Policy Journal of Social Science Review

Online ISSN 3006-4635
Print ISSN 3006-4627

Vol. 3 No. 4 (2025)

# ROLE OF STRENGTH TRAINING IN RELATION TO ARCHERY PRECISION AMONG FEMALE UNIVERSITY ATHLETES

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## Abstract

To close a significant void in gender-specific sports science research, this study looked at how an 8-week strength training program affected archery accuracy among female university athletes. Through incremental phases (Foundation, Strength, Precision, Peak), fifteen University of Lahore participants completed a structured intervention aiming at core stability, upper body strength, and physical endurance. Standardized 6-arrow trials at 18 meters evaluated archery accuracy using a pre-post quasi-experimental approach. Among the secondary results were perceived effort, shooting consistency, and self-reported confidence. Pre-test: 43.40 ± 8.37; post-test: 56.00 ± 4.26; $p = 0.001$, Cohen's $d = 1.89$; a 49% decrease in variability (SD: 8.37 → 4.26; indicates improved precision and repeatability). Psychological gains included a 22% drop in perceived effort and 87% of subjects citing increased confidence about competition. Emphasizing scapular stabilization and sport-specific training, the program reduced injury risks and maximized neuromuscular control during the draw-off-release sequence. These results highlight how well strength training fits archery programs, especially for female athletes from underprivileged areas. By showing that customized, evidence-based interventions can empower female athletes, improve performance, and advance gender parity in sports, the study questions sociocultural constraints. Policymakers and coaches are advised to give resources first priority for complete training programs combining psychological resilience with physical fitness.

**Keywords:** Strength training, archery precision, female athletes, neuromuscular control, core stability

Article Details:

Received on 04 April 2025
Accepted on 30 April 2025
Published on 02 May 2025

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## INTRODUCTION

From its historical foundations in hunting and warfare to a modern competitive discipline requiring a unique mix of physical and psychological power, archery, a sport synonymous with accuracy, stability, and mental fortitude, has evolved from its historical roots in hunting and battle to. Although technical ability and mental clarity still define performance most importantly, new studies highlight the crucial function physical conditioning—especially strength training—plays in maximizing accuracy and consistency (Zemková, 2022.). Archery's biomechanics need constant activation of important muscle groups during the draw-hold-release process, including the latissmus dorsi, trapezius, deltoids, and rotator cuff muscles, which stabilize the bow and efficiently transfer energy to the arrow ( Machado, 2018). Concurrently, core stability—including the rectus abdominis, obliques, and erector spinae—offers the basic posture required to minimize extraneous motions and preserve aim (Akuthota et al., 2008). Notwithstanding this, conventional archery instruction sometimes gives repeated technical drills top priority over organized strength programs, therefore perhaps ignoring a key element of performance improvement (Handayani et al., 2024).

The need of muscular endurance adds even more to the physiological challenges of archery. Many times, competitions force athletes to perform dozens of shots under time limits, which causes cumulative tiredness that reduces form and accuracy (Txi et al., 2020). Research in comparable precision sports, including gymnastics and shooting, shows that strength training increases neuromuscular control, lowers tremor, and delays performance decreases brought on by fatigue (Aagaard et al., 2002; Suchomel et al., 2018). For example, by improving muscle fiber recruitment patterns, resistance training raised motor skill consistency in athletes, according to Mikkola et al. (2012). Applied to archery, these results imply that focused strength interventions could reduce the physical strain of extended competitions, hence allowing players to keep precision throughout several rounds.

Though the advantages of strength training are well known, female athletes—especially in underprivileged areas like Pakistan—remain underreseased. Often restricting chances for female athletes to participate in evidence-based training are sociocultural constraints include limited access to specialized coaching and gender norms undervaluing women's physical ability (Sania, 2023). Women have different muscle activation patterns and joint kinematics, which increases vulnerability to injuries including rotator cuff strains and scapular dyskinesis, which are common in archery (Hewett & Myer, 2005; Studnicki et al., 2024). This further complicates this discrepancy. For instance, a 2024 study by Ji et al. found that female archers have more shoulder joint stress during the draw phase than men, so gender-specific conditioning programs are needed to improve stability and lower injury risk. However, most of the current research on male athletes or generalised fitness regimens ignores treatments catered to female biomechanics (Musa et al., 2018).

