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How Does Circuit Plank Exercise Affect Arm Muscle Strength and Archery Accuracy?

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Abstract Knowledge related to training programs that support archery accuracy improvement is vital. Circuit plank training is expected to improve archery accuracy supported by the dominant component in archery: arm muscle strength. This research used a one-group pretest-posttest design that provided circuit plank training activities in as many as 18 meetings and was carried out three times a week. The study populations were 22 athletes in Yogyakarta, which were then filtered again to take 12 athletes as the study sample using purposive sampling techniques with the criteria of male athletes aged 16-18 years. The instrument of this study included the holding bow digit test and archery distance of 40 meters. The movements of each post involved (1) Basic Plank, (2) Elbow Plank, (3) Single Leg Plank, (4) Plank Arm Reach, (5) Side Plank, (6) Elevated Side Plank, and (7) Archer Plank. The analytical techniques used were normality, homogeneity, and hypothesis tests. The hypothesis testing used a T-test, a statistical analysis technique that can be used to determine whether there is a significant difference between the two mean samples. The analysis of the arm muscle strength data resulted in a t-count value of (41,894) > t-table (1.80) and a p-value of (0.000) < 0.05. Meanwhile, the archery accuracy analysis obtained a t-count value of (55,001) > t-table (1.80), and a p-value of

(0.000) < 0.05. The results of the two t-tests showed that the t-count value > t-table increased after being given treatment. There was an increase in the strength and accuracy of archery athletes after having circuit plank training and increased endurance component of the arm muscles.

Keywords Circuit, Plank, Bodyweight Training, Archery Sports

1. Introduction

Archery achievements do not prioritize gender because gender is not an absolute thing that determines the superiority of performance, which means that when at the same level, male athletes are not necessarily superior to women [1], [2]. The world record of 144 arrows for the men's recurve number is held by Kim Woo Jin with a score of 1391, while the women's recurve Park Sung Hyun holds a number with a score of 1405 [3], [4]. The data can prove that in the sport of archery, women can compete fiercely with men and even surpass male athletes' achievements. Archery requires five components, namely: physical,

tactical, technical, mental, and proper bow tuning, and archery is a sport that not only requires cognitive skills but requires a dominant physical aspect [5], [6]. This aspect supports archery accuracy [7], [8], which is very important with the support of physical endurance and the strength of the arm muscles [9], [10].

Muscle strength is the ability of a muscle or muscle group to perform work by bearing the weight it lifts [11]. Strong muscles work efficiently daily and improve the body's shape. Muscles that are not trained for some reason, such as an accident, will become weak due to atrophy, and if this is left unchecked, the condition can result in muscle paralysis [12], [13]. Muscle strength is closely related to the neuromuscular system, which tells how much the nervous system can activate muscles to contract, so the more muscle fibers that are activated, the greater the muscle's strength [14], [15]. Various physical strength exercises need to be trained to improve the athlete's achievements, including the strength of the arms, shoulders, abdomen, and legs. One piece of training that could be applied is plank variation training.

Plank exercises are isometric exercises that train strength, which involves the whole muscle maintaining the same body position, such as push-ups for as long as possible [16]. Isometric contraction is the increase in muscle tension when lengthening so that the length of the muscle is in a fixed or unchanged state [17]. The isometric exercise was a popular form of strength training in the 1960s [18]. Strength training in an isometric way is more effective for maximum training strength, muscle hypertrophy, and muscle injury healing programs [19]. The results of plank training carried out systematically, continuously, and regularly in several reps and sets will affect the strength and flexibility of coordination and shoulder muscles [20]. The stronger and longer a person can perform plank movements, the better the strength of his shoulder muscles to improve physical condition.

