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Jump-to-Box exercise has an increasing effect on jumping ability in adolescents

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ABSTRACT

Aim: To determine the most effective dose of the box jump exercise for increasing explosive leg muscle strength in adolescents, as measured by vertical jump height.

Methods: This study is a field experimental study using a randomized control group pretest-posttest design by providing different doses of jump-to-box exercise. The experiment was conducted on Buqa'tum Mubarakah Junior High School students in Makassar, Indonesia, on February 16 to August 16, 2022 and obtained a total sample size of 60 male subjects aged 15-16 years. The participants were randomly divided into four experimental groups, each consisting of 15 people who were given jump-to-box exercises with different doses.

Results: The results of the ANOVA test analysis showed that training with a loading dose of 24 cm and 5 minutes duration had a significant effect on increasing leg muscle explosive power with a p-value = 0.005. The other three groups did not show statistically significant improvements in jump height.

Conclusion: The jump-to-box exercise with the box height of 24 cm and training duration of 5 minutes resulted in the highest average vertical jumping ability compared to other dose groups. This exercise protocol has an optimal effect on vertical jumping ability and limb explosive power in adolescents compared to other protocols.

Keywords: exercise, box jumping, muscle explosive power, adolescents

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Упражнение «Прыжок на ящик» увеличивает высоту прыжка у подростков

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АННОТАЦИЯ.

Цель: определить наиболее эффективную дозу упражнения «прыжок на ящик» для увеличения взрывной силы мышц ног у подростков, измеряемая высотой вертикального прыжка.

Материалы и методы. Данное исследование представляет собой полевое экспериментальное исследование с использованием рандомизированной контрольной группы по схеме «претест — посттест» путем предоставления различных доз упражнения «прыжок на ящик». Исследование проводилось на учащихся средней школы Букатум Мубарака в Макассаре, Индонезия, с 16 февраля по 16 августа 2022 года. Выборка включала 60 подростков мужского пола возраста 15–16 лет. Участники были случайным образом разделены на четыре экспериментальные группы, каждая из которых состояла из 15 человек, получавших упражнения по прыжкам в воду с разной дозировкой.

Результаты анализа теста ANOVA показывают, что тренировка с нагрузочной дозой 24 см и продолжительностью 5 минут оказывает существенное влияние на увеличение взрывной силы мышц ног со значением p = 0,005. Три другие группы не показали статистически зна-

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чимых улучшений в высоте прыжка. Выводы. Таким образом, можно сделать вывод, что умеренная доза упражнений по прыжкам на ящик влияет на увеличение взрывной силы мышц конечностей подростков.

Ключевые слова: упражнения; прыжки на ящик; взрывная сила мышц; подростки

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1. Introduction

School-age is one of the phases of living that will determine the quality of life and future achievements of the nation. Therefore, school-age children need to be prepared in conditions of maximum physical capacity and functional abilities, in order to have maximum abilities, including physical activities such as jumping. There is a difference in activity between students in villages and children in urban areas, where urban children generally do less physical activity due to a lifestyle that is influenced by technological advances. Moreover, with the Covid-19 pandemic that requires lockdown, and the community, especially school children, must quarantine at home and carry out independent isolation, causing decrease of physical activity [1]. Therefore, this study is intended to improve physical activity abilities, especially jumping activities. Jumping activity in school can be improved so that children can use their limbs optimally in their activities. This is important because the feet are the center of human movement activities, such as kicking, walking, running, and jumping. Jumping requires the ability to generate leg muscle explosive power as an important factor in many activities, especially activities that involve changing of direction, acceleration, jumping, and running [2]. The lack of children's ability to master jumping motor skills will contribute less to success in sports and other physical activities as a basis for obtaining achievements in competition. This condition can be obtained through exercises, that cause adaptation of several physical elements, both to the muscular system directly, and to other elements of physical condition as a result of adjustments to the neuromuscular system [3].

Mastery of basic movement skills such as running and jumping in children correlates with several health benefits such as higher levels of physical activity, cardiorespiratory fitness, perceived scholastic and athletic competence, and lower levels of overweight [4]. Socio-economic changes bring less active lifestyle activities, causing a decrease in children's fitness [1].

Aerobic training prior to muscle strengthening exercises has an effect on improving jumping performance and muscle flexibility. Gradual weight training with a focus on technique is a great way to improve strength, and speed. However, it is necessary to pay attention to the volume and intensity of exercise to match the ability and recovery of the neuromuscular system [5]. The characteristics that accompany physical fitness in squash consist of aerobic capacity, anaerobic power, strength, speed, flexibility, balance and coordination. Increased physical fitness will support the achievement of speed and muscle strength in training [6]. This is in line with the results of research on the dose-response relationship of resistance training that maximizes the improvement of physical performance in young athletes [7]. Similarly, research on the effect of jump-to-box and front-box jump training on explosive power and speed and the effect of depth jump training on explosive power and speed as well as differences in the effects of several types of training [8]. All the training techniques described above do not show how much load and length of training is needed to improve children's jumping ability due to increased leg muscle explosive power. The above studies also analyzed the effect of resistance training on improving muscle strength and jumping performance, where gender and resistance training were moderating factors. Thus the exercise only designs the type of resistance training by determining repetition and intensity. Therefore, this study aims to analyze the effective dose (training duration and amount of load) of jump-to-box training to improve jumping ability due to increased leg muscle explosive power, which according to researchers these variables have never been done in research.

