Cakrawala Pendidikan
Jurnal Ilmiah Pendidikan
Vol. 43 No. 2, June 2024, pp.305-313
https://journal.uny.ac.id/index.php/cp/issue/view/2677
DOI: https://doi.org/10.21831/cp.v43i2.63268

The differences in learning outcomes in students' archery skills according to physiological ability

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ABSTRACT

This study aims to compare how students learn archery skills in terms of physiological ability factors arising from first, middle, and last shots. Arm muscular strength is one physiological ability aspect that affects archery skills. Physical fitness has a big impact on archery success or accomplishment. This comparative quantitative study aims to ascertain how much student learning outcomes for archery skills vary or differ from one another. Thirty individuals from five different classes of Physical Education, Health, and Recreation (2019/2020) were sampled using the cluster random sampling method. Inferential one-way ANOVA descriptive statistics were employed for data analysis in this study, with a significance threshold of α 0.05. The research results show a difference in the average of the three archery skills learning outcomes for the students. The differences are between the outcomes of the first shot (encroachment), middle shot, and final shot. The results of Tukey's post hoc follow-up test indicated that (1) there was a significant difference ($p < 0.05$) in the average shot result (encroachment) between the first and the middle shots; (2) there was a significant difference ($p < 0.05$) in the average shot result (increase) between the first and the last shots; and (3) there is no significant difference ($p < 0.05$) in the average shot results between the middle shot and the last shot ($p < 0.05$).

Keywords: learning outcomes, archery skills, physiology

Article history

Received:	*Revised:*	*Accepted:*	*Published:*
17 September 2023	*27 February 2024*	*27 March 2024*	*5 June 2024*

Citation (APA Style): Widiyanto, W., Setyawan, H., Suharjana, S., García-Jiménez, J. V., Pavlovic, R., Nowak, A. M., & Izwan bin Shahri, M. (2024). The differences in learning outcomes in students' archery skills according to physiological ability. *Cakrawala Pendidikan: Jurnal Ilmiah Pendidikan*, *43*(2), 305-313. DOI: https://doi.org/10.21831/cp.v43i2.63268

INTRODUCTION

Archery is a cyclical activity that involves close skills or abilities with constant or predictable stimuli that call for a stable response in movement (consistency). Repetitive and automatic movements are a hallmark of closed-skill sports (Napolitano, 2014). Consistency is the essential prerequisite when practising archery. Every archery technique, including body position, pulling, anchoring hands, transferring energy, aiming to release arrows and follow-up actions, must be performed consistently each time an arrow is fired. Failure to do so will reduce accuracy and impair shot results. Athletes in archery must stay still and shoot arrows at exact targets (Borges et al., 2020). Three key factors are necessary for success in sports: physical fitness, motor abilities, and mental preparedness (Yongtawee et al., 2022).

Statistics show that archery is a physically demanding sport that calls for strength, endurance, and excellent physical health, particularly in the upper body muscles (Basuki & Sudijandoko, 2019). Isotonic contractions occur in the muscles during archery techniques, particularly while drawing the bowstring during the initial draw. An isometric contraction happens when the arm pulling the bowstring is fully pulled, causing the fingers to touch the chin and become lodged beneath (anchoring). The arm holding the bow must also be locked, much like the pulling arm. In archery, the muscles used to draw the bowstring must be given particular attention since they exert extra effort in pulling and supporting the bow's weight, which is very heavy and occurs frequently in a sequence of archery actions. Because of this, these muscles need to be strong and able to draw the bowstring in a way that keeps it constant and consistent with the movement process (axis). Maintaining good physical health for archery will improve productivity at work (archery performance). Physical conditions are important, especially when enhancing the functions and systems of the body's organisms. These include (1) improved heart and circulatory system performance; (2) increased strength, flexibility, speed, coordination, VO max, and other physical attributes; (3) improved movement economy; (4) quicker organ recovery following training or competition, and (5) prompt response from the body's organism whenever necessary. To improve learning outcomes for archery skills, dominating physical circumstances must be modified to the unique requirements of the activity (Soegiyanto, 2011).

