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Ergonomic Design of *Grip Bow*using Hand Arrow Antropometry in East Aceh District

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Abstract
Archery is a sport that moves the arrow to the target when shooting. In archery grip is a central point of shooting stability so it tends to be a performance different due to the size of the grip and the design of the grip does not match the athlete's hand anthropometry.Therefore this study was conducted to determine the size and design of a grip bow that is suitable for archery athletes. This research uses a quantitative approach with a descriptive type. The populations in this study are 10 athletes of East Aceh. The relatively small population, all population members are sampled (total sampling). Data collection techniques are (1) measuring hand anthropometry with a ruler / meter, and sliding anchor (2) to determine the design of a bow grip using 3D scanner. The Percentile of data analysis technique with SPSS application.Based on the results of the scanner to the CAD software. The results of the calibration of the grips bow show the same visual size measurements of male and female samples in the socket depth of 27.80 mm, socket width of 15 mm, window 48 mm, grip length of 90 mm, and grip tilt of 150, while the visual difference in male sample is in the size of the grip with a ring size from 33.82 to 33.87 mm, the size of the middle finger with a ring size of 17 to 20 mm, the size of the ring finger with a ring size of 15 to 17 mm, the size of the little finger with a ring size of 14 to 16 mm. Furthermore the difference in visual variation in the size of the female sample grip on the size of the grip with a ring size from 32.78 to 32.81 mm, the size of the fingers with a ring size of 16 to 18 mm, the size of the ring finger with a ring size of 14 to 17 mm, the size of the little finger with ring size from 14 to 16 mm. Based on the measurements that have been obtained, the grip bow design achieved there are several innovations that are applied, such as grip size, hand size, ring finger size, and size of the little finger and shaped according to the anthropometric size of each archery athlete in East Aceh Regency.

Key Words :*anthropometry,gripbow,ergonomics*

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I. Introduction

It is doing sports activities are commonly done by everyone, especially in Indonesia, and also in the province of Aceh. In Aceh Province it has positive potential areas in terms of human resources for the development and coaching of sports both in achievement and industry. East Aceh Regency is one of the regions in Aceh Province that has great potential in carrying out development efforts in sports. This is proof by the participation of East Aceh District in participating in all sporting events at the regional and national levels with an increase in good achievements every year.

Sports achievements have evolved and involved a lot of research to create athletes and perfect sports players. Indeed many role of science is playing an important role in the development of sports achievements one of which is the science of biomechanics. Biomechanics is the oldest branch of science of all branches of physics. According to (McGinnis, 2000) argues that: "mechanics is a sub-discipline of science that deals with the application of the principles of physics that study motion in every part of the human body". According to (Hay, 1993), Biomechanics is the study of internal and external forces and works on the human body and the results of the forces produced. Biomechanics is the study of internal and external forces and works on the human body and the results of the forces produced. Biomechanics is defined as the field of application of mechanics in biological systems. Mechanics is a combination of applied mechanics and biological sciences and physiology. Biomechanics concerns the human body and almost all organisms. Biomechanics has been defined as research on the movement of organism using mechanics (Hatze, 1974). The research practice uses quantitative and qualitative methods. How someone moves is examined to find out which movements are the most optimal to do. There are many studies about biomechanics, specifically biomechanics in sports. One of the main objectives is to analyze patterns of human movement while exercising and help improve the performance of athletes in their sport branches and reduce the risk of injury (Roger Bartlett, 2007: 12). Muscles and bones involved in moving joints create angles of movement and a series of movement patterns that occur in an activity so that it can be studied and maximized results, to find the most optimal pattern and reduce the risk of injury.However, in doing sports, movements that occur so fast and full force. In other words correcting the wrong movements requires a lot of repetition to train and reduce movement errors in achieving achievements, especially in archery.

Archery is a sport that moves the arrow to the target when shooting (Lee, 2009: 42). In archery sports the result of a shot is greatly influenced by consistent movements, and is repeated repeatedly for a long time. Shooting in archery can be summarized as pulling a bow, aiming and releasing arrows (McKinney 1997: 114). In archery, it is important that the archer is able to resist the isometric drag of the bow when released. The large number of missteps resulting from the pull results in a reduction in the speed of the arrow and this causes the arrow to move too slowly towards the target.

