Moderate-intensity Exercise Decreases Cortisol Response in Overweight Adolescent Women

by Abdul Hafidz

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MODERATE-INTENSITY EXERCISE DECREASES CORTISOL RESPONSE IN OVERWEIGHT ADOLESCENT WOMEN

Yasep Setiakarnawijaya[1ABD], Widiastuti[1ABD], Muhamad Syamsul Taufik[2BCD], Kuswahyudi[1ABD], Awaluddin[3BD], Ibnu Sina[4BD], Andi Hasriadi Hasyim[1BD], Hasyim[5BD], Abdul Hafidz[6BD] and Nur Ahmad Muharram[7BD]

[1]Universitas Negeri Jakarta
[2]Universitas Suryakancana
[3]Universitas Megarezky
[4]STKIP Banten
[5]Universitas Negeri Makassar
[6]Universitas Negeri Surabaya
[7]Universitas Nusantara PGRI Kediri

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Corresponding Author: Yasep Setiakarnawijaya, E-mail: yasep.s@unj.ac.id
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Abstract

The study purpose was to demonstrate the effect of moderate-intensity exercise on reducing cortisol levels in overweight adolescent women.

Materials and methods. This study is an actual trial study with a pre-test randomized control group design involving 20 overweight adolescent women aged 19–22 as research subjects who were randomly divided into two groups, namely CNG (n = 10, control group) and EXG (n = 10, moderate-intensity exercise group). The moderate-intensity exercise intervention was performed for 40 minutes on a treadmill. Cortisol levels were measured using an Enzyme-linked immunosorbent assay (ELISA) kit. Data analysis technique used t-test of independent samples and correlation test using Pearson's correlation coefficient with Statistical Package for Social Sciences (SPSS) version 21.

Results. Cortisol levels were obtained as a result of the best means between CNG and EXG (222.57 ± 56.04 vs 225.56 ± 63.96 ng/mL, ($p \geq 0.05$)), post-test cortisol levels between CNG and EXG (238, 27 ± 77.94 vs 118.13 ± 12.90 ng/mL, ($p \leq 0.001$)) and cortisol Δ between CNG vs EXG (15.71 ± 13.14 vs -107.43 ± 21, 13 ng/mL, ($p \leq 0.001$)). Cortisol levels also showed a positive relationship with markers of overweight ($p \leq 0.05$).

Conclusions. Based on the study results, it was concluded that the cortisol response decreased after moderate-intensity exercise and found a positive relationship between cortisol levels and markers of overweight. These results could be used as a long-term approach to modifying an active lifestyle to reduce stress levels.

Keywords: cortisol, exercise, metabolic syndrome, overweight, stress.

Introduction

The prevalence of overweight and obesity is increasing over the years (Chu et al., 2017) with the greatest increase in women of all age groups (The Global Burden of Disease (GBD) 2015 Obesity Collaborators, 2017). According to reports from several countries, the prevalence of overweight and obesity among 11- and 13-year-olds ranges from 5% to more than 25% (ENHIS, 2009). The increasing prevalence of overweight and obesity is not only occurring in developed countries but is increasing significantly in developing countries, not only among adults but also among children and adolescents (Seidell & Halberstadt, 2015). Even developing countries like Indonesia have problems with overweight and obesity (Shrimpton & Rokx, 2013). Based on the results of the 2013 Health Basics Study, the prevalence of overweight and obesity among adolescents aged 13 to 15 years was 11.2% and 4.8%, respectively (Riskesdas, 2018). Overweight is the accumulation of too much fat in adipose tissue, often associated with inactivity, unhealthy food consumption, and increased consumption under stressful conditions (Urbaneto et al., 2021). However, this issue is not widely understood.

Stress occurring in overweight individuals may result in a greater pathophysiological burden than in normal weight individuals (Heraclides et al., 2012). Stress not only causes a number of non-communicable diseases, but it also leads to a decrease in a person's immunity, facilitating disease (Glaser & Kiecolt-Glaser, 2005). In overweight women, ongoing stress exposure also has an impact on reproductive organs and mental disorders (Foss & Dyrstad, 2011; De Vriendt, 2009). Chronic stress can induce physiological responses in the form of increased mobilization of energy stores (Torres & Nowson, 2007), including increased gluconeogenesis and lipolysis to compensate for stress (Foss & Dyrstad, 2011). Chronic stress in overweight women may also increase the risk of developing type 2 diabetes (T2D) (Heraclides et al., 2012). Therefore, the stress experienced by overweight people must be managed properly.