Because dosage is a very important indicator in designing exercises to influence the increase in muscle explosive power, this research needs to be carried out as an effort to overcome the problem of children's jumping ability due to increased leg muscle explosive power.

2. Method

This research was conducted at Buqa'tum Mubarakah Junior High School (SMP) Makassar Indonesia on February 16 to August 16, 2022. This research is a field experiment using a randomized control group pretest-posttest design. The study population was Buqa'tum Mubarakah Junior High School students in Makassar, Indonesia who met the inclusion criteria, namely age 15–16 years, male gender, body weight 35–55 kg, height 145–155 cm, horizontal jumping ability 215–260 cm. General basic functional examination of participants included passive motion, active motion and isometric test of leg muscle endurance in order to exclude disorders of the neuromuscular

system. The sample was obtained using the Lemesow formula so that a sample size of 60 subjects was obtained. Samples were taken using simple random sampling technique. The participants were randomly divided into four experimental groups, each consisting of 15 people who were given jump-to-box exercises with different doses. The subject's vertical jumping ability was measured first before being given treatment as a pretest value. Then a random allocation was made which was divided into four experimental groups, where the first group jumped on a box that was 12 cm high for 3 minutes, the second group jumped on a box that was 12 cm high for 5 minutes, the third group jumped on a box that was 24 cm high for 5 minutes, and the fourth group did the exercise on a box that was 24 cm high for 3 minutes. The exercises were given three times a week for eight weeks to all experimental groups. Measurement of jumping ability was carried out 48 hours after the last workout to determine the subject's vertical jumping ability after intervention as a post-test value. Similarly to the pretest, measurements for the posttest were taken with the subject jumping vertically 3 times, then the size of the highest jump measured in in centimetres was taken. The data obtained was first analyzed for normality using the Kolmogorov Smirnov test. Because the data was normal, the data analysis used ANOVA statistical test to determine the most effective training dose that affects vertical jumping ability. An informed consent was obtained from all individual participants included in the study. The study was performed in accordance with the Declaration of Helsinki. This research has received approval from the Makassar Health Polytechnic Health Research Ethics Commission number 0547/KEPK-PTKMS/VII/2021.

3. Results

The research sample was boys aged 15–16 years with 60 subjects. There were 4 (four) levels of load and exercise duration factors, namely B1D1 (Box 1 Duration 1) = 12 cm load, 3 minutes exercise time, B1D2 = 12 cm load for 5 minutes exercise, B2D1 = 24 cm load for 3 minutes exercise, and B2D2 = 24 cm load for 5 minutes exercise. The amount of research data was 15 students per group or dose where each student measured 2 (two) vertical jumps as pretest and posttest.

To determine the dose of exercise that affects the child's vertical jumping ability, measurements were made on the ability to jump before and after being given jump-to-box training in each dose group.

The results of descriptive analysis showed that the mean posttest result of group 1 (B1D1) was 237.68 with a standard deviation of 9.591 cm. The mean jump height of group 2 was 239.97 with a standard deviation of 15.167 cm, group 3 obtained a mean of 237.83 with a standard deviation of 13.473 cm. Group 4 with the mean of 244.73 and a standard deviation of 7.674 cm showed highest jump height increase compared to the average jump of other groups.

The results of statistical analysis using ANOVA showed a dose of 12 cm and a 3 minutes duration of exercise, a dose of 12 cm and a 5 minutes duration of exercise, and a dose of 24 cm and a 3 minutes duration of exercise showed that there were no significant changes in the average vertical jump ability before and after training period. ($p > 0.05$), meaning that jump-to-box training with such volume did not provide a significant effect on increasing the explosive power of the lower extremities muscles among adolescents. However, jump-to-box training with a dose of 24 cm and a 5 minutes training duration showed a significant increase in the average vertical jumping ability after training period ($p < 0.05$), meaning that the ability of jump-to-box training with a training dose of 24 cm 5 minutes provides an optimal effect on vertical jumping ability as an indicator of increasing the explosive power of adolescent leg muscles.

4. Discussion

In this study, the researchers analyzed the effect of training duration and the amount of load given to assess the impact of jumping exercises on the increase in explosive power of leg muscles.

