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한국 양궁선수들의 부상으로 생긴 어깨 통증의 역학에 대한 연구

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Shoulder Pain Caused by Injuries in Korean Elite Archers

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Purpose: There has been a lack of study on the pains of Korean archers, who have been getting remarkable results in international competitions. In this study, we investigated the epidemiology of shoulder pain, which is known as the most commonly complained symptom of Korean archers.

Methods: The participants were 58 elite archers in the city of Gwangju, South Korea. The method of the study was a retrospective cohort study by questionnaire and ultrasound and physical examination. Variables of individual characteristics, training patterns, the character of pain were analyzed in different age groups. Furthermore, groups were divided into those with shoulder pain and those without pain to analyze each group's shoulder function.

Results: The most common injury was shoulder injury (65.6%), and hand injury was the second-highest prevalent injury (29.3%). These two injuries were most prevalent in all age groups. Among 58 participants, 40 showed shoulder pain, but most were mild (n=30, 51.7%) and severe pain was observed in some participants (n=2, 3.5%). Mild pain was most common in each group and it showed the highest prevalence in college students (70.0%). Pain was most observed in the drawing arm, and it was triggered most when drawing the bow. In the shoulder function test category, Constant-Murley score and American Shoulder and Elbow Surgeons score were observed the lowest in the group with shoulder pain with statistical significance.

Conclusion: Shoulder injury had a high prevalence in Korean archers. Correspondingly, those with shoulder pain had lower shoulder function test scores.

Keywords: Athletic injuries, Shoulder pain, Epidemiology

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Introduction

Usage of archery as a weapon in war and hunting has evolved into usage in recreational activities and noncontact sports, which has continued its popularity even after being introduced in the Olympic Games.

Archery is divided into six stages; bow hold, drawing, full draw, aiming, release, and follow-through[1]. The archer pushes the bow with the bowing arm straight. The bowing arm is positioned statically toward the target and the drawing arm pulls the bowstring[2]. When a sound is heard from the 'clicker', a device that makes the pulling length constant, bowstring is released at this time[2]. As the bowstring is released, the force stored in the bowstring is transferred into the arrow, which enables it to fly.

Through this mechanism, archery is a relatively static sport that requires upper body strength and endurance, but especially forearm and shoulder strength[3]. However, whether it is contact or noncontact sport, all have physical requirements to endure a certain level of stress, which is why certain injuries arise[4]. Likewise, archery is a sport that requires strength to hold heavy equipment and pull the bowstring, which can be a trigger to many different injuries.

There are several studies that show which sites are prone to pain and injuries in archers[4,5]. Niestroj et al.[5] reported that the most common pain due to overuse was shoulder pain (52.9%), where 64.6% showed pain when drawing the bow.

Archery is one of the international competitions that South Korea has shown remarkable results. Many young athletes and elite players exist in South Korea, which is why the country has high expectations for the future. Several studies describe the injuries of archers. For example, although there have been studies on sex-related injuries in adult athletes reported by Yoon et al.[6], there have been few studies on the injury patterns of Korean archers who perform well internationally. In addition, if there is a study on the location or pattern of injuries according to age, it will be good data for preventing injuries. Therefore, this study aims to investigate the epidemiology of injury-induced shoulder pain and the prevalence of injuries according to different age groups in Korean archery players.

Methods

1. Subject of study

Participants were elite archery athletes and young players of Gwangju, South Korea, who were given permission by coaches and affiliated Korea Archery Association after comprehensive explanation of the study. Fifty-eight athletes participated, where 29 were male and 29 were female. Participants were divided into age groups, where middle school team (aged 13–15 years), high school team (aged 16–18 years), university team (aged 19–22 years), and works team (aged 23 years or older) consisted of 27, 12, 10, and nine players, respectively. Those who did not complete the survey were excluded from the study. This study was approved by the Institutional Review Board of Wonju Severance Christian Hospital for research ethics with a waiver for the participant's informed consent (No. CR320203).

2. Methods

Surveys, which included questions on pain and individual profile, were used with consent from players and coaches. The questionnaire was based on the Oslo Sports Trauma Research Center Overuse Injury Questionnaire developed to record the patterns, symptoms, and results of injuries caused by overuse. Injury was defined as pain in a specific area that occurs during exercise or is currently being treated because of it. The frequency of injury sites was investigated with overlap allowed.

