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Comparison of Joint Position Sense in Competitive Recurve Archers and Non-Archers in the Age Group of 15-19 Years Old: A Cross Sectional Study

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ABSTRACT

Background: Archery is a sport requiring shoulder proprioception.
Objectives: This study aims to compare active joint position sense at shoulder joint of archers and non-archers.
Methods: In this cross-sectional observational study, competitive recurve archers and non-archers playing recreational sports were administered an active shoulder joint repositioning test with eyes closed. Three tries were given to accurately replicate administered joint position.
Results: Archers showed more accuracy in active joint repositioning than non-archers.
Conclusion: Archers have better shoulder joint position sense than non-archers.

Keywords: [archery, shoulder, proprioception]

INTRODUCTION

Archery is an ancient sport involving the use of a bow to aim and shoot arrows. By definition, archery is "a precision sport requiring archers to hit targets at various distances depending on the type of archery." [(1)] The stages of shooting an arrow include six phases: Bow holding, drawing, full draw, aiming, release, and follow through. It has now evolved into a competitive sport played at various levels including the highest, the Olympics. Apart from this, it can be done recreationally and is still used as a tool for food gathering in some tribal communities around the world. Proprioception is defined as "rate of movement sense, alternatively known as kinesthesia or joint position sense." [(2)] This term is mostly used for static joint position sense while dynamic joint position is called kinesthesia by some authors. It is carried from peripheral joints to the CNS by general somatic afferents (GSAs) through the dorsal column tract. Proprioceptors are present in skin, fascia, muscle spindle, tendon, joint capsule, ligaments and the labyrinth. Out of these areas, muscle spindle and Golgi tendon apparatus are present in muscles and tendons respectively, while all other sites have Pacinian corpuscles and free nerve endings. In small joints like the fingers, much of proprioception is sensed by the tactile receptors in the skin. Determining joint angulation in the middle of the total range of motion is a sense mediated via the muscle spindle, but for larger joints like the shoulder, deep receptors present in the tendons and capsule like Pacinian corpuscles and Ruffini endings are more useful. Proprioception is an important sense for archers since archery is a target-oriented sport. An archer uses their whole body to achieve maximum stability while shooting. The entire kinematic chain of the upper limbs bilaterally is involved in archery, but each

joint has contributions varying in proportion. The shoulder joint being the most proximal, acts as an important stabilizer for both the bow arm as well as the drawing arm, along with muscles of the scapula and back. It is the joint that provides the greatest mobility with multiplanar ranges of motion. The primary positioning of the bow and arrow before the actual release of the arrow happens at the shoulder, making it an important joint to assess in terms of joint position sense. The main movements needed in archery at the bow arm are glenohumeral abduction, extension and external rotation. [(3)] Archers need to replicate the same joint position for a target each time an arrow is fired to increase the chances of scoring the most points. Archery is a sport which requires different physiological movements in the drawing arm and bow arm. This leads to the respective muscles being activated, which are not the same. Hence the proportion of muscle training in terms of strength and proprioception must be carefully balanced. To ensure the same joint position every-time, maximum muscular coordination is necessary.

Need for study

Archery coaching historically, has not been modified greatly by biomechanical discoveries. Training of athletes is done by coaches and veteran players based on their experience and specific techniques and styles. There is not a lot of awareness about a regimen which incorporates not only strengthening, but different skills specific to archery like scapular stabilization and proprioceptive exercises. Owing to the COVID-19 pandemic too, for the past two years, physical training of athletes has been greatly affected. Improper training can lead to altered muscle activation, which can lead to impairments like rotator cuff injury, impingement syndrome, scapular dyskinesias, bicipital tendinitis etc. Since joint position sense receptors send information via the muscle spindle, any imbalance in muscular activity can lead to altered joint position sense. Any alterations measured, in time, can lead to early correction of the problem leading to safer archery practices. Based on which group shows lesser repositioning errors, some of their practice drills can be incorporated in the other target group to improve proprioception. This study aims to assess active joint repositioning sense in the archers' bow shoulder and compare it to the non-dominant shoulder of non-archer individuals in the same age group.

Aim

1. To assess active joint repositioning sense in the archers' bow shoulder and compare it to non-archer individuals in the age group of 15-19 years.

