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Increased leg muscle power and arm muscle strength of basketball athletes: through complex training method and circuit body weight training

Aumento de la potencia muscular de las piernas y la fuerza muscular de los brazos de los atletas de baloncesto: a través de método de entrenamiento complejo y entrenamiento de peso corporal en circuito

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Abstract. This study aims to analyze: (1) The effect of complex training methods and circuit body weight training on increasing leg muscle power and arm muscle strength of basketball athletes and (2) the difference in the influence between complex training methods and circuit body weight training on increasing leg muscle power and arm muscle strength of basketball athletes. This type of research is an experiment with the design of two groups pre-test and post-test. The sample in this study amounted to 70 athletes taken using random sampling techniques. The subjects were divided into 2 groups of athletes, namely the group given the complex training method of as many as 35 athletes and the group of athletes given the circuit bodyweight training method of as many as 35 athletes. The instruments used are to measure leg muscle power, namely the vertical jump test, and to measure hand muscle strength using an expanding dynamometer. The data analysis technique used is an independent sample t-test followed by a paired sample t-test. The results showed that: 1) There was a significant effect of complex training methods and circuit body weight training on increasing leg muscle power and arm muscle strength of basketball athletes with a significance value smaller than 0.05 ($p < 0.05$). 2) There is a significant difference in influence between the groups given the complex training method and circuit body weight training on increasing leg muscle power and arm muscle strength of basketball athletes, it is proven that the average value of leg muscle power in the athlete group given the complex training method is 143.5 kg/sec while the average value of leg muscle power in the circuit body weigh training method group is 120.5 kg/sec with an average difference in post-test 23 kg/sec. Furthermore, the average value of arm muscle strength in the complex training method group was 38.00 kg while the average value of hand muscle strength in the circuit bodyweight training method group was 32.10 kg with an average post-test difference of 5.9 kg. So it can be concluded that the basketball athlete group given the complex training method treatment has better leg muscle power and arm muscle strength compared to the circuit bodyweight training group.
Keywords: complex training, circuit bodyweight training, basketball, leg muscle power, arm muscle strength.

Resumen. Este estudio tiene como objetivo analizar: (1) el efecto de los métodos de entrenamiento complejos y el entrenamiento con peso corporal en circuito en el aumento de la potencia muscular de las piernas y la fuerza muscular de los brazos de los atletas de baloncesto y (2) la diferencia en la influencia entre los métodos de entrenamiento complejos y el entrenamiento con el peso corporal en circuito en el aumento de la potencia muscular de las piernas y la fuerza muscular de los brazos de los atletas de baloncesto. Este tipo de investigación es un experimento con el diseño de dos grupos pre-test y post-test. La muestra de este estudio fue de 70 atletas tomados mediante técnicas de muestreo aleatorio. Los sujetos se dividieron en 2 grupos de atletas, a saber, el grupo al que se le dio el método de entrenamiento complejo de hasta 35 atletas y el grupo de atletas al que se le dio el método de entrenamiento de peso corporal de circuito de hasta 35 atletas. Los instrumentos utilizados son para medir la fuerza muscular de las piernas, es decir, la prueba de salto vertical, y para medir la fuerza muscular de la mano utilizando un dinamómetro expansivo. La técnica de análisis de datos utilizada es una prueba t de muestra independiente seguida de una prueba t de muestra pareada. Los resultados mostraron que: 1) Hubo un efecto significativo de los métodos de entrenamiento complejos y el entrenamiento con peso corporal en circuito en el aumento de la potencia muscular de las piernas y la fuerza muscular de los brazos de los atletas de baloncesto con un valor de significación menor que 0,05 ($p < 0,05$). 2) Existe una diferencia significativa en la influencia entre los grupos dado el método de entrenamiento complejo y el entrenamiento con peso corporal en circuito en el aumento de la potencia muscular de las piernas y la fuerza muscular de los brazos de los atletas de baloncesto, está demostrado que el valor promedio de la potencia muscular de las piernas en el grupo de atletas dado el método de entrenamiento complejo es de 143,5 kg / seg, mientras que el valor promedio de la potencia muscular de las piernas en el grupo del método de entrenamiento de peso corporal del circuito es de 120,5 kg/seg con una diferencia media en el post-test de 23 kg/seg. Además, el valor medio de la fuerza muscular del brazo en el grupo del método de entrenamiento complejo fue de 38,00 kg, mientras que el valor medio de la fuerza muscular de la mano en el grupo del método de entrenamiento con el peso corporal en circuito fue de 32,10 kg con una diferencia media post-test de 5,9 kg. Por lo tanto, se puede concluir que el grupo de atletas de baloncesto dado el tratamiento con el método de entrenamiento complejo tiene una mejor potencia muscular en las piernas y la fuerza muscular en los brazos en comparación con el grupo de entrenamiento con peso corporal en circuito.
Palabras clave: entrenamiento complejo, entrenamiento de peso corporal en circuito, baloncesto, potencia muscular de la pierna, fuerza muscular del brazo.

