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STUDY ON THE STABILITY AND POSITIONING OF THE SHOULDERS ON THE POINTS AND ACCURACY IN ARCHERY

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ABSTRACT
The structure of competitive archery is part of a highly coordinated group of sports. Purpose: to examine the technical readiness of Bulgarian archers concerning shoulder stability and positioning. Methods: The study involved 18 archers. The Noraxon U.S.A., Inc. Mio Motion (2014) devices were used to measure shoulder stability and position during six indoor shots at 18 m. The following angular parameters were considered: Shoulder Total Flexion, RT Shoulder Total Flexion, LT Shoulder Flexion, RT Shoulder Flexion, LT Shoulder Abduction, RT Shoulder Abduction, LT Shoulder Rotation–out, and RT Shoulder Rotation–out. The data were analysed mathematically using descriptive statistics and correlation analysis. Results: Descriptive statistics show that some parameters are highly variable—LT Shoulder Rotation–out and RT Shoulder Rotation–out. Shoulder rotation–out stability is essential for the technical preparedness (points and accuracy) of archers. Discussion: This research provides evidence that the factors studied regarding an archer's readiness can more precisely refine and stabilise their performance.

Keywords: archer’s stability, preparedness, technical preparation

INTRODUCTION

Archery is a highly coordinated sport where, in addition to selecting materials and setting individual parameters, shot accuracy is heavily influenced by technical execution. Consistency in training and acquiring adequate skills through focused practice are essential for reaching the highest competitive levels. Archery involves four key components: shooting technique, physical abilities, mental skills, and proper equipment (1). Sportsmanship in archery requires substantial physical training, which closely relates to the technical effectiveness of the shot. Competitions and training often occur during continuous shooting in various and sometimes challenging weather conditions, leading to significant energy expenditure and both physical and psychological fatigue. This highlights the importance of developing endurance and resilience to achieve top results (2). Lee, J., & Hwang (3) examine factors contributing to athletes' successful shots.

They found that athletes’ physical data and the stability of the second phase (bow tension and stabilisation) account for a considerable proportion (55.4%). Respondents identified balance and correct hand positioning as crucial in executing good shots, as well as in controlling and increasing accuracy when shooting Xs and tens. Other authors state that the main factors influencing technique effectiveness include the ability to shoot with correct and consistent rhythm, maintain a dynamic structure, and control the kinetic properties and stability of motor actions throughout all shot phases. The athletes’ strength qualities largely influence their control and coordination abilities (4-7). The upper limbs play a vital role in archery, being closely linked to a person’s shooting ability (8). Lachance et al. (9) underscore the importance of stability in the shoulder and body, emphasising precise control of the shoulder girdle and scapular muscles during the tension and release phases. They highlight that strengthening the deltoid and trapezius muscles is vital for maintaining shoulder stability and enhancing performance. Movements during each archery phase are crucial for shot accuracy and for maintaining and improving archer stability (10). The bow, a mechanical device, must produce consistent impact on the target by affecting it similarly each time. The aim for each competitor is to execute identical shots that result in grouped, more precise hits. Physical conditioning influences a competitor’s ability to manage each shot properly.

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This study aimed to assess the technical preparedness of Bulgarian archers concerning stability and shoulder position. While there are limited studies focusing specifically on the shoulder joint, the body of literature on stability is significantly more extensive.

METHODS

This study was conducted in an 18-metre hall under controlled conditions to eliminate the influence of external factors such as wind, rain, and uneven terrain that might affect the outcomes. Eighteen elite shooters were observed and recorded as they fired six shots each. The target used in the experiment measured 40 cm, with vertically spaced triple five-sector zones. The bows were assumed to be well-balanced, ensuring they did not negatively impact the system's stability. This allowed focus to be placed on the proper execution and accuracy of the shot.

The Noraxon U.S.A., Inc. Mio motion apparatus (2014) was used to measure stability and shoulder position during the shots. The following angle parameters were considered: 'full shoulder flexion', 'RT full shoulder flexion', 'LT shoulder flexion', 'RT shoulder flexion', 'LT shoulder abduction', 'RT shoulder abduction', 'LT shoulder rotation-out' and 'RT shoulder rotation-out'. The data obtained were processed mathematically using descriptive statistics.