Objectives

1. To assess joint position sense of abduction and external rotation at 30 and 60 degrees of the bow arm in archers.
2. To assess active joint position sense of abduction and external rotation at 30 and 60 degrees in non-archer individuals in the non-dominant arm.
3. To compare active joint position in bow arm of archers and non-dominant shoulder of non-archer individuals in the age group of 15-19 years.

Hypotheses

- Null hypothesis: There is no difference in joint position sense of recurve competitive archers and non-archers in the age group of 15-19 years old.
- Alternative hypothesis: There is a difference in joint position sense of recurve competitive archers and non-archers in the age group of 15-19 years old.

LITERATURE REVIEW

1. Banafsheh Rajabzadeh, Ali Amiri et al in Function and Disability Journal in March 2019[(3)] evaluated "The Effects of Shoulder Kinesio Taping on Shooting Accuracy and Joint Position Sense in Female Archery Athletes." The subjects were female recurve archers with a mean

age of 24 years. The authors evaluated the active joint repositioning sense test for external rotation of the shoulder at 30 and 60 degrees using an inclinometer. These ranges were chosen since the ROM at the shoulder during maximum stretch position is between this range. The archers were then asked to shoot three arrows at 18, 30 and 50 meters abiding by proper guidelines of the archery federation. Afterwards, kinesio-tape was used to tape the deltoid and supraspinatus muscles and the above procedure was repeated. The results were that taping improved the accuracy in the archers in all three ranges of shooting. Accuracy was increased by reduction of the error in the 60-degree position in the joint repositioning test, no significant difference was found in the 30-degree angle. This is postulated to have occurred since maximum stretch on the bow is applied during 60 degrees of external rotation of the glenohumeral joint. Since taping was done on the posterior deltoid and supraspinatus, this provided additional sensory feedback leading to increased accuracy of joint positioning.

2. Tabitha Dorshorst in her study submitted to the University of Massachusetts Amherst in October 2019 titled "Archery's Lasting Mark: A Biomechanical Analysis of Archery" [(4)] has analyzed humeral asymmetries seen in archers from an evolutionary perspective. The aim was to analyze the humeral bone loading happening in archery from a biomechanical perspective in both the bow arm as well as the drawing arm. The author has given a detailed account of the muscles being activated in the bow and drawing arm with the help of surface EMG and motion capture. Key muscles associated with archery are the triceps, biceps brachii, latissimus dorsi, pectoralis major, deltoid and brachialis. The joint angles for the draw arm lead towards movements of elbow and shoulder flexion, internal rotation of the glenohumeral joint. The bow arm shows greatest activation of the lateral deltoid and long and lateral head of the triceps brachii, indicating abduction and extension. The author has observed that there were some variations between muscle activation of the drawing arm and bow arm, which is significant. There was maximal activation of the triceps brachii in the bow arm while the biceps brachii was the most active on the drawing arm. Ranges of motion for the draw arm and bow arm were found differing maximally at the elbow joint, no other significant differences were found. No differences were found based on levels of experience.
3. Archery Australia Inc. Coaching and Standards Committee, Shooting Techniques: Biomechanics, version 4 June 2010 [(5)] enlists guidelines made specifically for archers to direct them towards the ideal shooting technique. When the bones and axial muscles take more of the load, the limb muscles have a lesser chance of being overloaded. Since bones cannot experience fatigue like soft tissues, orientation of muscles should be such that the archer can make maximum use of the levers occurring naturally in the human body. This can happen only when the archer can align the forces along the line of the bone and through the joint. The optimum posture leads to a good draw force line which is biomechanically efficient. The draw force line ideally passes through the bow hand to the drawing hand and drawing elbow. It also enumerates the components of the correct orientation of the bones in the upper limb at various joints and how to prevent injury.
    - Ideal position for the bow arm: Stand upright,
    - Elevate arms to shoulder level without glenohumeral rotation, palm facing downward.
    - The ulna and radius should be in line without pronation or supination. The bow shoulder should be as close to the arrow as possible.

- The bow shoulder should be as close to the line of force as possible to engage minimum muscles and avoid fatigue. Archers should not roll the bow shoulder inwards, i.e., rotate the glenohumeral joint internally. Doing so will engage the internal rotators and cause fatigue. Instead, they should push the bow shoulder medially towards the bowstring, which is easily possible since the shoulder joint has ample of mediolateral motion possible.

