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ORIGINAL ARTICLE

Shoulder Girdle Muscles Activation of Compound Archers

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ABSTRACT

Background. Sports performance is the way sports participation is measured. Sports performance is a complex mixture of biomechanical function, emotional factors, training techniques, tactics, and many other aspects. **Objectives.** This research aimed to examine the muscle activation of compound archers during shooting. **Methods.** Twenty-four compound archers, consisting of 10 males and 14 females, who met the inclusion criteria were included in the study. Athletes were divided into three according to their shooting score. A wireless surface EMG system (Trigno EMG sensor, Delsys Inc., USA) measured activity on the middle deltoid, posterior deltoid, middle trapezius, lower trapezius, triceps, and anconeus muscles. The measurement was recorded of nine shots, and the distance between the archers and the target was 18m. **Results.** There was no statistically significant difference between the elite, intermediate, and junior compound archers. No significant difference was found between the genders upon comparing muscle use during shooting. However, in terms of percentages, compound archers employed the most sustained contractions of the posterior deltoid, middle trapezius, anconeus, and lower trapezius muscles when shooting. During shooting, they also used the most prolonged contraction of the posterior deltoid, middle trapezius, anconeus, and lower trapezius muscles. **Conclusion.** It can be concluded that these three findings show the same trend toward using muscles among compound archers during shooting. Therefore, more research on compound categories needs to be conducted to further findings and comparisons in the future.

KEYWORDS: ***EMG, Muscle Activation, Archery Performance, Compound Archers.***

INTRODUCTION

Archery is a sport that uses a bow to shoot an arrow at a target (1). It is also a sport characterized by the competitor's ability to correctly shoot an arrow at a specific target in a set amount of time. Archery sports need patience, attention, and a high level of mental endurance. As a result, an archer must have fundamental skills, movement mechanics, and a mindset and be in excellent physical condition (1, 2). Archery accomplishment may be quantified via training or competition since archery is a quantifiable activity emphasizing physical condition (3).

Furthermore, it is a static activity that requires upper body strength and endurance in the shoulder girdle (4). To increase accuracy, compound archery is a static sport that demands archers to standardize their shooting stance and reduce their motions while targeting the target. The six stages of archery are holding, drawing, full draw, targeting, release, and follow-through. An archer propels the bow towards the target with one arm extended from the drawing phase to the release phase; the shoulder modulates the force from the drawing arm. To draw the bow, the shoulder muscle must be strong enough (4, 5). Great arm muscular power allows the archer to shoot in his or her comfort zone, impacting archery performance (6). During the drawing

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phase, an archer cannot make a full draw without arm muscular strength.

Furthermore, the archer will not achieve proper shooting technique. For a well-balanced performance of these sequential phases, the strength and endurance of both upper extremity muscles, particularly the forearm and shoulder girdle muscles, are critical to achieving a good execution (7). A few studies have investigated the involvement of the forearm muscles in archery shooting (8, 9), and a few have looked at the shoulder girdle muscles (10, 11). Most of this research employed electromyography to analyze the activation patterns of the forearm or shoulder girdle muscles, with no kinesiologic methodology, such as isokinetic measures.

Although archery is a bimanual exercise, each arm executes separate actions, which activates different muscles (12). The dominant arm of a person is the one that pulls back on the bowstring and is referred to as the 'draw arm.' Bracing against the bow and aiming falls on the non-dominant arm, sometimes known as 'the bow arm' (12). Archers use strategies based on various elements such as bow type, individual physical features, and personal choice. Previous research on muscular activity during archery among recurve archers has focused on forearm muscles (i.e., flexor digitorum superficialis and extensor digitorum) to assess shooting techniques, particularly during arrow release (9, 13, 14). Lin et al. (11) assessed muscular activation in the shoulder's biceps brachii, infraspinatus, and deltoid muscles. Vendrame et al. (15) and Dorshorst et al. (16) systematically analyzed archery performance evaluation from 1986 to 2021 and found that most research focused on muscle activity among recurve archers, and fewer studies focused on compound archers.

