based on particular criteria so that their being homogeneous in representing health status-related obesity. It is already known that obesity is a complex disease (Perdomo et al., 2023). The study participants were 20 women aged 20-23 with a BMI between 25-28 kg/m^2 who willingly participated in the investigation. A participant-taking technique using consecutive sampling. All participants were divided into two groups, namely the control group and the exercise group. All participants then received a detailed explanation of the research and expressed their willingness to participate by filling out and signing an informed consent. The present study adhered to the principles outlined in the Declaration of Helsinki and received ethical approval from the Health Research Ethics Committee at the Faculty of Medicine, Airlangga University, with the following identification number: 309/EC/KEPK/FKUA/2019.

Moderate-intensity acute exercise is carried out once an intervention, duration of 40 minutes/session with an intensity of 60-70% HR_{max} using the Treadmill Life Fitness (Pranoto et al., 2023). The method used in determining HR_{max} uses the formula: HRmax – age in years (220 - age in years) (Susanto et al., 2023). Monitoring weight rate during exercise using the Polar H10 Heart Rate Sensor (Pranoto et al., 2023). Warm-up and cool-down were each carried out for 5 minutes with an intensity of 50% HR_{max} (Rejeki et al., 2023).

Data collection techniques. Pre-test data were taken just before the intervention was given. Then, conduct an exercise program. Meanwhile, the post-test data is done six hours after the exercise program. The data was obtained from the results of laboratory tests on the subject's blood sample. Blood samples were taken from the cubital vein of each group participant.

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The data was obtained by evaluating serum cortisol levels through the utilization of the Enzyme-Linked Immunosorbent Assay (ELISA) Kit (Cat.No.: E-EL-0157; Elabscience Biotechnology Inc., USA). The serum cortisol levels were evaluated at two distinct time points: 30 minutes prior to the exercise and 6 hours following the exercise.

Data analysis techniques were carried out using descriptive tests, normality tests with Shapiro Wilk, different tests using paired sample t-tests, and independent sample t-tests with a significant level of 5%. Data represented by Mean ± SD. All statistical analysis using SPSS version 20.

RESULT

Table 1 displays the demographic characteristics of the participants in both the control and exercise groups, indicating no significant differences between the two. Figure 1 illustrates the outcomes of the analysis conducted on the cortisol levels measured before and after the exercise, while the results of the analysis of serum cortisol levels between the control vs. the exercise groups are presented in Figure 2.

Table 1. Demographic Characteristics of Research Subjects

Variable	n	Group		p-value
		Control (*n*=10)	Exercise (*n*=10)	
Age (years)	10	22.20±1.32	22.10±1.45	0.874
Body Height (m)	10	65.15±3.59	65.04±4.05	0.909
Body Weight (kg)	10	1.56±0.04	1.55±0.03	0.949
BMI (kg/m^2)	10	26.86±0.67	26.74±0.97	0.752
SBP (mmHg)	10	115.10±4.65	115.70±4.24	0.767
DBP (mmHg)	10	75.20±4.44	75.30±4.22	0.959
RHR (bpm)	10	71.40±4.99	71.50±3.54	0.959

Description: Data represented by Mean ± SD. *P*-value was applied using paired sample t-test. BMI: Body mass index; DBP: Diastolic blood pressure; HR rest: Heart rate rest; SBP: systolic blood pressure.