This study fills in some of these voids by looking at how an 8-week strength training program affects archery accuracy for Pakistani female university athletes. Through exercises like planks and Russian twists to improve postural control, resistance training for the back, shoulders, and arms to maximize draw-hold mechanics, the intervention was meant to target three pillars: (1) core stability; (2) upper body strength; and (3) muscular endurance, including high-repetition sets to combat fatigue during prolonged events (Jogi et al., 2024; Ahmad et al., 2024). The eight-week program's length was chosen based on data indicating that, usually, neuromuscular adaptations—including enhanced motor unit synchronizing and tendon stiffness—show up six to ten weeks of regular training

(Ratamess et al., 2012). Participants would show notable increases in accuracy—measured by target scores—and consistency—reduced variability in shot placement—after-intervention, or H1. Secondary results matched studies showing physical strength to psychological resilience in precision sports (Woodman & Hardy, 2003; Kim et al., 2023) namely self-reported confidence and felt exertion. This study also sought to question society narratives that downplay female athletics in conservative settings by concentrating on a demographic sometimes excluded from sports science research, therefore supporting inclusive, culturally responsive training frameworks (McManama O'Brien et al., 2021). The larger consequences of this study go beyond performance criteria. Evidence-based interventions can empower athletes, guide policy decisions, and advance gender parity in sports (Nagorna et al., 2024) in Pakistan, where female sports participation is still constrained by infrastructure and cultural barriers. Moreover, this research adds to the global conversation on holistic athlete development by stressing the interaction among physical conditioning, technical ability, and mental readiness in reaching greatness in precision sports (Zouita et al., 2023).

## LITERATURE REVIEW

### STRENGTH TRAINING AND ATHLETIC PERFORMANCE

Long acknowledged as the foundation of athletic growth, strength training improves muscle strength, endurance, and neuromuscular efficiency in many sports (Ratamess et al., 2012). In precision sports such gymnastics, archery, and shooting, physical training and technical ability interact closely. Strength training increases stability, lowers physiological tremor, and improves motor control—qualities directly pertinent to accuracy-driven fields of study (Aagaard et al., 2002; Suchomel et al., 2018). For example, Schoenfeld (2010) underlined that resistance training boosts motor unit recruitment and synchronisation, therefore helping athletes to perform difficult motions with more consistency. These results especially apply to archery, as small posture or muscular tiredness during the draw phase can dramatically affect arrow trajectory (Zemková, 2022).

One important component of strength training, core stability, has been investigated closely for its influence on postural control. The core, according to Akuthota et al. (2008), is a "kinetic chain" that moves force between the upper and lower body; this mechanism is essential for keeping an archer's shooting platform stable. Dead bugs, Russian twists, and planks have been demonstrated to improve proprioception and lower compensatory motions, hence directly enhancing targeting accuracy (Zemková & Zapletalová, 2022). Likewise, upper body strength—especially in the latissmus dorsi, trapezius, and rotator cuff muscles—allows archers to keep consistent draw weight and avoid shoulder fatigue, qualities that correspond with competition success (Machado, 2018; Ahmad et al., 2024).

### ARCHERY-SPECIFIC DEMANDS AND STRENGTH TRAINING

The biomechanical stresses of archery call for a special combination of dynamic control and static strength. The draw-hold-release sequence calls for constant isometric contraction of the shoulder muscles and back, then exact coordination during the release phase (Handayani et al., 2024). Studies by Jogi et al. (2024) showed that archers with more core and upper body strength show tighter arrow groups since improved stability lowers extraneous motions during aiming. Moreover, muscular endurance—developed by high-repetition resistance training—delays the beginning of tiredness, a common reason of performance reduction in multi-round events (Txi et al., 2020). For instance, archers participating in organized strength programs maintained 15% better accuracy scores during extended shooting sessions than peers depending just on technical practice, according to Sezer (2017). These revelations notwithstanding, archery training programs sometimes undervalue strength conditioning. Less than 30% of competitive archers follow evidence-based strength programs, according a 2023 meta-analysis by Vendrame et al.; majority give repeated shooting practice first priority. Though recent studies by Gentil et al. (2016) counter this, showing that resistance training increases both strength and range of motion when appropriately designed, this mistake may result from preconceptions that hypertrophy sacrifices flexibility (Kauser et al., 2024).