MATERIALS AND METHODS

Participants. A sample of 24 compound archers consisting of 10 males and 14 females from the state team, ranging in age from 14 to 22 years old, were involved in this study. Their height was 163.42±8.91 cm (M±SD), and their weight was 70.45±20.42 kg. During the measurement, the participants were in normal health. They were assigned to three groups based on their shooting score: (i) elite archers (n=8) with a score range between 341 and 360; (ii) intermediate archers (n=8) with a score range between 321 and 340; and (iii) junior archers (n=8) with a score range between 301 and 320. During the testing, the subjects were in normal health. The study complied with the ethical guidelines of the 1975 Declaration of Helsinki. Each participant voluntarily provided written informed consent before participating. They were free to withdraw from the study without any consequences. This study was approved in advance by the ethical committee of Sultan Idris Education University (Research Code: 2022-0576-01) on 31st Mei 2022.

Instruments. The activity of the arm and deltoid muscles was measured using a wireless surface EMG system (Trigno EMG sensor, Delsys Inc., USA). All EMG reference standards were based on (17). Various factors influence EMG signal amplitude, are highly variable between individuals, and typically require normalization between subjects or across session comparisons (18). This study's data analysis represented the maximum voluntary concentration (MVC) percentage reading. The coefficient of variation for raw peak MVC ranged from 31.2-41.7% across muscles and ruptured/uninjured conditions. The recorded muscles on the bow arm side were the anconeus and triceps. The following muscles were measured on the draw arm side: middle deltoid, posterior deltoid, middle trapezius, and lower trapezius. Before the electrodes were put in, the skin was cleansed with alcohol, and the hair was removed to lower the skin's resistance. The EMG sensors were installed following established protocols (19).

Procedures. The participants were advised to wear comfortable or minimal clothing and use their bows and arrows for measurement purposes. The researcher and biomechanics laboratory assistant performed the test at the archery range. Before the test, the participants warmed up following their normal routine, consisting of three ends of 10m shooting. Then, surface electrodes were selected from the middle, posterior deltoid, middle trapezius, lower trapezius, triceps, and anconeus muscles (Figure 1). All EMG reference standards were based on Marco Barbero et al. (2012) (17). Then, they consecutive shots of two ends to the 18m target using JVD Archery Target face 3x20cm vertical compound with approximately 30-s rest between each shot for the trial. Then, the archers recorded nine shots, and the distance between the archers and the target was 18m.

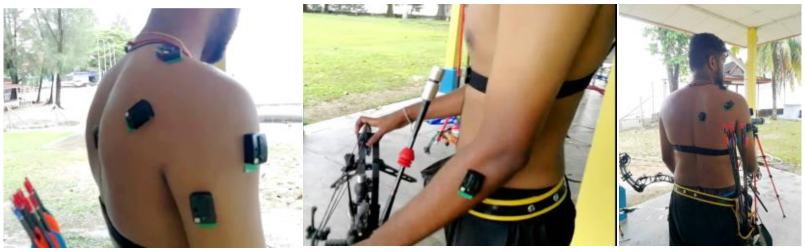

Figure 1. The surface electrode position during the measurement session.

Statistical Analysis. Descriptive statistics were applied to identify the characteristics of the subjects and groups. Mean scores were calculated for each participant's nine shots and averaged across each group. One-way analysis of variance (one-way ANOVA) was conducted to compare the muscle activation during each time interval among groups. The ANOVA test was followed by Tukey post-hoc comparisons to determine the intervals where significant differences did occur. A probability of $p<0.05$ was selected to indicate statistical significance. All statistical analyses were conducted using SPSS v19 (IBM SPSS Statistics).

RESULTS

The demographic characteristics data tabulated using descriptive distribution are reported as mean±SD for the age (yrs), weight (kg), height (cm), and personal best score for the 30m target are shown in Table 1.

The study found no significant statistical difference among the elites, intermediate, and junior compound archers, with a p-value greater than 0.05 (Table 2). However, based on the findings presented in Figure 2, the mean and standard deviation values for the six muscles measured during shooting among elite, intermediate, and junior compound archers were analyzed. The results indicate that elite compound archers exhibited the highest scores among the anconeus muscle (M=35.6, SD=10.5) and middle trapezius (M=32, SD=16.5). Like junior compound archers, the anconeus muscle (M=31.5, SD=8.5) exhibited the highest score, trailed by the middle trapezius (M=29.5, SD=18.8). In the case of intermediate compound archers, the posterior deltoid muscle (M=27.1, SD=21.3) exhibited the highest score, followed by the lower trapezius muscle (M=26.5, SD=14.3), which was actively engaged during the shooting process.

