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The Effect of Circuit and Strength Training on the Leg Power in Female Basketball Athletes

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Abstract The objective of this research was to determine the effect of the types of exercise training (free weight vs. resistance band) and athletes' initial leg power levels (high vs. low) and the interaction between the types of exercises and athletes' initial power levels on the leg strength. The study was an experimental study with a two-by-two factorial design involving 20 female basketball athletes. Leg muscle strength was measured with a leg and back dynamometer, and leg power was measured with a vertical jump. Two-way ANOVA was used in the data analysis technique, followed by simple effect analyses using Tukey HSD when the interaction effect was significant. The findings indicated significant main effects of exercise types and power levels. However, the main effects were superseded by a statistically significant interaction effect between exercise types and power levels (F(16, 1) = [16.133], p = [0.001). Resistance training outperformed free-weight training in improving leg strength among athletes with high leg power levels. In contrast, free-weight training was better than resistance training in improving leg strength among athletes with low leg power levels. The exercise training for improving leg strength, therefore, should consider initial power levels.

Keywords Circuit, Free Weight, Resistance Band, Power, Strength

1. Introduction

Basketball is a team sport with a variety of fundamental playing techniques, such as shooting, dribbling, defending, and pivoting. All techniques in playing basketball must be practiced repeatedly in a scenario such as game-based conditioning, general conditioning, offensive and defensive skills in a match [1], [2]. A basketball player must excel in physical conditions such as agility, strength, endurance, coordination, balance, speed, and muscle explosive power, because these components greatly influence every technique in playing basketball [3]. Physical structure, physiological capacity, psychological, biomotor characteristics (speed, endurance, mobility-flexibility, coordination), technical structure, tactical understanding, and team discipline are some of the fundamental aspects of playing basketball [4].

A basketball player is required to do layups and jump shots, so it is mandatory for basketball players to have good jumping skills to do this task well. The jump in basketball is very important because it relates to several game techniques, such as layups, blocks, jump shoots and rebounds. The jump is related to the strength and power of the leg muscles [5]. The leg power component has a significant effect on the quality of the jumping movement in basketball, because the higher the jump produced by a basketball player, the closer to the hoop and the easier it is to put the ball in a lay up [6]. The explosive power of the leg muscles and the balance of a basketball athlete are needed to produce a good and accurate jump shot. The

jump shoot technique makes it easy to get points, and the jump shoot arena is one of the attacks to increase the team's points towards victory [7]. In essence, the explosive power factor of the leg muscles has a very large influence and plays a very important role when a basketball athlete is going to make a shooting movement along with a jumping movement [8].

Strength and speed are the primary components in power formation; the greater a person's strength and speed, the greater the power produced [9]. Explosive power is the ability to direct force quickly and in a short time to provide the best momentum for a body or object in a complete explosive motion to achieve the desired goal [10]. Because explosive power is the result of muscle strength and speed, both of them play a role in increasing muscle strength and as an absolute and fundamental prerequisite for increasing the explosive power of a basketball player [11]. The explosive power of the muscles generated by leg muscle power influences the transfer of horizontal to vertical momentum. Because the repulsion movement must be carried out by directing the explosive power of the muscles, the thrust caused by the change in momentum will have an effect on this [12]. Power is calculated to be seen as the product of force and speed, as well as the actual position with the integration of speed that will be produced by a basketball player [13].

While power is a by-product of strength and speed, isokinetic leg strength is especially important among elite basketball athletes, because the ability of a muscle to contract to produce tension against resistance is referred to as strength [14]. Muscle strength is directly proportional to the volume/size of the muscles; the greater the volume of the muscle, the stronger the contraction produced to perform a movement, and the resulting movement is the result of activation of the motor unit in the muscle. The motor unit consists of a single motor neuron that innervates all the muscle fibers. The number of muscle fibers per motor unit and motor units per muscle differ [15]. The leg strength of 43 elite basketball players and suggested normative isokinetic leg strength data can be useful for coaches to evaluate strength training focused on the muscle strength of athletes [16]. Therefore, the exploration of women's basketball athletes is needed.

Weight training is a systematic exercise that uses weight to increase muscle strength. The training can incorporate one's own body weight (internal weight) or include training aids (external weight). The training can be designed as circuit training [17]. The circuit method allows the athlete's condition to be maximally formed by combining elements and other sports aspects [18]. The circuit training can incorporate external weight utilizing free weight or resistance bands. Free weight requires balance and coordination, which are also important in competition. Using free weight, various exercises with large muscle mass can increase energy expenditure and be used for ballistics and explosive exercises [19]. Resistance band training is also a popular exercise method for developing muscle fitness [20]. Resistance training is an exercise program that causes muscles to contract against external loads to increase endurance, strength, and muscle mass, whereas resistance band exercises increase an individual's strength and power [21].