A good learning process can lead to good learning outcomes. A person's process determines whether an accomplishment is successful or unsuccessful. Athletes must be physically prepared to undergo training to achieve optimal outcomes (Zanada et al., 2023). In this instance, internal and external influences may impact a person's learning outcomes. Psychological, fatigue, and physiological (physical) elements are examples of internal components that assist the learning process. Three categories of external influences that impact learning can be distinguished: school-related factors, community-related factors, and family-related factors (Aji, 2016). Students enrolled in archery lectures in Health and Recreation Physical Education still need to achieve the best learning outcomes regarding their archery skills. Some students in the field still have tremors in their left hand when archery. Arm muscle strength is another issue affecting the learning outcomes of archery skills due to a lack of physiological capacity. Tremors experienced will influence the groping of arrows, which produces a loss of accuracy in archery due to tremors.

The branch of science, physiology, examines how the body's organs operate normally. Basic physiology, the study that examines the purposes and modes of operation of the body's organs, is a subset of physiology. At the same time, the science of sports physiology examines many bodily systems during activity and exercise, as well as physiological reactions and adaptations (Hita et al., 2022). Physiology tracks how human organs adjust to normal function under an activity load or exercise physiology over time, thanks to technological advancements in sports (Fitrianto et al., 2022). Every sport needs to consider physiological aspects, which are significant. By focusing on these factors, a methodical approach to learning will produce the best possible outcomes (Anggriawan, 2015).

Athletes who participate in archery must consider physiological factors. Being a static sport, archery calls for high strength and endurance, particularly in the upper body muscles. To maintain a strong performance from the beginning of the match to the finish, an archer needs to possess tremendous strength and good endurance. It is also crucial for the archer to shoot arrows with accuracy and force. Based on the state of the body's joints, muscles, and balance. Thus, to achieve the best possible results, joint flexibility and muscle strength are essential (Spratford & Campbell, 2017). Particularly in archery, physical fitness has a major impact on success or achievement. Arm muscular strength is one measure of an athlete's physical health that has a significant impact on archery performance (Choi & Ok, 2019; Park et al., 2016; Paz, 2018). In this instance, increased arm muscle power is required to aid with concentration and improve the accuracy of the discharged arrows.

Previous studies on the management of archery sports classes have been carried out by Setyawan et al. (2023a) and Setyawan et al. (2023b). However, this research has not examined the differences in learning outcomes in archery skills of 2019/2020 Physical Education Health and Recreation (PJKR) students regarding physiological ability factors in terms of muscle

strength. Thus, research is needed that focuses on discussing and testing this topic, to contribute to a deeper understanding of how physiological ability factors influence archery skill learning.

METHOD

This study employed a quantitative comparative methodology. It used a comparative methodology to examine how learning outcomes for archery skills vary among Physical Education, Health, and Recreation (PJKR) students based on the physiological ability element of arm muscular strength after the first, middle, and last shots. The research population was the Physical Education, Health, and Recreation (PJKR) students from the 2019/2020 academic year. Thirty students from classes A, B, C, D, and E made up the selected research sample using the cluster random sampling method.

This study used an archery test with 36 arrows fired at 15 meters as the data-gathering method. Students can shoot six arrows during each extended session, with a maximum of three minutes allotted for each shooting session (round). After being compiled and transformed into numerical values on a scale of 1 to 100, the archery skill scores were divided into three categories: initial shot score (browse), middle shot score (browse), and final score of the shot.

Descriptive and inferential statistics were employed in data analysis. One-way ANOVA, a technique used for one-way classification analyses, is predicated on observations of a single criterion or one component contributing to variance. The Kolmogorov-Smirnov normality test was used for data precondition testing, and a Levene's Test variant was used for homogeneity testing.

FINDING AND DISCUSSION

Finding

The results obtained from the research are in the form of raw data, which provides an overview of the variables involved in the study. Processing this data revealed the results for each archery shot studied, following successful data collection during the specified test period. These results are presented in Table 1.

The initial, mid, and final data (browse) are presented separately from the One-Way ANOVA analysis, which will be discussed in the following section. Table 2 presents the results describing research data on learning outcome differences in archery for Physical Education, Health, and Recreation (PJKR) students (2019/2020). These differences are based on arm muscular strength across initial, middle, and final shots.

Descriptive analysis revealed 30 data points for the initial, middle, and final shot skill scores. The average value of the initial shooting skill score (encroachment) was 36.97, with a standard deviation of 17.758. The middle-skill score was 51.43 (SD = 21.128), and the final shot skill score (encroachment) was 54.47 (SD = 21.208). Based on these results, the initial shooting skill scores (round) were the lowest, while the final shooting skill scores (round) were the highest.

