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Original article

Acute effect of dynamic and static stretching exercises on targeting performance in archery

Bülent Turna[1], Burcu Bayazit[1], Mehmet Emre Eryücel[1], Mustafa Yildiz[1], Mehmet Bilgin Karademir[2]

[1] Faculty of Sport Sciences, Akdeniz University, Antalya, Turkey; [2]Alanya Alaattin Keykubat University Tourism Animation Department, Antalya, Turkey

Abstract. *Study Objectives:* This study aimed to investigate the acute effects of dynamic and static stretching exercises on targeting performance in archery. *Methods:* Thirty intermediate archers participated in the study, 15 females and 15 males. Participants were assigned into three groups randomly which are no stretching (NS), static stretching (SS), and dynamic stretching (DS). 3*10 Arrow shooting test (18 m) were applied to each group on three different days (with minimum 72-hour resting intervals between days) after each different stretching protocols with a random order. SPSS 20 statistical package program was used for statistical analyses and the significance level was set at $p < 0.05$. Friedman test was used to compare different stretching protocols, and Wilcoxon Signed Rank Tests were used to determine the differences between the groups. A statistically significant difference was found between the groups in the comparison of an arrow shot tests performed after different stretching protocols ($p < 0.05$). *Results:* As a result of the paired comparisons, there was no statistically significant difference between SG and GY groups ($p > 0.05$), but a statistically significant difference was found between SG and DG groups and GY and DG groups ($p < 0.05$). *Conclusion:* It was found that static stretching exercises performed after submaximal running and Archery specific warm-up did not affect targeting performance, but dynamic stretching exercises affected performance negatively.

Key words: Archery, Targeting Performance, Dynamic Stretching, Static Stretching

Introduction

The developments in sports sciences have led researchers to use different methods for achieving higher performances. The fact that specific exercises applied to improve the sportive performance level serve this purpose reveals the importance and effects of training science (1).

Archery – a sports branch based on throwing spikes called arrows with a bow to inanimate targets – originated in the steppes of Central Asia and was used for hunting, combating, and entertaining and spread to all around the world with the Turks (2,3). Archery, which had been an element of power in the army until the invention and use of firearms, has gradually become an Olympic sport (4,5). Archery was included in the Olympic Games program in the men's category at the 1900 Paris Olympic Games for the first time (2). Turkey was affiliated to the World Archery Federation, which was formerly known as Fédération Internationale de Tir à l'Arc (FITA) founded in 1931, as the 16th member in 1955 (6). As a result, the aim of archery, which has become an Olympic sport with modernization, is to hit a specific target and achieve the highest score (3). Force integrity, endurance, balance, reaction time, psychological state, hormonal changes, and postural competence play important roles in archery performance (7,8). Hormonal changes affect the target performance because they have an impact on the heart rate (7).

One of the most important issues in sportive performance is to select the best warm-up protocol (9). Commonly used warm-up methods are dynamic and static stretching exercises performed after submaximal warm-up conditions (10,11). Stretching exercises are divided into two groups, namely static and dynamic. Static stretching exercises include static stretching, passive stretching, active stretching, PNF (Proprioceptive Neuromuscular Facilitation), and isometric stretching studies. Dynamic stretching exercises are classified as ballistic stretching, dynamic stretching, and isolated active stretching (12). Various stretching exercises performed by using internal and external forces to increase muscle flexibility and range of motion (ROM) are frequently used by athletes, trainers, physicians, and physiotherapists to prevent sports injuries and also in post-injury rehabilitation (13,14). The respiratory system works more effectively and efficiently as a result of the reduction of total resistance to blood flow in the lungs due to moderate intensity warm-up exercises. Therefore, heart rate increases (15). Archery branch has been described as a sports activity where both moderate-level static and low-level dynamic exercises are used (15, 16). Although phasic muscle interactions, which produce explosive movements for successfully exhibiting the skills in most sports branches, vary based on the biomechanical efficiency level, the shooting skill in archery relies on the smooth release of the string and then the final throwing movement (17).

When examining the literature on the topic, the addition of appropriate stretching exercises for the activity into training programs seems to be a factor affecting the sportive performance (18). In this study, the purpose was to investigate the acute effect of different stretching exercises applied before shooting on the targeting performance in archery.