Table 1. The physical characteristics of the participants

Variables	Elite (n=8)	Intermediate (n=8)	Junior (n=8)
Age	19.0±2.3	18.1±2.3	15.1±0.6
Weight	80.7±21.0	70.0±17.0	70.4±20.4
Height	167.0±11.58	164.4±6.6	158.9±6.6
Best score	351.1±4.9	347.1±8.6	329.5±12.4

All values are expressed as Mean±SD.

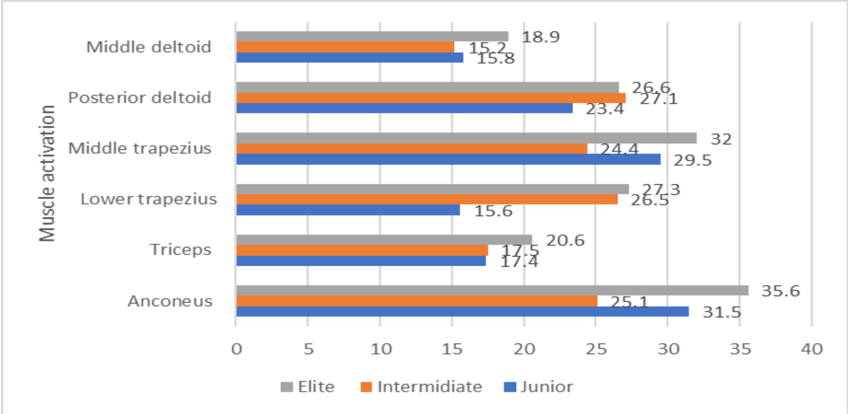

Figure 2. The mean of muscle activation during shooting for elite, intermediate, and junior compound archers.

Table 2. The muscle activation during shooting for the elite, intermediate, and junior compound archers

Muscles	Elite	Intermediate	Junior	P-value
Middle deltoid	18.9±7.2	15.2±8.8	15.8±4.7	0.53
Posterior deltoid	26.6±17.0	27.1±21.3	23.4±15.8	0.92
Middle trapezius	32.0±16.5	24.4±13.6	29.5±18.8	0.64
Lower trapezius	27.3±11.7	26.5±14.3	15.6±9.8	0.12
Triceps	20.6±5.7	17.5±7.4	17.4±7.1	0.19
Anconeus	35.6±10.5	25.1±11.9	31.5±8.5	0.16

All values are expressed as Mean±SD (%MVC)

A comparative analysis was conducted on the muscular activation patterns of male and female compound archers during shooting. The analysis revealed no significant gender-based disparity in muscle activation during shooting, as indicated by a p-value greater than 0.05 (Table 3). The statistical analysis for the mean and standard deviation values in Figure 3 indicates that the anconeus muscle is the most frequently activated muscle by archers of both genders during the shooting process, as evidenced by the mean score (male=27.8, female=32.8). After the middle trapezius, the mean values for males and females are 24.1 and 31.9, respectively.

In terms of the percentages of muscle activation during shooting among all groups (elite, intermediate, and junior compound archers), 74.64% of the archers are using the posterior deltoid, 68.61% are using the middle trapezius, 55.89% are using anconeus muscle, and 49.6% are using lower trapezius (Figure 4).