The plank exercise makes the muscles contract strongly as a response to the static loading of the muscles involved [21]. Such loading results in muscle hypertrophy, whose effect will increase muscle strength [22]. Muscle hypertrophy depends on the exercises performed. The muscle which will be large is the slow muscle. Hypertrophy caused due to exercise is usually accompanied by increases in myofibrils, actin filaments, myosins, sarcoplasms, and other supporting tissues [23], [24]. In archery, there are several muscles that contract including the deltoid, rhomboid, levator scapula and trapezius which are the main muscle groups used for back and shoulder tension [25]. When used properly, this muscle is responsible for holding the bow back when it is fully extended [26]. Muscle structure depends on the size of the muscle fibers that make up the structure of the muscle group; therefore, the endurance of the arm muscles is an ability that is influenced by muscle contractions [27]. Therefore, in this study, a circuit plank exercise is needed for archery athletes.

The circuit method consists of several items or kinds of

exercises that must be done within a particular time. After completing one exercise, the athlete moves on to another without any recovery time until the training is completed [28]. Circuit drills are exercises with many items and various posts that move between posts or items until the series of practice items are completed [26]. Circuit training is a form of exercise that uses weights as a medium to support the training process with the aim of increasing fitness, muscle strength, speed, muscle toning, muscle hypertrophy, rehabilitation, and weight gain and loss [29]. Archery cannot be separated from weight training where when holding the bow, the athlete's position does not feel vibration which causes a decrease in accuracy and is one way to simultaneously increase the level of overall physical fitness of the athlete's body which includes basic biomotor components [29]. It can be interpreted that circuit training is an exercise that uses a form of movement which is summarized in several posts which are sequenced according to the goals and rules that have been set, in this case related to increasing the endurance of the arm muscles of archery athletes.

Discrepancies occur from observations and empirical facts, archery trainers only provide monotonous training and do not understand variations in the special physical conditions of archery. Some athletes feel bored when participating in training and still feel heavy when pulling the bow, besides that athletes experience tremors in their left hand. The vibrations experienced have an impact on the feel of the arrows which causes the arrows to be less accurate. Some coaches think that training the physical condition of the archery branch is only in the field by shooting as many arrows as possible. Arm muscle strength data as measured by the holding bow digit test showed an average of 8.3. If converted to the norm, this result becomes less. From the data obtained, 20 athletes produced 10% in the good category, 35% in the moderate category, 45% in the less category, and 10% in the very poor category [30].

Sports coaching does not depend on the rapid application of sequential processes but on the quality of the coaches' knowledge [31]. In addition to tactics, techniques, and mentality, physical conditions are indispensable for improving achievement [32], [33]. Strength is the dominant component in archery to support bow drawing in the set-up to the full-draw position. However, on the field, the coaches only focus on technique and pay little attention to the physical condition of the athlete. Only understanding technique, mentality, or tactics will not help to obtain high points if the arrow misses. Therefore, to strengthen the tactics, physical training also needs to be done [34]. From the background above, it can be concluded that there was an effect of circuit plank training on the strength of the arm muscles and the accuracy of archery athletes.

2. Materials and Methods

This experimental research applied one group pretest-

posttest design, and carried out in one experimental group without a comparison group. In this study, one group was given a plank variation exercise activity in as many as 18 meetings carried out three times a week. The study sample did a pretest first before later being given activity and a posttest after treatment. The population in this study were archery athletes in Yogyakarta as many as 22 athletes with a sample of 12 athletes who were determined using a purposive sampling technique with the criteria of athletes being male and aged 16-18 years. The instrument of this study was a holding bow digit test for arm muscle strength with arm muscle strength measured in units (Kg). The validity of endurance was $0.895 > r$ table of 0.344 [35]. The accuracy of archery by a distance of 40 meters distance with validity $0.895 > r$ tabel 0.344 and reliability $0.944 > 0.60$ [36] was assessed by looking at where the arrows landed and comparing them with the determined target. The

way to calculate the accuracy of archery was by performing 36 arrow shots and totaling the number of each arrow, which is called scoring.

The researchers collected data by conducting an arm muscle endurance test with a holding bow digit test instrument and archery at 40 meters. After that there was a pretest. The sample was given an exercise treatment by doing a plank variation training with the circuit method.

Measurement to determine exercise dose using 1 RM [37], the results show 60-70% with 30 seconds recovery, 3-5 reps, 1-3 sets, and 3-minute breaks between sets. The analytical techniques used were normality (kolmogorov-Smirnov technique), homogeneity (Levene statistic technique), and hypothesis testing applied a T-test, a statistical analysis technique that can be used to determine whether there is a significant difference between the mean samples.