RESULTS

Table 1 presents the mean values and variability of the researched indicators.

Table 1. *Descriptive statistics of the studied indicators (mean values, max, min, standard deviation and coefficient of variation)*

	AVERAGE						MIN						MAX						S						V%					
SHOTS	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
LT Shoulder Total Flexion	75.5	75.2	74.3	74.8	74.6	75.0	65.4	67.4	64.6	65.2	65.1	65.4	88.6	88.4	82.0	83.1	82.6	82.0	5.8	5.6	4.9	4.8	4.6	4.7	7.7	7.4	6.6	6.4	6.2	6.3
RT Shoulder Total Flexion	119.3	119.7	119.7	118.9	119.2	119.2	100.3	102.6	105.5	102.3	103.0	104.1	140.6	142.4	134.9	135.4	136.7	135.9	12.4	12.5	10.7	11.7	11.3	11.2	10.4	10.5	8.9	9.9	9.5	9.4
LT Shoulder Flexion	53.2	53.0	55.9	54.4	53.1	54.0	28.4	30.3	35.1	21.1	19.6	23.4	88.1	87.6	77.6	78.2	76.8	78.5	17.4	17.6	16.2	17.1	17.2	16.6	32.7	33.3	29.0	31.4	32.4	30.8
RT Shoulder Flexion	132.4	134.1	135.0	133.0	134.4	134.5	102.2	105.2	107.8	103.5	104.6	105.9	164.5	169.2	167.4	167.2	165.1	164.8	19.1	19.7	18.4	18.4	17.8	18.5	14.4	14.7	13.7	13.8	13.2	13.7
LT Shoulder Abduction	74.5	73.9	72.5	72.8	72.7	73.0	65.3	66.7	64.3	65.1	65.0	65.3	88.0	87.9	80.5	81.8	81.4	80.6	5.7	5.4	4.4	4.7	4.4	4.2	7.6	7.3	6.0	6.4	6.0	5.8
RT Shoulder Abduction	126.8	126.6	126.9	127.5	126.9	126.5	108.4	109.6	109.8	105.5	107.9	107.4	149.6	149.4	148.7	150.8	149.3	148.6	13.3	13.2	11.9	13.2	12.5	12.0	10.5	10.4	9.4	10.4	9.9	9.5
LT Shoulder Rotation - out	3.4	16.2	8.9	18.1	14.3	15.0	-129.0	-38.1	-43.5	-28.0	-36.4	-39.0	113.1	162.9	162.9	160.6	165.3	163.4	53.2	48.6	50.0	49.5	49.5	51.3	0.0	0.0	0.0	0.0	0.0	0.0
RT Shoulder Rotation - out	-48.5	-48.9	-47.7	-49.4	-45.8	-45.7	-80.7	-84.3	-90.0	-96.6	-93.1	-90.5	-10.1	-4.6	-11.1	-4.1	-5.9	-10.6	25.6	27.1	28.1	30.4	30.1	28.6	52.8	55.4	59.0	61.7	65.8	62.5

Figure 1 compares the average values of the indicator "complete flexion of the left shoulder" across the six shots. All shots exhibited similar average values.

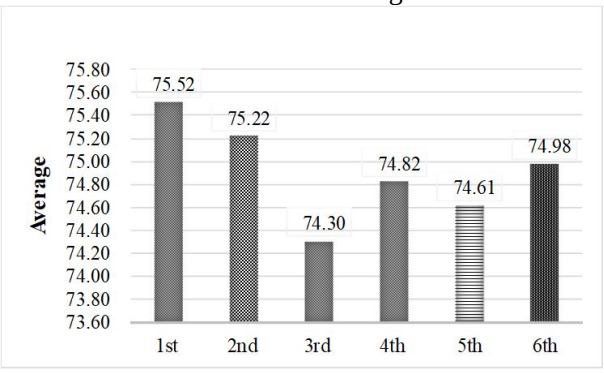

Figure 1. LT Shoulder Total Flexion

In **Figure 2,** the coefficient of variation ranges from 6% to 8%, indicating that the sample for this indicator is homogeneous.