Table 1. Physical characteristics of archers

	Female (n=15) Mean±SD	**Male (n=15) Mean ±SD**
Age (year)	17,13±,74	17,00±,75
Athlete age (year)	3,06±,70	3,26±1,03
Bodyweight (kg)	55,00±2,17	67,60±4,17
Height (cm)	163,26±2,43	173,00±2,10
BMI	20,63±,78	22,57±1,38

Materials and Methods

Participants

30 athletes being 15 male and 15 females participated in the study by filling the "informed consent form". The study was deemed appropriate scientifically and ethically based on the decision taken on September 11, 2019, by the Akdeniz University Faculty of Medicine Clinical Research Ethics Committee. The levels of the athletes were determined as intermediate by considering their current background and their rankings in the competitions. The research was conducted in accordance with the principles of the Declaration of Helsinki.

Height Measurement

Height was measured with 0.1 m accuracy in an upright position using SECA (Germany) height scale.

Body Weight Measurement

Body weights of the athletes were obtained barefoot with only shorts and t-shirts using SECA (Germany) electronic scale with a sensitivity of 0.5 kg.

BMI Calculation

Body mass index (BMI) was calculated using the relationship "weight (kg)/height $(m)^2$.

Archery Score Measurement

FITA target sheet of 3 × 20 cm was used in determining the archery score.

Procedure

The athletes were randomly subjected to shooting tests for 3 days (a 72-hour resting interval between each exercise) in three different stretching exercises: no stretching (NS), static stretching (SS), and dynamic stretching (DS). Therefore, the research design shown in Figure 1 was used to minimize both

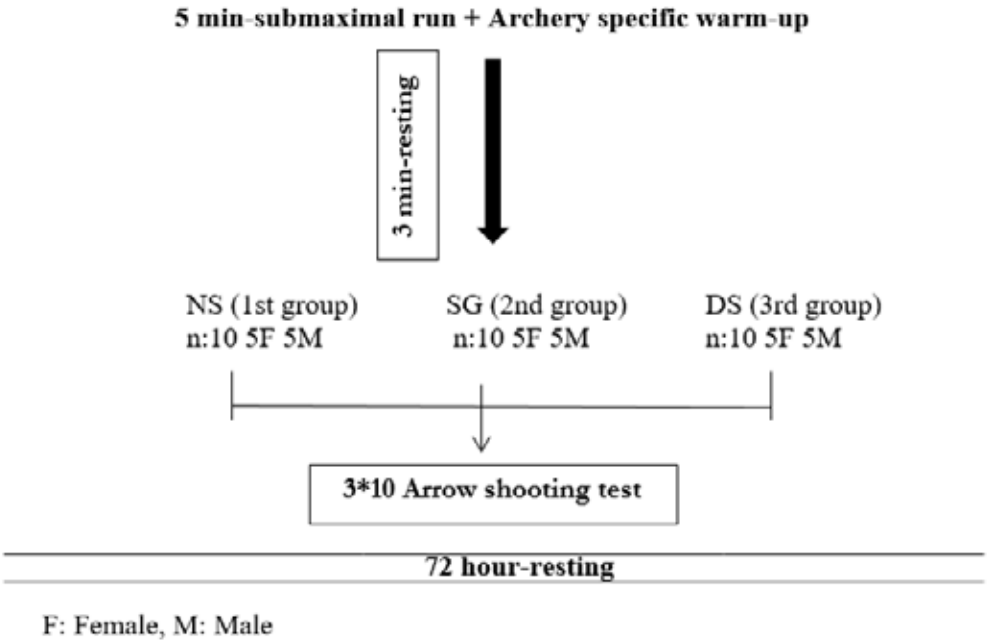

Figure 1. The research design (participants applied each protocol with cross over design)