The participants in this study were adolescent boys aged 15–16 years. Males were used in this study to prevent sexual

Table 1

Influence of different Jump-to-Box exercise protocols on Jumping Ability

Таблица 1

Влияние различных протоколов упражнений «Прыжок на ящик» на прыгучесть

Dose	Jumping Ability				*p*
	Pretest		Posttest		
	Mean (cm)	SD (cm)	Mean (cm)	SD (cm)	
The load is 12 cm and the training time is 3 minutes	232.700	30.647	237.68	9,591	0.066
The load is 12 cm and the training time is 5 minutes	232.989	25.675	239.97	15.167	0.063
24 cm load and 3 minutes training time	232,462	22.414	237.83	13.473	0.064
24 cm load and 5 minutes training time	231.800	31.769	244.73	7.674	0.005

differences in physical activity ability. Similarly, age was in the same range, so that gender and age factors could be controlled as a combined variable. In addition, the age of 15–16 years is the age maturation and growth [9, 10]. This sample is expected to have the same results with the same intervention. Therefore, it is the differences in exercise dosage that will result in differences in jumping ability. The same muscle maturation will result in the same increase in strength. [11]. In addition to the same age and muscle maturity factors, the desired muscle strength during exercise is also influenced by fatigue and environmental factors. High-intensity training such as resistance training is one form of exercise that can increase muscle strength due to increased muscle explosive power [12, 13].

The results of the paired t test analysis showed that jump-to-box training with a dose of 24 cm and 5 minutes training duration had the maximum effect on jumping ability as an indicator of additional explosive power of adolescent leg muscles. This can occur because jump-to-box training in any dosage will cause the leg muscles to work continuously with shortening or lengthening types of contractions. [8]. A workout can only be maximal if the muscles are maximally contracted, meaning that a greater load with sufficient training time will engage more muscle fibres to activate the muscle spindle. This process occurs because jump-to-box training is an exercise that provides a load or resistance caused by increased motor unit function [13]. The addition of muscle explosive power is also strongly influenced by the shape of muscle fibers, both white and red fibers, which will affect the ability of a muscle to withstand resistance or load in a movement [14]. In addition, this exercise also relies on neurological reflexes and elasticity of the tendon-muscle component resulting in increased muscle explosive power [15, 16]. Neuromuscular abilities will produce, reduce, or control force during functional activities and muscle strength increase during training is greatly influenced by neural adaptation and muscle size [14]. However, muscle strength is also influenced by power and endurance. Strength is influenced by force, distance, and time, where the jump to box exercise in this study is designed where the subject provides a force in the form of jumping from the floor to the top of the box with different distances and training times. The maximum muscle strength obtained is in the group of subjects who perform given exercise with great strength and higher distances and loads. Therefore, the greater the load and the longer the training time given to a muscle, the greater the volume received, so that the ability of the muscles to function will be higher than muscle training with lower loads and duration. This can occur because exercise with a greater load and duration of exercise cause the neuromuscular system to work more optimally. Muscle fibers, especially those with high prevalence of type II fibers, will experience hypertrophy, this also occur due to protein synthesis in the muscles as a result of mechanical effects [17]. Exercising regularly at the same dose for 6-8 weeks will get optimal results. [18]. In addition to the load, endurance, and muscle strength are the factors that can determine the increase in muscle strength due to exercise. Another influential factor is the angle of the jump [18]. The angle formed in training with the B2D2 dose has high angle compared to the angle of other doses so that the load on the muscles is greater so that the ability of large muscle contractions as a parameter of increasing skeletal muscle explosive power. Jump to box training has almost the same effect as sit up training so that it can affect muscle strength and endurance, as a factor that affects a person's jumping ability. [19]. In other aspects, jumping exercises also have a close relationship with the occurrence of delayed-onset muscle soreness, that should be monitored in order to avoid injury.

5. Conclusion

Based on the results of the study, it is known that jump-to-box exercise with a dose of B2D2 (box height 24 cm, training duration of 5 minutes) obtained the highest average vertical jumping ability compared to other dose groups. This exercise protocol has an optimal effect on vertical jumping ability and limb explosive power in adolescents compared to other protocols.

Author contributions:

Hendrik Hendrik — conceptualization and design, data collecting, writing the first draft of the manuscript;

Yonathan Ramba — conceptualization and design, editing of the text;

Arpandjam'an — conceptualization and design, editing of the text;

Gaurav Kapoor — conceptualization and design, statistical analysis, editing of the text.

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Хендрик Хендрик — концепция и дизайн публикации, сбор данных, написание первого варианта рукописи;

Йонатан Рамба — концепция и дизайн публикации, редактирование текста;

Арпанджаман — концепция и дизайн публикации, редактирование текста;

Гаурав Капур — концепция и дизайн публикации, статистический анализ, редактирование текста.

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