

Correlation study between arm muscle endurance and arm length and accuracy of 30-meter arrow shots in a national round

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Abstract:

Indonesian archery as a sport has contributed a silver medal to the Indonesian contingent at the 1988 Seoul Olympics, but at the next Olympics, Indonesian archery did not contribute medals to the Indonesian contingent. Archery achievement is determined by the accuracy of arrows shot at the target of each series, and many factors affect the arrow shot accuracy. This study aimed to determine a correlation between the arm muscle endurance and the long arm with the accuracy of arrow shot at a distance of 30 m in the National Round of junior archery athletes in DKI Jakarta. The population included in this study were archery athletes in DKI Jakarta. The sample in this study consisted of 20 junior athletes, and we used a purposive sampling method. The study was conducted in the archery field at DKI Jakarta. The research method for this study was a survey method with correlation techniques. To process the data obtained from the results of the arm muscle endurance test (X_1), the results of the arm length (X_2) and the accuracy of arrow shot 30 m in the National Round (Y), we used regression and correlation analysis techniques. This research was conducted with data in the field to determine the correlation between arm muscle endurance (X_1) and arm length (X_2) using the arrow shot 30-meter National Round (Y) which was determined by the regression equation $Y = 5.183 + 0.447X_1 + 0.449X_2$. The relationship between these variables is shown by the subordinates. The correlation coefficient was $R_{Y_{1-2}} = 0.632$. The coefficient correlation significance test showed that $F_{\text{count}} = 11.075$ was greater than $F_{\text{table}} = 3.592$, which indicated that the coefficient correlation of $R_{Y_{1-2}} = 0.752$ is meaningful. The coefficient of determination as $(R_{Y_{1-2}})^2 = 0.566$. Thus, it was determined that 56.6% of the accuracy of arrows shot 30 m in the National Round were due to the combined arm muscle endurance (X_1) and the arm length (X_2). Based on these results, there was a significant relationship between arm muscle endurance and arm length and the accuracy of arrows shot at 30 m in the National Round. This study was shown that it is still necessary to know and examine some of the factors that affect arrow accuracy and calculate the joint relationship.

Key Words: Archery sport, accuracy, arm muscle endurance, arm length, national round

Introduction

The Indonesian archery sport made history by providing the first silver medal for the Indonesian contingent at the 1988 Seoul Olympics, which was presented by a trio of Indonesian heroines in the women's team. However, in several subsequent Olympic activities, Indonesia archery did not contribute medals to the Indonesian contingent. This of course has invited the attention of some researchers to determine what factors influenced this. In this case, we looked at the physical aspects that can affect the performance of an archery athlete. Archery is a sport of accuracy to hit a target because the ultimate goal of archery is to shoot arrows at a target face at a certain distance as precisely as possible; thus, so one of the factors needed in the archery movement is regularity that must be carried out continuously during practice and during competition. Archery that has several numbers in the race are (1) the traditional number of the bow is made of whole wood in cross-legged sitting position, (2) the national number of the bow is made of wood and bamboo, (3) the international number of the bow is made of synthetic (Suffa, 2019). For categories that are contested in Indonesia, there are three rounds, and the classification is based on : (1) Recurve, (2) Compound, (3) Standard Bow (Parena, 2017).

Athlete's performance is affected by several components. They are physical, technique, and psychological (Herfiantoro, 2019). With proper and correct archery techniques, consistent archery technique movements can be achieved, which if done continuously will result in high achievement. In archery, everything is simple. There is no complicated motion. Thus, it is not very difficult for an athlete to perform the same each time. They can shoot 1440 if they repeat this same motion exactly 144 times (Mc Kinney, 1977). This is necessary so that athletes can shoot their arrows precisely and stably from the beginning to the end of the match; thus, they will be expected to achieve high scores and eventually become champions. Taha Zahari said archery is a fine and gross motor skill sport, wherein success is defined by the capacity to shoot a target repeatedly with tremendous precision and accuracy (Taha et al., 2018).