4. Carpenter, Ralph et al from the Orthopaedic Research Laboratories, MedSport, Section of Orthopaedic Surgery, University of Michigan, Ann Arbor, Michigan in 1998 have studied "The Effects of Muscle Fatigue on Shoulder Joint Position Sense."[6] effect of muscle fatigue and its corelation to proprioception was tested in 20 healthy volunteers with no history of shoulder derangements. The threshold to first detection of humeral rotation was used as the marker with the arm in 90 degrees of abduction and 90 degrees of external rotation. The dependent variables for proprioception were taken to be arm dominance, direction of rotation, and muscle fatigue. Results showed that fatigue increased the threshold of the first detection of rotation by up to 173% of pre fatigue values. This indicated that fatigue hampers shoulder joint stability. Loss of normal muscular coordination can be seen. Hypothetically, endurance training might improve this loss of proprioception post fatigue, thereby making this study clinically significant for rehabilitation of the upper extremity in athletes.

MATERIALS & METHODS

Inclusion criteria

1. Age: between 15-19 years.
2. Archer's training hrs./week: 7 at least.
3. Practicing archery for 4 years at least.
4. Non-archer individuals with or without participation in any other sport activity for recreation.

Exclusion criteria

1. No history of shoulder injuries, surgery or pain in upper limbs, no active pathologies of upper limbs in past 6 months.
2. No pain greater than NRS 3/10 in upper limbs, neck and upper back.
3. Inability to attain test position.

Methodology

1. Study design: Cross sectional study.
2. Study setting: Community.
3. Study population: Archers and non-archers between the ages of 15-19 years old.
4. Sampling method: Convenience.
5. Sample size: 44

Procedure

1. The study design & procedure had been approved from the institutional ethics committee.
2. Participants were screened according to the inclusion criteria and exclusion criteria.
3. Control group of recreational players was found to be involved in lawn tennis, table tennis, football and swimming recreationally.
4. Subjects were positioned in prone with non-dominant shoulder hanging off the edge of the bed in 90 degrees of abduction. [3]
5. Olecranon process and radial styloid were marked with micropore tape.
6. Using a standard universal goniometer fixed with straps on subject's forearm, arm was taken to 30 and 60 degrees of external rotation passively by examiner with subject's eyes closed to eliminate visual feedback.
7. Position was held for 10 seconds; arm will be brought to neutral in between passive repositioning at 30 and 60 degrees.
8. Subject was given three tries each to replicate each of the two positions actively, with their eyes closed. Mean of three measures was taken for analysis.

9. Testing method was ipsilateral testing for bow arm of archer and non-dominant arm of non-archer individual.
10. Data was analyzed by statistician and results were computed.

Participant information

1. Participant type: healthy.
2. Risk of participation: none.
3. Time required for assessment: 15 mins.
4. Participant recruitment method: direct.
5. Precautions against COVID-19: use of mask and sanitizer.
6. Funding: self.
7. Feasibility: project is feasible.

Statistical Analysis

The test used is t Test for two independent samples. Software used for analysis is SPSS 20.

Group Statistics

Groups		N	Mean	Std. Deviation	Std. Error Mean
30 degrees final column	Archery	22	25.21	6.16	1.31
	Non-archery	22	33.98	6.72	1.43
60 degrees final column	Archery	22	45.61	9.18	1.96
	Non-archery	22	51.71	6.59	1.41

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	P value (2-tailed)
30 degrees final column	Equal variances assumed	.004	.949	-4.514	42	.000
	Equal variances not assumed			-4.514	41.680	.000
60 degrees final column	Equal variances assumed	1.439	.237	-2.534	42	.015
	Equal variances not assumed			-2.534	38.118	.015