For functional evaluation of the upper extremities, Constant-Murley score and American Shoulder and Elbow Surgeons (ASES) score were applied. Myometry was used to measure muscle strength, and ultrasound examination was performed on the shoulder. These scoring methods are used to assess the functional status of a normal, injured, or treated shoulder[7,8]. Scores are ranged from 0 to 100, and the higher the score, the better the functional status[7,8]. Pain was expressed on a visual analogue scale (no pain, 0; mild, 1–3; moderate, 4–6; and severe, 7–10). Myometry was used to test muscle strength during the abduction of the drawing arm. Ultrasonography was used by two specialists on injury sites and shoulder regions of archers. If no pain was observed, the drawing arm was evaluated.

3. Statistical analysis

General characteristics of the participants, survey variable were presented as means±standard deviations for continuous variables, and frequencies (percentages) for categorical variables in archery player. The distribution of the data was verified by the Kolmogorov-Smirnov test. Each differences between sexes and age groups and shoulder pain groups were assessed using the independent t-test or Mann-Whitney U-test for continuous variables, and the chi-square test or Fisher exact test for categorical variables. All statistical analyses were considered significant for p-value of <0.05 and were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). All tables were completed using R statistical software (version 3.6.3; R Foundation for Statistical Computing, Vienna, Austria).

Results

The sample size of this study consisted of 58 athletes. Table 1 shows the individual characteristics of the athletes divided into different age groups in average and frequency. Warm-up time was shorter in the old age groups (college team, 10.20±3.85 minutes; works team, 11.11±8.49 minutes) compared to the young age groups (middle school, 16.78±9.90 minutes; high school, 28.67±18.02 minutes). Intake of nutritional supplements was lower as age increased, with works team showing the lowest value (11.1%).

The most common injury site was the shoulder, which was consistent in all age groups. Shoulder occurred in 65.5% of the athletes, and the next highest injury site was hand with 29.3% prevalence. In middle school team, other than the shoulder and hand, the frequency of injuries to the neck, foot, and ankle was also high (Table 2).

Shoulder pain existed in 40 out of 58 participants, and was mostly mild (n=30, 51.7%), although there were cases of severe pain (n=2, 3.5%). Mild shoulder pain was observed to be the most common in all age groups, and it was highest (70.0%) in the university team (Table 3). Characteristics related to shoulder

Table 1. Average personal and sports characteristics in each age group

Characteristic	Total	Middle school team	High school team	University team	Works team
No. of participants	58	27	12	10	9
Personal characteristics					
Age (yr)	17.28±5.13	13.59±1.01	16.50±0.90	19.30±1.16	27.11±4.59
Sex					
Male	29 (50.0)	14 (51.9)	7 (58.3)	4 (40.0)	4 (44.4)
Female	29 (50.0)	13 (48.2)	5 (41.7)	6 (60.0)	5 (55.6)
Body mass (kg)	62.76±11.47	58.22±8.70	65.75±8.82	65.50±12.93	69.33±15.97
Height (m)	1.67±0.084	1.64±0.084	1.68±0.077	1.71±0.081	1.71±0.060
Body mass index (kg/m^2)	22.28±2.76	21.6±2.67	23.17±1.87	22.1±2.39	23.34±3.97
Sports characteristics					
Career (yr)	7.50±5.33	3.59±2.21	6.83±1.59	10.6±1.17	16.67±4.8
Frequency of team training (time/day)	3.33±1.47	2.67±0.92	3.50±0.90	2.80±0.92	5.67±1.58
Duration of team training (min/day)	101.29±44.19	122.04±47.03	65.83±17.82	116±35.65	70±12.25
Time of warm-up exercise (min)	17.22±12.73	16.78±9.90	28.67±18.02	10.20±3.85	11.11±8.49
Injury prevention education					
Yes	28 (48.3)	13 (48.2)	4 (33.3)	5 (50.0)	6 (66.7)
No	30 (51.7)	14 (51.9)	8 (66.7)	5 (50.0)	3 (33.3)
Health supplements					
Yes	28 (48.3)	15 (55.6)	7 (58.3)	5 (50.0)	1 (11.1)
No	30 (51.7)	12 (44.4)	5 (41.7)	5 (50.0)	8 (88.9)

Values are presented as number only, mean±standard deviation, or number (%).