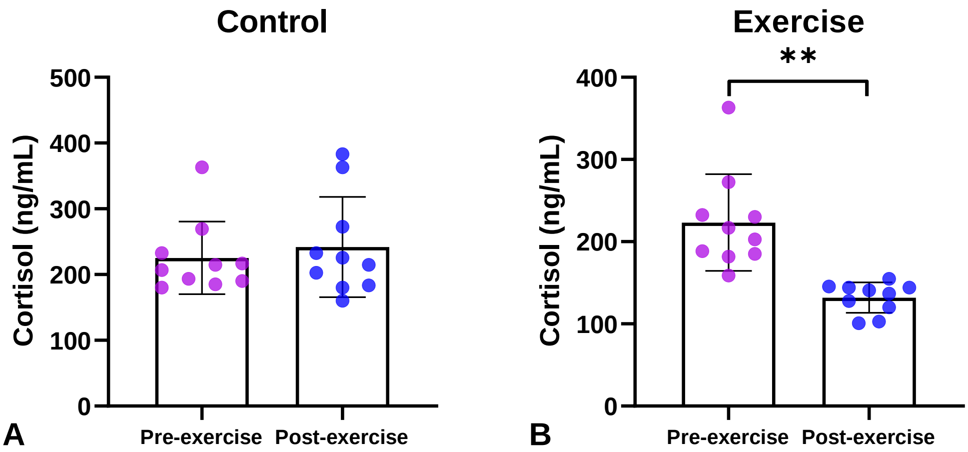

Figure 1. Mean serum cortisol levels (ng/mL) pre-exercise and post-exercise in both groups
Description: (**A**) Control group; (**B**) The acute exercise group performed moderate-intensity physical activity. The data is presented as Mean ± SD. Paired sample t-test was employed to calculate the p-value. (**) denotes statistical significance with pre-exercise ($p \leq 0.001$).

Results of analysis of paired sample t-test mean serum cortisol levels between pre-exercise and post-exercise in the control group (225.33±55.22 vs. 241.87±76.07 ng/mL, (p=0.231)) and the exercise group (223.28± 58.84 vs. 131.85±18.52 ng/mL, (p=0.001)). These results show no change in cortisol levels in the pre-and post-test control groups, and cortisol levels in the exercise group showed a significant decrease.

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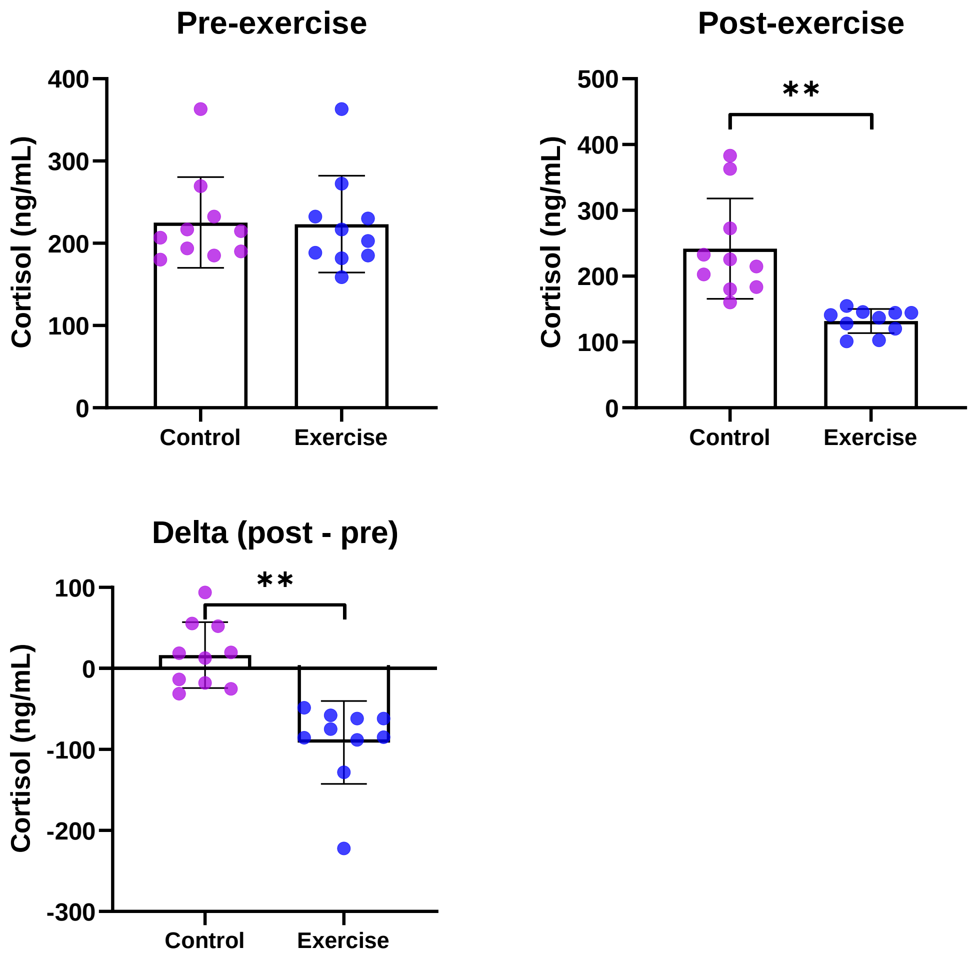

Figure 2. Mean serum cortisol levels (ng/mL) in both groups (control vs. exercise)
Description: Data represented by Mean ± SD. P-value was applied using an independent sample t-test. (**) Significant with pre-exercise ($p \leq 0.001$).

