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The Effect Of Calisthenic Exercise On Leg Explosive Power

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ABSTRACT

Background: Physical fitness is a condition where the human body can perform daily activities without experiencing excessive fatigue. Physical exercise is one way to achieve physical fitness. Calisthenics is a strength exercise that utilizes body weight as resistance to increase muscle strength. Previous research has shown that strength training can increase the explosive power of leg muscles measured through vertical jumps.
Objective: Knowing the effect of calisthenic exercises on the explosive power of the leg muscles.
Methods: Experimental research with quasi-experimental design and pre-test and post-test nonequivalent control group methods. The subjects were 37 active Diponegoro University, Semarang students, who were selected by purposive sampling and grouped into two groups. The control group without treatment (n=19) and the treatment group (n=18) were given calisthenic exercises for six weeks. The explosive power of the limb muscles was measured before and after the intervention with the vertical jump instrument and expressed as the vertical jump score (V.J. score).
Results: The results showed a significant increase in the V.J. score ($p=0.030$) in the treatment group compared to the control group. There was also a significant increase in V.J. score ($p<0.001$) before and after the intervention in the treatment group.
Conclusion: Calisthenic exercises for six weeks can increase muscle explosive power in young adults.

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1. Introduction

Physical fitness is a condition in which the human body can perform daily activities without experiencing excessive fatigue. An essential component in achieving physical fitness is adequate physical exercise (1,2). Physical exercise is generally divided into aerobic exercise, which increases cardiovascular endurance, and anaerobic exercise, which increases muscle strength and endurance (3).

Today, people are often fixated on aerobic exercise, such as jogging and cycling, while anaerobic sports, such as weight training, are particular for bodybuilders. Aerobic and anaerobic exercise are equally important in maintaining physical fitness and improving one's health and quality of life. Physical activity guidelines released by the U.S. The Department of Health and Human Services recommends combining aerobic and anaerobic exercise to achieve meaningful health benefits (4).

Strength training is a form of physical exercise that aims to increase muscle strength and endurance (5). Calisthenics is a form of strength training consisting of diverse movements that work for large muscle groups and are performed with minimal equipment, relying only on body weight (bodyweight exercise). Based on a study by the University of Parlemo, calisthenics training is a practical and feasible exercise option to improve the quality of posture, body strength, and body composition without or with minimal use of tools (6).

The COVID-19 pandemic that has hit the world lately has dramatically impacted people's lifestyles, including the increase in sedentary lifestyles (7). Sedentary is any activity with minimal calorie needs (1,8). A sedentary lifestyle has a direct and independent impact on health, with obesity being the most prominent direct impact. Based on a study by the Centers for Disease Control and Prevention, 8.3% of the mortality rate was associated with a level of physical activity that did not reach the recommended standard of 150 minutes of moderate-intensity exercise each week (9).

Calisthenic exercises prioritize body weight and are suitable for individuals who cannot access exercise equipment or fitness centers due to restrictions during the pandemic. One measurement that can measure muscle strength is muscle explosive power. Muscle explosive power can be measured with the vertical jump test (Sargent Test) (10). Based on previous studies, exercises with weights have a significant impact on increasing muscle explosive power (11).

There has yet to be any research in Indonesia on the relationship between calisthenics training and the explosive power of leg muscles. This causes the researcher to intend to compile research on the subject. Through the implementation of this study, a correlation between calisthenics exercise and muscle strength is expected to be found.

2. Methodh

This research is a type of experimental research with a quasi-experimental research design with a pre-test and post-test nonequivalent control group. Samples in this study were young adults age group 18-22 years who are registered as students of Diponegoro University, Semarang was selected purposively sampling based on inclusion criteria in the form of male sex, young adult age (18-22 years), has a body mass index of 18-24.9 kg/m2, did not do exercise more than three times a week, willing not to do other exercise for six weeks, and has no exclusion criteria. The subjects were grouped into two groups: the treatment group and the control group. The treatment group was given exercise for six weeks with a frequency of exercise three times a week, while the control group was asked to do activities as usual and was not allowed to exercise for six weeks.