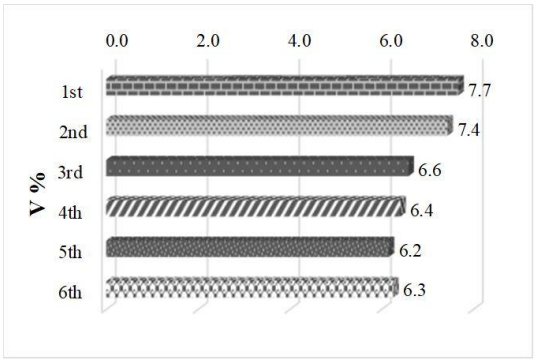

Figure 2. LT Shoulder Total Flexion

For the indicator *"complete flexion of the right shoulder"* **(Figure 3),** comparable mean values were noted between individual shots, with the most significant variation occurring between the third and fourth shots. However, even in this case, the difference did not exceed 1%.

The coefficient of variation **(Figure 4)** shows that most values are below 10%, indicating low variance.

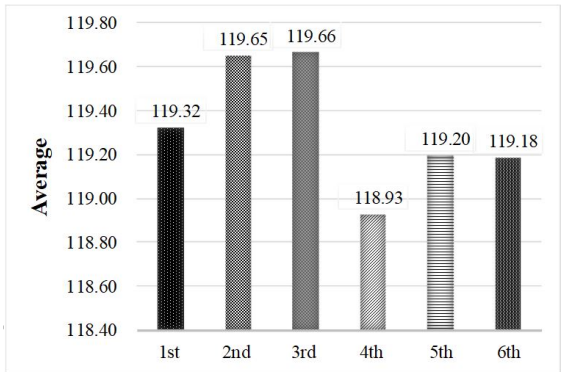

Figure 3. RT Shoulder Total Flexion

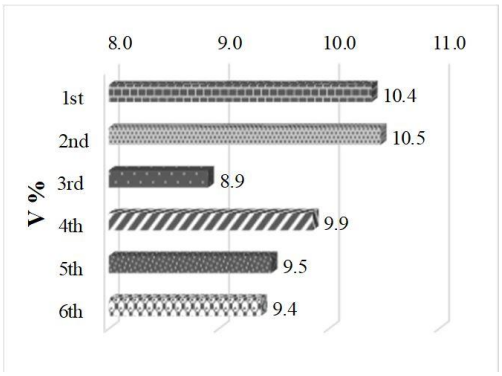

Figure 4. RT Shoulder Total Flexion

Figure 5 presents the mean values for the *'left shoulder flexion'* trait. The data show similar values across the six shots, with differences ranging from 52.96 ± 17.6 to 55.92 ± 16.21 degrees. Similarly, the minimum and maximum values show minor differences: Min, 19.6 to 35.1 degrees; Max, 70.6 to 88.1 degrees. For the coefficient of variation **(Figure 6)**, the values are higher, with a maximum of V = 33.3%, indicating that the variance of the trait is significant. This underscores the importance of our research, as the sample is heterogeneous concerning this trait.