Basic archery techniques are important to consider. To acquire good archery skills, several things must be considered, including (1) physical condition, physical conditions must be fulfilled in sports, and their fulfillment is adjusted to the sports that are followed by the athletes (Sumariyanto, 2018). Which includes arm muscle strength, trunk muscle strength (back), leg muscle strength, arm pulling endurance, cardiovascular endurance, flexibility, and coordination motion; (2) technique, which include basic techniques of archery and setting the interval from one arrow to another within a few minutes and tuning the equipment (bow adjustment); (3) equipment, which includes suitability of the equipment to be used and knowledge of tool settings; (4) psychological aspects, which include self-confidence, sportsmanship, self-control, endurance, overcoming pressure, concentration, and a willingness to proceed.

The things mentioned above must receive adequate time in training and seriousness based on existing scientific theories. According to Ahmad (2008). Archery technique is divided into 12 steps: (1) stance (standing position), (2) nocking (placing arrows), (3) hooking and gripping (preparing the pulling finger and grip position), (4) mind set (concentration towards the target), (5) set-up (pre-full pull the bow), (6) drawing (full pull of the bow), (7) anchoring (anchoring the pulling hand), (8) loading/transfer to holding (transfer of traction force), (9) aiming and expansion, (10) release (releasing the string/arrow), (11) follow-through (advanced motion), and (12) feedback (Kisik Lee et al., 2005).

Athletes must learn to do the archery techniques well. Learning the techniques above is not as easy as one may think, and all of them require a long training process so that athletes can apply the techniques given by the coach properly. Evaluation is considered as a process which determines the accomplishment of the goals of the planned activities (Adzalika, 2019). Athletes must have overall physical ability which is commonly referred to as general motor ability or motor ability, whose component division includes: (1) heart and lung endurance, (2) muscle strength, (3) flexibility, (4) speed, (5) explosive power (power), (6) agility, (7) balance, (9) coordination (Rawe, 2017). According (ArgadhiaHartono, 2020), psychomotor abilities generally include physical fitness, agility, and coordination as the elements of movement skills. To detect the initial ability of an archery athlete, the components required by the athlete must be considered, such as (1) aerobic capacity, (2) heart volume and VO_2 Max capacity, (3) ability to cope under pressure and (4) tenacity. Archery is a sport that uses a bow and arrow (Dio Lavarino, 2016). In this game, each player must be able to shoot arrows to predetermined targets. Archery is typically a closed skill sport characterised by repetition that is as precise as possible for a movement already known and that is automated. The aim is to evaluate the effects of motor imagery practice in training. Motor imagery is a cognitive process of mental simulation of actions in the absence of movement. There are two methods to improve skill learning through motor imagery: in first person and in third person. The biological basis, on which the motor imagery theory is founded, is formed by: mirror neurons (Tursi & Napolitano, 2014). We hypothesized that an athlete's superior motor skills stem from a re-organization of neural circuits in the brain (Nakagawa et al., 2020).

In archery competitions, many factors can affect an athlete's performance. They include physical, technical, mental and environmental factors. Sometimes, athletes often feel meaningful fatigue when they are participating in a qualifying round with a long duration that is combined with the hot sun and strong winds, all of which greatly affect the athlete's shooting rhythm. Mental is the mover force and booster force to strengthen physical, technical and tactical abilities in sports performances (Jamaliah, 2015). Sometime, athletes experience a psychological stress, and in this case, we can observe the appearance of anxiety in the athlete, which can be influenced by themselves and the environment (Herfiantoro, 2019). If an athlete does not have good physical abilities and a strong mentally to face various conditions while competing, this will greatly affect the athlete's technique.

