

## **THE RELATIONSHIP BETWEEN ARM MUSCLE STRENGTH, MUSCLE ENDURANCE, BALANCE AND DRAW FORCE LENGTH ON ARCHERY PERFORMANCE**

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### Abstract

*Archery is a type of sport which participants release the arrow after aiming the target. The shot of an arrow must be accurate to the highest score on the target face. Purpose: The purpose of this study was to determine the most the most contributing variable in archery performance. Methodology: A total of 31 females and males, aged between 13 – 18 years old from Pusat Latihan Negeri Unit Sukan Prestasi Tinggi, Majlis Sukan Negeri, Negeri Sembilan participated in this study. They were involved in different level of achievement in archery competition, ranging from beginner until expert archers. They were also free from any injuries. The participants engaged in three tests, which were arm muscle strength test, push-up test, stork balance stand test. Result: The Pearson correlation analysis showed there was significant relationship among variable measured. In addition, regression analysis showed the arm muscle strength and muscle endurance were the most contributed variable in archery performance. Findings and discussion: These elements can be indicators of an archer's skill level and can be applied as important parameter to select potential archers and also assessment of archer's performance. The time taken to develop the archer to become an expert archer can be shortening due to focusing on important variables.*

**Key Words:** *Archery Performance, Arm Muscle Strength, Balance, Endurance, Draw Force Length*

## INTRODUCTION

Archery is a sport that shoots the arrow with a bow to a certain target during shooting. It requires upper body strength and muscular endurance, especially the shoulder girdle (Kolayış & Ertan, 2016). Besides strength and endurance, balance also plays a role to determine the outcome of every shot (An, 2018). The shot of an arrow must be accurate to achieve the highest score on the target face (Quan & Lee, 2016). In order to achieve the highest score, the draw force line also plays part in determining a correct technique of shooting.

Muscular strength is the ability of muscle to produce maximal force (Taber et al., 2016). Maximal force is required in archery as an archer needs to pull the string to make a full draw (Debnath & Debnath, 2016). The arm is controlled by two large muscles together with a few small muscles consisting of biceps and triceps. The biceps will pull the forearm towards the upper arm while the triceps work against the function of biceps by extending and straightening the forearm (Marsden, 2015). Biomechanically, the arm muscle strength is the power house of muscle to make contraction of the contracted muscle (Khushaba et al., 2016). During pushing movement of the bow, the shoulder is responsible in adjusting the force from the drawing arm. The shoulder muscle must have enough strength to draw the bow (Kolayış & Ertan, 2016; Simsek et al., 2018). A great arm muscle strength, it enables the archer to shoot in a comfort zone thus it will influence the archery performance (Humaid, 2014). Without the arm muscle strength, an archer cannot perform a fully draw during the drawing phase. In addition, correct technique of shooting will not be achieved by the archer.

Muscular endurance is defined as the ability of the muscle to maintain the force during certain periods of time (Ertan, 2017). It is another crucial component in archery as an archer has to pull the bow string and shoot in a long duration of time during archery competition. In archery muscle endurance has linked with the strength of arm muscle (Musa et al., 2016). Any physical requirement is easier and repeatable with existence of strength. If an archer does not develop his arm muscle strength, he cannot endure in long period of time. As fatigue protocol occurred, an archer took a longer time during aiming phase before he releases the arrow (Peljha et al., 2018). Contrary with an archer who has great muscle endurance, he takes immediately and shoots over a short period of time (Takai, Kubo, & Araki, 2012). With less time needed, focus on the centre of target is achieved.

Balance is another critical element in determining the successiveness of every shot. An archer has to stabilize his body posture in every action to avoid any unwanted movement during shooting (Sarro et al., 2020). The possibility to achieve the highest score on target is greater as the body movement is minimized. Movement in archery must be accurate and specific during shooting (Spratford & Campbell, 2017). Any unstable of body movement will affect the scoring. Archers must know to control their movement in every action part for correct aim and release arrow at accurate point (Kim, 2018; Park & Han, 2018). Archer who able to control their postural stability has more stable during aiming compared to those who cannot control unnecessary postural sway (Sarro et al., 2020; Νασούλας et al., 2016). Any shaking or irregularities during aiming will cause the arrow's direction to diverge from the centre (Edelmann-Nusser et al., 2006; Sabers, 2019). In the game of archery, body balance has related to the stability of shooting technique. In order, to enable the arrow path going straight, the center of body stability need to be increased. The instability of the body can affect the alignment of the arrow (Patil & Koley, 2019).