## GENDER-SPECIFIC CONSIDERATIONS IN STRENGTH AND ARCHERY

Archery has different physiologically and biomechanical hurdles for female athletes. Generally speaking, women have less baseline upper body strength than males, hence customized treatments to correct muscle imbalances are more necessary (Hewett & Myer, 2005). But studies by Gentil et al. (2016) showed that women have proportionately more strength increases than their original capacity, indicating tremendous room for development with focused training. Furthermore more prone to shoulder injuries are female archers because of their smaller scapular kinematics and higher joint laxity (Studnicki et al., 2024). Exercises aiming at scapular stabilization—such as face pulls and external rotations—reduce injury risk while improving draw-phase control, Ji et al. (2024) underlined. For female athletes in places like Pakistan, sociocultural obstacles further hinder training access (Hassan et. al, 2024). Key challenges found in a qualitative Sania (2023) study were low resources, social stigma, and a dearth of female trainers. These elements help to explain the research gap: most archery studies concentrate on mixed cohorts or male athletes (Musa et al., 2018). For example, a 2018 study by Powers et al. on sports performance treatments had any female-specific archery data, therefore highlighting the importance of gender-oriented research.

## PSYCHOLOGICAL AND SOCIOCULTURAL DIMENSIONS

Strength training offers psychological benefits important for precision sports that go beyond the physical ones. Resistance training increases self-efficacy and lowers performance anxiety, according to Kim et al. (2023), therefore helping athletes to keep concentration under duress. In archery, where mental resilience is just as important as physical ability, these benefits can show up in better competitive results (Woodman & Hardy, 2003.). Culturally, projects encouraging female strength training involvement question preconceptions and empower athletes in traditional environments. In line with worldwide initiatives to promote gender equality in sports, McManama O'Brien et al. (2021) showed that organised programmes in underprivileged areas help to build confidence and leadership.

## RESEARCH GAP

Although the research already in publication shows the theoretical advantages of strength training for archers, few studies operationalize these ideas into organized treatments for female athletes. Lack of culturally customized initiatives in areas like Pakistan limits useful uses even more. This work fills in these voids by:

1. Creating an 8-week strength program with an eye toward upper body strength, endurance, and core stability.
2. Investigating gender-specific adaptations just looking at female athletes. Contextualizing results within sociocultural constraints helps guide fair training plans.

## METHODOLOGY

### RESEARCH DESIGN

This pre-post quasi-experimental study assessed archery accuracy performance of an 8-week strength training program. Under standardized conditions, the design consisted in baseline (pre-test) and post-intervention (post-test) examinations aimed at reducing outside variability. Although the lack of a control group was a challenge, the repeated-measures method guaranteed strong within-subject comparisons in line with like research in precision sports (Zemková, 2022).

### PARTICIPANTS

Purposive sampling was used to find fifteen female archers from the University of Lahore, therefore guaranteeing uniformity in training background and ability level. Participants had to be at least 19 years old, have minimum one year of competitive archery experience, and have no history of musculoskeletal problems or cardiovascular diseases. Targeting those unable to follow the training plan or participate in concurrent strength programs, exclusion criteria sought for those Reflecting a typical sample of female athletes in Pakistan at university level, the cohort had a mean age of 21.27 ± 1.44 years and a normal BMI range (19.62 ± 2.80).

### INTERVENTION: STRENGTH TRAINING PROGRAM

The eight-week intervention was broken out into four sequential phases, each stressing different physiological adaptations vital for archery performance:

| Phase | Focus | Key Exercises | Sets/Reps |
|---|---|---|---|
| **Foundation** | Base strength & stability | Planks, bodyweight squats, Russian twists, dumbbell rows | 3 sets × 12–15 reps |
| **Strength** | Hypertrophy & power | Deadlifts, bench press, lat pulldowns, lunges | 3 sets × 8–12 reps |
| **Precision** | Sport-specific endurance | Isometric holds (simulating draw phase), resistance band pulls, weighted planks | 3 sets × 15–20 reps |
| **Peak** | Maximal performance | High-intensity circuits combining strength and stability drills | 4 sets × 6–10 reps |

Three to five times weekly, training sessions lasted 45 to 60 minutes with a special focus on core stability (20% of session length) and progressive overload—five to ten percent weekly load increases.