Various attempts to improve archery skills have been made by trainers. The methods used vary from archery practice in indoor and outdoor fields. Currently, many archery athletes from various regions in Indonesia have dual status: apart from being athletes, they also work as employees or students. Many activities at work or school prevent the athletes who are employees and students from being about to train optimally. For this reason, the training program needs to be modified so that athletes can optimally participate in these activities. Athletes should not feel bored and be comfortable while practicing to carry out the maximum training program in a limited time. Known exercising methods or devices for archery generally consist of weightlifting, rubber or metal spring pulling, and bow pulling without releasing an arrow. Weight training is a form of training that uses weight media to support the training process with the aim of increasing fitness, muscle strength, speed, muscle tightening, muscle hypertrophy, rehabilitation, as well as weight gain and reduction (Irawan, 2020). However, all manufacturers of bows strongly recommend against "dry firing" (the releasing of the video in an archery exercise with a practice device that has a string of the bow without shooting an arrow) because it can severely damage the bow and adversely affect the tendency of forwardness of the handle riser of the bow and archer. Coaching sports achievements, there are many factors that must be considered, including clear coaching objectives, systematic training programs, appropriate training materials and methods, and evaluations that can measure the success of the coaching process itself (Andriani, 2019). Planned and implemented coaching is a step that must be taken, which is the responsibility of all parties involved in developing archery sports.

The rules and regulations that apply to archery matches refer to the FITA Constitutional and Rules (FITA, 2008). The contests include the following: FITA recurve, FITA compound, and barebow division. The National Round is a division (part) of the archery sport that is competed nationally based on the provisions stipulated by PB. PERPANI (Indonesia Archery Association) is based on the provisions of the FITA. The technical characteristics of the National Round are the same as the recurve rounds. The difference is in the equipment used. Archery contests can be organized outdoors or indoors, and the ultimate aim is to collect the highest scores by hitting the yellow area (Eroglu et al., 2014). In general, the National Round archery competition in the qualifying round lasts between 3 and 4 h and is sometimes even up to 5 h, which does not take into account the weight of the bow drawn. If it is calculated in real terms, then a simple calculation can be made as follows. There is an archery athlete who uses a bow weighing 42 lbs. If the unit is converted from pounds to kilograms, then 42 pounds is $42 : 2 = 21$ kg. This means that this 21-kg load is what is pulled by an archer to release one arrow in sequence. In the National Round archery competition, both male and female archers must shoot 108 arrows divided into 3 distances, namely at 50 m, 40 m, and 30 m. For each distance, the archer must shoot 36 arrows. Thus, the total number of loads that must be pulled by the archer in one match is $108 \text{ arrows} \times 21 \text{ kg} = 2.268 \text{ kg}$. From the results of the above calculations, it is quite clear that an archer in addition to needed large arm muscle strength must also have good arm muscle endurance. Moreover, in addition to having good arm muscle endurance, every archer must be able to maintain consistency of movements he makes every time he shoots an arrow from the first arrow to the last arrow. Therefore, it is necessary to determine how much anatomical and physical or biomotor factors affect the accuracy of the arrows so that the achievements of Indonesian archery athletes can be increased, allowing them to compete at the international level, such as in the Olympics. Several studies have been done but have only focused on biomotor components and technical and psychological factors. However, no one has examined how anatomical factors affect an athlete's performance, especially archery. Thus, we aimed to determine more deeply how the relationship between anatomical factors (arm length) and biomotor components (arm muscle endurance) separately or together could improve the accuracy of 30-m shots in National Round archery athletes.

Materials & methods

We aimed to determine a correlation between arm muscle endurance and the long arm with the accuracy of an arrow shot at a distance of 30 m in the National Round of junior archery athletes in DKI Jakarta. This study was conducted in the DKI Jakarta archery field on March 11, 2021 starting at 08.00 WIB until finished. The method used in this study was a survey method with correlation techniques. The population for this study included DKI Jakarta archery athletes, and the sample size for this study was 20 DKI Jakarta junior archery athletes using the purposive sampling method and the following criteria: 1) active as an archery athlete in DKI Jakarta, 2) male gender, 3) age under 15 years, 4) willing to take part in the study, 5) physically and mentally healthy, and 6) already shooting at 30 m. In this study, there were three variables, namely one dependent variable (accuracy of arrow shot at 30 m in the National Round) and two independent variables (arm muscle endurance and arm length).