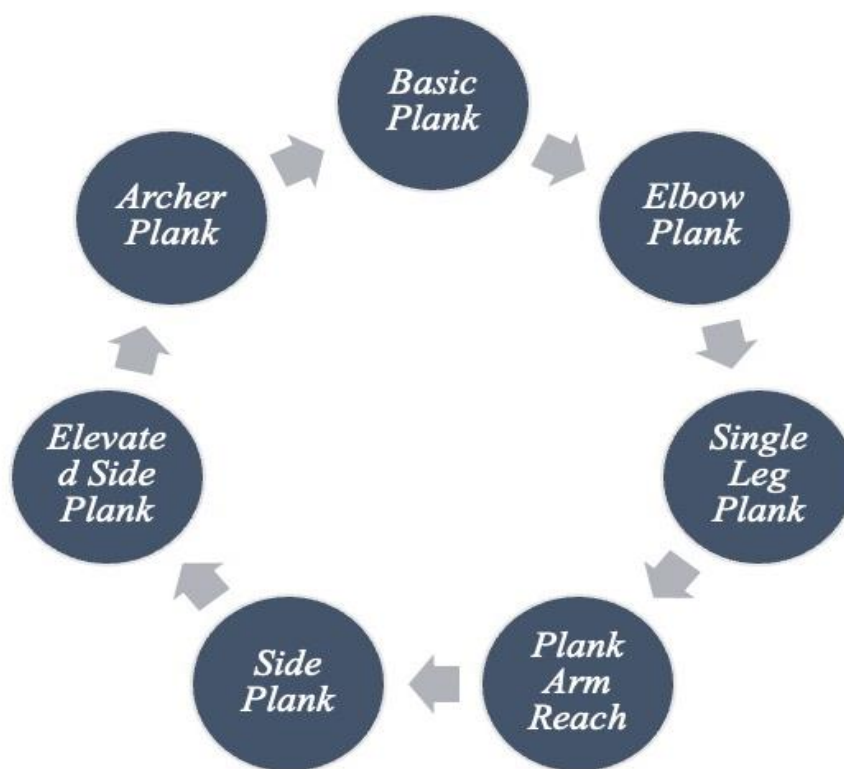


Figure 1. Circuit Plank Training Program

Table 1. Descriptive Statistics of Archery Strength and Accuracy

	<i>N</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>	<i>Std. Deviation</i>
Pretest Arm Muscle Strength (Kg)	12	188	621	443.92	152.005
Pretest Archery Accuracy (Score)	12	424	639	547.00	81.981
Posttest Arm Muscle Strength (Kg)	12	242	552	419.58	112.642
Posttest Archery accuracy (Score)	12	461	587	535.08	123.778

3. Results

The hypothesis in this study is that there is an effect of Circuit Plank Exercise on Arm Muscle Strength and Archery Accuracy.

Based on the data in table 1, the mean of pretest and posttest arm muscle strength increased, which meant that the data/research group experienced an increase in strength. The mean of pretest and posttest data on archery accuracy had also increased, meaning that the data/group also increased archery accuracy.

The results of table 2 were obtained from the Shapiro-Wilk test. From the table, the pretest and posttest data had a p-value (sig.) > 0.05, which concluded that the variables were normally distributed.

Table 2. Normality Test Calculation

Data		p	Sig.	Information
Arm Muscle Strength	pretest	0,754	0,05	Normal
	posttest	0,134	0,05	Normal
Archery Accuracy	pretest	0,309	0,05	Normal
	posttest	0,354	0,05	Normal

The results of the homogeneity test of this study can be seen in table 3 as follows: the sig value of the pretest and posttest significance was > 0.05, so the data were homogenous.