Exercise is one of the proven modalities for the treatment of overweight and obesity (Niemiro et al., 2021). On the other hand, exercise also has a positive effect on reducing stress levels, which is characterized by a decrease in the cortisol response (Gerber et al., 2020; Caplin et al., 2021). Exercise can reduce the activation of the hypothalamic-pituitary-adrenal (HPA) axis (Caplin et al., 2021), which is the main mechanism that regulates cortisol secretion through an endocrine feedback mechanism neurology (Pauli et al., 2006; Sugiharto, 2012; Corazza et al., 2014; Pranoto et al., 2020). However, based on the reports of several studies, it is still found that there is a difference in the results regarding the effect of exercise on lowering cortisol levels. According to the study conducted by Irandoust & Taheri (2018) reported a decrease in cortisol levels after high intensity interval training (HIIT) intervention in obese women. Study of Koc (2018) reported that there was no significant difference in cortisol levels between before and after exercise in athletes and sedentary subjects. The study of Karacabey (2009) reported increased cortisol levels after exercise for 12 weeks in obese children. However, the study by Singh et al. (2019) reported a decrease in cortisol levels after moderate-intensity acute exercise. Similarly, the study by Davitt et al. (2017) reported that plasma cortisol levels decreased after a moderate-intensity endurance exercise intervention in obese women. However, study of Koch (2010) reported that cortisol levels increased 120 min after exercise at 60% HRmax intensity.

The aim of this study was to demonstrate the effect of moderate-intensity exercise on reducing cortisol levels in overweight adolescent women. We hypothesized that increasing cortisol levels in overweight subjects with moderate-intensity exercise would significantly reduce cortisol levels.

Material and Methods

Study protocol

20 overweight adolescent women between the ages of 19-22 were enrolled as subjects in the study. The inclusion criteria for this study were individuals with a body mass index (BMI) between 25.52 kg/m² – 28.72 kg/m² (mean ± SD BMI 27.48 ± 1.07 kg/m²)), normal blood pressure, normal resting heart rate (RHR), oxygen saturation (SpO_2) 96% – 99% (mean ± SD SpO_2 97.7 ± 0.87%). The exclusion criteria for this study were people with chronic medical conditions, such as diabetes, lung disease, and coronary heart disease, who were on a weight loss program. Written informed consent was obtained prior to conducting the study. The procedures used in this study adhered to the principles of the World Medical Association (WMA) Declaration of Helsinki regarding the ethical conduct of research involving human subjects.

Exercise protocol

The physical training program is implemented and supervised by professional staff from the Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Jakarta, Indonesia. Strength training is performed intensively with an intensity of 60-70% HRmax for 40 minutes with details of 5 minutes warm-up with an intensity of 50-60% HRmax, 30 minutes of the main exercise perform continuous exercise with an intensity of 6070% HRmax and 5 min of cooling with an intensity of 50-60% HRmax (Rejeki et al., 2021). Exercise was performed from 07:00 to 09:00 on a treadmill (Pulsar 4.0 HP Cosmos Sports & Medical, NussdorfTraunstein, Germany) (Nedić et al., 2017; Rejeki et al., 2022). Heart rate monitoring during exercise using a Polar heart rate monitor (Polar Heart Rate Sensor H10, Inc., USA) (Rejeki et al., 2022).