The instruments in this study included the following. 1) We measured the endurance of the arm muscles with a bow resistance test, a test kit, such as a bow, a stopwatch, a paper assessment form and a pen. For implementation of the test, the archer stood in a standing position while preparing to draw the bow using an arrow, then the bow was lifted like in a shooting position after the archer was given a signal, the archer started holding the bow, which was when the time began. Time stopped when the position of the arrow moved. 2) We measured the length of the arm via a measuring test using a meter with test equipment that included a measuring tape, markers, forms and writing tools. Implementation of the test was done as the archer stood upright with feet shoulder-width apart and hands stretched sideways; then, the tester began measuring the arm starting from the point of motion of the upper arm to the tip of the middle finger, and then, the results were recorded. 3) We measured the level of accuracy of the arrow shot 30 m in the National Round, and in this case, the archer was shooting at a distance of 30 m in 2 session with each session consisting of 6 series and each series consisting of shooting 6 arrows. Then, the total score is calculated. To process the data obtained from the arm muscle endurance test (X_1), arm length (X_2) and the accuracy of arrow shot 30 m in the National Round (Y), regression and correlation analysis techniques were used. The steps included: 1) determining the simple regression equation, 2) determining the coefficient of correlation, 3) testing the meaning of the correlation coefficient, 4) determining the coefficient of determination, 5) determining the multiple linear regression equation, 6) determining multiple correlation coefficients (RY_{12}), and 7) testing the significance of multiple correlation coefficients. Then, we obtained the statistical hypothesis.

Results

The data from the arm muscle endurance (X_1) measurement ranged from 26 to 49 with an average of 39.60, a standard deviation of 6.29 and a variance of 64.95; then, the data were converted to a Tscore with the highest score at 49 and the lowest score at 26. Below shows the frequency distribution for the arm muscle endurance data:

Table 1. Frequency Distribution of Arm Muscle Endurance (X_1)

No.	Interval Class	Median	Frequency	
			Absolute	Relative
1	26–30	28	3	15,0%
2	31–35	33	1	5,0%
3	36–40	38	7	35,0%
4	41–45	43	7	35,0%
5	46–50	48	2	10,0%
Amount			20	100

The data from the measurement of arm length (X_2) was in the range of 62 to 75 with an average of 70.50 and a standard deviation of 3.30 (variance of 10.86). Then, the data was converted to a Tscore with the highest score of 75 and the lowest score of 62. Below shows the frequency distribution of the arm length data.

Table 2. Frequency Distribution of Arm Length (X_2)

No.	Interval Class	Median	Frequency	
			Absolute	Relative
1	62–64	63	1	5,0%
2	65–67	66	2	10,0%
3	68–70	69	8	40,0%
4	71–73	72	4	20,0%
5	74–76	75	5	25,0%
Amount			20	100

The data for the accuracy of an arrow shot 30 m in the National Round (Y) were in the range of 200 to 328 with an average of 271.60 and a standard deviation of 37.10 (variance of 13776.67). Then, the data were changed to a T-score with the highest score of 328 and the lowest score of 200. Below, the frequency distribution for the archery achievement data for the 30-meter National Round is provided.