According to (Mukaiyama, et al, 2011: 64) High shooting performance in archery is defined as ability. Therefore, increasing the time and refinement of bows and arrows is improved to get good performance results. Shooting in archery is a target with accuracy (Soylu, Ertan, &Korkusuz, 2006: 265). The line of the bow arm is important because it will produce a certain angle and if the alignment is incorrect, the force applied to the muscles can increase. The styles on archers can be varies because the level of skills and techniques differ from one athlete to another, especially in Indonesia. This also involves a different performance between elite and sub-elite archers (Hu & Tang, 2005: 72). Biomechanics in archery are very useful. This helps in controlling muscle movements and reduces the effects of fatigue that may occur, possibly causing serious injury in the long run. In addition, joint movements are also important in analyzing human body movements and to better understand how or why injuries occur (Kristianslund, Krosshaug, & van den Bogert, 2012: 32).

According to the biomechanical principle in archery, the force acting on the bone must be maximized while the force acting on the muscles must be minimized to reduce the impact of injury on the archer. The angle and position of the elbows play an important role in strength. Therefore, the position of the grip placement on the arc is crucial to get the correct movements. The movement must be parallel to the strength line, because the distance of the shoulder line and the shortest force line. This line is called a draw force line.

Grip bow is a part of the bow that functions to determine how to hold the bow. The bow grip is also considered the most important central point to put pressure on the bow when the archer pulls up to release the arrow to the target. Research has focused on biomechanics of archery shooting. Then studies have considered the relationship between body stability and bow performance in the contribution of the arm and hand to the bow grip that is used to pull the string backwards through the arrow release process. (Martin, Siler, & Hoffman, 1990: 121), (Martin &Mungiole, 1987; Mason &Pelgrim, 1986; Nishizono, Sasaki, Nakagawa, & Saito, 1987).

Research on stability in grips bow has indicated that while a stable body position may be a prerequisite for successful performance, grip stability tends to be a clear differentiator of performance. Although it is the general consensus of the archery instructor that the bow of the arm is grasping and stabilizing the grip of the gripbow when the arrow is pulled and released. In the sport of archery grip bow plays an important role in keeping the bow stable during shooting, there is no empirical data to confirm the general level of importance associated with its role. Many archery instructors have commented on the importance of positioning the grip bow hand that holds exactly the same position for each shot and keeps the wrists unmoving during the whole shooting process. (Haywood, 1989; Klann, 1970; Pszczola, 1976).

In addition, many archers also commented on problems in the bow, especially the central point, namely the bow grip with the size and shape of the grip on the bow making it difficult for archers when holding the bow (Bow). alignment of grip size on the bow is very necessary because the posture and size of each archer's hand varies greatly between male and female archers, especially in East Aceh Regency athletes.

In line with Haywood noted that "a skilled archer can demonstrate the importance of the consistency of the position of the hand by varying the position of only a few in successive shots and resulting in the placement of arrows on the target" (p.87). The desired distribution of force is the force in which forces applied to the bow by the hand are distributed almost completely on the posterior surface of the grip (Barrett, 1980; Klann, 1970; Pszczola, 1976). It is recommended that the moment of effect is produced by poor grip patterns or changes in hand and wrist positions in preparation for release directly affecting the direction of arrow flight.

This study is to illustrate the distribution between hand grips and bows, and adjustments to experienced archers when archers prepare to release arrows during normal draws. The aim is to produce a bow grip product design.

The design is a draft plan or a physical translation idea about the social, economic, and human aspects of life, and is a reflection of the culture of his day. "Design is also one of the manifestations of culture in the form of products of values that apply at a certain time period" Sachari and Sunarya (2001: 10).

The design for archery athletes with the concept of ergonomics that can produce comfortable and effective bow grip products making it easier for archery athletes, especially archery athletes in East Aceh District to practice or in competitions.