Prerequisite test

The Shapiro-Wilk test was used to assess data normality. A significance level (α) of 0.05 was applied. If the Sig. value is greater than 0.05, the data is considered normally distributed. The initial shooting skill score (encroachment) had a Sig. value of 0.765, the middle-distance shooting skill score had a Sig. value of 0.398, and the final shot skill score (encroachment) had a Sig. value of 0.230. Since all Sig. values are greater than 0.05, the data can be considered normally distributed.

The homogeneity test was used to test whether the sample of this study has a variant of similar (homogeneous) data. Levene's Test was used to assess the data homogeneity. A significance level (α) of 0.05 was applied. If the Sig. value is greater than 0.05, the data is considered homogeneous. The Levene's Test statistic resulted in a Sig. value of 0.439, which is greater than 0.05. Therefore, the data can be considered homogeneous.

Table 1. Raw data on archery skill results

No	Name	Shot Result			Conversion Value		
		Beginning	Middle	End	Beginning	Middle	End
1	S1	28	8	32	60	17	68
2	S2	10	34	7	21	72	15
3	S3	12	38	6	26	81	13
4	S4	25	21	21	53	45	45
5	S5	14	12	31	30	26	66
6	S6	22	20	25	47	43	53
7	S7	12	35	28	26	74	60
8	S8	21	7	27	45	15	57
9	S9	12	21	10	26	45	21
10	S10	20	34	19	43	72	40
11	S11	7	27	34	15	57	72
12	S12	22	34	43	47	72	91
13	S13	23	18	7	49	38	15
14	S14	0	11	25	0	23	53
15	S15	23	26	24	49	55	51
16	S16	30	37	34	64	79	72
17	S17	27	21	27	57	45	57
18	S18	18	17	34	38	36	72
19	S19	11	15	33	23	32	70
20	S20	17	43	21	36	91	45
21	S21	11	12	26	23	26	55
22	S22	11	33	26	23	70	55
23	S23	19	38	31	40	81	66
24	S24	0	15	47	0	32	100
25	S25	36	28	15	77	60	32
26	S26	11	20	22	23	43	47
27	S27	16	30	33	34	64	70
28	S28	23	16	16	49	34	34
29	S29	16	29	26	34	62	55
30	S30	24	25	33	51	53	70

Table 2. Results of descriptive data analysis

Archery Skill Score Results	N	std. Deviation	Means
Shot (Round) Early	30	17,758	36,97
Middle Shot (Round)	30	21,128	51,43
Final (Round) Shot	30	21,075	54

Hypothesis test

Research hypothesis testing is based on data analysis and interpretation, particularly the results of a one-way ANOVA analysis. One-way ANOVA, a one-way classification analysis, examines the influence of a single factor on observed variation. In this study, the one-way ANOVA test is used to determine whether there are differences in learning outcomes for archery skills among students in the 2019/2020 Health and Recreation Physical Education (PJKR) class. The factor of interest is arm muscle strength, assessed through initial, middle, and final shooting skills. The one-way ANOVA test employs a significance level (α) of 0.05 for decision-making. A Sig. value less than 0.05 (Sig. < 0.05) leads to rejection of the null hypothesis (H_o) and acceptance of the alternative hypothesis (H_a). Conversely, a Sig. value greater than 0.05 (Sig. > 0.05) results in retaining H_o and rejecting H_a.

The one-way ANOVA analysis yielded a significant result (Sig. = 0.003 < 0.05). This indicates a statistically significant difference between the average learning outcomes for the initial shot, the middle shot, and the final shot. Therefore, the null hypothesis (H_0) stating no difference in learning outcomes between initial, middle, and final shots is rejected (Sig. < 0.05). This supports the alternative hypothesis (Ha) that there are in fact differences. Given this finding,

further analysis using Post Hoc Tukey's HSD test is employed to conduct multiple comparisons among the means of initial, middle, and final shot scores.

Tukey's post hoc follow-up test

A Post Hoc Tukey HSD test was performed to make multiple comparisons and to determine whether the mean of the resulting scores on the dependent variable is significant in the total analysis of variance. Table 3 presents the results of the Tukey HSD test, detailing the mean differences between each pair of shot types.