Table 3. Frequency Distribution of Accuracy of Arrow Shot at 30 Meters in the National Round (Y)

No.	Interval Class	Median	Frequency	
			Absolute	Relative
1	200–225	212,5	3	15,0%
2	226–251	238,5	5	25,0%
3	252–277	264,5	2	10,0%
4	278–303	290,5	5	25,0%
5	304–329	316,5	5	25,0%
Amount			30	100

The relationship between arm muscle endurance (X_1) and the accuracy of an arrow shot 30 m in the National Round (Y) is expressed by the regression equation $\hat{Y} = 18.467 + 0.631X_1$. This means that the accuracy of an arrow shot 30 m in the National Round can be estimated by the regression equation if the variable arm muscle endurance (X_1) is known. The relationship between arm muscle endurance (X_1) and the accuracy of an arrow shot at 30 m in the National Round (Y) is shown by the correlation coefficient of $RY_1 = 0.631$, and this correlation coefficient must be tested first in terms of meaning before it can be used to draw conclusions. The test for the significance of the correlation coefficient above showed that $T_{count} = 3,448$ was greater than $T_{table} = 2,101$, meaning that the correlation coefficient $RY_1 = 0.631$ was meaningful. Thus, the hypothesis that there is a significant relationship between the endurance of arm muscles (X_1) and the accuracy of an arrow shot at 30 m in the National Round (Y) is supported by our data. The coefficient of determination for the endurance of the arm muscles in the accuracy of an arrow shot at 30 m in the National Round (RY_{12}) = 0.398. Thus, 39.8% of the accuracy of an arrow shot at 30 m in the National Round was determined by the endurance of the arm muscles (X_1).

The relationship between the length of the arm (X_2) and the accuracy of an arrow shot at 30 m in the National Round (Y) is expressed by the regression equation $Y = 535,930 + 539.041X_2$. This means that the accuracy of an arrow shot at 30 m in the National Round can be estimated by the regression equation if the variable arm length (X_2) is known. The relationship between the length of the arm (X_2) and the accuracy of an arrow shot at 30 m in the National Round (Y) is shown by the correlation coefficient $RY_2 = 0.752$; the correlation coefficient must be tested in terms of its meaning before it can be used to draw conclusions. The test

for the significance of the correlation coefficient above showed that $T_{count} = 3.458$ was greater than $T_{table} = 2.101$, which means that the correlation coefficient $RY_2 = 0.632$ was meaningful. Thus, the hypothesis that there is a significant relationship between the length of the arm (X_2) and the accuracy of an arrow shot at 30 m in the National Round (Y) is supported by our data. The coefficient of determination for arm length in terms of accuracy of an arrow shot at 30 m in the National Round (RY_{22}) = 0.399. Thus, 39.9% of the accuracy in the National Round at 30 m was determined by the length of the arm (X_2).

The relationship between arm muscle endurance (X_1) and arm length (X_2) with the accuracy of an arrow shot at 30 m in the National Round (Y) is expressed by the regression equation $Y = 5.183 + 0.447X_1 + 0.449X_2$. The relationship between the three variables is shown by the correlation coefficient $RY_{1-2} = 0.632$, and the correlation coefficient must be tested in terms of meaning before it can be used to draw conclusions. The significance test of the correlation coefficient above showed that $F_{count} = 11.075$ was greater than $F_{table} = 3.592$, confirming that the correlation coefficient $RY_{1-2} = 0.752$ was significant. The coefficient of determination was (RY_{1-22}) = 0.566. This means that 56.6% of the accuracy of an arrow shot at 30 m in the National Round is determined by the endurance of the arm muscle (X_1) and the length of the arm (X_2) combined.

Discussion

Archery is a sport that requires coordination, arm muscle endurance, flexibility, length of pull, arm length, and balance to provide a good archery technique. The factors above must be supported by good training and an excellent and long lasting physical condition. The physical condition referred to here means that the archer not only has great muscle strength but also must be supported by good muscular endurance so that the athlete's appearance is not only good at the beginning of the match but is consistent until the end of the competition. The appearance of an athlete when participating in an archery competition is influenced by several factors, such as physical, technical and mental factors. Important factors include visual coordination (accuracy), feeling of motion (feeling/sense of kinesthetics), arm strength (strength endurance), length of pull, concentration and emotional balance. The physical condition is an integral part of components that cannot be separated, in terms of both improvement and maintenance. If an athlete is in good physical condition, there will be signs of an improvement in his abilities when carrying out motion.