Table 2. Shoulder static stretching exercises applied in the study

Pectoral Static Stretching	The athlete places the inner surface of the hand parallel to the wall and the body is fixed at the elbow-shoulder level by slightly rotating in the opposite direction.
Latismus Dorsi Stretching	The athlete kneels. The two hands are stretched over the fixed object at the body level parallel to the floor. The body is fixed at the point where it can stretch as much as possible.
Trapezius Static Stretching	The athlete kneels. One hand is fixed by holding the tibia of the foot on the floor. The other hand stretches the head slightly in the opposite direction.
Subscapular Static Stretching	The athlete lies on the left arm. Elbow is fixed parallel to the floor at the 90° shoulder level. The shoulder is stretched to the internal rotation with the other hand.
Shoulder Rotator Cuff Stretching	The arm is fixed at 45° to the body. The outer surface of the hand is fixed to the lumbar region by flexing the elbow. With the help of the other hand, the hand is slightly pulled in while holding from the elbow.

the learning effect and physical advantages of the athletes among each other. The research was carried out in 3 sessions and a 72-hour resting was provided between sessions. Before each session, the athletes first do submaximal running exercise for 5 minutes and then performed warm-up shootings traditionally practiced in archery. Static and dynamic stretching exercises were applied in 3 sets for 15 seconds with providing 10 seconds between each set. These exercises were applied to the shoulder region as five different stretching movements being static and dynamic. In the study, the Olympic bow was used. Immediately after the dynamic and static stretching exercises applied in the study, the athletes were subjected to the 3 × 10 (18 m) shooting test.

Statistical analysis

Descriptive statistical values such as arithmetic mean and standard deviation were calculated for all variables. The Friedman test was used to compare different stretching applications between each other, and

Table 3. Shoulder dynamic stretching exercises applied in the study

Frontal Plane Arm Swing	The arm is swung with abduction on the frontal plane. The athlete touches the back of the shoulder of the other arm from the back of the head. The same movement is performed rhythmically in the other arm.
Frontal and Sagittal Plane Arm Swing	The arm is swung with flexion in the sagittal plane and the same arm is touched to the shoulder, then it is abducted swing on the frontal plane and the other arm is touched to the back of the shoulder. The movements are performed rhythmically in the other arm.
Shoulder Diagonal Rotation	While doing the frontal rotation with the right arm starting from the front of the body, the rotation is performed from the shoulder area in the sagittal plane before ending the movement.
Flexion Extension Dynamic Stretching	While the right arm is flexed, the left arm simultaneously is extended.
Shoulder Internal and External Rotation	The elbow is fixed at the shoulder level by bending the elbow 90º. Internal and external rotation is done from the shoulder area.

Table 4. Comparison of different stretching exercises among groups

	Wilcoxon Test	
Stretching Protocols	**Z**	**p**
Static Stretching & Dynamic Stretching	-4.69	.000*
No Stretching & Dynamic Stretching	-4.49	.000*
No Stretching & Static Stretching	-1.92	.055
	Friedman Test	
Static Stretching Dynamic Stretching No Stretching	**X^2**	**p**
	40.24	.000*

p<0,05*

Table 5. Scores of groups with different stretching exercises applied

Groups	**Minimum**	**Maximum**	**Mean±SD**
DS	215,00	262,00	244,8333±12,58648
SS	204,00	265,00	245,4667±13,57923
NS	210,00	265,00	246,2000±12,19497

the Wilcoxon Signed-Rank test was used to determine in which groups the differences were seen.

Results

When examining Table 4, a statistically significant difference was found between SS and DS groups ($p<0.001$). A statistically significant difference was determined between NS and DS groups ($p<0.001$). However, there was no statistically significant difference between NS and SS groups ($p>0.001$).

Discussion and Conclusion

The data obtained as a result of the shooting score tests applied to the archers participating in the study were examined and it was found that 5 min-submaximal run and static stretching exercises performed after archery specific warm-up did not affect targeting performance, but dynamic stretching exercises decreased it. This study reveals the importance of stretching exercises that should be selected in the warm-up phase for targeting performance in archery.

There are limited studies in the literature investigating the acute effect of stretching exercises applied

before shooting in archery on targeting performance. Turan and Çilli (2016), examining the effect of different warm-up methods on targeting performance in archery, concluded that the dynamic warm-up method decreased the targeting performance in archery, while the static warm-up method did not cause a change in the targeting performance (18). The results of that study support the results of the present study. The reason that dynamic stretching exercises harm targeting performance is due to the physiological changes caused by dynamic stretching on the body. It is considered that dynamic stretching exercises have negative effects on aiming in some branches like archery where static movements are applied more intensely (19). Physiological, anthropometric, and psychological features are significant factors in achieving success in sports (20).