Table 2. Main injury sites in each age group

Injury site	Total (n=58)	Middle school team (n=27)	High school (n=12)	University (n=10)	Works team (n=9)
Shoulder	38 (65.5)	17 (63.0)	6 (50.0)	9 (90.0)	6 (66.7)
Elbow	2 (3.5)	0 (0)	0 (0.0)	1 (10.0)	1 (11.1)
Wrist	6 (10.3)	3 (11.1)	2 (16.7)	1 (10.0)	0 (0)
Hand	16 (29.3)	8 (29.6)	5 (41.7)	3 (30.0)	1 (11.1)
Hip and pelvis	1 (1.7)	1 (3.7)	0 (0.0)	0 (0.0)	0 (0)
Knee	6 (10.3)	1 (3.7)	1 (8.3)	3 (30.0)	1 (11.1)
Lower leg	4 (6.9)	1 (3.7)	0 (0.0)	2 (20.0)	1 (11.1)
Ankle	10 (17.2)	6 (22.2)	0 (0.0)	3 (30.0)	1 (11.1)
Foot	10 (17.2)	6 (22.2)	0 (0.0)	3 (30.0)	1 (11.1)
Neck	13 (22.4)	7 (25.9)	2 (16.7)	3 (30.0)	1 (11.1)
Back	4 (6.9)	3 (11.1)	1 (8.3)	0 (0)	0 (0)
Eye	1 (1.7)	0 (0)	0 (0)	1 (10.0)	0 (0)

Values are presented as number (%).
The frequency of injury sites was investigated by allowing overlap, and the ratio of each site was expressed as the number of each site in the total number of athletes.

Table 3. Degree of shoulder pain and frequency in each age group

Shoulder pain	Total (n=58)	Middle school team (n=27)	High school (n=12)	University (n=10)	Works team (n=9)
No pain	18 (31.0)	9 (33.3)	5 (41.7)	1 (10.0)	3 (33.3)
Mild	30 (51.7)	13 (48.5)	6 (50.0)	7 (70.0)	4 (44.4)
Moderate	8 (13.8)	4 (14.8)	1 (8.3)	1 (10.0)	2 (22.2)
Severe	2 (3.5)	1 (3.7)	0 (0)	1 (10.0)	0 (0)

Values are presented as number (%).
Shoulder pain was expressed on visual analogue scale: none, 0; mild, 1-3; moderate, 4-6; severe, 7-10.

pain in each age group have been organized in Table 4. Pain was frequently observed in the drawing arm, and was most common during the action of drawing the bow. Return from injury in less than one week was observed in 86.7% of participants.

Among those who did not have shoulder pain, 66.7% of the athletes had training sessions of less than 100 minutes. In archers with shoulder pain, 62.5% had warm-up sessions that lasted less than 15 minutes. However, these two data did not hold statistical significance (Pearson χ^2=0.697, p=0.404). Among those with no pain, 61.1% completed injury prevention education programs, but this data was also not statistically significant (Pearson χ^2=0.921, p=0.337), as it did not show a significant difference when other variables were applied (Table 5). In ultrasonography, biceps tendinosis and subacromial bursitis were observed in 22.4% and 10.3% of the archers respectively (Fig. 1).

Table 6 organizes the functional characteristics of those with shoulder pain and those without. Constant-Murley score and ASES score were lower in the group with pain, which showed statistical significance. However, strength did not show statistical significance.

Discussion

This study was showed that shoulder is the main injury site of Korean archers of each age group. The reason for the location and pattern of a typical injury is thought to be because of the specific movement pattern required in archery. When holding and drawing a bow, muscle, tendon, and ligaments of the arm and shoulder need to give strength, and especially more on the drawing arm that causes asymmetric strain. The causes of overuse are reported as risk factors such as the number of arrows shot, lack of pulling strength, excessive pulling strength, wrong technique[3,9,10].

Shoulder pain is known to occur mostly on the drawing arm[3,5].

Table 4. Frequency of pain profile in each age group

Variable	Total (n=58)	Middle school team (n=27)	High school team (n=12)	University team (n=10)	Works team (n=9)
Pain laterality					
Drawing arm	33 (80.5)	14 (77.8)	7 (87.5)	7 (77.8)	5 (83.3)
Bow arm	5 (12.2)	2 (11.1)	1 (12.5)	1 (11.1)	1 (16.7)
Both	3 (7.3)	2 (11.1)	0 (0)	1 (11.1)	0 (0)
Moment of pain					
Drawing phase	20 (48.8)	6 (33.3)	5 (62.5)	5 (55.6)	4 (66.7)
Full draw phase	15 (36.6)	10 (55.6)	1 (12.5)	3 (33.3)	1 (16.7)
Release phase	6 (14.6)	2 (11.1)	2 (25.0)	1 (11.1)	1 (16.7)
Time to return after recovery					
<1 wk	26 (86.7)	12 (85.7)	2 (66.7)	6 (85.7)	6 (100)
≥1 wk	4 (13.3)	2 (14.3)	1 (33.3)	1 (14.3)	0 (0)
Relationship between injury and record					
Yes	4 (8.5)	1 (5.3)	1 (9.1)	1 (12.5)	1 (11.1)
No	43 (91.5)	18 (94.7)	10 (90.9)	7 (87.5)	8 (88.9)
Nonsurgical treatment for the last 1 yr					
Yes	44 (75.9)	22 (81.5)	10 (83.3)	6 (60.0)	6 (66.7)
No	14 (24.1)	5 (18.5)	2 (16.7)	4 (40.0)	3 (33.3)
Surgical treatment for the last 1 yr					
Yes	3 (5.2)	2 (7.4)	0 (0)	0 (0)	1 (11.1)
No	55 (94.8)	25 (92.6)	12 (100)	10 (100)	8 (88.9)
Pain recurrence					
Yes	23 (56.1)	11 (61.1)	4 (50.0)	5 (55.6)	3 (50.0)
No	18 (43.9)	7 (38.9)	4 (50.0)	4 (44.4)	3 (50.0)