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Introduction

Physical exercise is a very important aspect for athletes because it is a systematic process to improve physical quality to improve sports performance. Athletes who have good physical qualities will have a great chance to get a champion in a match (Bridge & Ferreira, 2014; Kyslenko et al., 2019). Optimal physical ability is one of the supporting elements in achieving maximum various kinds of sports activities. Sports achievements are inseparable from the elements of the physical component (Lochbaum & Gottardy, 2015; Van Yperen, Blaga, & Postmes, 2014). In basketball, in addition to having good technique, tactics, and mentality, it is also necessary to master a good physical condition in the athlete. Increasing the physical component of athletes aims to make physical abilities excellent and useful to support sports activities to achieve the highest athlete achievement (Arwandi et al., 2023; Bafirman et al., 2023; Putra et al., 2023). Efforts to improve the achievements of basketball players, practice is one of the most decisive factors in achieving achievements. The form of exercise chosen will also be very decisive in achieving the desired training target. Every training process always requires an excellent training program that has both physical and technical skills. Physical exercise that is done precisely, measurably and regularly and with adequate nutritional intake will improve fitness that can be seen or observed with cardiac endurance, flexibility, movement speed, balance, endurance and other components of physical conditions. The main goal of sports is the process of moving in a better direction, including improving physical quality, functional quality of body equipment, and psychological quality (HB et al., 2023; Munir et al., 2024; Wijaya et al., 2024). The main target of exercise is the process towards better, including improving the physical, and functional quality of body equipment and psychic quality. Sports achievements are not permanent, so training requires an adaptation process so that the results are relatively longer, therefore to produce potential champions requires a long training process and time. The duration of exercise processing does not guarantee that it will succeed without the support of the right dose of exercise (Zouhal et al., 2020).

One sport that requires excellent physical condition is basketball. Basketball is a team game that is currently very popular abroad and in Indonesia. This is evident from the various kinds of events or competitions in Indonesia. Understanding basketball itself is a sports game that is carried out in groups consisting of two teams of five people each who compete with each other to score points by putting the ball into the opponent's basket or hoop (Rasulovna, 2022; Sarlis & Tjortjis, 2020). Basketball is liked by various groups ranging from old, young, men and women besides that there are several companies, agencies, governments, educational institutions, and universities enthusiastic about this basketball game.

The basketball game is a game that has the aim of inserting the ball into the basketball target on the floor as high as 305 cm, to be able to return the ball well, it is necessary to do movement techniques well so that it can be work efficiency with regular practice, it can affect the effectiveness of good work as well (Ferioli et al., 2020; O'Grady, Fox, Dalbo, & Scanlan, 2020). The physical components that basketball players must have are agility, strength, endurance, coordination, balance, speed, and explosive power (Mancha & Gonzalez, 2019). While the most dominant physical components used in basketball are leg muscle power and arm muscle strength (Mbada et al., 2020). This is to the results of previous studies that said that there is a contribution of leg muscle power and arm muscle strength to the success of the lay ap technique in the hoop in basketball (Candra, 2018).

The way to earn points is to put the ball in the hoop. Most players have to jump to lay up, jump shoot, or slamdunk. This shows that players must have good jumping skills to produce maximum performance. Jumps in basketball are very necessary because they relate to several techniques in the game such as lay-ups, blocks, jump shoots, slamdunks, and rebounds. Jumps are closely related to explosive power and strength. One things that affect a person's explosive power is the athlete's anaerobic energy system, if the anaerobic energy is high then the jump will also be higher (Aksović, Kocić, Berić, & Bubanj, 2020).

Based on previous literature (Russell, Mclean, Impellizzeri, Strack, & Coutts, 2020) shows that the physical condition of basketball athletes, especially leg muscle power and arm muscle strength is still lacking. This is because the physical exercise program to train leg muscle power and arm muscle strength is not optimal. Other research Er & Erik, (2015) also revealed that the shooting ability of basketball athletes is still relatively low. This is due to the lack of variety and lack of innovative physical training provided so the training carried out is not optimal with the needs of physical components, especially leg muscle power and arm muscle strength in basketball (Bafirman et al., 2023; Munir et al., 2024). To do the perfect shooting, basketball players must have excellent leg muscle power and arm muscle strength. Given the importance of the role of leg muscle power and arm muscle strength for basketball athletes, the leg muscle power and arm muscle strength of athletes need to be improved. The most effective way to increase leg muscle power and arm muscle strength of basketball athletes is to do physical exercise programmatically, varied, innovative, and on target.

But in reality, the power ability of the leg muscles is still not optimal for basketball athletes in Jambi province. Based on observations made by researchers on January 20, 2024, at a basketball club with a basketball coach, it was revealed that the ability of leg muscle power and arm muscle strength of

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basketball athletes is still relatively lacking, because the exercise program to increase leg muscle power and arm muscle strength is still not effective, still not on target, and not yet by the dominant physical abilities trained in basketball. Other factors that affect the low power ability of leg muscles and arm muscle strength of basketball athletes include: 1) The shooting punch is not strong so that it is easily received and returned by the opposing player, 2) The shooting is not strong enough so that it is easy to block the opponent, 3) every time the ball is shot it often does not enter the basketball hoop, and 4) Shooting done by athletes often leaves the field or is not on target.

Researchers obtained the latest data from basketball coaches when the leg muscle power test using vertical jump obtained a jump value as high as 20 cm, the results were included in the less category, and in the arm muscle strength test using an expanding dynamometer obtained an arm muscle strength value of 20kg this was included in the low category. The previous exercise was only more speed and agility training so that leg muscle power and arm muscle strength were neglected. If this continues to be allowed then it will certainly have a bad impact and there will be a decrease in achievement for basketball athletes who want to take part in international championships.

