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Enhancing archery-specific physical fitness: A controlled trial on the effects of medicine ball load variations

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ABSTRACT

Background: Precision sports like archery require high levels of balance and upper limb muscular endurance to maintain bow stability and aiming accuracy. While general strength training is often applied, research specifically investigating targeted physical conditioning methods—such as medicine ball load variations tailored for archers—is still limited. **Research Objectives:** This study aimed to evaluate the effectiveness of medicine ball training on balance and upper limb muscular endurance among collegiate archery athletes. **Methods:** A total thirty university-level archers voluntarily participated and were randomly divided into three groups: a 3 kg medicine ball training group (MTG), a 4 kg medicine ball training group (MFG), and a control group (CAG), each consisting of 10 participants. A pretest and posttest true experimental design was applied over eight weeks of training. **Finding/Results**: Both MTG and MFG groups showed significant improvements in balance and upper limb muscular endurance ($p < 0.05$), while the control group showed no significant changes. However, no statistically significant difference was found between the two experimental groups, indicating that both 3 kg and 4 kg medicine ball loads were similarly effective. **Conclusion:** Medicine ball training—regardless of moderate load variation—is effective in enhancing archery-relevant physical fitness, particularly balance and muscular endurance. These findings support the integration of medicine ball exercises into archery training programs as a practical and evidence-based strategy. Future studies should examine load progression, gender-specific responses, and long-term performance outcomes.

Keywords: Archery; medicine ball training; physical fitness; balance; muscular endurance

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INTRODUCTION

Archery is a precision-based sport characterized by release arrows along a predetermined trajectory toward a designated target at a spesific distance (Salleh et al., 2023). This sports demands a high level of movement consistency and stability to ensure that each arrow reaches the target with optimal accurately (Humaid et al., 2021). The physical component of balance is essential in archery, as it enables archers to maintain a stable

posture throughout the phases of drawing, holding, and releasing the arrow (Kesilmiş et al., 2024). Previous research has emphasized that balance is crucial for archers to sustain a stable body position before excecuting a shot (Baskoro et al., 2023; Salleh et al., 2023). Moreover, balance plays a vital role in regulating body weight distribution during the fine motor movements involved in the archery cycle (Lau et al., 2020; Prasetyo et al., 2023).

In addition to balance, upper limb endurance is another crucial factor influecing success in archery (Lau et al., 2020). Previous research has indicated that upper limb endurance in archery is affected by sensorimotor coordination, core muscle strength, and proprioceptive ability (Kim, 2018). Other studies have concluded that core muscles strengthening and muscle endurance can improve the archer's movement control, ultimately leading to more precise shots (Ertan et al., 2021; Suppiah et al., 2017). Therefore, training methods aimed at enhancing muscle coordination and control, particularly in body stabilization, are essential for improving balance and endurance of archery athletes.

Previous studies have emphasized the importance of specific training programs in improving the physical components of archery performance, especially the balance, and arm muscle endurance components. Previous studies have found that core muscle stability programs can reduce sway and make you more balanced when releasing arrows (Suppiah et al., 2017). Other studies have emphasized that circuit training significantly affects physical fitness and archery accuracy in novice athletes (Pratama et al., 2024; Susanto et al., 2021). While recent studies have shown that psychological training with mental training techniques can improve the accuracy and balance of young archers (Priambudi et al., 2023; Yachsie et al., 2023). However, the type of specific training such as using various sized medicine balls is still limited. Meanwhile, previous studies were limited to training using bolu bonsu which has been proven effective in improving the performance of archery athletes (Prasetyo et al., 2023).

Medicine ball exercises have been widely implemented to enhance overall fitness in both general populations and various sports, particularly in improving balance and muscular endurance among athletes. Previous research has demonstrated that medicine ball training effectively enhances physical fitness in children (Faigenbaum et al., 2018; Trajković et al., 2017), and adolescents (Firdauz et al., 2017). More recent studies have highlighted its effectiveness in developing core stability and balance in karate athletes (Ravichandran et al., 2020). Additionally, other findings suggest that medicine ball training can optimize body weight distribution, thereby contributing to enhanced static and dynamic balance in handball players (Natalia) and improved upper limb endurance in soccer athletes (Hari & Dey, 2024).