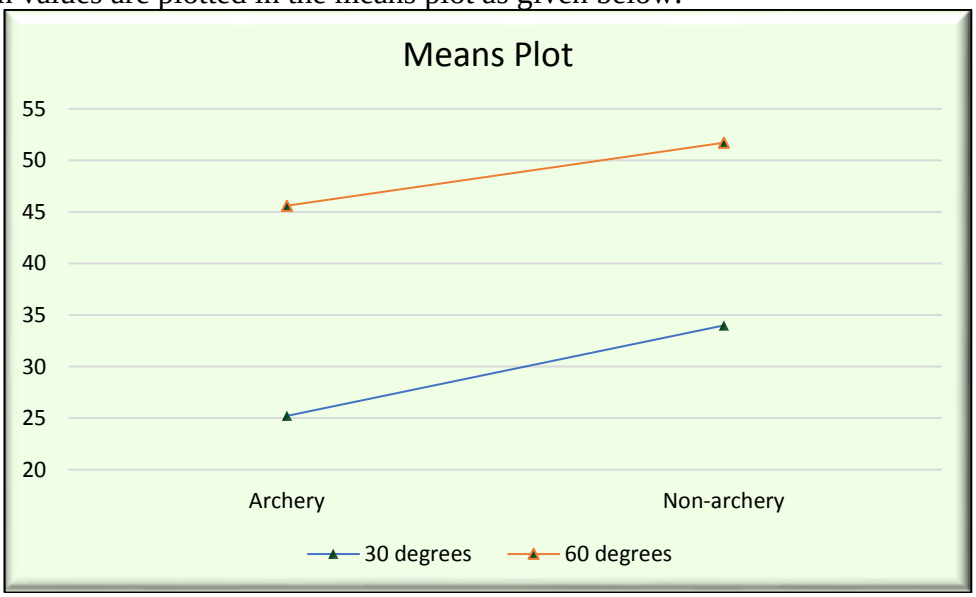
Since p value < 0.05, the level of significance for all factors, there is strong evidence to reject the null hypothesis for all factors.

RESULT

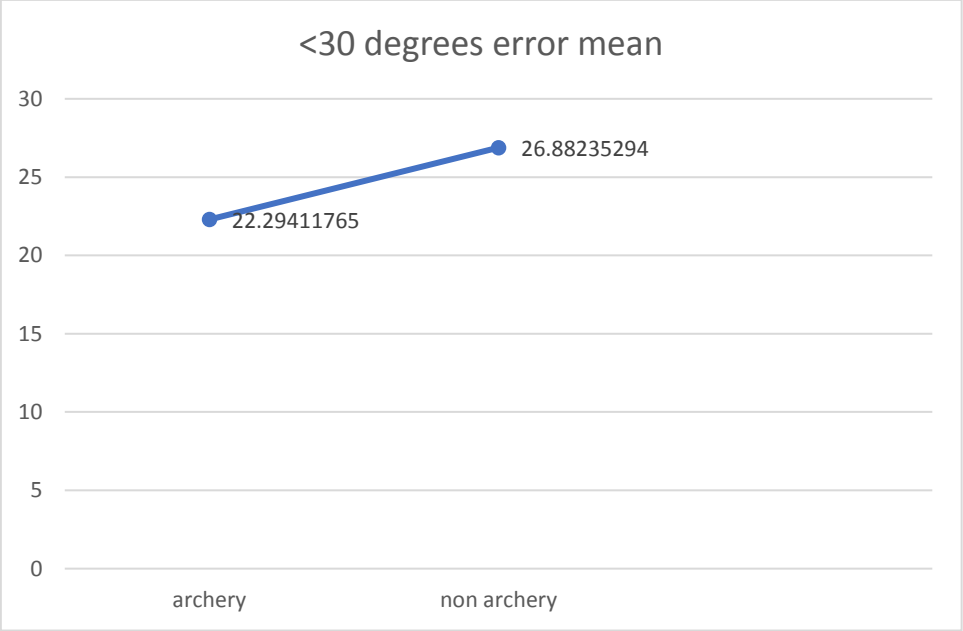
There is significant difference in all the factors stated above between archers and non-archers. The mean values in group statistics table suggest that the 30 degrees, 60 degrees values are lower significantly for archery group than that for non-archery group on an average.