Based on the results of previous literature, there have been several physical exercise methods to increase leg muscle power and arm muscle strength. The previous physical exercise program did more squat jumps, box jumps, push-ups, and pull-ups, but there were no more varied and innovative physical exercise methods. One of the exercises given to maximize leg muscle power and arm muscle strength is by training complex methods and circuit bodyweight training. Complex training is an exercise method that combines a set of strength training with a comparable set of plyometrics exercises in the same training session and is believed to improve the quality of the plyometrics exercise stimulus (Wang, Lv, Qin, Ji, & Dong, 2023). This training method is a dynamic training method with high intensity (Pagaduan & Pojskic, 2020).

This exercise technique takes advantage of post-activation potentiation (PAP) which is defined as a muscular phenomenon that causes an acute increase in muscle power (Pratama, Remaja, Tungkai, & Lengan, 2020). This increase in muscle performance is caused by the muscle being in a potential or active state. In the complex training method, the crucial factor that determines exercise efficiency and results is the exercise intensity factor based on the initial exercise test (Thapa, Lum, Moran, & Ramirez-campillo, 2021).

Another exercise that can increase muscle power and muscle strength is the circuit bodyweight training method. The circuit bodyweight training method is an exercise system that can simultaneously improve the entire body, namely endurance, strength, flexibility, power, muscular endurance, agility, speed, balance, and several other components of physical condition (Yuniana, Nasrulloh, Nurhadi, Sabillah, & Elumalai, 2024). In addition, circuit bodyweight training can also improve cardiovascular because with this exercise the blood supply to the heart is smoother which results in the perfection of the metabolic process in the body. The smooth flow of blood in the body is not only necessary to channel the juice of food and oxygen, but also helps maintain body temperature from excessive heat and cold through a neatly arranged and good process in the body. Circuit bodyweight training is a combination of aerobic and endurance exercises using one's body weight that is done in a short time and can be done anywhere (Paoli et al., 2013; Yadav & Sardar, 2017; Yuniana, Kushartanti, Nasrulloh, & Pratama, 2023). Their initial circuit training series consisted of several stations arranged in circles to train muscle groups alternately from station to station (Romero-arenas, Martí, Alcaraz, & Murcia, 2013). Circuit training is a form of conditioning that combines high-intensity resistance and aerobic training. It is designed to be easy to follow and targets strength building as well as muscle power.

Leg muscle power and arm muscle strength are some of the supporting aspects when shooting in basketball. Leg muscle power and arm muscle strength are a series of physical abilities that support several elements of muscle motion that can support the ability of strength and explosive power to shooting skills in basketball. Leg muscle power and arm muscle strength in basketball shooting skills are very important because when shooting shots are needed leg muscle power when jumping and hand muscle strength when throwing a basketball into the hoop appropriately and optimally (Gastaldi et al., 2018). Explosive power is not only determined by the strength of muscle contractions, but also by the distance and number of muscles that contract every minute. So that a person's ability to use the maximum force deployed in the shortest possible time so that the arm muscles experience a more optimal contraction. Basketball is a sport that requires players to move quickly and continuously, so skills and physical conditions in playing basketball must be high. In performing basic techniques, a basketball player must have good arm muscle strength and endurance. If the strength of a player's arm muscles in a basketball team is not good, then this can be a shortcoming for the team to achieve maximum achievement. The result is an adjustment to a very influential physical ability, namely speed endurance which is followed by power ability, especially arm muscle strength. Muscle strength increases as muscle volume increases. This very dizzying muscle volume is important in training to increase muscle strength and use muscles according to their needs.

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Methods and Materials

Research Design

This research uses a type of quasi-experimental research with a pre-test design and a post-test two-group design. This experimental research used 2 different groups, namely the group of athletes who were given complex training methods and the group of athletes who were given circuit bodyweight training. The following is an overview of the research design in the table below.

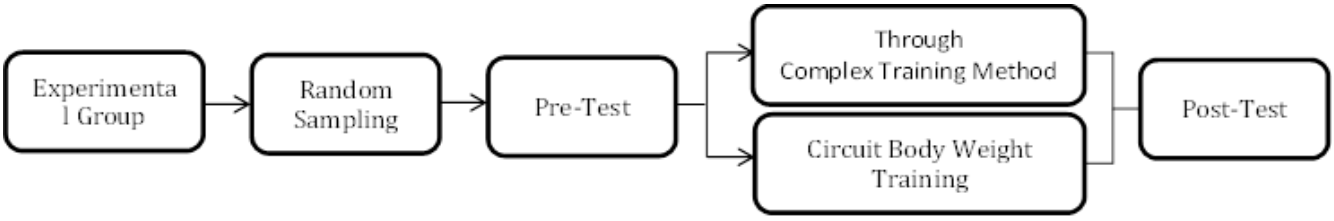

Figure 1. Research design

Research Participants

The population in this study was all basketball athletes in Jambi Province amounting to 120 people. The sample in this study amounted to 70 basketball athletes taken using random sampling techniques. The subjects were divided into 2 groups, namely the group of athletes who were given complex training methods as many as 35 athletes, and the group of basketball athletes who were given circuit bodyweight training as many as 35 athletes. This research has received approval from all samples who have filled out a statement of ability to become a research sample and have met the requirements of the research code of ethics.