Table 3. Post hoc test results

(I) Shot (Brown)	(J) Shot (Brown)	Mean Difference (IJ)	Std. Error	Sig
Shot (Round) Early	Middle Shot (Round)	-14,467*	5.177	.017
	Final (Round) Shot	-17,033*	5.177	.004
Middle Shot (Round).	Shot (Round) Early	14.467*	5.177	.017
	Final (Round) Shot	-2,567	5.177	.873
Final (Round) Shot	Shot (Round) Early	17.033*	5.177	.004
	Middle Shot (Round)	2,567	5.177	.873

Differences in early and middle-round shots

The mean difference in student archery learning outcomes between the initial and middle shots is -14.467. This value indicates a gap in the achievement of learning outcomes in students' archery skills in the initial shot (round) and the middle shot (round). The multiple comparisons output reveals a significance value of 0.017, which is lower than the predetermined alpha level of 0.05. Therefore, the difference in learning outcomes between the initial and middle shots can be considered statistically significant.

Differences in early and final-round shots

The mean difference in student archery learning outcomes between the initial (browse) and final (browse) shots is -17.033. This substantial difference suggests a notable improvement in the achievement of learning outcomes for students' archery skills at the initial shot (round) and the final shot (round). The multiple comparisons output reveals a significance value of 0.004, which is considerably lower than the established alpha level of 0.05. Therefore, the difference in learning outcomes between the initial and final shots can be considered statistically significant.

Differences in middle and final-round shots

The average difference in student archery learning outcomes between the middle and final shots is -2.567. While this difference exists, it is not statistically significant based on the multiple comparisons output (Sig. = 0.873 > 0.05). This suggests that students' archery skills in the middle shot are likely similar to their skills in the final shot.

Discussion

This research aims to determine differences in learning outcomes for archery skills for Physical Education and Recreation (PJKR) students in terms of the physiological ability factor of arm muscle strength resulting from the initial shot (round), middle shot (round), and final shot (round). Sports physiological factors in archery are important. The most important physiological mechanisms in archery are the heart rate and the moment when launching the arrow (Guru et al., 2020). The ideal archer must master simple overall shooting techniques. All movements should be smooth and natural. From head to toe, the archer's entire body must be composed and balanced without stress; mentally and physically, it must be relaxed but alert (Axford, 1995). Research shows that shots that hit the center of the target create momentum, resulting in better performance. Apart from that, vital fitness and motor skills, upper body muscle strength, and core muscle strength also influence the performance of a class archer (Taha et al., 2018). Susandi and Wikananda (2018) in their research showed the results of physiological observations on archery athletes, with the highest pulse rate of 96 beats/minute, energy consumption of 2.13294

kcal/minute, oxygen consumption of 0.4266 liters/minute, and cardiovascular 21.97%. All research results show a very light category. In line with that, Fahrizqi et al. (2021) revealed that archery is a sport that does not require many movement skills and is very simple. However, good upper body components are necessary for consistent archery movements, including arm muscle coordination, arm muscle endurance, shoulder strength, and support for back strength and endurance. A study conducted in Korea showed that fitness is an important factor in the performance of archery athletes apart from mental and skill factors (Kim et al., 2015).

The results of the descriptive analysis test showed differences in the average scores of students' learning outcomes for archery skills. The results showed that in the initial shot (crop), students had an average score of 36.97. In mid shot (crop), students had an average score of 51.43; at the final picture taking (browse), students had an average score of 54.00. This data shows that Physical Education and Health and Recreation (PJKR) students who take archery courses can launch arrows well, and they get an increase in scores at each stretch. This aligns with research conducted by (Hamdan et al., 2022) that showed an increase in the initial shot of 51.17, and the second shot had an average value of 52. According to Yachsie (2019), arm muscle strength and stability are important because archery requires calm and high accuracy to release the arrow right on target. With strong arm muscles, an archer can stretch the bow with maximum pull, making the arrow go faster to the target. Other research shows that regular aerobic endurance training can help athletes regulate their heart rate and improve their shooting ability (Umar & Fadilla, 2019). Research conducted by Yachsie et al. (2021) proved a significant relationship between athlete concentration and shooting accuracy, where the better the athlete's concentration, the better the shooting accuracy. Other research shows a significant relationship between physical fitness, muscle strength, cardiovascular endurance, and concentration levels (Krissanthy et al., 2020).