The draw force line is the alignment and balance of the forces between angle of the elbow and the hand of the bow arm connected through the bow (Ertan, 2009; Kolayış & Ertan, 2016; Needham, 2006). A draw force length occurs when the extension of drawn bow string is touches the nose, lips and chin of an archer. This action acts as an indicator for the archer to get a draw force line. If the string does not touch the nose of an archer, the draw force length will not happen, hence it considered as poor technique of shooting. Therefore, it will affect the position of elbow to be straight, aligned with the bow arm (Lin et al., 2010; Suppiah et al., 2017) In addition, it has a direct influence on archery performance (Humaid, 2014). It is also important for the archer to have drawn force length constant consistent in the final pull. Any irregularities in the final pull which is called as shrinking can have a negative influence on scoring (Edelmann-Nusser et al., 2006).

It can be summarized that, arm muscle strength, muscle endurance, balance and draw force length will affect the archery performance. Due to this, many researchers did not include all variables that contributed on archery performance and yet they did not focusing which variables were contributed the most towards archery performance. Apart from that, the coaches and archers as well, still seeking the answer which variable contribute the most in shooting performance of an archery. The present study focusing on to determine the variable that contributed most in archery performance.

## **METHODOLOGY**

There were 31 females and males aged between 13 – 18 years from Pusat Latihan Negeri Unit Sukan Prestasi Tinggi, Majlis Sukan Negeri, Negeri Sembilan participated in this study. All participants were free from the injury. They were involved in different level of achievement in archery competition, ranging from beginner until expert archers.

The instruments used in this study were an EASTON handheld digital bow scale to measure the strength of arm muscle, The WINEX bow recurve type to shoot arrows, a digital camera Canon IXUS 105 with 12.1 megapixels to record the movement of shooting, a lightweight carbon fiber of Easton Ace ES51 arrow shaft to shoot the arrow on target face, and non-reflective markers to put on wrist, elbow, and shoulder of participants later to draw and measure the length of draw force line in KINOVEA software.

The participants were asked to do three tests which were arm muscle strength test, push-up test, and stork balance stand test. The arm muscle strength was tested by using bow scale. As the subject pulls the string to his maximum effort, the bow scale will show a number that indicates the strength of the muscle. It was measured in pounds. The muscle endurance was tested by doing push-up test. It was determined by counting the frequency of doing push-up. Postural balance was tested by using the stork balance stand test. It was measured by counting the time taken for the participants to stand with one foot. The draw force length was measured by drawing using tools in Kinovea software. Markers were put in the hand of the subject which is wrist, elbow and shoulder. Cameras were put at the top view to record the subject's movement. The video was analysed using Kinovea software. The length of the draw force line was measured using tools in Kinovea software.

The descriptive analysis was used to describe the minimum score, maximum score, mean and standard deviation of arm muscle strength, muscle endurance, balance, and draw force length.

The Pearson Correlation Coefficient Test was used to determine the relationship among variables on archery performance. The multiple regression analysis was used to identify which variables contributed most on archer performance.

## RESULTS

*Table 3.1 Descriptions of Variable Measured (N = 31).*

Variables	Minimum score	Maximum score	Mean	Standard deviation
Arm muscle strength (kilogram)	7.80	19.14	13.7629	3.51753
Muscle endurance (frequency)	13.00	48.00	34.3871	8.83432
Balance (second)	17.00	49.00	33.1935	10.52115
Draw force length (centimetre)	103.10	132.15	121.9655	7.21827
Archery scoring	18.00	58.00	39.2581	12.96654

From the table, the lowest archery scoring was 18. On the other hand, the highest score was 58. In addition, the longest time the participant can maintain their body balance was 49 sec and the shortest time was 17 sec.

*Table 3.2 Intercorrelations between Arm Muscle Strength, Muscle Endurance, Balance, and Draw Force Length on Archery Scoring.*

Variable	Arm muscle strength	Muscle endurance	Balance	Draw force length	Archery scoring
Arm muscle strength	-				
Muscle endurance	.831**	-			
Balance	.908**	.838**	-		
Draw force length	.662**	.555**	.579**	-	
Archery scoring	.945**	.896**	.906**	.669**	-

*Note: \*\*Correlation is significant at the 0.01 level (2 tailed) N = 31*

The Pearson Correlation Coefficient Test result showed that all variables have correlated with archery performance. It indicated that all variables have correlated with archery scoring. Furthermore, the analysis showed strong positive correlated between arm muscle strength, muscle endurance and balance. Apart from that, the length of draw force length showed a moderate positive correlation. Besides that, the arm muscle strength has the highest correlation towards archery scoring compared with other variables.