Research Procedure

Data collection techniques in this study are tests and measurements. The instrument used to measure leg muscle power is the vertical jump, and the instrument used to measure arm muscle strength is the expanding dynamometer. After that, treatment or exercise is given as much as 16 meetings with a frequency of 3 times a week. And ended with taking the final test value or post-test to measure leg muscle power and arm strength after treatment.

Data Analysis

The data analysis technique used in this study used SPSS version 22, namely by conducting an independent sample t-test and continuing with a paired sample t-test. Previously, prerequisite tests were carried out for normality and homogeneity tests.

Results and Discussion

Results

Normality Test

A normality test is performed to test whether the data has a normally distributed distribution or not. The calculation of data normality is carried out using the Kolmogorov-Smirnov test. The results of the normality test are shown in the table below.

Group Complex Training Method

Based on a statistical analysis of normality tests that have been carried out using the Kolmogorov Smirnov test, the pretest and post-test data on leg muscle power and arm muscle strength of the complex training athlete group were obtained from the results of the normality test data of $p > 0.05$ significance value, which means that the data is normally distributed, it can be concluded that all pre-test and post-test data in the complex training athlete group are declared normal.

Table 2.
Normality test results of pre-test and post-test data of athlete groups Training Complex Training Method

Data	Significance	*P*	Information
Pre-test leg muscle power	0,05	0,716	Usual
Post-test leg muscle power	0,05	0,838	Usual
Pre-test arm muscle strength	0,05	0,728	Usual
Post-arm muscle strength test	0,05	0,846	Usual

Circuit Body Weigh Training Training Group

Based on the statistical analysis of normality tests that have been carried out using the Kolmogorov Smirnov test, the pretest and post-test data of the circuit body weigh training group were obtained from the results of the normality test of $p > 0.05$ significance value data, which means that the data is normally distributed, it can be concluded that all pre-test and post-test data in the circuit body weigh training group is declared normal.

Table 3.
Normality test results of pre-test data circuit bodyweight training

Data	Significance	*P*	Information
Pre-test leg muscle power	0,05	0,529	Usual
Post-test leg muscle power	0,05	0,628	Usual
Pre-test arm muscle strength	0,05	0,589	Usual
Post-arm muscle strength test	0,05	0,656	Usual

Homogeneity Test

The homogeneity test is used to test the similarity of variance between the compared data. The results of the

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homogeneity test of pre-test and post-test data between the complex training method exercise group and the circuit body weight training exercise group in this study are as follows.

Table 4.
Test results of homogeneity of pre-test and post-test data

Data	Group	F Count	*P*	Keterangan
Pre-test leg muscle power	Complex Training Method Exercises	3,779	0,076	Homogeneous
	Circuit Bodyweight Training			
Post-test leg muscle power	Complex Training Method Exercises	3,636	0,088	Homogeneous
	Circuit Bodyweight Training			
Pre-test arm muscle strength	Complex Training Method Exercises	3,638	0,078	Homogeneous
	Circuit Bodyweight Training	3,772	0,082	Homogeneous
Post-arm muscle strength test	Complex Training Method Exercises	3,778	0,084	Homogeneous
	Circuit Bodyweight Training	3,648	0,086	Homogeneous

Results of homogeneity test to test the similarity of variance of pre-test post-test data between the complex training method exercise group and the circuit body weight training exercise group. Since the significance value is greater than 0.05 (p>0.05), it can be stated that the pre-test and post-test data between the complex training method training group and the circuit bodyweight training training group are homogeneous.

Test Effectiveness

Independent Sample t-Test Results

a) Pre Test

The results of the independent sample t-test on the pre-test data compared the complex training method exercise group with the circuit body weight training exercise group are as follows.

Table 5.
Results of Independent Sample T-test Data Pre-Test

Data	Group	*Mean*	t Count	*p*	Information
Power leg muscles	Complex Training	115,5	6,542	0,571	Significant
	Circuit Body Weight Training	113,5			
Arm muscle strength	Complex Training	30,00	6,430	0,585	Significant
	Circuit Body Weight Training	29,00			

Based on the results of the Independent Sample t-test data analysis of leg muscle power, a calculated t value of 0.542 was obtained with a p significance value of 0.571, and in arm muscle strength, a calculated t value of 0.542 was obtained with a p significance value of 0.585. Because the significance value of p is greater than 0.05 (p>0.05), it can be concluded that there is no significant difference in leg muscle power between the complex training group and the circuit body weight training exercise group at the time of the pre-test. This means that both groups had the same leg muscle power and arm muscle strength before treatment.

Based on the results of the analysis, the average value of leg muscle power in the complex training group was 115.5 kg/sec while the average value of leg muscle power in the circuit bodyweight training group was 113.5 kg/sec. This means that the group of athletes given complex training has a better average leg muscle power compared to the circuit bodyweight training group.

b) Post Test

The results of the independent sample t-test on the post-test data compared between the complex training exercise group and the circuit body weight training exercise group are as follows.

Table 6.
Hasil Independent Sample T-test Data Post-Test

Data	Group	Mean	t Count	p	Information
limb muscle power	Complex Training	143,5	7,782	0,000	Significant
	Circuit Body Weight Training	120,5			
Arm muscle strength	Complex Training	38,00	7,683	0,000	Significant
	Circuit Body Weight Training	32,10			

Based on the results of the Independent Sample t-test analysis, the data on leg muscle power obtained a calculated t value of 7.782 with a significance value of 0.000, while arm muscle strength obtained a calculated t value of 7.683 with a significance value of 0.000. Because the significance value is smaller than 0.05 (p < 0.05), it can be concluded that there is a significant difference in leg muscle power and arm muscle strength between the complex training group and the circuit bodyweight training group.