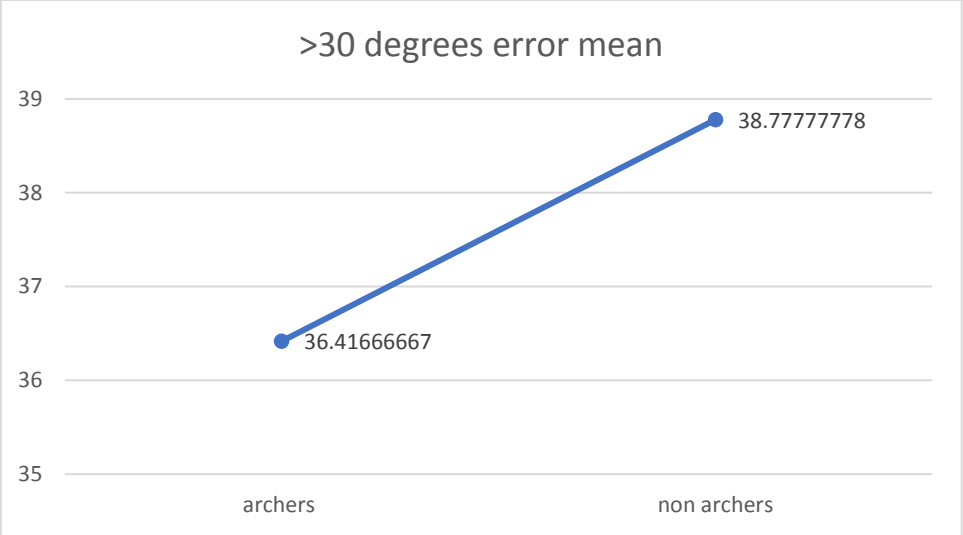
Means Plot:

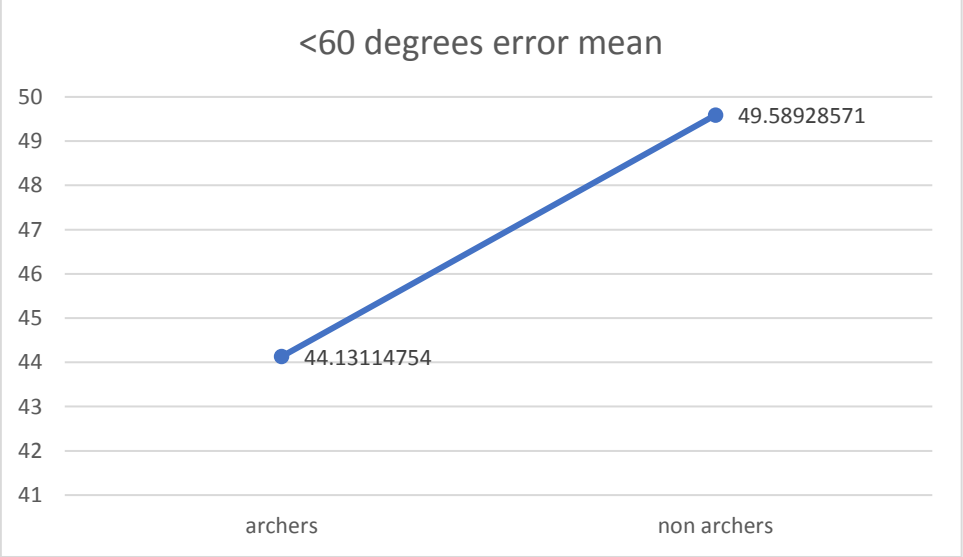
The mean values are plotted in the means plot as given below.