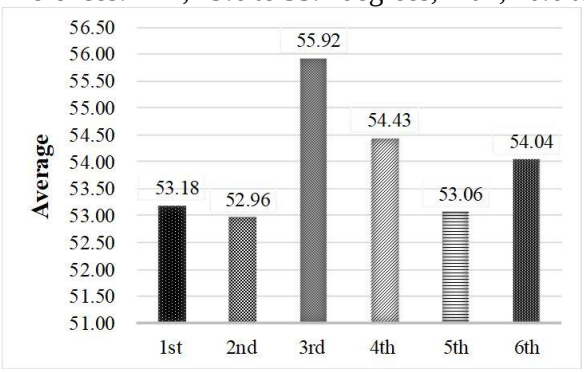

Figure 5. LT Shoulder Flexion

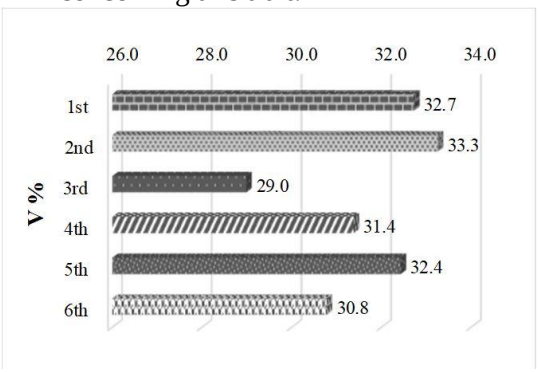

Figure 6. LT Shoulder Flexion

In the "right shoulder flexion" study data **(Figure 7),** values ranged from 132.36 ± 19.05 to 134.96 ± 18.45 degrees. The coefficient of variation **(Figure 8)** indicates a difference of up to 1% across the different shots, suggesting that the sample is approximately homogeneous (V = 13.2% to V = 14.7%).

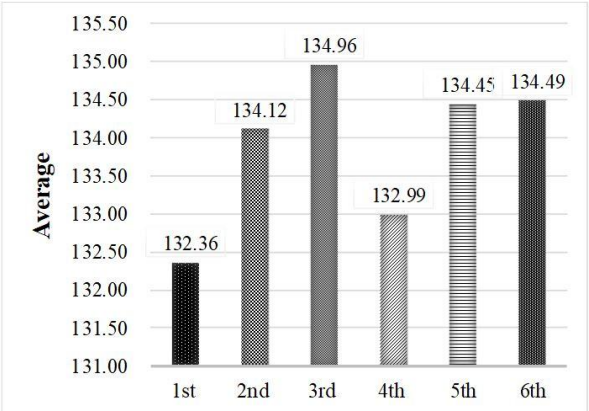

Figure 7. RT Shoulder Flexion

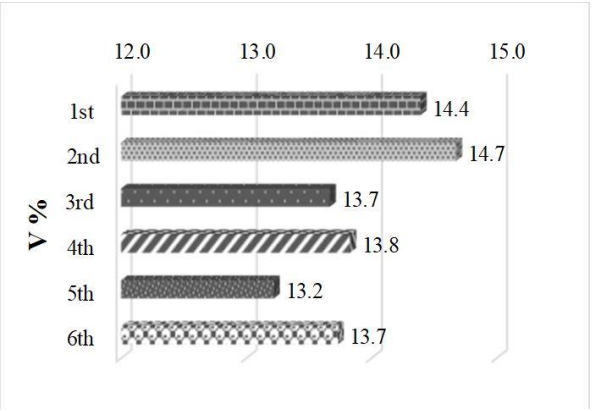

Figure 8. RT Shoulder Flexion

The data in **Figure 9** reflect "left shoulder abduction"; here, the mean values range from 72.52 ± 4.36 to 74.50 ± 5.67 degrees. The coefficient of variation in all six shots ranged from 5.8% to 7.6%, indicating high homogeneity of the sample **(Figure 10).**