This means that the group of athletes given complex training has better leg muscle power and arm muscle strength compared to the circuit bodyweight training group.

Paired Sample t-Test Results

a) Complex training exercise groups

Table 7.
Results of Paired Sample T Test complex training exercise group

Data	Group	*Mean*	t Count	*P*	Information
limb muscle power	Pre-test	115,5	7,785	0,000	Significant
	Post-test	143,5			
arm muscle strength	Pre-test	30,00	7,667	0,000	Significant
	Post-test	38,00			

Based on the results of the Paired Sample t-test analysis, the limb muscle power data obtained a calculated t value of

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7.785 with a significance value of 0.000, and in the arm muscle strength data, a calculated t value of 7.667 was obtained with a significance value of 0.000. Because the significance value is smaller than 0.05 ($p < 0.05$), it can be concluded that there is a significant difference in leg muscle power and arm muscle strength during the pre-test and post-test in the complex training exercise group. This means that there is a significant increase in leg muscle power and arm muscle strength before and after treatment.

b) Circuit body weight training exercise group

Table 8.
Results of Paired Sample T Test Group Exercise circuit bodyweight training

Data	Group	*Mean*	t Count	*P*	Information
limb muscle power	Pre-test	113,5	7,769	0,045	Significant
	Post-test	120,5			
arm muscle strength	Pre-test	29,00	7,739	0,002	Significant
	Post-test	32,10			

Based on the results of the Paired Sample t-test analysis, the limb muscle power data obtained a calculated t value of 7.769 with a significance value of 0.045, and in the arm muscle strength data, a calculated t value of 7.739 was obtained with a significance value of 0.002. Because the significance value is smaller than 0.05 ($p < 0.05$), it can be concluded that there is a significant difference in leg muscle power and arm muscle strength during the pre-test and post-test in the circuit body weight training exercise group. This means that there is a significant increase in leg muscle power and arm muscle strength before and after treatment.

Discussion

The discussion of the results of this study provides a further interpretation of the results of the data analysis that has been presented. The discussion of the results of the analysis can be further described as follows.

The effect of complex training and circuit bodyweight training on increasing leg muscle power and arm muscle strength of basketball athletes

Based on hypothesis testing, it is known that there are complex training exercises and circuit body weight training to increase leg muscle power and arm muscle strength of basketball athletes. Complex training is an effective training method to increase physical variables, one of which is leg muscle power and arm muscle strength. These findings are in line with several previous studies (Vretaros, 2021) They revealed that they found complex training exercises can improve the ability of muscle power components and muscle strength with a large enough number of samples. These findings are consistent with some previous evidence (Tomás T Freitas et al., 2018) Explained that complex training for 16 sessions with a frequency of 3 times a week is an effective method to increase the power and muscle strength of athletes. The complex training method is weight training followed by pliometric exercises that are mechanically similar to weight training (Michaloglou et al., 2018). The complex training method can be used for both the upper and lower body. The two elements contained in complex training have their respective roles in developing the athletic abilities of athletes. Further recent discoveries support the hypothesis that complex training exercises can improve the physical condition of the limbs (Wang et al., 2023). This is because plyometric elements cause rapidly acting muscle contractions that increase the speed of stretching and the resulting force (Falces et al., 2021). While the weight training element is used to increase strength production at the end of a range of motion. The weights used in this study were barbells, body weights, and medice balls. Several factors may have contributed to the increase that occurred in this study, namely the increasing muscle power due to exercise and the increasing level of muscle coordination.

Furthermore, in circuit bodyweight training, they found that high-intensity circuit training can increase muscle power and muscle strength in a fairly fit population. These findings are consistent with some previous evidence explaining that 5 weeks of circuit weight training is an effective method for developing physical fitness variables such as hand strength, foot explosive power, and muscular endurance. The increase in hand strength and muscle power may be due to the intensity of training, the circuit load, and the speed of movement and explosive power. This is supported by research Romero-arenas et al., (2013) which states that circuit training is very effective and can be applied to improve strength and functional fitness. Circuit training is an excellent way to improve mobility, strength, and stamina. Circuit training Consists of 6 to 8 strength and explosive power exercises completed one after another exercise. Each exercise is performed for a specific number of reps or for a set amount of time before moving on to the next exercise. Training within each circuit is separated by short rest periods, and each circuit is separated by longer rest periods. The total number of circuits performed during a training session can vary from two to six depending on our training level (beginner, intermediate, or advanced), our training period (preparation or competition), and the purpose of the training.

In basketball, leg muscle power, and arm muscle strength are very important physical components to support performance when competing for basketball athletes. Having good muscle power and muscle strength allows an athlete to move quickly and strongly, and can jump so that he performs shooting techniques precisely into the ring. So, to perform attacking and defensive techniques, leg muscle power and arm muscle strength are needed. Thus, the success of a skill in the game of basketball requires good leg

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muscle power and hand muscle strength.