Anthropometry and cortisol response measurements

Measure body height with an altimeter (Seca® Handheld Altimeter, North America). Measure body weight using a digital scale (OMRON model HN289, Omron Co., Osaka, Japan). Body mass index (BMI) was calculated by dividing body weight (kg) by body height (m²) (Nimptsch et al., 2019; Adji et al., 2021; Raharjo et al., 2021). Blood pressure was measured with an OMRON digital sphygmomanometer (OMRON Model HEM7130 L, Omron Co., Osaka, Japan) in the non-dominant arm 3 times in a row with an interval of 12 min (Rejeki et al., 2022; Andarianto et al., 2022; Yosika et al., 2020). Measure RHR and SpO_2 with a Beurer pulse oximeter (Pulse Oximeter PO 30, Beurer North America LP, Hallandale Beach, FL, USA) (Rejeki et al., 2022). A blood sample was obtained 30 min before and 24 h after exercise on 4 ml cubital vein. The blood sample was inserted into the Vacutainer tube, after which the blood sample was centrifuged for 15 min at 3000 rpm. Serum was separated and stored at -80°C for cortisol levels analysis the next day. Check cortisol levels using the Enzyme Linked Immunosorbent Assay (ELISA) kit method (Catalog No: MBS269825; MyBioSource; San Diego, CA, USA) with a sensitivity of 0-5 ng/mL and range detection is 15.6 ng/mL – 1000 ng/mL.

Statistical analysis

Statistical analysis used the Statistical Package for the Social Sciences (SPSS) version 21.0 (SPSP Inc., Chicago, IL, USA). Normality test using Shapiro-Wilk test. To find out the difference in cortisol levels before and after the exercise in each group, a different paired t-test was performed, while to find the difference in cortisol levels between CNG and EXG, another t-test for independent samples was performed. The potential relationship between markers of overweight and cortisol levels was assessed using Pearson's correlation coefficient test. All data are shown with mean ± standard deviation (SD). All statistical analyzes used a threshold of significance ($p \leq 0.05$).

Results

The results of the analysis of the characteristics of the study subjects, including age, body weight, body height, body mass index, systolic blood pressure, diastolic blood pressure, resting heart rate, and storm oxygen saturation in both groups, shown in Table 1 below.

Table 1. Characteristics of research respondents

Variable	Unit	n	CNG	EXG	p-value
Age	yrs	10	20.40±1.17	20.30±1.16	0.850
Body weight	kg	10	65.66±3.21	66.44±4.70	0.670
Body height	m	10	1.55±0.03	1.55±0.04	0.644
Body mass index	kg/m2	10	27.47±0.99	27.49±1.15	0.969
Systolic blood pressure	mmHg	10	118.00±9.19	120.00±8.17	0.613
Diastolic blood pressure	mmHg	10	76.00±9.66	79.00±8.76	0.476
Resting heart rate	bpm	10	70.60±6.11	71.10±3.93	0.830
Oxygen saturation	%	10	97.70±0.82	97.80±0.92	0.801

Description: CNG: control group; EXG: Moderate-intensity exercise group. Values obtained using t-test of independent samples compared between CNG and EXG. Data are presented as mean ± SD.

Based on Table 1, it can be seen that the average data on the characteristics of the study subjects tend to be the same. The results of the t-test of independent samples showed that there was no significant difference in the mean data on the characteristics of the study subjects ($p \geq 0.05$).

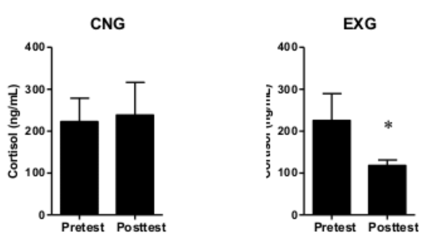

Fig. 1. Cortisol levels pretest and posttest on CTG and ECG. *Description:* CNG: control group; EXG: Moderate-intensity exercise group. (*) Shows a significant difference with the best sample in the paired t-sample test ($p \leq 0.001$). Data are displayed as mean ± SD

Based on Figure 1, it can be seen that the cortisol level on CNG between best and after test tends to be the same, while on EXG, it shows a decrease in cortisol level between best and after test. The results of the paired sample t-test on CNG between the sample before and after the test showed no significant difference (222.57±56.04 vs 238.27±77.94 ng/mL, ($p \geq 0.05$), while EXG showed a significant difference (225.56 ± 63.96 vs 118.13 ± 12.90 ng/mL, ($p \leq 0.001$)).