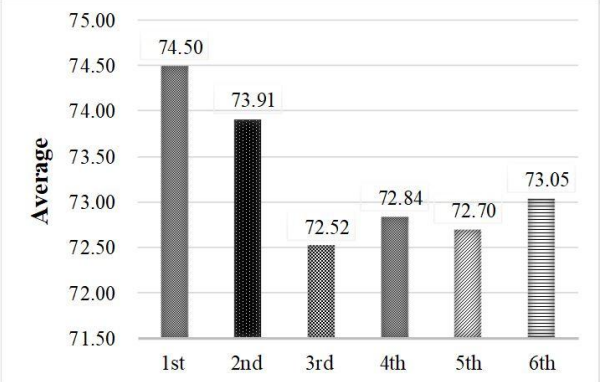

Figure 9. LT Shoulder Abduction

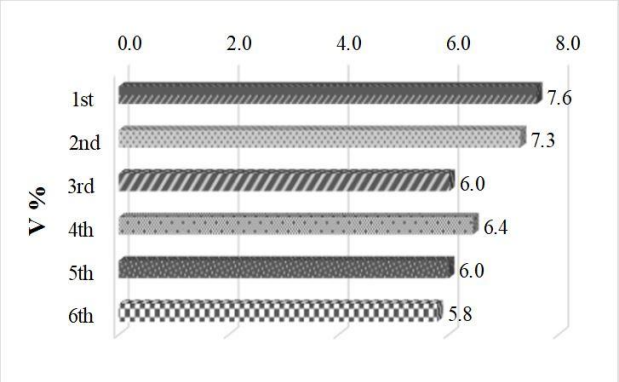

Figure 10. LT Shoulder Abduction

For the "right shoulder abduction" index **(Figure 11),** the mean values are close, ranging from 126.54 ± 12.02 degrees to 127.46 ± 13.23 degrees. In contrast to all previous indicators, the coefficient of variation **(Figure 12)** is the highest here, at V = 35%. The values extend beyond 100% (V = 126.54% to V = 127.46%), indicating extreme heterogeneity of the sample concerning this metric.

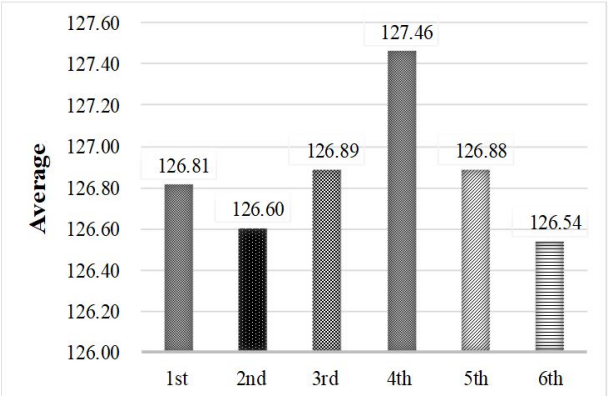

Figure 11. RT Shoulder Abduction

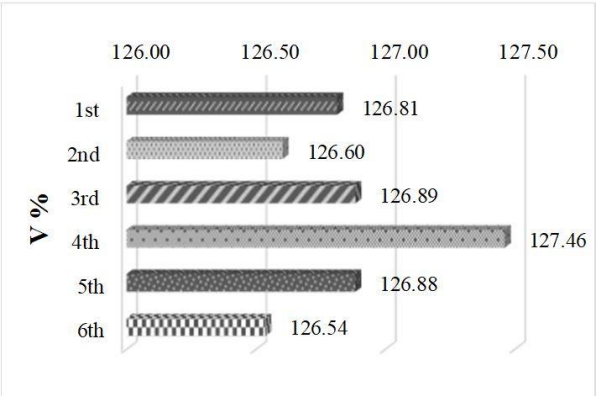

Figure 12. RT Shoulder Abduction

The data in **Figure 13** reflect a "backwards rotation of the left shoulder," with mean values varying over a larger range, from 3.39 ± 53.17 degrees to 18.09 ± 49.47 degrees. In addition to the notable variations between shots, substantial disparities in minimum and maximum values were also observed. The standard deviation (S) was also the largest for this parameter, reaching a value of 53.2.

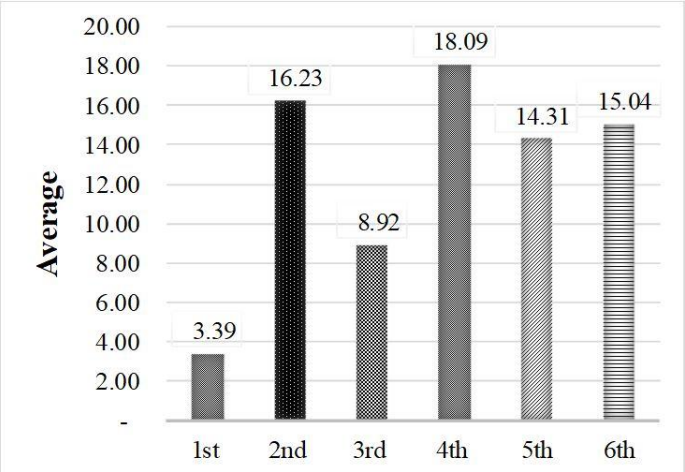

Figure 13. LT Shoulder Rotation - out

In the study of "right shoulder outward rotation" **(Figure 14),** mean values ranging from -45.72 ± 28.56 degrees to -49.37 ± 30.45 degrees were observed, which lie within a relatively narrow range.