From the description above, the writer assumes that there should be the objectives in this study are (1) To find out the size of the bow grip of archery athletes in East Aceh District. (2) To obtain a suitable grip bow design for East Aceh Regency archery athletes.

II. Methodology Of Research

The variable of this study is namely a quantitative approach with a descriptive type. Quantitative approach is a scientific approach that aims to develop and use mathematical models, theories or hypotheses in which the measurement process is the central part of this research. In organizing research planning, subjects include: Determine research methods, determine population and research samples, determine research instruments, collect data, and, analyze according to their goals and nature.

Every research must use object to study or called population. The populations in this study were archery athletes in East Aceh District consisting of 10 people. The research instrument used in this study was to use a meter, shove, 3D scanner, and 3D Printer.

However, in getting the appropriate bow grip design for every East Aceh district archery athletes by using a 3D scanner and 3D printer. The process of taking a shape of a grip bow with 3D scener and making a grip bow is done at the Lab of the Faculty of Engineering, Syiah Kuala University, Banda Aceh.

In this research, after all data has been collected through measurement, the next step is the data analysis technique. Data and information will be analyzed and interpreted continuously from the beginning of the study to the end of the study. The data analysis procedure was carried out based on three stages in accordance suggested by Furchan (2005: 513), stating that: analyzing the data that was collected was to look back at the research proposal to check the data presentation plan that was originally arranged. Anthropometric measurement techniques are using a meter hand, sliding anchor and 3D scanner tool to see the shape of the grip bow and to form a grip bow on archery athletes in East Aceh District using a 3D printer.

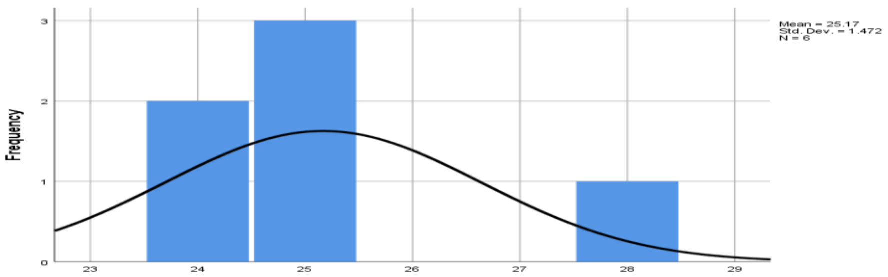
III. Results Of The Study

A. Overall test data

1. Male overall test data

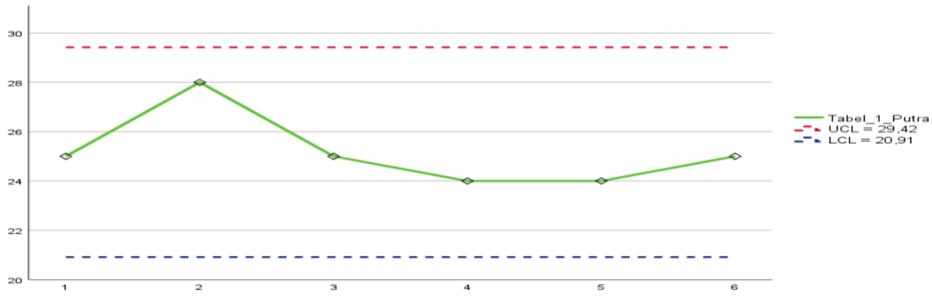
The purpose of the data uniformity test is to determine that the research data obtained are from the same cause system.

a. The hand circles including the thumb of the first step in the data uniformity test are as follows:
The following is a graph of the frequency of the dimensions of the hand's circle including the thumb of the male.



Picture 1: hand ring frequency including male's thumb

b. The following is a graph of the upper dick limit (BKA) lower control limit (BKB) of anthropomteri data on the dimensions of the hand's circle including the thumb of the male.



picture 2 : Graph of upper control limit and lower control limit of hand circle including the thumb of the male.