The difference in the effect of complex training and circuit bodyweight training on increasing leg muscle power and arm muscle strength of basketball athletes

The results of the analysis showed that there was a significant difference in the effect between the complex training group and circuit body weight training on increasing leg muscle power and arm muscle strength of basketball athletes. The group of athletes who were given complex training treatment was better than the circuit bodyweight training group to increase the muscle power of the limbs of basketball athletes. Complex training is a very good training compared to circuit bodyweight training to increase leg muscle power and arm muscle strength.

The complex training method can be used for both the upper and lower body. The two elements contained in complex training have their respective roles in developing the athletic ability of athletes. Strength training before plyometrics exercise leads to an increase in synaptic excitation in the spinal cord, which in turn results in an increase in postsynaptic potential and subsequently an increase in the strength-generating capacity of the muscle groups involved (Booth & Orr, 2016).

This statement is reinforced by the results of research (Przewłócka, Folwarski, Kaźmierczak-Siedlecka, Skonieczna-żydecka, & Kaczor, 2020) which states that the increase in muscle strength is due to the increase in the number of contractile proteins, actin filaments, and myosin and increases the strength of connective tissue and ligaments. Some previous research results that support that complex training can increase muscle power of the body include, the results of research conducted by Tomas T Freitas et al., (2017) who found that complex training has the potential to increase lower body strength. Further in the findings Talpey et al., (2016) showed that the complex training group had a significantly greater improvement than the conventional exercise group. While the speed did not experience a significant increase. The findings (Çankaya et al., 2018) Show that complex training can increase the strength and power of male athletes.

In basketball, these two different motion systems have an important influence in supporting strength to improve both, the system can train both simultaneously to produce explosive power and good muscle strength. This is in line with research (Nasrulloh, Prasetyo, & Apriyanto, 2018) which states that in principle a good and appropriate exercise program will be able to improve physical skills.

According to Sabillah et al., (2022) It is posited that plyometric elements cause rapidly acting muscle contractions that increase the speed of stretching and the strength of the resulting muscles. While the weight training element is used to increase strength production at the end of a range of motion. Several factors may contribute to the increase that occurred in this study the increasing muscle power due to exercise and increasing levels of muscle coordination. Furthermore, the implication of this study is for coaches to apply complex training to basketball athletes to improve and improve the quality of leg muscle power and arm muscle strength.

Conclusion

Based on the results of data analysis using the Independent Sample t-test and continued with the Paired Sample t-test, conclusions can be drawn in this study: a) there is a significant increase between complex training and circuit bodyweight training to increase leg muscle power and hand muscle strength before and after treatment, b) the group of athletes given complex training treatment has leg muscle power and Hand muscle strength was better compared to the group of basketball athletes who were given circuit bodyweight training.

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Conflicts of Interest

We as authors affirm that there is no conflict of interest in this publication and that the manuscript has been approved and submitted by all the authors mentioned above.

References

Aksović, N., Kocić, M., Berić, D., & Bubanj, S. (2020). Explosive power in basketball players. *Facta Universitatis, Series: Physical Education and Sport*, (1), 119–134.

Arwandi, J., Bais, S., Padli, Zarya, F., Haryanto, J., Putra, T. I., … Soniawan, V. (2023). The effects of training using an android-based media blocker tool on the West Sumatra pelatprov sepaktakraw smash in 2023. *Journal of Physical Education and Sport*, *23*(12), 3391–3399. https://doi.org/10.7752/jpes.2023.12389

Bafirman, Munir, A., Zarya, F., & Nia, T. A. (2023). Comparison of Learning Methods Based on Animals Name and Conventional Learning to Improve Free Throw Shooting Skills in Basketball Games. *International Journal of Human Movement and Sports Sciences*, *11*(5), 1150–1157.

© Copyright: Federación Española de Asociaciones de Docentes de Educación Física (FEADEF) ISSN: Edición impresa: 1579-1726. Edición Web: 1988-2041 (https://recyt.fecyt.es/index.php/retos/index)

https://doi.org/10.13189/saj.2023.110524

Bafirman, Zarya, F., Wahyuri, A. S., Ihsan, N., & Batubara, R. (2023). Improving the martial art skills and physical fitness quality of students grade VII through e-module development. *Journal of Physical Education and Sport*, *23*(12), 3271–3281. https://doi.org/10.7752/jpes.2023.12374

Booth, M. A., & Orr, R. (2016). Effects of Plyometric Training on Sports Performance. *Strength & Conditioning Journal*, *38*(1).

Bridge, C. A., & Ferreira, J. (2014). Physical and Physiological Profiles of Taekwondo Athletes Physical and Physiological Profiles of Taekwondo Athletes. *Sports Medicine*, (February). https://doi.org/10.1007/s40279-014-0159-9

Candra, O. (2018). Contribution of Leg Muscle Explosive Power and Flexibility on Lay-Up Shoot in Basketball. *2nd Yogyakarta International Seminar on Health, Physical Education, and Sport Science (YISHPESS 2018) and 1st Conference on Interdisciplinary Approach in Sports (CoIS 2018)*, 479–482. Atlantis Press.

Çankaya, C., Arabacı, R., Kurt, E., Doğan, S., Erol, S., Gürak, A. N., & Korkmaz, F. (2018). Examining the effects of the pliometric (jump squat) exercise on vertical jump in female volleyball players. *European Journal of Physical Education and Sport Science*. https://doi.org/10.5281/zenodo.1997613

Er, F., & Erik, Š. (2015). Basketball Shot Types and Shot Success in Different Levels of Competitive Basketball. *PloS One*, 1–14. https://doi.org/10.1371/journal.pone.0128885

Falces, M., Raya, J., Sáez, E., Rodicio, J., Iglesias, F., & Gonzalez, F. (2021). Effects of combined plyometric and sled training on vertical jump and linearspeed performance in young soccer players. *Retos*, *2041*, 42.