Values are presented as number (%).
Some questionnaire questions were not answer by participants, and therefore the n values may vary in each variable.

This study showed similar results as 80.5% of the participants showed pain mainly on the drawing arm. When drawing the bow, sufficient strength is required. However, when one lacks enough muscle strength, one becomes easily prone to injuries. The study by Mann and Littke[3] was reported that female archers with weak muscle strength are more likely to injure the drawing arm. In this study, female archers had a high prevalence of pain, but there was no statistical difference.

Also, if repetition of the drawing arm and the arm that holds the bow continues, supraspinatus tendon and the long head of biceps tendon is pressed by the subacromion, which may result in impingement syndrome. This may lead to inflammation and problems of the tendon that is the main source of pain[3,11-14]. In this research, ultrasonography proceeded and the most common finding was biceps tendinosis and subacromial bursitis.

Shoulder injury occurs in athletes who rigorous use the upper body since youth, and this decreases the function and range of motion of the shoulder[15]. In this study, the shoulder was the highest among the frequency of injuries in middle school team (63.0%) and high school team (50.0%). Pain was observed the most during full draw phase, which is when the bow is drawn at its maximum. It is thought that when the athlete was young, the muscle strength was weak, and the drawing arm was strained.

Injuries other than the shoulder were observed in hand and fingers. The repetitious movement of the hand and the vibration of the bow during release may be the main causes. However, in Ertan's study[16], hand injury was not reported as an acute injury or an injury stemming from overuse.

Neck and back injuries were also reported. Usually, microtrauma or major trauma is the main cause. When the bow is drawn, the core muscles are strained and repetitious tension may cause stress to the spine which may lead to early degenerative changes. Korean male athletes, who shoot at a fixed distance in "target archery," on average exert 45 pounds of force on the bow[17]. If back muscle is incessantly used, considerable strain may be exerted. In research by Lapostolle et al.[10], prevalence of neck

Table 5. Relationship between shoulder pain and variables

Characteristic	Without pain (n=18)	With pain (n=40)	p-value
Personal characteristics			
Sex			0.570
Male	10 (55.6)	19 (47.5)	
Female	8 (44.4)	21 (52.5)	
Age group			0.433
Middle school team	9 (50.0)	18 (45.0)	
High school team	5 (27.8)	7 (17.5)	
University team	1 (5.6)	9 (22.5)	
Works team	3 (16.7)	6 (15.0)	
Body mass (kg)	63.94±12.39	62.23±11.15	0.602
Height (m)	164.72±7.94	168.53±8.44	0.112
Body mass index (kg/m^2)			0.219
Normal, <23	10 (55.6)	30 (75.0)	
Overweight, ≥23	8 (44.4)	10 (25.0)	
Sports characteristics			
Career (yr)	7.22±6.39	7.63±4.87	0.793
Frequency of team training (time/day)			0.863
≤3	13 (72.2)	28 (70.0)	
>3	5 (27.8)	12 (30.0)	
Duration of team training (min/day)			0.404
≤100 mins or less	12 (66.7)	22 (55.0)	
>100	6 (33.3)	18 (45.0)	
Time of warm-up exercise (min)			0.617
≤15	10 (55.6)	25 (62.5)	
>15	8 (44.4)	15 (37.5)	
Injury prevention education			0.337
Yes	11 (61.1)	19 (47.5)	
No	7 (38.9)	21 (52.5)	
Health supplements			0.189
Yes	7 (38.9)	23 (57.5)	
No	11 (61.1)	17 (42.5)	

Values are presented as number (%).