Based on Figure 1 above, it can be concluded that from the 6 respondents' anthropometric data on the dimensions of the hand circle including the thumb of the male it has been said identical because there is no data that comes out of the upper control limit and the lower control limit.

The following is a recapitulation table of identically test for male hand anthropometry.

Table 1: the recapitulation of identically test for the male hand anthropometry

No.	Dimension	N	$\overline{X}$	SD	Z	BKA	BKB	Percentile	
								5	50
1	Hand Circles, including Thumbs	6	25,17	1,472	2,6	29,42	20,91	24	25
2	Hand circles, without thumbs	6	21,67	1,366	2,6	26,45	16,88	20	21,5
3	Fist circle	6	27,83	0,752	2,6	29,96	25,706	27	28
4	Hand width including thumbs	6	11,25	0,612	2,6	12,313	10,187	10,5	11
5	Hand width without thumbs	6	8,75	0,418	2,6	9,813	7,687	8	9
6	The length of the palm to the tip of the middle finger	6	19	0,707	2,6	21,392	16,607	18	19
7	The length of the palm	6	10,667	0,605	2,6	13,059	8,274	10	10,75
8	The whole of middle finger	6	8,333	0,408	2,6	9,397	7,27	8	8,25
9	The length of the middle finger from the base of the finger to the middle	6	6,717	0,402	2,6	8,418	5,015	6	6,9
10	Grip diameter inside the middle finger	6	3,383	0,611	2,6	5,617	1,150	2,6	3,25
11	Grip diameter inside index finger	6	3,017	0,462	2,6	4,452	1,581	2,4	2,95
12	The length of index finger from the base of the finger to the middle	6	6,05	0,339	2,6	7,007	5,093	5,5	6
13	The length of ring finger from the base of the finger to the middle	6	5,817	0,491	2,6	7,625	4,009	5	6
14	The length of little finger from the base of the finger to the middle	6	4,683	0,530	2,6	6,863	2,503	4	5
15	The length of thumbs finger	6	6,633	0,383	2,6	7,856	5,41	6	6,65
16	The length of index finger	6	7,8	0,275	2,6	8,917	6,683	7,4	7,95
17	The length of little finger	6	6,4	0,4	2,6	7,783	5,017	5,9	6,5
18	The length of ring finger	6	7,767	0,233	2,6	8,936	6,597	7,5	7,8
19	Size of the top little finger	6	1,367	0,081	2,6	1,633	1,101	1,3	1,35
20	Size of the top middle little finger	6	1,5	0,89	2,6	1,766	1,234	1,4	1,5
21	Size of the top of the ring finger	6	1,467	0,051	2,6	1,573	1,36	1,4	1,5
22	Size of the middle of the ring finger	6	1,75	0,083	2,6	1,963	1,537	1,7	1,7
23	Size of the top of the middle finger	6	1,6	0,063	2,6	1,813	1,387	1,5	1,6
24	Size of the middle of the middle finger	6	1,883	0,098	2,6	2,096	1,671	1,8	1,85
25	Size of the top of the index finger	6	1,483	0,116	2,6	1,856	1,111	1,3	1,5
26	Size of the middle of index finger	6	1,833	0,121	2,6	2,099	1,567	1,7	1,85

27	Size of the middle of thumbs finger	6	2,017	0,075	2,6	2,229	1,804	1,9	2
28	The length of thumbs finger from the base of the finger to the middle	6	3,467	0,350	2,6	4,743	2,190	3,1	3,35
29	The length of middle finger from the base of the finger to the thumbs	6	1,367	0,081	2,6	1,633	1,101	1,3	1,35
30	The length of the little finger from the base of the finger to the top middle finger	6	2,6	0,126	2,6	2,813	2,387	2,4	2,6
31	The length of the index finger from the upper to the tip of the finger	6	2.633	0,121	2,6	3,059	2,208	2,5	2,6
32	The length of the middle finger from the middle to the upper	6	3	0,236	2,6	3,851	2,149	2,6	3,05
33	The length of the middle finger from the upper to the tip of the finger	6	2,717	0,194	2,6	3,142	2,291	2,5	2,65
34	The length of ring finger from the middle finger to the upper	6	2,733	0,175	2,6	3,212	2,255	2,4	2,8
35	The length of ring finger from the upper to the tip of the finger	6	2,75	0,151	2,6	3,229	2,271	2,6	2,75
36	The length of little finger from the middle to the upper	6	2,083	0,229	2,6	2,509	1,658	1,9	2,05
37	The length of the little finger from the upper to the tip of the finger	6	2,417	0,172	2,6	2,895	1,938	2,2	2,4