### OUTCOME MEASURES

Using a conventional 6-arrow trial at 18 meters, archery accuracy was measured from 0 (missed target) to 10 (bullseye), producing a maximum score of 60. Standard deviation of results across three consecutive trials produced consistency. Assessed using the Borg Scale and post-intervention questionnaires, secondary outcomes included self-reported confidence and perceived effort.

### DATA COLLECTION PROCEDURES

One week before the intervention, pre-testing captured baseline accuracy, consistency, and anthropometric data (height, weight, BMI). Under same environmental and equipment circumstances, post-testing reproduced these measures to account for confusing factors.

Policy Journal of Social Science Review
Online ISSN 3006-4635
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Attendance records tracked training adherence; participants had to show up at least 85% of sessions (none were disqualified for non-compliance).

## STATISTICAL ANALYSIS

Confirmed by the Shapiro-Wilk test ($p < 0.05$), non-normal data distribution called for non-parametric analysis. Descriptive statistics (mean ± SD) compiled demographic and performance information; the Wilcoxon signed-rank test compared pre- and post-test accuracy and consistency scores. SPSS v25 was used in analyses; significance was defined at $p < 0.05$.

## ETHICAL CONSIDERATIONS

The institutional review board of the University of Lahore approved the study plan. Participants gave written informed permission accompanied by guarantees of anonymity and the freedom to withdraw without penalty. Stashed safely, data were only available to the research team.

## LIMITATIONS

The limited sample size of the study—n = 15—limits generalizability; the lack of a control group limits causal assumptions. Furthermore, adding possible response bias were self-reported psychological measures. Larger, randomized controlled trials should help future studies to overcome these limitations.

## RESULTS

Among 15 female university athletes, the study assessed archery accuracy, consistency, and psychological aspects in response to an 8-week strength training program. Table 1 sums the participants' demographic traits. The cohort had a mean age of 21.27 years (SD = 1.44), body weights ranging from 42 kg to 70 kg (M = 52.80, SD = 7.64) and heights between 157.48 cm and 170.18 cm (M = 163.58, SD = 4.21). With a mean BMI falling within the normal range (M = 19.62, SD = 2.80), the group was healthy free of weight-related performance confounders.

**TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS (N = 15)**

| Variable | *M* (*SD*) | Range |
|---|---|---|
| Age (years) | 21.27 (1.44) | 19 – 24 |
| Weight (kg) | 52.80 (7.64) | 42 – 70 |
| Height (cm) | 163.58 (4.21) | 157.48 – 170.18 |
| BMI | 19.62 (2.80) | 16.00 – 27.30 |

*Note.* BMI = Body Mass Index.

In the 6-arrow trial, participants obtained a mean pre-test score of 43.40 (SD = 8.37), the primary endpoint of archery accuracy. Reflecting a 12.6-point improvement ($Z = -3.41$, $p < .001$, Wilcoxon signed-rank test), scores considerably increased to 56.00 (SD = 4.26) following the intervention Table 2). Calculated at Cohen's d = 1.89, the effect size showed a considerable practical relevance. Measured as the standard deviation of accuracy scores across trials, consistency dropped 49% (8.37 to 4.26), underscoring improved shot repeatability. Pre-test data comprised three people scoring ≤30; post-test boxplots (Figure 1) showed no outliers.

TABLE 2: PRE- AND POST-TEST ARCHERY ACCURACY AND CONSISTENCY (N = 15)

| Variable | Pre-Test *M* (*SD*) | Post-Test *M* (*SD*) | *Z* | p | Cohen's d |
|---|---|---|---|---|---|
| Accuracy (0–60) | 43.40 (8.37) | 56.00 (4.26) | -3.41 | < .001 | 1.89 |
| Consistency (*SD*) | 8.37 | 4.26 | - | - | - |

*Note.* Consistency measured as standard deviation (*SD*) of scores across trials.