*Table 3.3 Relationship between Archery Scoring and Arm Muscle Strength, Muscle Endurance, Balance and Draw Force Length.*

Variable	N	beta	Std. Error	R square	t	Sig.
Arm muscle strength	31	.507	.220	.363	3.853	.001
Muscle endurance	31	.323	.138	.312	3.435	.002
Balance	31	.129	.154	.039	1.032	.312
Draw force length	31	.079	.117	.054	1.213	.236

For the regression analysis result it showed that arm muscle strength and muscle endurance were the most contributed variable on archery performance. The percentage contributed by arm muscle

strength towards archery performance was 36.3%, followed by muscle endurance was 31.2%.

## DISCUSSION

This current study found that there was significant relationship between strength of arm muscle and archery performance. The researcher postulated that the best archer will have a high level of arm muscle strength that enables the archer to make a full draw during shooting. It revealed that the upper arm strength has direct influence on archery performance. Thus, it is also play significant role on archery technique (Humaid, 2014). Apart from that, it is believed to attain the best control on the bow with strength of arm muscle. The arm muscle strength allows the archer to alter the technique of shooting so that the bow are correctly aligned (Kian ,Ghomshe, & Norang 2013). From this study, it is indicating arm muscle strength plays major part to make a full draw during shooting. A correct technique of drawing in archery shooting determined the performance of an archer. Besides that, upper arm strength also play significant role on archery technique . An archer who has fully developed of upper arm strength has better control of muscle to utilize the important muscle during shooting (Juliana et al., 2019). A correct utilization of muscle will lead an improvement of archery performance. An archer who has better control on muscle has consistency in shooting (Axford, 2017; Simsek et al., 2018). He will not easily get fatigue during long hours of training and tournament.

Apart from that, there was a significant relationship between muscle endurance and archery performance in this study. Based on analysis, it revealed that the greater time the archer can endure, the higher the consistency of scoring. According to Sabers, (2019), the performance of an archer can deteriorate due to muscle fatigue. Muscle fatigue can cause an increase in bow lateral sway. The increased of bow sway will lead to a longer aiming thus the focus onto the target is affected. Another finding conducted by Munawar et al., (2003) muscle endurance has significant effect on archery performance. It can be seen through correlation analysis indicated muscle endurance has relation with archery performance. The researcher classified muscle endurance has two types which is general endurance and local endurance. General endurance is the capability of an archer to work the heart system, lung, and blood flow effectively for contraction of some muscle in long duration of time (Decheline et al., 2020). While local endurance is ability of an archer to endure a continued contraction of muscle with specific load (Yadav, 2019). It can relate that muscle endurance can creates stability during drawing that result in consistency of scoring.

In present study, balance was tested as an indication of postural stability. Due to this, it gives a contrary result from present study as it showed that balance has significant on archery performance. Many researchers were only studied on one variable which was balance (Park & Han, 2018). From their finding balance does play it roles on archery performance. A finding conducted by Zawi & Mohamed, (2013), summarized that postural stability plays a role in shooting outcomes. However, the past finding reported that, the postural stability was influenced only 9% to the expert archer.

This study also found that there was no significant relationship between length of draw force line and archery performance. It gives a contrary result from the previous finding which was the draw force length has positive relationship with archery performance (Humaid, 2014). However, in this study, the result indicated that the draw force length only gives an indicator for the archer to adjust the position of the elbow in order that his elbow does not exceed the draw force

line. Even though an archer will have a long draw force length, it will not affect at all the technique of shooting and performance as well. Literally, the contribution of draw force length on archery performance was not contributed at all. It does not enhance the performance of archery.

## CONCLUSION

It can be concluded from the result that arm muscle strength and muscle endurance were the most contributed factor in archery performance. These variables were related to one another. Using correlation analysis, all four variables were correlated, however regression done was found that only arm muscle strength and muscle endurance were significantly on archery performance. It is suggested that the coaches and archers as well, have to focus on these two variables in order to improve performance of an archer.

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