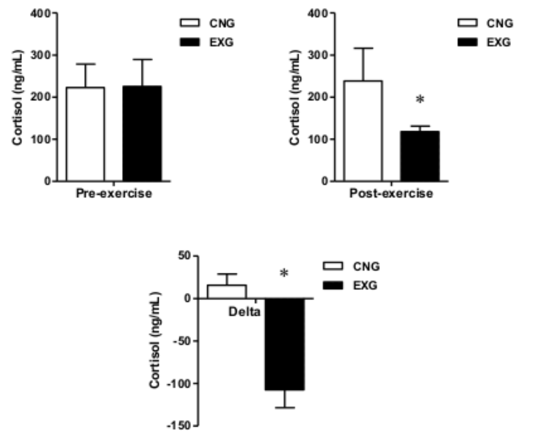

Fig. 2. Cortisol levels pretest, posttest, delta (Δ) between CNG vs. EXG. Description: CNG: Control group. EXG: Moderate-intensity exercise group. (*) The t-test of independent samples shows a significant difference from CNG ($p \leq 0.001$). The data is expressed as mean ± SD

Based on Figure 2, it can be seen that the pretest cortisol levels between CNG and EXG tend to be the same, while the posttest and delta (Δ) levels show a decrease in cortisol levels. The results of the Independent Samples t-Test pretest between CNG and EXG did not show a significant difference (222.57 ± 56.04 vs. 225.56 ± 63.96 ng/mL, ($p \geq 0.05$)), while the posttest and Δ showed a significant difference (238.27 ± 77.94 vs. 118.13 ± 12.90 ng/mL, ($p \leq 0.001$)) and (15.71 ± 13.14 vs. −107.43 ± 21.13 ng/mL, ($p \leq 0.001$)). The relationship between pretest cortisol levels and overweight markers is presented in Figure 3.

Based on Figure 3, it can be seen that the pretest cortisol levels positive correlation with body weight (BW) ($r = 0.570$, $p = 0.009$), body mass index (BMI) ($r = 0.688$, $p = 0.001$), FAT ($r = 0.695$, $p = 0.001$), fat mass (FM) ($r = 0.799$, $p = 0.000$), free fat mass (FFM) ($r = 0.772$, $p = 0.000$), waist circumference (WC) ($r = 0.626$, $p = 0.003$) and shows a moderate correlation between variables. However, other markers of overweight, such as hip circumference (HC) ($r = 0.529$, $p = 0.016$), and waist to hip ratio (WHR) ($r = 0.469$, $p = 0.037$) showed a weak positive correlation with cortisol levels.

Discussion

The results showed no significant difference in mean cortisol levels between before and after the test in the control group (CNG), while the moderate-intensity exercise (EXG) group showed a difference. on the mean decrease in cortisol

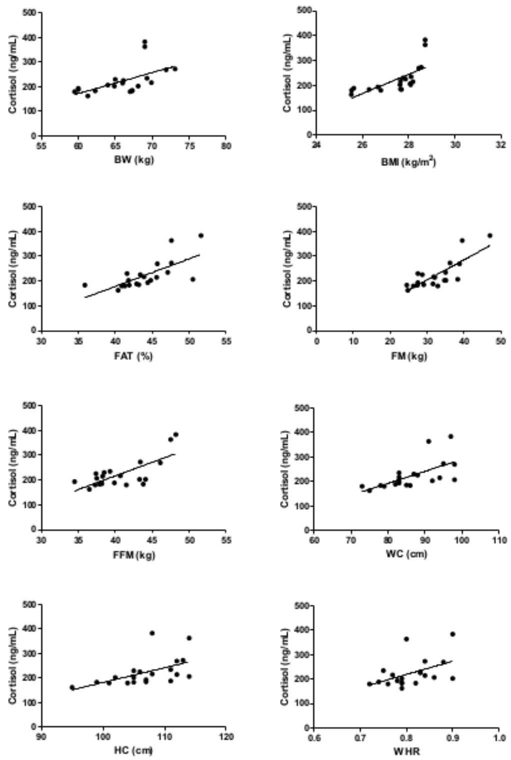

Fig. 3. A positive relationship between pretest cortisol levels and markers of overweight. Description: Value (r) and (p-value) were obtained using the Pearson correlation coefficient test