However, the differences between the minimum and maximum values are significant. The coefficient of variation for "right shoulder outward rotation" ranged from 52.8% to 65.8%, indicating considerable heterogeneity among the studied archery athletes in this parameter **(Figure 15).**

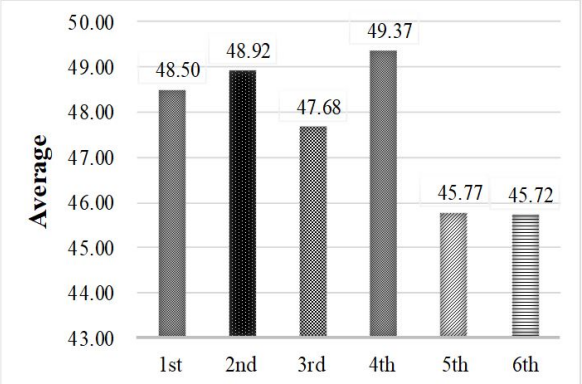

Figure 14. RT Shoulder Rotation – out

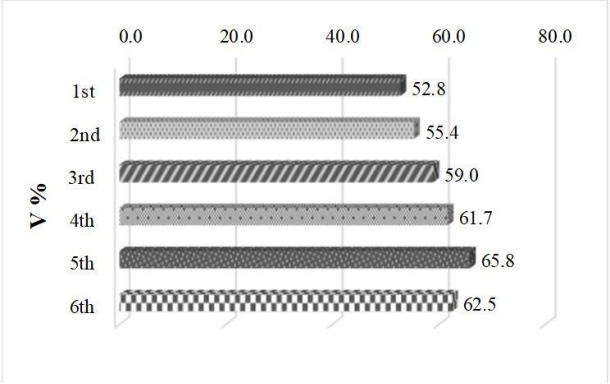

Figure 15. RT Shoulder Rotation - out

DISCUSSION

The stability of the bow-shooter system determines the accuracy of hits. Stability is affected by external factors, including weather conditions, wind strength and direction, terrain irregularities, noise, and the presence of spectators. Additionally, it is influenced by the bow balance setting and the morpho-functional characteristics of the archers. Good physical data helps the archer align both the bow and all parts of their body in certain positions and exert control throughout the entire process, from preparation to the completion of the shot.

The study of "full flexion and abduction of the left and right shoulder" determines the position of the bones and joints relative to each other.

One of the primary objectives of this study is to position the forearm in a manner that ensures the load is distributed along the bone and joint axes, with the musculature responsible solely for controlling these positions. The mean values and variability of the indices for each of these, separately for the six shots studied, show little variability, rarely exceeding V = 10%-12 %. All these indicators influence the hits of the shots in the same manner **(Table 2).**

Table 2. *Average results from 6 shots*

Sequence of the shots	***Overall average score***	***Total number of hits off target (0 points)***
First shot	8,3	0
Second shot	7,5	1
Third shot	8,5	1
Fourth shot	8,0	2
Fifth shot	7,7	2
Sixth shot	7,6	2

The only indicator that exhibits significant differences regarding minimum and maximum values, both in absolute terms, is the "rotation of the left shoulder" outward. What stands out about this indicator is the marked difference in the minimum values of 'left shoulder rotation outwards'. The minimum values show considerable differences, whereas the maximum values are pretty similar. This leads to a significant contrast when compared to the average values of all other shots. When contrasting this data with the average shot values, it becomes evident that the influence of "left shoulder outward rotation" is a crucial factor that strongly affects hit rates. The "left shoulder rotation" also impacts shots that fall outside the boundary of the six and are recorded as zero points.

CONCLUSION

Data analysis revealed that "left shoulder outward rotation" significantly affects shot accuracy. Maintaining the position of the left shoulder from the moment of "butt" to the moment of "shot" results in highly accurate hits. Conversely, when "left shoulder outward rotation" occurs during the "shot," hits deviate significantly from the center of the target.

This study concludes that the factors influencing archery performance and stability are directly linked to the archer's level of technical training.

LIMITATIONS

The study was conducted indoors (in a hall), and if it were done outdoors (in a stadium), the results might be different due to weather conditions.

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