The efficacy of medicine ball training in enhancing physical performance has been extensively investigated across various sports disciplines, including cricket (Putu et al., 2022), basket ball (Cao et al., 2024), karate (Ravichandran et al., 2020), soccer (Hari & Dey, 2024), and handall (Chukhlantseva, 2023; Ignjatovic et al., 2012). However, to our knowledge, no previous studies have examined differences in medicine ball loads in archery-specific training. Unlike sports that involve high-intensity movement and dynamic changes of direction, archery demands postural precision, prolonged static muscle activation, and fine motor control, particularly in the upper body. Previous studies have not specific investigated the effects of medicine ball training on the balance and upper limb muscular endurance of archers, which are crucial for maintaining shooting stability and accuracy. Therefore, this study aims to evaluate the effectiveness of medicine ball training in improving balance and accuracy of archery athletes. This study is expected to provide stronger empirical evidence on how medicine ball training can be optimally applied to university-level archery athletes.

METHOD

Research Design

Our study used a true-experimental pretest and posttest design with a control group. This design was chosen to measure changes in balance and endurance among university-level archery athletes before and after the implementation of a medicine ball training program. The intervention group received medicine ball training for an 8-week period, with a frequency of three sessions per week, while the control group continued their regular training without medicine ball training intervention.

Research Subject

The population for this study consisted of college-level archery athletes aged 19-22 years. The sample was selected using purposive sampling, with the following inclusion criteria: active archery athletes who trained at least three time a week for the past 3 years. No history of injury, especially upper body in the past six months. Willing to complete the full training program and participate in all tests. This study has obtained ethical approval from the Ethics Committee of the State University of Jakarta (No. 516/UN39.14/PT.01.05/VI/).

Research Procedure

The research procedure was conducted in three phases: pretest, training intervention, and posttest. In the pretest stage, participants were randomly assigned to three groups: the 3 kg medicine ball training group (MTG), the 4 kg medicine ball training group (MFG), and the control group (CAG). Baseline measurements included height, body weight, body mass index (BMI), and body fat percentage, followed by tests of upper limb muscular endurance (one-minute push-up and sit-up) and balance (Stork Stand Test), with examiners blinded to group assignments to minimize bias. These instruments have been validated in previous studies as reliable measures of muscular endurance and balance (Ojeda et al., 2020; Pontaga et al., 2024). The intervention phase lasted eight weeks, during which the training groups performed progressive medicine ball exercises, each session consisting of a 10-minute warm-up, core training, and a 5–10-minute cool-down, while the control group continued regular archery practice. Training adherence was monitored by coaches, and only participants with ≥90% attendance were included in the analysis. In the ninth week, the posttest phase was conducted, consisting of archery accuracy assessment at a 30-meter distance and a balance test using the Stork Stand Test, without further anthropometric measurements.

Table 1. Structured Medicine Ball Training Program for Each Group

Component	Group	
	MTG	MFG
Movement	1. Overhead Throw 2. Chest Pass 3. Side Twist Throw 4. Squat and Push Throw 5. Lunge and Pass	
Repetition	10 repetitions per movement 2-3 set per session	
Intensity	Moderate to high intensity	
Progression	Week 1-2: 2 sets Week 3-5: 3 sets Week 6-8: 3 sets	
Coach Supervision	Exercises supervised by a certified archery coach to ensure correct form and training safety	

Statistic Analysis

IBM SPSS statistical software version 24 was used to perform data analysis. The results of the study are presented as mean ± SD. Two-Way Repeated Measures Analysis of Variance was used to examine differences between groups and determine the presence of significant variation. The Shapiro-Wilk test was used to assess the homogeneity of the data. If a significant difference was found with a confidence level of $P < 0.05$, it indicated a statistically significant difference between the groups. A paired sample t-test was conducted to evaluate the changes in accuracy and balance from pretest to posttest between groups. In addition, a paired sample t-test was used to compare endurance and balance at posttest between groups.

RESULTS AND DISCUSSION

This study aims to determine the effectiveness of medicine ball training on the balance and arm muscle endurance university-level archery athletes. Based on our knowledge, our study is the first attempt to evaluate the effects of medicine ball training on the the balance and arm muscle endurance of university-level archery

athletes. The main findings of this study indicate that a medicine ball training program is effective in improving the arm muscle endurance and balance of university-level archery athletes.