levels between pre-test and post-test (Figure 1). Based on Figure 2, it can be seen that pre-test cortisol levels between CNG and EXG tend to be almost the same, while post-test and delta (Δ) levels indicate decreased cortisol levels. This is consistent with the study of Kong et al. (2016) concluded that cycle exercise at 65% of maximal oxygen consumption resulted in a 13% decrease in cortisol levels in obese women. Reduced cortisol levels may be due to the effects of moderate-intensity exercise intervention. Regular moderate-intensity exercise can increase the secretion of endorphins, thereby inhibiting the activity of the HPA axis and reducing the sympathetic nervous system (Rimmele et al., 2007; Anderson & Shivakumar, 2013). Inhibition of HPAaxis activity may modulate cortisol secretion through a neuroendocrine feedback mechanism (Sugiharto, 2012; Corazza et al., 2014).

During exercise, cortisol secretion can be affected by duration, intensity, type of exercise (Mukarromah et al., 2016), physical fitness, and nutritional status (Beaven et al., 2008). This study used moderate intensity exercise (60-70% HRmax). Exercise performed at moderate intensity can induce positive stress (eustress) (Sugiharto, 2012), while excessive and prolonged exercise can induce negative stress (distress) may increase oxidative damage, thereby increasing the risk of injury (Mrakic-Sposta et al., 2015). The results showed that moderate-intensity exercise significantly reduced cortisol levels compared with the control group (Fig. 2). According to Popovic et al. (2019) exercise performed at an intensity of at least 60% VO_2max can reduce the cortisol response. Research by Kong et al. (2016) using 18-30 years old female subjects with a BMI of 2330 kg/m^2 who received a moderate-intensity exercise intervention (60% VO_2max) using a 40 minute work cycle that showed decreased cortisol levels. Research by Singh et al. (2019) also reported decreased cortisol levels after moderate-intensity acute exercise. Tomiyama (2019) also reported that moderate-intensity exercise can reduce stress levels, which are characterized by lower cortisol levels. Thus, moderate-intensity exercise could be used as a method to reduce stress levels in overweight adolescent women.

The main finding of this study was that moderate-intensity exercise significantly reduced cortisol levels. These results could be used as a long-term approach to active lifestyle modifications to reduce cortisol levels as a marker of stress levels and prevent the risk of complications from the effects of being overweight. The limitation of this study is that only one marker was used as a stress marker, namely cortisol level, so evidence of a reduction in stress level markers has not yet been established given less precise. Further study is recommended to add other parameters related to stress levels, such as catecholamines, epinephrine, norepinephrine, HPA axis, adrenocorticotropic hormone (ACTH), and corticotropin releasing hormone (CRH). In addition, future research is also recommended to demonstrate the effects of long term exercise (chronic exercise) on reducing cortisol levels by involving adolescent and young respondents overweight youth.

Conclusion

Overall, these results indicate that the cortisol response is reduced after a 40-minute single session of moderate-intensity exercise and found a positive relationship between basal cortisol levels with markers of overweight.

Conflict of interest

All authors declare that they have no competing interests.

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ВПРАВА ПОМІРНОЇ ІНТЕНСИВНОСТІ ЗНИЖУЄ РІВНІ КОРТИЗОЛУ В ЮНИХ ЖІНОК ІЗ НАДЛИШКОВОЮ ВАГОЮ

Ясеп Сетіакарнавія[1ABD], Відіастуті[1ABD], Мухамад Сямсул Тауфік[2BCD], Кусвахюді[1ABD], Авалуддін[3BD], Ібну Сіна[4BD], Енді Хасріаді Хасим[1BD], Хасим[5BD], Абдул Хафідз[6BD], Нур Ахмад Мухаррам[7BD]

[1]Джакартський державний університет
[2]Університет Сур'яканчана
[3]Мегарезкий університет
[4]Бантенський педагогічний коледж
[5]Макассарський державний університет
[6]Сурабайський державний університет
[7]Кедірійський університет Нусантара Асоціації вчителів Індонезії

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 1 табл., 3 рис., 41 джерело.

Метою дослідження було продемонструвати вплив виконання вправи помірної інтенсивності на зниження рівнів кортизолу в юних жінок із надлишковою вагою.