Based on the results of the One-Way Anova variance test, the significance value is $0.003 < 0.05$, which means that there is a significant difference in the average learning outcomes of archery skills of Physical Education Health and Recreation (PJKR) students in terms of the physiological ability factor of arm muscle strength resulting from initial shots (round), middle shots (round), and final shots (round). Archers develop specific muscle strategies and aiming habits, and posture sway is applied to produce better shots (Tinazci, 2011). Research (Humaid, 2014) shows that arm muscle strength directly affects archery performance. In the shooting motion of archery, the tendency of left asymmetry in maximal muscle use can increase the robustness of the left humeral bone, and specific individual activity patterns suggest that archery can be identified using skeletal features related to muscle activity (Sládek et al., 2022).

In the first Tukey Post Hoc follow-up test, it was found that the Output Multiple Comparisons had a Significance value of $0.017 < 0.05$, so it can be concluded that there is a difference in the achievement of student archery skills learning outcomes between the initial (browse) shot, and the mid (browse) shot. This is supported by research conducted by Wattimena (2020) that there is a difference between the pre-test and post-test on the 10-meter archery score after treatment in the form of visualization and relaxation methods. Research conducted by Rampp et al. (2022) also showed differences in the results of shooting from 3 archery training sessions carried out for 3 days, participants shot 100 arrows each session, and significant differences were seen from the average results of the first 10 shots and the last 10 shots. Other research shows that the archery shot accuracy test on the 30-meter pre-test and post-test data shows an increase in the average shooting results in the post-test after treatment in the form of arm muscle training (Yachsie et al., 2022). Then Susanto (2015) in his research revealed significant differences in the accuracy of aiming at the pre-test, middle, and post-test after circuit training.

In the second Tukey Post Hoc follow-up test, it is known that the Output Multiple Comparisons has a Significance value of $0.004 < 0.05$, so it can be concluded that there is a difference in the achievement of student archery skills learning outcomes between the initial (browse) shot and the final (browse) shot. This follows research conducted by Kurnia (2017) that there are differences in pre-test and post-test scores at a distance of 25 meters after being given a plank exercise. Another research conducted by Fahrizqi et al. (2021) showed that circuit training by targeting the shoulder and back muscles could affect archers during the phases of pulling the

bow, holding the weight of the bow, and holding the string just before the arrow is released so that it can hit the desired target. Weight training exercises (bench press and full lateral downs) which increase arm muscle strength, also positively affect archery performance (Bernhardin & Pasundan, 2021). In addition, the anchoring technique in archery requires good finger muscle strength, push-up exercises using the fingers as support have been shown to increase finger muscle strength (Hardi, 2018).

In the third Tukey Post Hoc follow-up test, it is known that the Output Multiple Comparisons has a Significance value of 0.873 > 0.05, so it can be concluded that there is no difference in the achievement of student archery skills learning outcomes between mid and final shots. This finding aligns with research by Septiana et al. (2020) which found a decrease in recorded scores among the three female PPLP DIY athletes.

CONCLUSION

Arm muscle strength is the ability of the muscles to overcome resistance or load in carrying out activities such as holding or moving weights. Someone with good muscle strength can do and carry heavy work for a long time. In archery, the strength of the push depends on the power that arises due to the pull on the bow, where the energy obtained from the pull is converted into thrust when the arrow is released. This study proves it by holding the bow pull with the time specified for everyone. It can be seen based on the results of the One-Way Anova variance test showing a significance value of 0.003 <0.05, which means that there is a significant difference in the average learning outcomes of archery, namely between the initial shot (round), the middle shot (round), and the final shot (encroachment). The test results show that the hypothesis stating that there are differences in the learning outcomes of archery skills of Physical Education Health and Recreation (PJKR) students between the initial shot (round), the middle shot (round), and the final shot (browse) is accepted. H_o is rejected because the Sig value < 0.05, and H_a is accepted. Then, the Post Hoc Tukey additional test analysis can be carried out. With a significance value of 0.017 < 0.05, the post hoc test findings show a significant difference in the average learning outcomes of students' archery skills between the first and middle shots. With a significance value of 0.004 < 0.05, there is a significant difference in the average learning outcomes of student archery skills between the first and final shots. Furthermore, with a significance value of 0.873 > 0.05, there is no discernible difference between the average learning outcomes of students' archery skills between center shots and final shots.

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