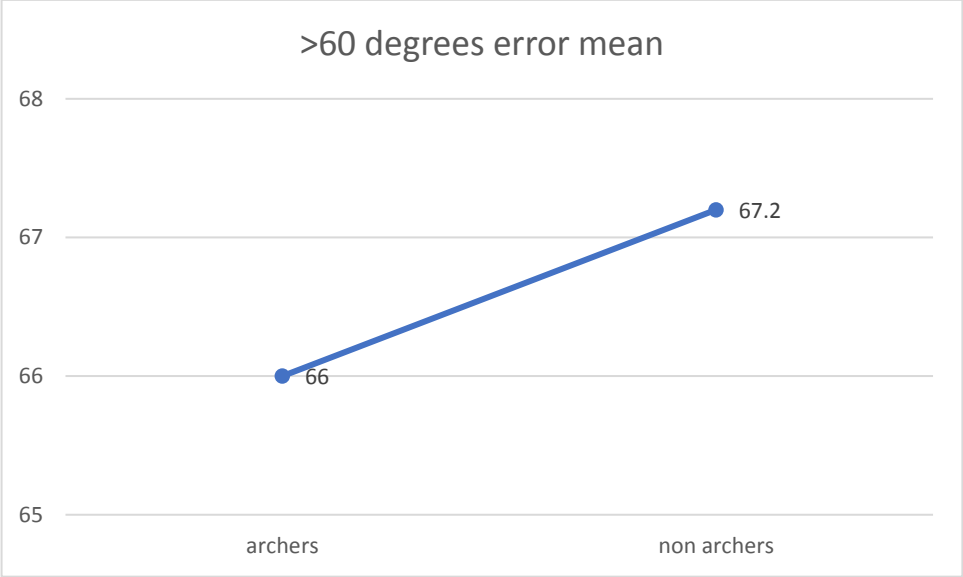


Mean errors plot:









The mean error values suggest that the degree of accuracy is higher in archers than non-archers.

DISCUSSION

This study was conducted to find out if there were any differences between the shoulder joint position sense of adolescent competitive recurve archers and non-archers. Such a study has not been performed prior to the best of the authors' knowledge. Majority of the non-archers included in the study are found to have been participating recreationally in some form of upper limb dominant sport e.g., tennis, table tennis, cricket and not participating in any other form of exercise like gym etc. On an average, non-archers were playing their recreational sport for 7 or less hours a week, while the archers included in the study practice for 7-8 hours daily. The age group selected is 15-19 years. This is chosen on the basis of literature which has stated that proprioceptive abilities develop from the age of 8 years and continue to develop till 13 years of age. There is no corelation of pubertal changes with proprioceptive abilities.[7] According to the statistical analysis, archers showed a greater degree of accuracy in both the 30- and 60-degrees ABER active joint repositioning tests. Between 30 and 60 degrees, archers showed greater accuracy at 30 degrees than 60. Out of all the JPS receptors, the most relevant receptors to this study are the muscle spindle and the Golgi tendon apparatus. Determining joint angulation in the middle of the total range of motion is a sense mediated via the muscle spindle. The shoulder joint being the most proximal, acts as an important stabilizer for both the bow arm as well as the drawing arm, along with muscles of the scapula and back. The primary positioning of the bow and arrow before the actual release of the arrow happens at the shoulder. The main movements needed in archery at the bow arm are glenohumeral abduction, extension and external rotation. In the recurve method in the drawing phase, maximum stretch is applied on the bow and the arrow must be released immediately. The drawing phase corresponds to 60 degrees of external rotation. In the bow arm, the position of the bow arm with reference to the line of force made by both shoulders is elevated and forward flexed during full draw and aiming. There is peak adduction and extension torque generated in these phases on the bow shoulder for stability. Shoulder extensors act as primary antagonists against the force of the bow and the string, irrespective of the bow arm or drawing arm. Muscle mechanoreceptors are mainly responsible for signaling of proprioception in the mid-range, because the joint capsule is fairly loose in this position. Hence the muscles become the main source of JPS

information. [(2)]Therefore it can be hypothesized that the adductor and extension torque overpower the external rotator torque at 60 degrees reducing the JPS accuracy. Statistically, a deviation of up to 5% is considered normal. Both the populations show a deviation more than this value. Archers have a lesser deviation as compared to the non-archers. Hence, even though archers have a superior joint position sense as compared to non-archers, there is still scope for improvement for higher shooting accuracy. This study shows lack of proprioceptive training in archery coaching with a need to add separate proprioceptive training regimen. [(8)]

Limitations of study: Lesser number of samples could be collected from both the populations due to COVID-19 restrictions affecting participation of archers and non-archers in their respective activities. No assessment for scapular dyskinesia or other muscular imbalances was done in archers.

Future scope: The study can be done with a greater number of samples.

CONCLUSION

Active joint repositioning sense in the archers' bow shoulder was assessed and compared to non-archer individuals in the age group of 15-19 years. It was assessed at 30 and 60 degrees of abduction and external rotation in the bow arm of archers and the non-dominant arm of non-archers. Archers showed a greater degree of accuracy in both the 30- and 60-degrees abduction-external rotation active joint repositioning tests. Between 30 and 60 degrees, archers showed greater accuracy at 30 degrees than 60.

Clinical Implication: Mean values in the archers group show that there is still room for improvement in archers using a regimen focused on proprioception. This will help in improving the accuracy of archers, leading to better scores competitively.

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Conflict of Interest: None

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Ethical Approval: Approved

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