Subjects in the treatment group were instructed to follow a series of calisthenic exercises. The warm-up and cool-down phases are carried out before and after training for 5 minutes. The calisthenics exercises are bodyweight squats, lunges, and glute bridge exercises. Each training session trains one movement, each carried out in 3 sets. Movements are replaced at each session. The number of reps in each set is increased throughout the workout. In Weeks 1-2, do three sets with eight reps in each set; in Weeks 3-4, do three sets with ten reps. At weeks 5-6, he executed three sets with 12 repetitions in each of his sets. Each session is followed by a 1-2 day muscle recovery period.

Measure muscle explosive power by taking the initial state (pre-test) and after-treatment state (post-test) by carrying out the vertical jump test. The test was conducted at a location with the same temperature and relative humidity. The study subjects warmed up for 10 minutes to avoid the risk of injury. The subjects stood beside the wall upright, and both feet tread the floor; then, the subjects raised their hands sprinkled with powdered lime as high as possible to search for maximum range (H1). The subjects jumped as much as possible from a static position while patting their hands against the wall so that chalk marks could be seen on the wall (H2). Researchers measured the distance from H1 to H2. The vertical jump test is performed three times, and then the average of the three jumps is calculated.

Data analysis includes descriptive analysis and hypothesis testing. Hypothesis tests of each group were analyzed using paired T-Tests / Wilcoxon and unpaired T-Tests /Mann-Whitney.

Ethics for this research was obtained from the Medical and Health Research Ethics Commission (KEPK) of the Faculty of Medicine, Diponegoro University (No 270/EC/KEPK/FK-UNDIP/VII/2022). Before the study was conducted, informed consent was given to students who were the research subjects.

3. Result

Thirty-seven male students of Diponegoro University who met the inclusion criteria participated in the study with the characteristics shown in Table 1. The subjects were divided into the control group (n=19) and the treatment group (n=18). There were no significant differences in age (p=0.307; Mann-Whitney), weight (p=0.388; independent t-test), height (p=0.466; independent t-test), and body mass index (p=0.128; independent t-test) between the control group and the treatment group. All subjects were classified as not routinely exercising, had no history of limb injury, and had no history of musculoskeletal disease.

Limb muscle explosive power was measured using a vertical jump test on all subjects. The vertical jump test was carried out twice, first before the intervention in the treatment group (pre-test) and second after the intervention for six weeks in the treatment group (post-test).

Table 1. Characteristics Of Research Subjects

Characteristic	Group		*p*
	Control (n=19)	Treatment (n=18)	
Age	20,11±0, 295	20,56±0,271	0,307ᵐ
Sex			
Male	19 (100%)	18 (100%)	
Female	0 (0%)	0 (0%)	
Weight	65,32±2,222	68,00±2,114	0,388ᵗ
Height	171,32±1,447	170,33±1,536	0,466ᵗ
Body Mass Index (BMI)	22,30±0.532	23.37±0,509	0,128ᵐ
Exercise regularly			
Yes	0 (0%)	0 (0%)	
No	19 (100%)	19 (100%)	
Prior Leg Injury			Prior Leg Injury
Yes	0 (0%)	0 (0%)	Yes
No	19 (100%)	19 (100%)	No
Prior Musculoskeletal Illness			Prior Musculoskeletal Illness
Yes	0 (0%)	0 (0%)	Yes
No	19 (100%)	19 (100%)	No

Average±Standard Deviation ᵗIndependent Samples Test; ᵐ Mann-Whitney

Table 2 shows the mean V.J. scores for the control and treatment groups. The mean score of the V.J. pre-test of the treatment group was higher than the control group, but there was no significant difference between the two groups (p=0.828; independent t-test). The average score of the V.J. post-test treatment group was higher than the control group, and a significant difference was obtained between the two groups (p=0.030; independent t-test). The average difference between the results of the pre-test and post-test of the treatment group was higher than the results of the pre-test and post-test of the control group and obtained

significant differences between the two groups (<0.001; Mann-Whitney).

Table 2. V.J. Score of Control Group and Treatment Group

Time of Measurement	V.J. Score Control (n=19) average±SD	V.J. Score Treatment (n=18) average±SD	*p*
Pre-test	40,245±2,190	40,815±1,389	0,828 ŧ
Post-test	39,316±0,551	45,037±1,230	0,030 ŧ
Delta pre-post test	-0,621±1,04	4.223±0,575	<0,001 m

Average±Standard Deviation
ŧ Independent Samples Test; m Mann-Whitney

Table 3 shows the statistical T-test results based on pre-test and post-test V.J. scores. In the control group, the difference between pre-test and post-test V.J. scores was insignificant (p = 0.110; paired t-test). While in the training group found an increase in pre-test and post-test scores used V.J. (p = <0.001; paired t-test).