Ferioli, D., Schelling, X., Bosio, A., La Torre, A., Rucco, D., & Rampinini, E. (2020). Match activities in basketball games: comparison between different competitive levels. *The Journal of Strength & Conditioning Research*, *34*(1), 172–182. https://doi.org/10.1519/JSC.0000000000003039

Freitas, Tomás T, Calleja-González, J., Carlos-vivas, J., Marín-, E., Alcaraz, P. E., Freitas, T. T., … Marín-cascales, E. (2018). Short-term optimal load training vs a modified complex training in semi-professional basketball players. *Motriz: Revista de Educação Física*, *0414*. https://doi.org/10.1080/02640414.2018.1504618

Freitas, Tomas T, Martinez-Rodriguez, A., Calleja-Gonzalez, J., & Alcaraz, P. E. (2017). Short-term adaptations following complex training in team-sports: A meta-analysis. *PloS One*, *12*(6), e0180223. https://doi.org/doi.org/10.1371/journal.pone.0180223

Gastaldi, A. C., Sousa, N. T. A. De, Guirro, R. R. J., Ribeiro, V. B., Philbois, S. V, & Souza, H. C. D. (2018). Do muscular strength and jump power tests reflect the effectiveness of training programs for basketball athletes ? *Motriz: Revista de Educação Física*, (4), 1–8.

HB, B., Wahyuri, A. S., Zarya, F., Sabillah, M. I., & Annasai, F. (2023). Revitalizing student physical fitness: The vital role of post?pandemic physical activity programs. *Fizjoterapia Polska / Polish Journal of Physiotherapy*, *23*(4), 226–232. https://doi.org/10.56984/8ZG20A4D3

Kyslenko, D., Bondarenko, V., Plisko, V., Bosenko, A., Danylchenko, V., Kuzmichova-Kyslenko, Y., … Donets, I. (2019). Dynamics of security specialists' physical condition during professional training. *Journal of Physical Education and Sport*, *19*(2), 1099–1103. https://doi.org/10.7752/jpes.2019.02159

Lochbaum, M., & Gottardy, J. (2015). A meta-analytic review of the approach-avoidance achievement goals and performance relationships in the sport psychology literature. *Journal of Sport and Health Science*, *4*(2), 164–173. https://doi.org/10.1016/j.jshs.2013.12.004

Mancha, D., & Gonzalez, J. C. (2019). Physical fitness in basketball players: A systematic review. *J. Sports Med. Phys. Fit*, (October). https://doi.org/10.23736/S0022-4707.19.09180-1

Mbada, C. E., Quadri, S. A., Oghumu, S. N., Oke, K., Fasuyi, F., & Oyewole, A. I. (2020). Hand grip strength , leg explosive power and vertical jump performance among Nigerian university male basketball players and healthy controls. *Sports Medicine Journal/Medicina Sportiva*, *XVI*(1), 3156–3162.

Michaloglou, K., Avloniti, A., Leontsini, D., Deli, C. K., Vlachopoulos, D., Gracia-marco, L., … Kingdom, U. (2018). The effect of training circuit training on the vo2max ability of East Lombok degree fighting porprov athletes. *Journal Health Sport Rehabilitation*.

Munir, A., Sumaryanti, Rismayanthi, C., Nasrulloh, A., Padli, Prayoga, A. S., … Rahman, D. (2024). The effect of animal name and wall shoot training on the accuracy of shooting free throw in terms of hand eye coordination in beginner athletes. *Retos*, *56*, 538–545. https://doi.org/10.47197/retos.v56.104895

Munir, A., Sumaryanti, S., Rismayanthi, C., Bafirman, B., Nia, thesya alda, & Zarya, F. (2024). Reviving ancestral heritage: games traditional sports as key to improve innovative child endurance. *Fizjoterapia Polska*, *1*(1), 126–130. https://doi.org/doi.org/10.56984/8ZG2EF8Sbq

Nasrulloh, A., Prasetyo, Y., & Apriyanto, K. D. (2018). Dasar-dasar latihan beban. *Yogyakarta: UNY Pres*.

O'Grady, C. J., Fox, J. L., Dalbo, V. J., & Scanlan, A. T. (2020). A systematic review of the external and internal workloads experienced during games-based drills in basketball players. *International Journal of Sports Physiology and Performance*, *15*(5), 603–616. https://doi.org/10.1123/ijspp.2019-0785

Pagaduan, J., & Pojskic, H. (2020). A meta-analysis on the effect of complex training on vertical jump performance. *Journal of Human Kinetics*, *71*(1), 255–265.

Paoli, A., Pacelli, Q. F., Moro, T., Marcolin, G., Neri, M., Battaglia, G., … Bianco, A. (2013). Effects of high-intensity circuit training , low-intensity circuit training and endurance training on blood pressure and lipoproteins in middle-aged overweight men. *Lipids in Health and Disease*, 1–8. https://doi.org/10.1186/1476-511X-12-131

Pratama, R., Remaja, B. V., Tungkai, O., & Lengan, O. (2020). Pengaruh Latihan Sirkuit (Circuit Training) Terhadapvolume Oksigen Maksimal (VO2MAX) Pemain Sekolah Sepak Bola (SSB). *Jurnal Sport Area*, *5*, 146–154.