Table 2. Anthropometric Characteristics of Research Subjects

Variable	Group	*Mean* ± SD	*P-value*
Age (years)	MTG	19.8 ± 1.9	
	MFG	20.1 ± 1.8	0.228
	CAG	20.3 ± 2.1	
Weight (kg)	MTG	63.2 ± 4.5	
	MFG	64.8 ± 5.1	0.383
	CAG	65.1 ± 4.8	
Height (cm)	MTG	171.6 ± 4.7	
	MFG	170.4 ± 5.3	0.284
	CAG	171. 1 ± 4.9	
BMI (kg/cm^2)	MTG	21.8 ± 2.6	
	MFG	22.1± 1.9	0.424
	CAG	22.2 ± 3.3	

Figure 1 illustrates the paired sample t-test analysis used to compare the upper limb muscular endurance components between the pretest and posttest across each group. The graph shows a marked increase in the mean number of repetitions for both push-up and sit-up tests in the MTG and MFG. Specifically, the MTG improved from a pretest mean of 38 repetitions to a posttest mean of 46 repetitions in the push-up test, and from 56 repetitions to 64 repetitions in the sit-up test. Similarly, the MFG improved from 36 to 44 repetitions in push-ups and from 57 to 63 repetitions in sit-ups. In contrast, the CAG showed minimal improvement, with push-up repetitions increasing only from 36 to 39 and sit-ups from 56 to 59, which were not statistically significant.

Figure 2 displays the comparison of balance performance before and after the intervention using the Standing Stork Test for both the left and right legs across the three groups: MTG (3 kg medicine ball group), MFG (4 kg medicine ball group), and CAG (Control Group). For left-side balance, the MTG group showed a notable improvement from a pretest score of 41 seconds to a posttest score of 52 seconds, while the MFG group increased from 42 to 53 seconds. The CAG group, however, demonstrated only a slight increase from 41 to 46 seconds, which was not statistically significant. Similarly, in the right-side balance, the MTG improved from 43 to 55 seconds, and the MFG improved from 41 to 52 seconds. Meanwhile, the CAG group showed a minimal gain, increasing from 42 to 47 seconds.

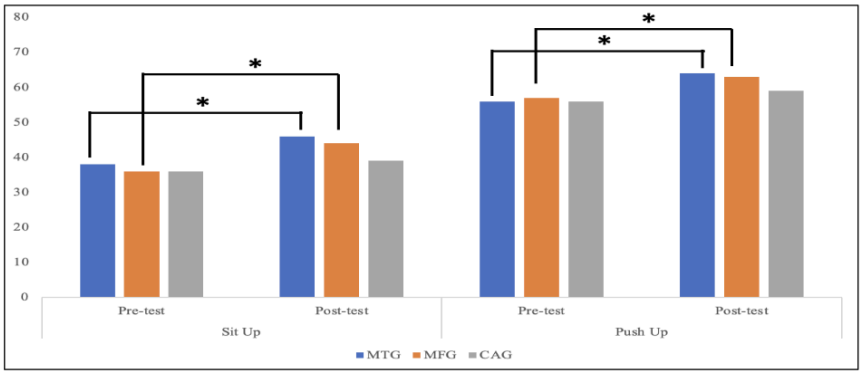

Figure 1. Paired Sample T-Test for Sit-Up and Push-Up, * Indicates statistical diference compared to Pretest and Posttest

This study investigated the effects of a medicine ball training program on balance and muscular endurance in collegiate archers. Left and right leg balance data showed significant improvements in the MTG ($p < 0.05$) and MFG ($p < 0.05$) groups after 8-weeks of medicine ball training intervention. However, the difference in improvement between the two groups was not significant, indicating that varying the medicine ball load within the range of 3-4 kg did not significantly affect balance-related neuromuscular adaptations. Meanwhile, the control group did not experience significant improvements, indicating that no substantial changes in balance in collegiate archers could occur without specific intervention.

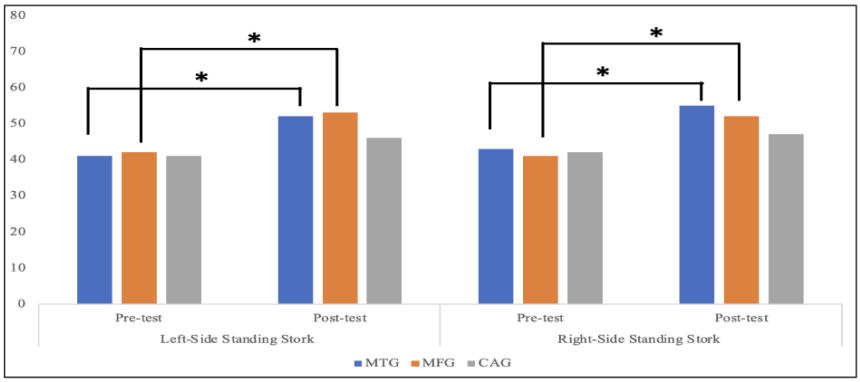

Figure 2. Paired Sample T-Test for Left and Right Side Standing Stork, * Indicates statistical diference compared to Pretest and Posttest