Explosive power is a muscle ability possessed by a human who uses maximum strength in a very short time when carrying out various activities including activities in basketball [22]. Explosive power is a factor that is very much needed in various sports where fast and strong muscle contractions are predominant, these two elements influence each other. So that a quality activity depends on the explosive power and strength possessed by the individual. The explosive power possessed by an individual is influenced by the level of testosterone in the body as well as the various types of training programs arranged by trainers that will improve the quality of muscle explosive power [23]. In simple terms, explosive power is defined as one of the components needed by a basketball athlete, in carrying out various movements contained in the sport, and it should be noted that explosive power cannot be separated from the muscle strength of an individual.

Muscle explosive power is a combination of strength and speed or maximal muscle exertion that involves the strength and speed of dynamic and explosive muscle contractions, and expends muscle strength or the ability of the muscles to contract with optimal and maximum strength in the shortest possible time [24]. So the authors draw the conclusion that strong muscles have great explosive power, and almost certainly have great strength values. Explosive power is the ability to work muscles (effort) in units of time (seconds). This power is the result of multiplying work (effort) by speed, so the unit for power is kg (kilogram) x meters/second. Meanwhile, kg x meter is a unit of effort, thus power can be interpreted as effort per second.

Strength is an ability of the human physical condition that is needed in increasing the learning achievement of motion [25]. Strength is a very important element of physical condition that must be owned by an individual in carrying out various sports activities, because muscle strength can help improve other muscle components such as speed, agility and accuracy. Strength is defined as energy used to change the state of motion or shape of an object and can define specifically that strength as energy to resist resistance or the ability to generate tension [26]. There are three types of contractions in human muscles namely; static, concentric and eccentric. Thus it can be concluded that strength is closely related to the process of muscle contraction and the ability to exert maximum power in one attempt [27].

Weight training increases muscle hypertrophy and muscle strength [28]. A basketball athlete needs at least ten sets per week to maximize the quality of muscle mass. Because each set per week, a trainer expects an increase in muscle mass of 0.36 percent, in the sense that athletes should not have muscle mass below 0.36 percent during

training. A six-week strength training program (STP) using elastic bands effectively increases muscle strength and ball speed in young female handball players [29]. Elastic band resistance training significantly benefits muscle mass, quality, and physical function in obese older women [30]. Muscle quality, physical capacity, and physical function outcomes yielded similar results. As power is closely associated with strength, it is still unknown whether the responses of female athletes to leg strength resulting from these different exercise training are dependent upon the initial leg power. Therefore, this study aimed to investigate the effect of the strength training modality types (free weight vs. resistance band) and the initial level of leg power (high vs. low) on the leg strengths among female basketball athletes.

2. Method

2.1. Study Design and Participants

A 2 x 2 factorial design was used in this type of research. The first factor was exercise types (i.e, free weight vs. resistance bands exercises, while the second factor was the leg power levels (i.e., high vs. low leg power). The inclusion criteria were active in training, were not injured, and agreed to participate in the exercise training. There were 38 athletes meeting these criteria. We selected 10 participants with the highest 27% level of leg strength (n=10) and 27% lowest level of leg strength (n=10). The participants were then divided into two exercise groups using ordinal pairing.

2.2. Exercise Training

The circuit free weight training involved performing Dumbell Squats, Sumo Squat Dumbbells, Bulgarian Dumbbells, Dumbbell Step-ups, Reverse Lunge Dumbbells, Lateral Lunge Dumbbells, Calf Raise Dumbbells, and Deadlift Dumbbells with 10-25 repetitions, 50% intensity - 70% 1RM, sets of 2-4, 30-second rest between posts, and 2-minute rest between sets. While the circuit resistance band exercise was a movement that starts from a standing position, then squats and returns to a standing position using a resistance band with the same elasticity as before. Treat through models of Squat Resistance Bands, Sumo Squat Resistance Bands, Bulgarian Resistance Bands, One Leg Resistance Bands, Lunge Resistance Bands, Lateral Walk Bands and Calf Raise, Repetition with an intensity of 50% - 70%. Repetitions are performed by basketball athletes in 2-4 sets, then rest for 30 seconds between repetitions, and rest 2 minutes between sets. The exercise program was conducted within 18 seasons.

2.3. Outcomes and Measures

Leg strengths were the primary outcomes of the exercise training. The leg strength test instrument used in this study was a leg and back dynamometer, which aimed to measure the static strength of the leg muscles. The initial leg power was measured using a vertical jump test, which aimed to measure the explosive power component of the leg muscles vertically. The leg power was measured in the initial program, while leg strength was measured before and after the exercise training.