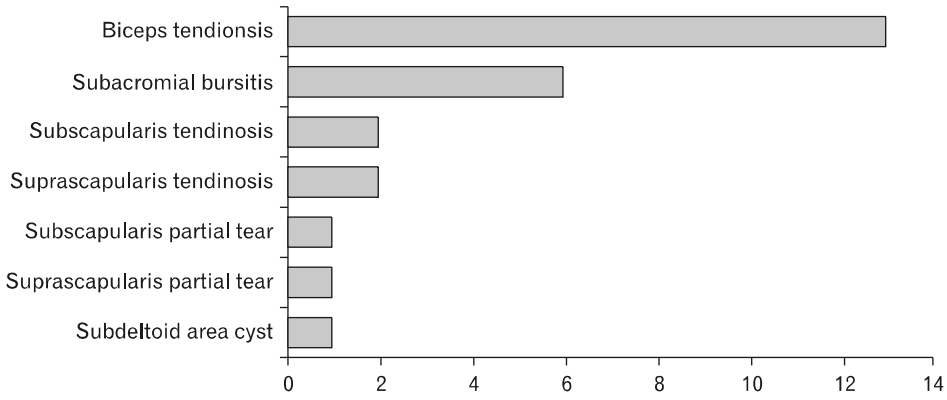

Fig. 1. Ultrasonographic findings of a painful shoulder or drawing arm.

injury was 4.0%, and Ertan[16] notes back injury as 2.7%. In this study, neck injury and back injury prevalence was 22.41% and 6.9%, respectively.

In previous studies, shoulder pain showed the highest proportion[4,5]. Niestroj et al.[5] reported that there were 27 shoulder injuries due to overuse (52.9%) among 52 archers. This research

Table 6. Comparison of shoulder pain scores according to presence of pain

Shoulder pain score	Without pain (n=18)	With pain (n=40)	p-value
Constant-Murley score	85.25±6.78 85.95 (80.10-100.00)	83.81±7.91 83.675 (69.00-98.50)	0.048*
ASES score	99.71±0.65 100.00 (98.33-100.00)	82.97±13.62 85.83 (46.67-100.00)	<0.001†
Strength	14.20±6.50 12.10 (5.10-25.00)	14.56±5.21 13.70 (5.60-25.00)	0.606*

Values are presented as mean±standard deviation or median (range).
ASES: American Shoulder and Elbow Surgeons.
Statistical test used: *independent t-test and †Mann-Whitney U-test.

also showed the same results. Variables that showed a significant relationship to shoulder pain was not found. However, adequate training frequency and duration may have a significant relationship to shoulder pain as this may prevent overuse of muscles. Hence, education on warm-up may be necessary to prevent or decrease injuries[18].

If athletes are injured, the athlete's ability is lost and high costs for treatment are consumed. In this study, 69.0% of the participants showed shoulder pain. If injuries can be prevented, excessive costs on treatment may be saved. To prevent such injuries, athletes need special care and attention, but a fundamental strategy is thought to be needed. Commonly, warm-up is a requirement to prevent injuries. Adequate warm-up time is useful in injury prevention. The most ideal warm-up time is known to be 15 minutes before the actual training[19]. In this study, participants with shoulder pain spent less than 15 minutes in the warm-up (Table 5). Also, not only does injury prevention education decrease the number of injuries, but it also decreases the severity of injuries[20]. Our study showed that 61.1% of the participants without shoulder pain had undergone injury prevention education.

Shoulder pain affects athletes' daily life and also match performance. Likewise, this study showed that participants with shoulder pain had lower Constant-Murley score and ASES score, which measures one's shoulder function. To decrease shoulder injuries, which is the most common form of injury among archers, specific training methods and early intervention is thought to improve the performance of each athlete.

This study had some limitations. The population size was small and when groups were divided into different age groups, statistically significant results were difficult to be obtained. The number of injuries may have a recall bias because it is a study based on a questionnaire rather than an accurate examination. In addition, only the abduction of the drawing arm was measured for muscle strength, but it would be helpful to further subdivide and measure the muscle strength used in archery.

In conclusion, as observed in other international studies, shoulder injury, one of the most common injuries of elite archers, was also prevalent in Korean archers, also in younger athletes. Also, the presence of pain has decreased the functional score of the shoulder. To prevent advanced injuries, appropriate muscle strengthening and training methods should be implemented as this is also expected to improve the performance of the athletes. In addition, strengthening warm-up exercises or injury prevention education to reduce pain or prevent injuries can be of sufficient help to reduce other injuries including the shoulders of athletes.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Conceptualization: YSK. Data curation: JSP, WGC. Formal analysis: SHK, BSL. Project administration: DSK. Writing–original draft: JSS. Writing–review & editing: all authors.

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