Our results are in line with previous studies showing that there is a significant increase in the balance of athletes and ordinary individuals after intervention using medicine training for 8-10 weeks (Bana et al., 2024; Firdauz et al., 2017). Previous studies have indicated that the activation of a greater number of muscle fibers stimulates enhanced development of the nervous and biochemical systems, this process contributes to

increased muscular strength, which in turn positively influences various physical performance components (Plotkin et al., 2021).

The similar results occurred in upper body muscle endurance which showed a significant increase in push-up and sit-up variables in the MTG group ($p < 0.05$) and MBG ($p < 0.05$) after undergoing training using a medicine ball. However, the difference in the level of increase between the two groups did not reach sufficient statistical significance to indicate the superiority of one method. It is possible that a 1 kg difference in load is not sufficient to produce differentiated neuromuscular adaptations (Plotkin et al., 2021). Meanwhile, the control group did not experience a significant increase indicating that without specific intervention there cannot be substantial changes in the muscle endurance of university-level archery athletes.

Our results are in line with previous studies showing a significant increase in endurance in normal individuals and athletes after intervention with medicine ball training (Chukhlantseva, 2023; Hari & Dey, 2021; Trajković et al., 2017). Previous studies specifically stated that the increase in push-up ability was due to an increase in the strength of the deltoid, triceps, and chest muscles (Syafii et al., 2024). In line with the significant increase in sit-ups, this mechanism is characterized by an increase in the strength of the rectus abdominis and oblique muscles that produce contraction movements when training using a medicine ball (Aandstad, 2020). These findings support the application of balance-oriented conditioning methods, such as medicine ball exercises, as a relevant intervention for archery performance enhancement. Although specific research on short-term medicine ball training for archery is scarce and limited, evidence from previous studies provides a strong basis for assuming that the duration and nature of training are important in producing significant effects. Previous study reported no meaningful enhancement in core stability and balance after a short-term core spesific program training, suggesting that training duration and intensity are critical factors influencing outcomes (Giboin et al., 2019; Szafraniec et al., 2020). These findings suggest that the effectiveness of training depends on factors such as population characteristics, program design, and the degree to which the exercises align with sport-specific demands

According to the study findings, coaches and physical therapists can design training sessions using medicine balls to improve balance and arm muscle endurance, which have been shown to be highly effective for upper body strength and endurance in collegiate archers. For best results, coaches should start with an appropriate weight (< 4kg) to ensure proper form and gradually increase weight and intensity as athletes develop strength and control. Coaches should aim to schedule training sessions using these medicine balls 2-3 times per week, ensuring adequate recovery time between sessions (48-72 hours, as recommended for high-intensity training), to prevent fatigue and reduce the risk of injury.

A limitation of this study is the relatively small sample size, which may affect the generalizability of the findings. With only 30 participants divided into three groups, the results may not be representative of the broader population of collegiate archers or athletes from other sports. The 8-week intervention period limited the assessment of long-term effects on balance and hand muscle endurance. A longer intervention period would provide more insight into the sustainability of the observed improvements. The lack of external factors included control of participants' sleep patterns, dietary intake, and physical activity outside of the intervention sessions. Several uncontrolled factors could have indirectly influenced performance outcomes, making it difficult to attribute improvements to the medicine ball training intervention.Additionally, the use of general physical fitness assessments to evaluate upper body muscular endurance and balance was also a limitation of this study. Although these instruments had been widely validated to assess basic physical attributes, they might not have fully captured the specific demands of archery. Therefore, Future research is encouraged to incorporate assessment methods that are more specific to archery performance.

CONCLUSION

This study demonstrated that training using a medicine ball for 8 weeks can effectively enhance balance and upper limb muscular endurance among collegiate archery athletes. These improvements are essential physical components that support shooting consistency and overall performance in precision sports like archery. Given its simplicity and applicability, medicine ball training may serve as a practical alternative for developing physical attributes relevant to archery without the need for specialized equipment. As a practical

implication, coaches are encouraged to integrate 2-3 medicine ball sessions weekly to enhance balance and upper limb stability in archery athletes

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CONFLICT OF INTEREST

The authors state no conflict of interest.

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