Przewłócka, K., Folwarski, M., Kaźmierczak-Siedlecka, K., Skonieczna-Żydecka, K., & Kaczor, J. J. (2020). Gut-Muscle Axis Exists and May Affect Skeletal Muscle. *Nutrients*, *12*(5), 1–19.

© Copyright: Federación Española de Asociaciones de Docentes de Educación Física (FEADEF) ISSN: Edición impresa: 1579-1726. Edición Web: 1988-2041 (https://recyt.fecyt.es/index.php/retos/index)

Putra, A. N., Zarya, F., Bahtra, R., & Sepriadi. (2023). The Development of a differentiation-based learning model in football school students. *Journal of Physical Education and Sport*, *23*(12), 3282–3291. https://doi.org/10.7752/jpes.2023.12375

Rasulovna, S. N. (2022). The Mechanism of Improving the Primary Training Methods of Basketball Sports, Training Skilled Basketball Players. *Web of Scientist: International Scientific Research Journal*, *3*(02), 1085–1091. https://doi.org/10.17605/OSF.IO/YMRTH

Romero-arenas, S., Martí, M., Alcaraz, P. E., & Murcia, A. De. (2013). Impact of Resistance Circuit Training on Neuromuscular , Cardiorespiratory and Body Composition Adaptations in the Elderly. *Aging and Disease*, *4*(5), 256–263.

Russell, J. L., Mclean, B. D., Impellizzeri, F. M., Strack, D. S., & Coutts, A. J. (2020). Measuring Physical Demands in Basketball : An Explorative Systematic Review of Practices. In *Sports Medicine*. Springer International Publishing. https://doi.org/10.1007/s40279-020-01375-9

Sabillah, M. I., Tomoliyus, Nasrulloh, A., & Yuniana, R. (2022). The effect of plyometric exercise and leg muscle strength on the power limb of wrestling athletes. *Journal of Physical Education and Sport*, *22*(6), 1403–1411. https://doi.org/10.7752/jpes.2022.06176

Sarlis, V., & Tjortjis, C. (2020). Sports analytics—Evaluation of basketball players and team performance. *Information Systems*, *93*, 101562. https://doi.org/10.1016/j.is.2020.101562

Talpey, S. W., Young, W. B., & Saunders, N. (2016). Is nine weeks of complex training effective for improving lower body strength, explosive muscle function, sprint and jumping performance? *International Journal of Sports Science and Coaching*, *11*(5), 736–745. https://doi.org/10.1177/1747954116667112

Thapa, R. K., Lum, D., Moran, J., & Ramirez-campillo, R. (2021). Effects of Complex Training on Sprint , Jump , and Change of Direction Ability of Soccer Players : A Systematic Review and. *Frontiers in Psychology*, *11*(January), 1–15. https://doi.org/10.3389/fpsyg.2020.627869

Van Yperen, N. W., Blaga, M., & Postmes, T. (2014). A meta-analysis of self-reported achievement goals and nonself-report performance across three achievement domains (work, sports, and education). *PloS One*, *9*(4), e93594. https://doi.org/10.1371/journal.pone.0093594

Vretaros, A. (2021). Methodological Considerations in the Use of Complex Training in Basketball Players. *Italian Journal of Sport Rehabilitation*, *8*, 70–88.

Wang, X., Lv, C., Qin, X., Ji, S., & Dong, D. (2023). Effectiveness of plyometric training vs. complex training on the explosive power of lower limbs: A Systematic review. *Frontiers in Physiology*, *13*(January), 1–15. https://doi.org/10.3389/fphys.2022.1061110

Wijaya, ridho gata, Fitri, ebtana sella mayang, Nugraha, pratama dharmika, Sepriyanto, A., & Zarya, F. (2024). Improving the performance of karate athletes: fartlek and circuit training in the increasing VO2max. *Fizjoterapia Polska*, *2024*(1), 98–104. https://doi.org/doi.org/10.56984/8ZG2EF824g

Yadav, M., & Sardar, S. (2017). Effect of Circuit Weight Training on Physical Fitness Variables Of Gorakhpur University Football Players. *International Journal of Physical Education and Sports*, *125*, 25–29.

Yuniana, R., Kushartanti, B. M. W., Nasrulloh, A., & Pratama, K. W. (2023). The Effectiveness of the Weight Training Method and Rest Interval on VO 2 max , Flexibility , Muscle Strength , Muscular Endurance , and Fat Percentage in Students. *Journal of Human Movement and Sports Sciences*, (February). https://doi.org/10.13189/saj.2023.110125

Yuniana, R., Nasrulloh, A., Nurhadi, F. I., Sabillah, M. I., & Elumalai, G. (2024). The Effectiveness Of The Circuit Bodyweight Training Method In Improving Cardiovascular Endurance. *Retos*, *2041*, 1220–1225. https://doi.org/10.47197/retos.v51.100430

Zouhal, H., Ben Abderrahman, A., Khodamoradi, A., Saeidi, A., Jayavel, A., Hackney, A. C., … Jabbour, G. (2020). Effects of physical training on anthropometrics, physical and physiological capacities in individuals with obesity: A systematic review. *Obesity Reviews*, *21*(9). https://doi.org/10.1111/obr.13039

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