A. The Data of adequacy test

The instruments for collecting data in this research to determine whether the amount of data used is representative of the observed population. Data is considered sufficient if N '<N.

The following is a recapitulation table for the data adequacy test for male and female hand anthropometry.

Table 3: the recapitulation of data sufficiency test for anthropometry of male and female hands

No.	Dimension	Male	Female	Explanation
		N'	N'	
1	Hand Circles, including Thumbs	1,927	0,383	enough
2	Hand circles, without thumbs	2,24	1,018	enough
3	Fist circle	0,412	0,405	enough
4	Hand width including thumbs	1,632	1,375	enough
5	Hand width without thumbs	1,226	3,745	enough
6	The length of the palm to the tip of the middle finger	0,780	1,043	enough
7	The length of the palm	1,815	0,845	enough
8	The whole of middle finger	1,352	3,960	enough
9	The length of the middle finger from the base of the finger to the middle	2,081	2,647	enough
10	Grip diameter inside the middle finger	1,804	1,131	enough
11	Grip diameter inside index finger	1,238	3,880	enough
12	The length of index finger from the base of the finger to the middle	1,539	2,022	enough
13	The length of ring finger from the base of the finger to the middle	3,884	0,160	enough
14	The length of little finger from the base of the finger to the middle	6,848	0,500	enough
15	The length of thumbs finger	1,706	0,303	enough
16	The length of Index finger	0,616	0,527	enough
17	The length of little finger	2,292	2,347	enough
18	The length of ring finger	0,622	0,085	enough
19	Size of the top little finger	4,645	0,704	enough
20	Size of the top middle little finger	2,002	1,724	enough
21	Size of the top of the ring finger	4,538	0,599	enough

22	Size of the middle of the ring finger	2,819	0,544	enough
23	Size of the top of the middle finger	2,053	0,404	enough
24	Size of the middle of the middle finger	5,186	0,732	enough
25	Size of the top of the index finger	5,290	0,723	enough
26	Size of the middle of index finger	2,456	2,860	enough
27	Size of the middle of thumbs finger	2,677	0,451	enough
28	The length of thumbs finger from the base of the finger to the middle	1,695	1,133	enough
29	The length of middle finger from the base of the finger to the thumbs	5,068	0,602	enough
30	The length of the little finger from the base of the finger to the top middle finger	2,332	2,412	enough
31	The length of the index finger from the upper to the tip of the finger	0,216	0,206	enough
32	The length of the middle finger from the middle to the upper	4,173	1,877	enough
33	The length of the middle finger from the upper to the tip of the finger	2,544	2,498	enough
34	The length of ring finger from the middle finger to the upper	2,512	0,561	enough
35	The length of ring finger from the upper to the tip of the finger	2,481	1,435	enough
36	The length of little finger from the middle to the upper	4,326	0,918	enough
37	The length of the little finger from the upper to the tip of the finger	3,215	0,726	enough

IV. Conclusion

Based on the results of research and what has been done by researchers about the design of ergonomic grip bow using anthropometry archery athletes in East Aceh district,the results can be obtained that the use of a 3D scanner in this study has a positive impact on the product design process with several stages passed, including: the scanning process of work objects converting the results of scanning into CAD software, the digital measurement process and the calibration process. The calibration results on the sample bow grips show a difference where the size varies. The results of the bow grip design achieved were several innovations applied such as the size of the bow grip in accordance with the size of each athlete's hand. So that the athlete is easier and more comfortable using grip bow.

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