2.4. Statistical Analysis

A two-way ANOVA test was conducted to assess the main effect of the exercise training and the initial leg power levels and the interaction effect between these two on the leg strengths after the exercise training. All of the normality tests for assessing the two-way ANOVA assumption were performed using the Shapiro-Wilk technique, while the homogeneity test was performed using the F test. When an interaction was demonstrated in a two-way ANOVA test, a further simple effect analysis using the Tukey HSD test was performed. All analyses were conducted using the SPSS version 20.0 software program for Windows with a significance level of 5% or 0.05.

3. Result

The normality and homogeneity analyses support the two-way ANOVA assumptions. Table 1 indicates the pretest and post-test data of the leg strengths, while Table 2 summarizes the main and interaction effects resulting from the Two-way Anova Analyses.

Table 1. The pretest and post-test data of the leg strengths

	Pre test	Post test
Free weights high power	45.6	47.0
Free weights low power	37.4	39.2
Resistance high power	45.6	48.8
Resistance low power	37.0	38.4

As seen in Table 2, a significant interaction effect was indicated. Figure 1 further illustrates the cross-interaction between the exercise training and the initial power levels.

Figure 1 indicates that the group with a high power level increased the leg strength using resistance band training compared to a group with free weight training. In contrast, in the group with lower leg power levels, free weights appear to increase power strength more than resistance band training. The summary of the simple effect analyses using Tukey's HSD test is available in Table 3, while Table 4 indicates the distribution of the group subsets based on Tukey's HSD.

Table 2. Further summarizes the results of the main and interaction effects of the two-way ANOVA analyses.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Exercise Training	2.450	1	2.450	6.533	0.021
Power Level	2.450	1	2.450	6.533	0.021
Exercise training* Power level	6.050	1	6.050	16.133	0.001

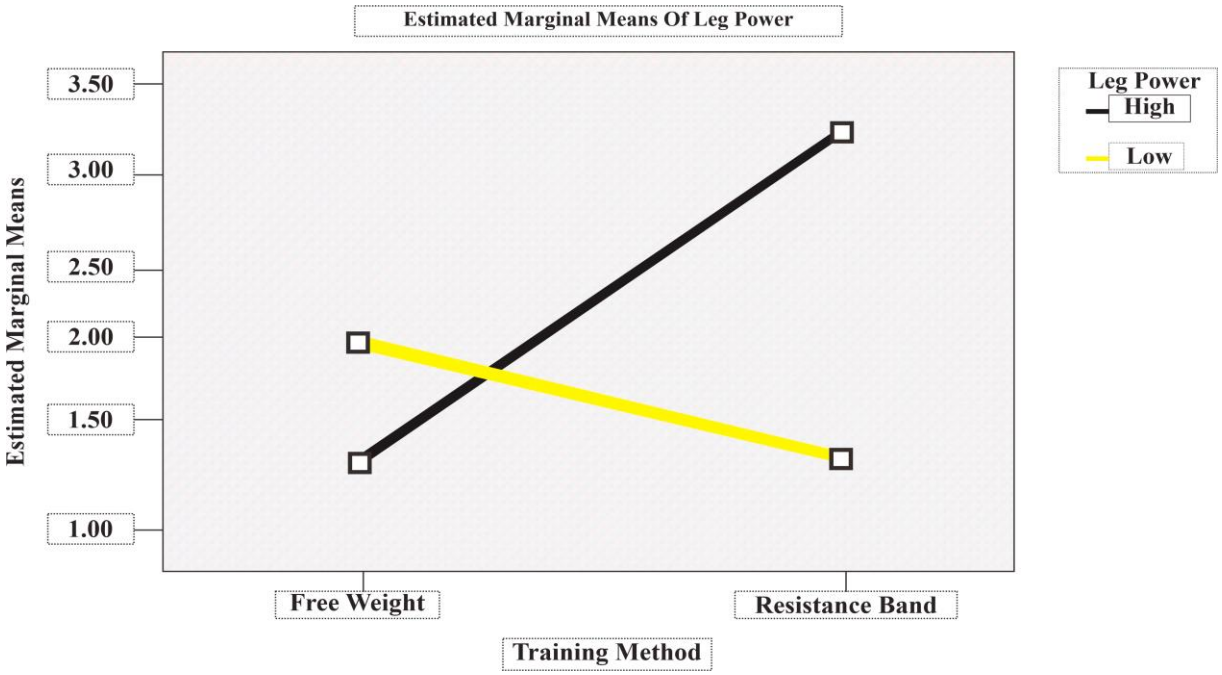

Figure 1. Interaction of Circuit Training and Leg Power Levels on the Leg Strengths

Table 3. Tukey's Test Results Summary

Group	Interaction	*Mean Difference*	*Std. Error*	*Sig.*
Free weights high power	Resistance high power	-1,8000*	,38730	,001
Free weights high power	Free weights low power	-,4000	,38730	,733
Free weights high power	Resistance low power	,0000	,38730	1,000
Resistance high power	Free weights low power	1,4000*	,38730	,011
Resistance high power	Resistance low power	1,8000*	,38730	,001

Table 4. Tukey HSD Test Results*

Group	N		
		1	2
Free weights high power	5	1,4	
Resistance low power	5	1,4	
Free weights low power	5	1,8	
Resistance high power	5		3,2
Sig.		.733	1.000

Based on Tables 3 and 4, the resistance band- high power group was in a different subset column, indicating that the participants in the group increased their leg strengths more than other groups.