Table 3. Homogeneity Test Calculation

Data	Sig.	Information
Arm Muscle Strength	0,387	Homogeneous
Archery Accuracy	0,346	Homogeneous

The data analysis of the arm muscle strength obtained a t-count value of (41,894) > t-table (1.80), and a p-value of (0.000) < of 0.05 (Table 4). The results showed that the t-count value was greater than the t-table. Thus, it meant that there was an influence of circuit plank training on arm muscle strength in archery athletes in Yogyakarta. Based on the analysis of archery accuracy above, the t-count value was (55,001) > t table (1.80), and the p-value was (0.000) < 0.05. The results stated that the t-count value was greater than the t-table. Thus, it can be interpreted that there was an influence of circuit plank on the archery accuracy of archery athletes in Yogyakarta. The results of the two t-tests showed that when the value of t-count > t-table, the hypothesis was accepted.

Table 4. Hypothesis Test 1

Pretest – posttest	Df	T table	T count	P	Sig 5 %
Arm muscle strength (Kg)	11	1,80	41.894	0,000	0,05
Archery accuracy (Score)	11	1,80	55.001	0,000	0,05

4. Discussion

This research concluded that the increased arm muscle strength and archery accuracy resulted from circuit plank training exercises. The results were obtained when pulling the bow in the set-up position to the full-draw position. Athletes could pull the bowstrings until they touch the lips and the towing finger touch the chin. Therefore, circuit plank training exercises improved the strength and accuracy of this archery.

Body weight training is the same as weight training and is only distinguished by different exercise models and variations. Body weight training can be done without using tools and body weight [38], [39]. This body weight exercise is often combined with the circuit method, which is an exercise that uses a form of movement summarized in several posts sorted according to the goals and rules set [40]. Weight training with this circuit training system stimulates the muscles [41].

Some of the muscle groups that were given stimulation in this study to be increased were: large muscle groups consisting of the pectoralis, hamstring, quadriceps, laticinio Dorsi, low back, biceps, triceps, and abdominal [42]. Plank weight training given according to the exercise's dosage, purpose, and dosage can significantly influence arm muscle strength [43]. One of the essential elements in archery athletes' physical fitness is the arm muscles' strength [44]. Excellent muscle strength is the basis for success in sports and the optimization of other physical abilities.

Strong muscles make daily work efficient and shape the body better [45]. Muscle strength is related to the neuromuscular system, namely how much the nervous system can activate the muscles to contract, so the more muscle fibers are activated, the greater the strength the muscle produces [46].

The plank body weight training program provides exercise movements from the first post to the last, which is arranged in a circle, and after the time is up, the researcher gives a sign to stop, and the athlete moves to the next post. Furthermore, the movement of the seven posts is called one circuit. After the athletes do one circuit, they will be given a break for 3 minutes. A good training program increases the score. This can be obtained when the physical condition is supportive or is in shape and balanced with programmatic training [47].

The research showed that archery accuracy was significantly increased along with good muscle strength. Pulling the tremor bow will decrease so that when releasing the arrow, the approval will be right on target so that it will obtain good points: X, 10, and 9. This archery accuracy uses a bow and arrow to aim at objects to stick to the point at which they are shot [48]. This means that every time the arrow is released, it should not be separated from the intended target [49]. Based on the results above, there was an improvement in archery accuracy due to the condition of the shoulders, strong arms, and good endurance, which

caused the athletes not to feel tired. In contrast, the athlete felt light when pulling the bow, so the accuracy increased. From the monthly observations and scoring carried out once every month in Yogyakarta, archery accuracy was increased by looking at the average score obtained at a distance of 40 meters, 322-332.

On the other hand, muscle endurance also increased, marking a significant increase experienced by the hand when grasping - being trained regularly increased strength and endurance.

5. Conclusions

Based on the results of research and data analysis, it was concluded that circuit plank body weight training can improve arm muscle strength and archery accuracy, as well as significantly increase arm muscle endurance. By increasing the endurance of the arm muscles and the accuracy of archery, it is hoped that athletes can perform optimally in facing other championships. However, this plank exercise is more suitable for athletes at a young age because this exercise does not use external loads so it does not interfere with the athlete's growth system and this plank exercise can improve balance so that the plank is a complete exercise where arm muscles are endurance, arm muscle strength, balance and the accuracy of his shot increased.

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