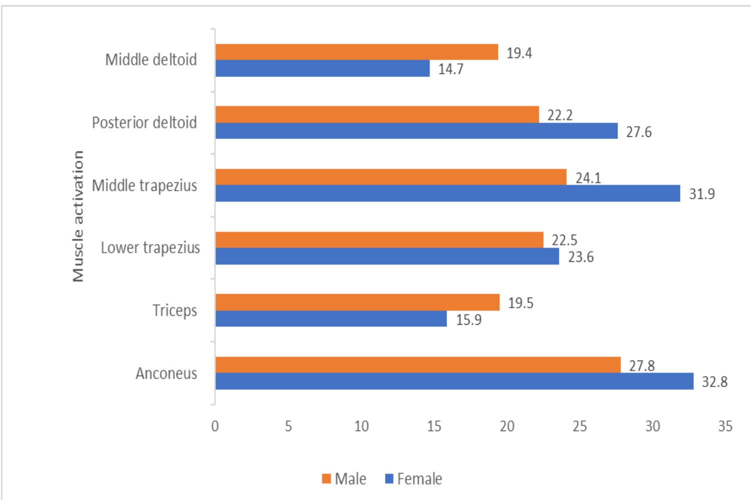

Figure 3. The mean of muscle activation during shooting for male and female compound archers.

Table 3. The comparison between male and female compound archers on muscle activation during shooting

Muscles	Male	Female	P-value
Middle deltoid	19.4±8.8	14.7±4.8	0.51
Posterior deltoid	22.2±14.0	27.6±19.7	0.44
Middle trapezius	24.1±16.0	31.9±15.8	0.27
Lower trapezius	22.5±13.1	23.6±13.0	0.85
Triceps	19.5±8.5	15.9±5.7	0.26
Anconeus	27.8±10.7	32.8±10.9	0.28

All values are expressed as Mean±SD (%MVC)

DISCUSSION

Despite several studies assessing muscle activation during archery shooting, there is a dearth of research on the muscle activation patterns of compound archers during shooting. Most of the research was conducted on archers who utilize recurve bows for diverse purposes, examining muscular utilization factors.

Consequently, the present investigation was undertaken to ascertain the muscular activation patterns exhibited by three distinct cohorts of elite compound archers during shooting. No significant variations in muscular activation were observed among elite, intermediate, or junior compound archers during the shooting process. This contradicts previous studies on muscle activity among recurve archers, which showed a difference between elite, intermediate, and junior archers during archery shooting. Elite recurve archers actively involve their posterior deltoid and middle trapezius muscles to pull the bowstring until the full-draw position is reached (4). Meanwhile, mid-level and novice recurve archers rely on the lower trapezius muscle and inferiorly retract the scapula, resulting in arm instability (5).

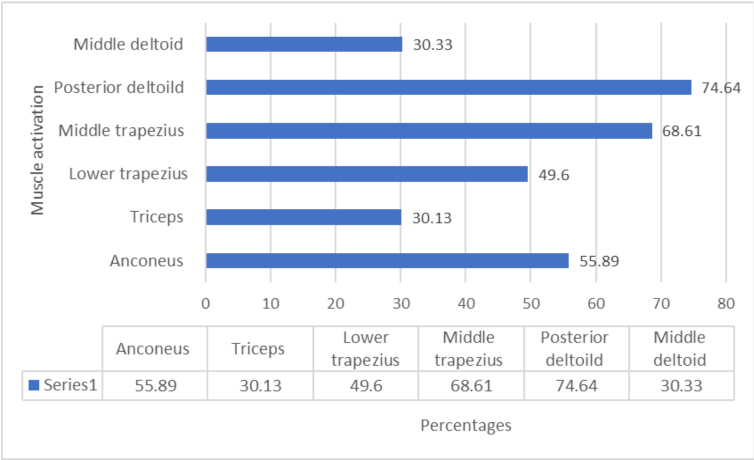

Figure 4. The percentages of muscle activation during shooting among compound archers.

Moreover, novice recurve archers tend to activate the arm muscles (biceps) instead of the back muscles in the drawing phase, possibly because of the greater elbow flexion angle (20). However, this study's statistical analysis revealed that the anconeus and middle trapezius muscles were significantly activated among elite and junior archers during the shooting process. On the contrary, archers at an intermediate level depend on the lower trapezius and posterior deltoid muscles.