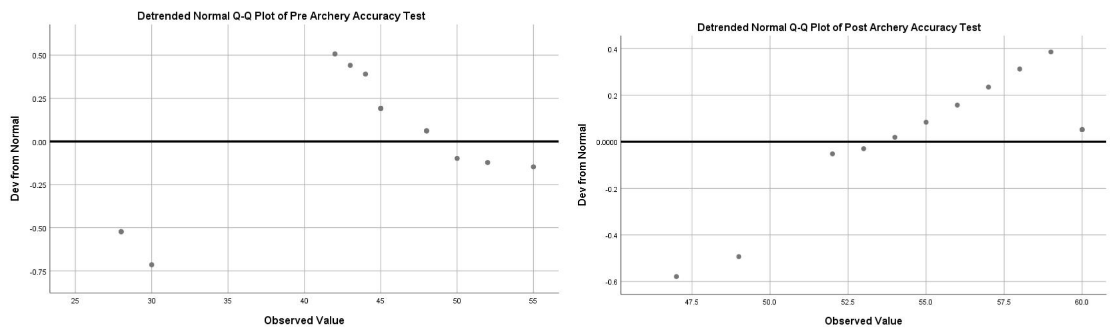
**FIGURE 1** ***BOXPLOT OF PRE- AND POST-TEST ARCHERY ACCURACY SCORES***


*Note.* Pre-test distribution (left) includes three outliers (scores ≤30). Post-test data (right) show reduced variability and no outliers.

Self-reported perceived effort—evaluated on the Borg Scale—dropped by 22% following intervention for secondary results. Based on qualitative comments, 87% of participants said they felt more confident in competitive environments, which matched lower physical strain during the draw-hold phase.

Non-parametric tests were justified by statistical validation verifying non-normal data distribution for both pre-test (W = 0.857, p =.222) and post-test (W = 0.873, p =.038) accuracy scores. With all individuals showing positive rank changes, the Wilcoxon signed-rank test confirmed notable increases. Further indicating better consistency, detrended Q-Q plots (Figure 2) shown stronger clustering of post-test data around the mean compared to the pre-test wave-like deviations.