Table 3. V.J. Score of Pre-test and Post-test

Group	Pre-post test V.J. Score
Control	0,110 ₵
Treatment	<0,001 ₵

₵ Paired Samples Test

4. Discussion

This study showed that calisthenic exercise affects the explosive power of the lower leg muscles as measured by the vertical jump test. Based on the statistical analysis of primary data obtained, a significant increase in vertical jump results was recorded in the treatment group after carrying out the exercise for six weeks. In the control group, there was a decrease in vertical jump results but insignificant (p=0.110; paired T-test). This can occur due to differences in activity and nutritional intake of everyone in the control group. This is by research by Ortiz, A M et al., who found that strength training can increase muscle explosive power by 3.96% in the male group measured through the difference in vertical jump results before and after implementing a strength training program for 12 days (12).

Strength training for at least six weeks can lead to physiological changes as a form of adaptation to the introduced loads (13). Changes occur in the nervous system where the exercises are carried out progressively by increasing the firing rate of motor neurons and increasing the recruitment ability of motor units. Changes that occur in skeletal muscle in the form of an increase in skeletal muscle size are triggered by G.H. and IGF-1 hormones that increase after exercise. The increase in skeletal muscle size is directly related to the increase in actin and myosin, so the number of cross-bridges that can be formed in the contraction cycle increases (14).

Increasing exercise intensity through increasing the number of repetitions of movements in each exercise gradually overloads the muscles being trained to increase muscle ability, according to the principle of overload and progression (15).

Calisthenic squats, lunges, and glute bridges activate several muscles with M. Quadriceps femoris and M. Gluteus maximus as the primary agonist muscle in such exercises (16). Through a controlled regimen of calisthenic training, there is an improvement in the neuromuscular abilities of these muscle groups. The vertical jump test has several major agonist muscles, namely M. Quadriceps femoris, M. Sartorius as a genu joint extensor, and M. Gluteus maximus as a genu joint extensor. Through targeted training, it is expected that there will be an increase in the ability of the muscle groups being trained by the principle of specificity.

Based on the analyzed data, it was found that there was a significant difference in muscle explosive strength between the treatment group, who had performed calisthenic exercises for six weeks, and the control group. The results of this study are in line with previous research by Fathinia, A R et al., where there was an increase in vertical jump results in the treatment group who carried out anaerobic exercise for six weeks, and there was no significant difference in vertical jump results in the control group. The difference with the study is that it uses anaerobic exercise that uses sprint exercises, while this study uses calisthenic exercises.

This study's limitation is the researchers' inability to control and monitor all physical activity and nutritional intake of research subjects. The oral explanation related to this was delivered to the subject before the study began, so it is expected to be independent of the study's validity. Another limitation of this study is the need for indicators for assessing the explosive power of leg muscles, where only vertical jump measurement instruments are used. Other instruments can be used to measure the explosive power of the leg muscles, such as the force plate and the leg dynamometer, but due to limited tools and costs in research, these instruments are not used.

5. Conclusion

Calisthenic exercise for six weeks affected muscle explosive power measured through the vertical jump test in the young adult age group. It is necessary to consider other calisthenic exercise regimens that target other muscle groups, such as upper limb and trunk muscles and other muscle explosive measurement instruments, involving female research subjects to determine the effect of sex on research results and further research with other age groups, such as children, adolescents, and the elderly.

Ethical Approval

This research has been approved by the Ethical Committee for Health Research, Faculty of Medicine, Diponegoro University, with approval number 270/EC/KEPK/FK-UNDIP/VII/2022

Conflicts of Interest

There is no conflict of interest in this research.

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Conceptualization, W.R., E.K., and S.A.; methodology, W.R., E.K., and S.A.; software, W.R.; validation, W, R.; formal analysis, W.R.; investigation, W.R.; resources, W.R.; data curation, W.R.; writing—original draft preparation, W.R., E.K., and S.A.; writing—review and editing, W.R., E.K., and S.A.; visualization, E.K., and S.A.; supervision, E.K., and S.A.; project administration, W.R.; funding acquisition, W.R.

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