Besides that, the compound archers were compared regarding their muscle activation during shooting for male and female compound archers. No statistical difference was found between the gender and the comparison of muscle activation during shooting. However, the mean data showed that the anconeus muscle has the highest muscle activation of both genders when performing the shooting, followed by the middle trapezius muscles. This finding is similar to previous research findings, which showed that elite and junior compound archers use the same muscles during shooting. The results of this finding reinforce that, among compound archers, the most active muscles during shooting are the anconeus and middle trapezius muscles. Nevertheless, no study examined gender and muscle activity among compound and recurve archers.

Another notable finding is the percentage of muscle activation during shooting among all groups (elite, intermediate, and junior compound archers). The compound archers used the most prolonged contraction of the posterior deltoid, middle trapezius, anconeus, and lower trapezius muscles. These four muscles used in the compound have a similar finding to studies on the recurve archer on the shoulder and back muscles (draw arm). However, for the bow arm muscles, previous studies have found that the forearm muscles used were Muscle Flexor Digitorum Superficialis and Muscle Extensor Digitorum Communis (12), and there were no studies on the anconeus muscle. This is one of the earliest studies regarding the anconeus muscle. Besides, regarding archery technique for compound archers, the bow holding, length, and position of the bow arm vary according to their suitability and technique.

Moreover, some archers shoot with their bow arms straight, but archers will shoot primarily by bending a little on their bow arm during their shooting. This is because of muscle fatigue, but bones do not. Hence, we should develop a shooting technique that relies on the maximum activation of our bones and the minimum use of our muscles. Therefore, it was found that compound archers use the anconeus muscle highly. The anconeus is a small muscle located at the elbow, attaching the humerus and ulna. A compound archer pulling 45lbs and up to 60lbs uses more anconeus muscle to have a stable bow arm and aiming pattern.

It can be inferred that these three observations exhibit a consistent pattern in terms of muscle activation among compound archers during shooting. Hence, additional investigation into this category is imperative to explicate the outcomes of this research potential for further research due to the scarcity of available literature on the subject matter. The study's findings were limited by the inability to conduct a detailed comparison and validation of results with other studies. The compound category, uncontested in major sporting events such as the Olympic Games, may have received relatively less attention from researchers in investigating its potential for enhancing athletic performance. The dataset under consideration exhibits certain constraints. As a result of insufficient studies on the compound category, our study is subject to several limitations. With the increasing interest of researchers in this area, we anticipate that the study can be replicated in the future with a larger sample size and diverse research outcomes. This study was conducted with compound state archers aged 14 to 22, so the results may not be generalized and limited to the participants ' age.

CONCLUSION

In conclusion, this study represents the initial attempt to investigate this discovery within the population of compound archers in Malaysia. The collected data can serve as a fundamental reference point for tracking the impact of muscle activation in supporting compound archers to enhance their performance and achieve uniformity in their shooting. The findings show the same trend toward using muscles among compound archers during shooting. Therefore, more research on compound categories needs to be conducted to further findings and comparisons in the future.

APPLICABLE REMARKS

- More studies on muscle activation or patterns among compound archers can provide evidence and impact to improve athletes' shooting performance.
- There is still a lack of research on compound compared to recurve archers. Hence, more studies are needed to provide data and guidance to athletes, coaches, and various parties in designing their training programs.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Fatin Nurfatehah Mat Salleh. Acquisition of data: Fatin Nurfatehah Mat Salleh. Analysis and interpretation of data: Mon Redee Sut Txi. Drafting the manuscript: Mon Redee Sut Txi. Critical revision of the manuscript for important intellectual content: Mon Redee Sut Txi. Statistical analysis: Mon Redee Sut Txi. Administrative, technical, and material support: Fatin Nurfatehah Mat Salleh. Study supervision: Mon Redee Sut Txi.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to the materials in the manuscript.

FINANCIAL DISCLOSURE

We declare no financial interest in the article "Shoulder Girdle Muscle Activation of Compound Archers."

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ETHICAL CONSIDERATION

This research was approved by the ethical committee of Sultan Idris Education University (Research Code: 2022- 0576-01) on 31st Mei 2022. All subjects provided information consent before participating in the study.

ROLE OF THE SPONSOR

This research was not sponsored.

ARTIFICIAL INTELLIGENCE (AI) USE

Artificial intelligence (AI) was not used in any capacity to develop, draft, or edit writing, nor was it used in data processing and analysis.

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