Матеріали та методи. Це дослідження є дослідженням на базі поточного клінічного дослідження, побудоване за планом попереднього тестування з рандомізованим розподілом учасників і з використанням контрольної групи. Учасницями дослідження стали 20 юних жінок із надлишковою вагою віком від 19 до 22 років, які методом випадкового відбору були розподілені на дві групи: CNG (n = 10, контрольна група) та EXG (n = 10, група, у якій виконували вправу помірної інтенсивності). Інтервенційну вправу помірної інтенсивності виконували протягом 40 хвилин на тренажері «бігова доріжка». Вимірювання рівнів кортизолу здійснювали за допомогою набору для фермент-зв'язаного імуносорбентного аналізу (ELISA). Як метод аналізу даних використовували t-критерій Стьюдента для незалежних вибірок і перевірку кореляції з використанням коефіцієнта кореляції Пірсона, обробку даних здійснювали з використанням ПЗ Statistical Package for Social Sciences (SPSS) версії 21.

Результати. Були одержані та порівняні значення рівнів кортизолу як результат оптимальних середніх значень у групах CNG та EXG (222,57 ± 56,04 проти 225,56 ± 63,96 нг/мл, ($p \geq 0{,}05$)), підсумкових рівнів кортизолу в групах CNG та EXG (238, 27 ± 77,94 проти 118,13 ± 12,90 нг/мл, ($p \leq 0{,}001$)) та значення дельти (Δ) кортизолу в групах CNG та EXG (15,71 ± 13,14 проти -107,43 ± 21,13 нг/мл, ($p \leq 0{,}001$)). Значення рівнів кортизолу також показали позитивний зв'язок із маркерами надлишкової ваги ($p \leq 0{,}05$).

Висновки. На підставі результатів дослідження було зроблено висновок про те, що після виконання вправи помірної інтенсивності рівні кортизолу знижувалися, і було встановлено позитивний зв'язок між рівнями кортизолу та маркерами надлишкової ваги. Ці результати можна використовувати як перспективний підхід до змінювання активного способу життя з метою зниження рівнів стресу.

Ключові слова: кортизол, вправа, метаболічний синдром, надлишкова вага, стрес.

Information about the authors:

Yasep Setiakarnawijaya: yasep.s@unj.ac.id; https://orcid.org/0000-0002-5105-5007; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Widiastuti: widiastuti@unj.ac.id; https://orcid.org/0000-0003-4047-1969; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Muhamad Syamsul Taufik: syamsul@unsur.ac.id; https://orcid.org/0000-0001-5936-515X; Department of Physical Education, Health and Recreation, Faculty of Teacher and Education, Universitas Suryakancana, Pasir Gede Raya Street, Cianjur, West Java, Indonesia.

Kuswahyudi: kuswahyudi@unj.ac.id; https://orcid.org/0000-0002-1677-6968; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Awaluddin: awaluddin@universitasmegarezky.ac.id; https://orcid.org/0000-0001-9706-5182; Department of Physical Education, Health and Recreation, Faculty of Teacher and Education, Universitas Megarezky, Antang Raya Street, Makassar, South Sulawesi, Indonesia.

Ibnu Sina: Ibnu.sina@binabangsa.ac.id; https://orcid.org/0000-0002-2107-7803; Department of Physical Education, Health and Recreation, STKIP Banten, Raya Cilegon Street, KM. 3.5 Cilegon, Banten, Indonesia.

Andi Hasriadi Hasyim: andihasriadihasyim@unj.ac.id; https://orcid.org/0000-0003-2905-9746; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Hasyim: hasyim@unm.ac.id; https://orcid.org/0000-0002-4286-8137; Department of Physical Education, Health and Recreation, Faculty of Teacher and Education, Universitas Negeri Makassar, Makassar, Indonesia.

Abdul Hafidz: abdulhafidz@unesa.ac.id; https://orcid.org/0000-0002-1171-2367; Department of Sport Coaching Education, Faculty of Sport Science, Universitas Negeri Surabaya, Lidah Wetan Street, Surabaya, East Java 60213, Indonesia.

Nur Ahmad Muharram: nurahmad.2019@student.uny.ac.id; https://orcid.org/0000-0002-8741-0664; Faculty of Health and Science, Universitas Nusantara PGRI Kediri, Ahmad Dahlan No. 76 Street, Kediri, East Java 64112, Indonesia.

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