Archery can be described as a comparatively static sport that requires strength and endurance of the upper body, in particular in the forearm and shoulder girdle (Tinazci, 2011). If, when in the archery stance, the bow arm is formed in a straight line, the shooting movement will be more efficient, meaning that the energy expended while holding it will coordinate well (Susanto, 2015). Efficient motion will form proportional motion, which means doing it economically and with automation. An archer examines himself if he misses the target, that is, he reviews the skills of archery that he possesses and continues to improve them. Because the mean is likened to the art of archery, we may say that, if a person fails to hit the mean with actions, he should examine himself and continue to cultivate the inner mean. This also indicates that archery is the craft model used when he constructs his doctrine of the mean (Jiyuan, 2010).

Archery comparatively demands a very specific strength and endurance for successful intermittent repetitive shooting and performance, both during training and competitions. Compared to other strength or endurance events, it does not require very high demanding efforts in terms of strength and endurance fitness areas, yet, in its own sense, it demands much fitness to result in accurate shooting (Açıkada et al., 2019). In archery, the arm is a major factor in determining the accuracy because arm muscle strength and arm balance play a very important role in the ability of archers to direct arrows to predetermined targets (Ilham, 2014). With good endurance skills, the movements made by an archer will remain constant and stable during the process of training and at competitions.

Many factors influence success in archery, and two factors include the physical condition and ability to move (Prasetyo Y, 2016). The elements that support these achievements need to be pursued so that they can support the optimal results. Based on our observations in the field and the results of fostering archery athletes at regional and national levels, these two factors are very dominant. In archery, arm muscle endurance is in high demand considering the amount of push and pull force that must be done continuously by the arm muscles. Endurance will have a big influence on the shooting rhythm of the athlete. Moreover, the arm length affects the athlete's bow range, which gives additional power to the bow that is shot so that the accuracy of the shot can be maintained.

It is our opinion that the physical aspect is the most important factor in archery. This is supported by our study and data analysis, which showed that 39.8% of the accuracy of an arrow shot at 30 m in the National Round was determined by arm muscle endurance, and 39.9% of the accuracy of an arrow shot at 30 m in the National Round was determined by the arm length, whereas 56.6% of the accuracy of an arrow shot at 30 m in the National Round was determined by the combination of the arm muscle endurance and arm length. Of course, this can be the basis for other studies to determine how much other physical aspects contribute to determining archery achievement. Compared with several studies that have been carried out related to archery, this study was high in terms of novelty. Thus far, research has only been related to the biomotor, technique, and psychology components separately or together but has never examined the meaningful relationship between the biomotor

components and the anatomy of athletes themselves, although the athlete's anatomy is also very important (in this case, the arm length because it is very important for archery athletes).

Therefore, we recommend that coaches pay more attention to the anatomical and biomotor components of athletes combined when carrying out training programs in the field. This is so that exercise can be done optimally to increase athletic performance. In addition, we also recommend other researchers look more closely at the anatomical factors of athletes associated with the biomotor, technical or psychological components in combination. This is aimed at the talent scouting process carried out in the field because, by looking at an athlete's anatomy, the talent scouting process will be easier and more effective.

Conclusions

This study was showed that it is still necessary to know and examine some of the factors that affect arrow accuracy and calculate the joint relationship. This will help to determine what factors most affect the accuracy of arrows fired at a distance of 30 m in the National Round. Thus, the trainer can choose the most suitable training method to improve each factor that affects the level of accuracy. Thus, this will improve the achievements of Indonesian archery athletes so that they can compete again at the Olympic level so that they will be able to repeat the glory of archery at the international level, especially the Olympics.

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