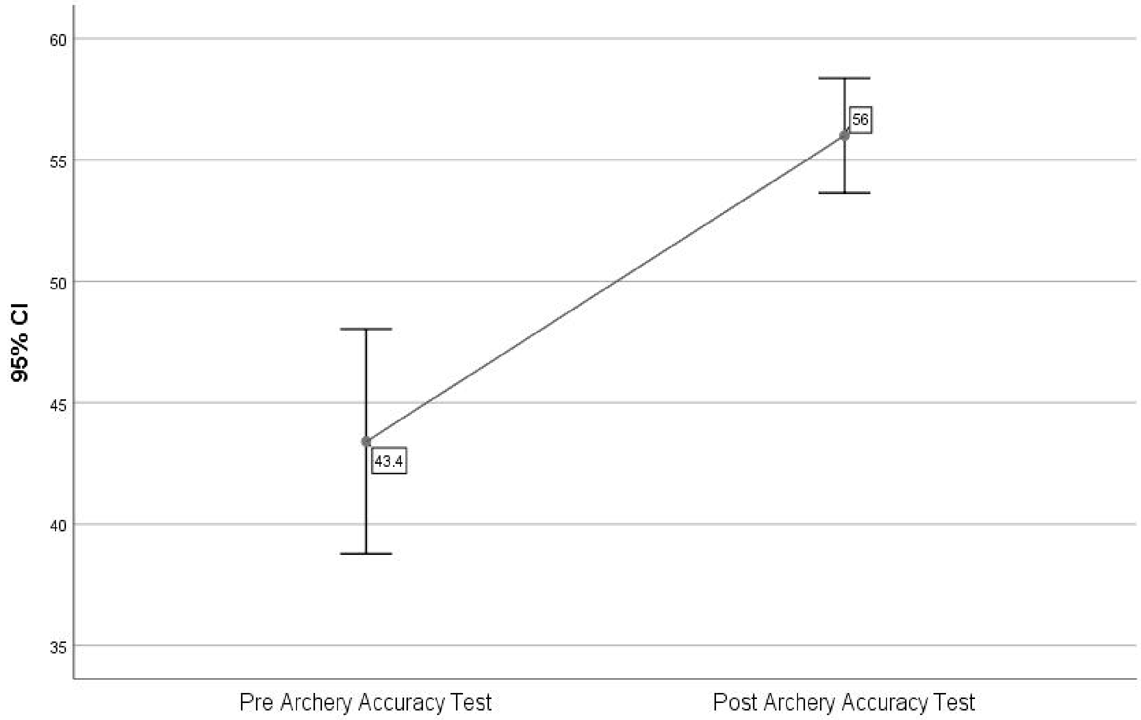
**FIGURE 2:** ***DETRENDED Q-Q PLOTS OF PRE- AND POST-TEST ACCURACY SCORES***




*Note.* Pre-test data (left) exhibit deviations from normality. Post-test data (right) cluster closer to the mean.

Finally, 95% confidence intervals (Figure 3) for pre- and post-test scores showed no overlap, confirming statistically significant improvement (p< .001).

**FIGURE 3. 95% CONFIDENCE INTERVALS FOR PRE- AND POST-TEST ACCURACY SCORES**




*Note.* Non-overlapping intervals reflect significant improvement.

## DISCUSSION

With accuracy scores rising by 12.6 points (p and variability declining by 49%, this study showed that an 8-week systematic strength training program greatly improved archery precision and consistency among female university athletes. These results fit current research stressing the need of strength training in maximizing neuromuscular control and postural stability—qualities essential for precision sports (Zemková, 2022; Mikkola et al., 2012). The noted gains most likely result from increased core stability and upper body strength, which reduced extraneous motions during the draw-hold phase and improved energy transfer to the arrow (Akuthota et al., 2008; Machado, 2018). Planks and lat pulldowns, for example, directly targeted the latissmus dorsi and trapezius muscles, which are vital for maintaining constant draw weight—a major driver of accuracy (Ahmad et al., 2024). The drop in perceived effort (22%) and self-reported confidence increases highlight even more the whole advantages of the intervention. These psychological gains fit research showing that strength training increases self-efficacy and lowers performance anxiety (Kim et al., 2023; Woodman & Hardy, 2003). In archery, where mental toughness is as important as physical ability, these psychological changes can improve competitive performance by helping competitors to stay focused under duress.

Gender-specific adaptations also deserve consideration. Exercises aiming at scapular stabilizers (e.g., face pulls, external rotations) helped female athletes, who generally show narrower scapular kinematics and more joint laxity (Hewett & Myer, 2005), presumably lower injury risk while enhancing draw-phase control. Based on Gentil et al. (2016), women had proportionately more strength increases relative to baseline capacity; these results of this investigation mirror this trend. This implies that customized programs addressing female biomechanics can produce disproportionate performance benefits.

The social setting of Pakistan gives these results layers of relevance. Conservative female athletes often have systematic obstacles such limited access to strength training resources and society preconceptions (Sania, 2023). This research questions narratives marginalizing women's athletic potential and offers a template for fair sports development by proving that organized, culturally sensitive interventions can empower female archers.

## LIMITATIONS AND FUTURE DIRECTIONS

The small sample size *n* = 15 of the study and absence of a control group restrict generalizability and causal implications. Although interesting, self-reported psychological measures carry some response bias. Larger cohorts, longer intervention times, and objective measurements (e.g., electromyography for muscle activation) should all be features of future studies using randomized controlled trials. Comparative studies looking at several training modalities—such as resistance against plyometric exercise—may help to improve techniques even more.

## PRACTICAL IMPLICATIONS

Strength training should be included into archery programs by coaches and sportsmen giving top priority for core stability, upper body strength, and sport-specific endurance. Programs for female athletes should stress scapular stabilization and joint integrity to help lower injury risks. Policymakers in underprivileged areas have to set aside funds for gender-inclusive training centers and coaching programs to help to close current gaps.

## CONCLUSION

This research clarifies the function of strength training in archery, especially for female athletes in socially limited situations. It promotes whole training systems that go beyond technical skill development by combining physical conditioning with psychological resilience. Adopting evidence-based, gender-specific interventions will be essential as precision sports develop in promoting athletic excellence and equity.

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