4. Discussion

The findings of this study indicate significant effects of exercise types (free weight vs. resistance training) and leg power levels (high vs. low) in leg strength among female basketball athletes. However, these effects were superseded by an interaction effect between exercise types and leg power levels. Resistance training outperformed free-weight training in improving leg strength among athletes with high leg power levels. In contrast, free-weight training was better than resistance training in improving leg strength among athletes with low leg power levels.

Strength gains can be achieved using a variety of resistance training methods and equipment, such as body weight, free weights, resistance bands, and machine-based exercise equipment [31]. Resistance training has been reported to improve several performance measures, including vertical jumps, countermovement jumps, and sprint times, as well as increased maximal oxygen uptake with a combination of resistance and aerobic training programs [32], [33]. The benefits of training using resistance bands have also been proven in elite athletes that, resistance band training improves physical function and muscle strength significantly, in addition, there is an effect of 45 lbs forward kick resistance band based exercises and 75 lbs forward kick resistance bands on leg muscle power [34]. And resistance training with elastic bands has the same effect on increasing muscle strength as conventional resistance training with weight machines and dumbbells in sedentary adults. The use of a resistant band also has the advantage of being less costly and more portable than traditional resistance devices such as weight machines or dumbbells [35].

Resistance training is the primary natural anabolic stimulus for skeletal muscle growth, with 2-3 days per week of moderate to vigorous intensity sufficient to reduce the risk of mortality and musculoskeletal dysfunction [36]. Resistance training programs have improved muscle function and mass in older people [37]. Investigated the effects of a resistance band loop wrapped around the distal thigh on medial knee collapse and muscle activity during barbell back squats. These bands were evaluated specifically regarding training status (trained or untrained) and load (3 maximal repetitions or body weight). Surprisingly, load intensity (3 maximal repetitions or bodyweight) significantly affected lower extremity muscle activity.

Resistance training is the most effective method for increasing muscle mass, because resistance training is a type of conditioning that involves training models and resistive loads ranging from body weight to using aids such as dumbbells, barbells and so on [38]. To provide the resistance needed to increase strength, an endurance training program may include free weights (barbells and dumbbells), weight machines, medicine balls, kettlebells, elastic hoses, or body weight alone. Resistance band exercises are very effective for increasing jump height and leg strength, as well as increasing speed and agility. Exercise with resistance bands can also improve joint strength and be used for aerobic exercise. Elastic band exercise with isotonic contractions can increase flexibility, ROM in joints, and proprioceptive stimuli in joints, muscles, and tendons by activating the Golgi tendon and muscle spindles. Golgi tendon and muscle spindles are motor units that will be activated if the motor and sensory nerves are controlled by repeated muscle contractions [39].

The increased ability to work muscles due to exercise is caused by physiological changes in the neuromuscular system (adaptation of the neuromuscular system). Increased muscle strength results in stronger muscle contractions (more power), faster contraction repetitions (more speed), and a longer period of exercise (increased muscle endurance). Efforts to increase the size of an athlete's muscles, often an increase in muscle fiber or a change in muscle size that is different from the previous muscle size [40]. Actin and myosin proteins have increased, resulting in an increase in muscle fibers. Muscle strength is determined by the size of the muscle fibers and the number of nerve fibers that supply the muscle fibers. Weight training raises the concentration of contractile proteins, which raises the concentration of ATP-PC (Adenosine Triphosphate-Phosphocreatine) and glycolysis enzymes.

Our study has indicated that free weight training was more effective for athletes with low leg power, while resistance band training was more effective for athletes with high leg power. Several limitations in this study, however, need to be acknowledged. Firstly, our study was conducted with a limited sample size constrained by resource limitations. Secondly, we did not control our analysis with confounding variables such as muscle mass. Future research with larger and more heterogeneous samples and accounts for possible confounding factors are recommended to confirm these findings.

5. Conclusions

A significant interaction effect between the exercise types and the initial leg power level is demonstrated in this study. Among female basketball players, resistance training outperformed free-weight training in improving leg strength among athletes with high leg power levels. In contrast, free-weight training was better than resistance training in improving leg strength among athletes with low leg power levels. Couches can consider the findings in determining the exercise types for their athletes. Future research, however, are recommended to confirm these findings.

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