The results of independent sample t-test analysis mean serum cortisol levels between the control group and the exercise group in pre-exercise (225.33±55.22 vs. 223.28±58.84 ng/mL, (p=0.937)), post-exercise (241.87±76.07 vs. 131.85±18.52 ng/mL, (p=0.001)), and delta (16.53±40.67 vs. -91.42±51.17 ng/mL, (p=0.001)). These results show no significant difference in both groups' pre-test data for cortisol levels. Meanwhile, the post-test data in both groups show a significant decrease, and the delta data for cortisol levels in the post-test control group for the two groups show a significant decrease.

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DISCUSSION

This research aims to demonstrate the immediate impact of moderate-intensity exercise in reducing cortisol levels among female students who are obese. Results show no significant difference in both groups' pre-test data for cortisol levels. Meanwhile, the post-test data in both groups show a significant decrease, and the delta data for cortisol levels in the post-test control group for the two groups show a significant decrease. The study yielded a reduction in cortisol levels following a single moderate-intensity exercise session (Figures 1 and 2). These results align with research conducted by Sugiharto et al. (2023), who reported that acute or single sessions of moderate-intensity exercise reduced serum cortisol levels in obese women. Previous studies have also reported that moderate-intensity acute exercise reduces cortisol response (Wang et al., 2019). The improvement in cortisol levels produced after acute exercise is caused by the body's mechanism in response to stress (Torres et al., 2021).

Circulating cortisol levels are regulated by the hypothalamic–pituitary–adrenal axis (HPA axis) through neuroendocrine feedback circuits, which can be activated by exercise-induced stress stimuli (Corazza et al., 2014). Cortisol is produced by exercise in response to stress biologically, which is closely related to neuroendocrine interactions and immune responses. The exercise involves the skeletal muscles, which are influenced by central commands from the motor to the spinal cord via the pyramids by activating the sympathoadrenal system (SNS). The collateral motor center of the command pathway is activated by the central autonomic nervous system in the hypothalamus (Mukarromah et al., 2016). Acute exercise is a trigger of the human stress response, the activation of the HPA axis can impact the physical, physiological, and psychological aspects (Bermejo et al., 2022). So, increased cortisol levels are a good indicator for someone experiencing stress due to exercise (Mukarromah et al., 2016). The cortisol response can differ based on various factors such as the type and intensity of exercise, level of exercise,

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nutritional status, and stress level. Acute exercise typically results in an elevation of cortisol levels (Corazza et al., 2014). The outcomes of this study may also be attributed to the dysregulation of the HPA axis caused by obesity. HPA axis dysregulation has been associated with obesity and may indicate a pathophysiological process that affects mood and weight gain, particularly in metabolic disorders (McLaughlin et al., 2022).

The results obtained in exercise may also be because cortisol is involved in adaptation to moderate-intensity acute exercise performed in this study. Cortisol plays a crucial role in the body's adaptation to exercise as it prepares the body for subsequent exercise by prolonging the release of cortisol before returning to basal levels (Scheffer et al., 2020). Adaptation of the HPA axis following exercise is usually reflected in altered sensitivity to cortisol (Elder et al., 2023). Following acute exercise, there is an elevation in tissue sensitivity to glucocorticoids which work to counteract muscle inflammation, cytokine synthesis, and muscle damage (Dunford & Riddell, 2016). Additionally, a reduction in monocyte sensitivity to glucocorticoids 24 hours post-exercise may function to safeguard the body from extended cortisol secretion resulting from exercise (Kraemer et al., 2020).

The limitation of this study was that the intervention was given only one exercise so that the changes obtained in the body were only temporary. Therefore, future research is suggested to provide chronic exercise intervention. The type of subject in this study is only to describe the age range in this study, and then further studies are needed regarding the busyness of the participants because it might affect them. This study only used female subjects, so the results of this study cannot be generalized to both sexes. In addition, this study was only conducted on individuals with obesity so that future studies can add different BMI, such as underweight, normal weight, and overweight.

CONCLUSION

The main finding of this study was a decrease in serum cortisol levels after acute moderate-intensity exercise. Measurements of cortisol

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were made in the laboratory by obtaining blood samples from collecting six hours after the exercise intervention was given.

Moderate-intensity acute exercise that is carried out for 40 minutes per exercise session can be the basis for recommendations for overcoming metabolic health problems in individuals with obesity. Obesity was chosen to represent the result of a poor lifestyle. In addition, any other consequences-related stress may be encountered by adolescents.

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