There are studies in the literature about the effect of different stretching exercises on performance. These studies mostly examine the effects of dynamic and static stretching exercises on sportive performance. Turna (2018) suggests that static stretching exercises should be performed together with dynamic stretching on the account of the fact that they eliminate the negative effects caused by static stretching exercises. Another result obtained from the findings of that study is that although dynamic stretching has a positive effect on some biomotor properties such as speed and strength, static stretching exercises may have a negative effect (12). It is stated that static stretching applications temporarily suppress the strength, which is due to neural and mechanical effects. It is known that the elongation occurring in the tendon length at the end of the stretching reduces the tension and these stretching exercises decrease the motor unit activation and firing frequency, causing a reduction in strength (21). Muscular strength is very important in practicing the archery technique. If the athlete has enough strength to pull and hold the bow, he/she can practice the correct archery technique. Because the pulled bow load is much lower than the maximum muscle strength threshold, the muscles in contraction do not experience excessive tension. Therefore, archery technique and muscle strength have a direct relationship (22). Studies are discussing the negative effects of static stretching, as well as those indicating that static stretching doesn't effect. Torres et al. (2008) claimed that static stretching exercises have no effect on upper body muscle strength (23). Ogura et al. (2007) determined a decrease in voluntary maximal muscle contraction values with 60-second static stretching exercises, while they could not find a significant change with 30-second static stretching exercises (24). Egan et al. (2006) stated that the isokinetic test results were not affected by static stretching movements applied with 4 movements and 4 repetitions for 30 seconds (25). Cramer et al. (2006) stated that the isokinetic test results were not affected by static stretching movements (26). The findings of these studies provide insight into why static stretching exercises of the present study did not affect targeting performance. Papadopoulos et al. (2006) stated that static stretching causes a statistically insignificant decrease in isokinetic strength, but a significant decrease in the EMG (electromyography) values of the rectus femoris muscle (27). Maisetti et al. (2007) stated that the ankle plantarflexion isokinetic strength was negatively affected after static stretching exercises applied to the calf muscle group and there was no difference in the isometric strength generated as a result of dorsal flexion movement (28).

There are various literature studies about the effect of stretching exercises on performance in various sports branches. Eken (2015), investigating the acute effects of different warm-up protocols on various performance parameters in judoists, stated that combined static and dynamic stretching exercises had a positive effect on 30 m-speed performances while static stretching exercises improved the flexibility (29). Iner et al. (2012), examining the effects of different warm-up methods on the serving speed of tennis players, stated that static stretching exercises applied immediately after traditional warm-up did not affect the serving speed (11). This study is similar to the results of the present study in terms of static stretching. Stretching exercises applied before shooting in archery are one of the important parameters affecting the targeting performance. Although there are a limited number of similar studies, the literature supports the results of the present study.

In conclusion, in this study conducted to reveal the importance and advantages of stretching exercises that should be selected in the warm-up phase of

archery, it was found that 5 min-submaximal run and static stretching exercises applied after archery specific warm-up did not affect the targeting performance, but dynamic stretching exercises decreased the performance. According to these results, shooting should not be done immediately after applying dynamic stretching exercises just before archery competitions or the negative effects caused by dynamic stretching exercises can be eliminated by performing static stretching exercises. Further studies to be performed on elite archers can compare various variables such as the application time of the combinations of different stretching methods, the number of repetitions, rest intervals, and the percentage ratio of different stretching exercises combined. Moreover, while similar studies are being conducted, it is considered that determining the heart rate during the aiming phase will be useful in explaining the effect of stretching exercises on targeting performance.

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Conflicts of interest: The authors declare that there is no conflict of interest about this manuscript.

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Correspondence
Bülent TURNA
Faculty of Sport Sciences,
Akdeniz University, Antalya, Turkey
E-mail: bulentturna@akdeniz.edu.tr