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한국 청소년 엘리트 테니스 선수의 어깨 근골격계 통증에 대한 설문 및 초음파 평가: 파일럿 연구

삼육서울병원 재활의학과

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Survey and Sonographic Evaluation of Shoulder Musculoskeletal Pain in Korean Junior Elite Tennis Players: A Pilot Study

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Purpose: The purpose of this pilot study was to present basic data on shoulder musculoskeletal pain in junior elite tennis players, with data collected via a survey, physical examinations, and musculoskeletal ultrasound.

Methods: The participants were eight healthy junior elite Korean tennis players, registered with the Korea Tennis Association. The participants' characteristics were surveyed using a questionnaire, musculoskeletal pain was assessed, and physical examination and ultrasound examination of the shoulder were performed.

Results: The average age of the participants was 13.1±0.8 years (range, 12–14 years), average duration of tennis experience was 3.5±1.5 years (range, 1–6 years), and average player career was 1.6±0.7 years (range, 1–3 years). Six players (75.0%) complained of shoulder pain during and after games. Tennis experience, career length, and training hours were not related to the during- or post-match musculoskeletal pain in the shoulder. Four players (50.0%) showed a 5° to 10° decrease (average, −7.5°±2.4°) in shoulder internal rotation. Acromioclavicular (AC) joint widening (average, 1.8±0.9 mm) was observed in the dominant shoulder in seven players (87.5%).

Conclusion: Decreased shoulder internal rotation was observed in half of the participants. Ultrasonographic evaluation confirmed significant AC joint widening in the dominant arm. Further research on AC joint widening in junior tennis players is required.

Keywords: Athletic injuries, Adolescent, Shoulder, Tennis, Ultrasonography

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Introduction

Tennis is a game played by two or four players with rackets and an elastic ball on a level court divided by a low net. Since the coronavirus disease 2019 pandemic, tennis has gained increasing attention as a noncontact sport, and the population of people enjoying tennis is increasing[1]. The injury profile of tennis players remains unique compared to other racket and overhead sports in terms of prolonged match duration, physical demands, biomechanical loads, and equipment[2,3]. The most common injury in young tennis players is repetitive microtrauma[3-5], for which the shoulder is the most commonly affected upper limb, with incidence rates of 25.7% to 45.7%[4,6,7].

In general, it is known that high-intensity training and initiating practice at an early age are necessary to succeed in certain sports as a junior athlete; however, high-intensity or excessive training is also known as a risk factor for injury. Moreover, growth explosions in adolescence can be risk factors for injury[2,3,8,9]. In comparison to adult players, preadolescent and adolescent players have open growth plates, reduced muscle strength, a lower level of coordination, and smaller stature[7,10]. The physical properties of junior tennis players impose unique demands on developing athletes, resulting in different types and patterns of injuries[3,7].

Despite recent advances in epidemiological research on tennis injuries, there is still a need for more injury research in junior players. In particular, no studies in Korea have yet evaluated the musculoskeletal state of junior tennis players using shoulder imaging.

Therefore, the aim of this pilot study was to present basic data regarding shoulder pain in junior elite tennis players through a survey, physical examination, and musculoskeletal ultrasound examination.

Methods

Healthy junior elite Korean tennis players, registered as elite tennis players with the Korea Tennis Association, were recruited for this study. The word junior indicates a player under the age of 18 years, as classified by the Korea Tennis Association. To recruit participants, a recruitment notice was sent to five prestigious tennis academies and coaches instructing only junior elite tennis players; one of these coaches helped with recruitment. The exclusion criteria were shoulder injury at the onset of the study, or receipt of shoulder surgery or clinical treatment for a shoulder injury during the 6 months prior to the start of the study.

All study participants were provided with an explanation of the purpose and methodology of the study. Written consent was obtained from all participants in the presence of their parents. This study was approved by the Institutional Review Board of the Sahmyook Medical Center for research protocol (No. 116286-202210-HR-01).

Our questionnaire was based on the questionnaire used in a previous study by Kim et al.[8], with some additional questions. The questionnaire comprised two sections. The first section contained questions on the basic demographic information of players and basic tennis-related information, such as the dominant hand years of tennis experience, years of player experience, training hours per day and week, number of competition games per year, ranking, playing style, and backhand stroke style. The second section was related to musculoskeletal pain of the upper extremities, including the frequency and occurrence of pain during or after games, players' thoughts on the cause of pain, players' preferred methods of preventing and treating pain, effects of shoulder pain on playing, and psychological impact (Supplementary Material). Participants entered a private examination room and completed the survey in 30 minutes, after which they underwent a physical examination in the same room, which was immediately followed by a sonographic evaluation. By making players complete the survey on their own, without assistance from parents, coaches, or other players, we aimed to reduce potential prejudice and influence of others' opinions on players' answers.

Open questions were used to collect basic demographic information about the players and a history of any injuries. The Likert scale was used to assess the frequency and occurrence of musculoskeletal pain during or after games. All other questions were in the form of multiple choice. Multiple responses were permitted for questions assessing athletes' thoughts on the causes of pain and how they were currently managing pain.

All participants were examined on their day off from training. All measurements were performed by a single examiner who placed the goniometer in the position determined by the examiner. Shoulder range of motion (ROM) was measured in the supine position on a physiotherapy bench. The ROM of internal rotation

(IR), external rotation (ER), flexion, and extension were measured. Measurements were assessed in degrees (units of angle measurement). Muscles, including the biceps, upper trapezius, middle trapezius, lower trapezius, levator scapulae, supraspinatus, infraspinatus, and acromioclavicular (AC) joints, were palpated to see where participants experienced pain. The examiner was blinded to the physician who performed the ultrasonographic examinations.

Ultrasonographic examinations were performed by a single-board physiatrist who was qualified as a specialist in musculoskeletal ultrasonography and sports medicine. All sonograms were obtained in real time using high-resolution ultrasonography (frequency band, 3.0–14.0 MHz; Samsung Medison Co., Ltd.). The long head of the biceps tendon and sheath, AC joint, rotator cuff tendons, posterior glenohumeral (GH) joint, and thickness of the upper trapezius and supraspinatus muscle belly were investigated bilaterally[11]. Dynamic ultrasonographic examinations were also performed by the same examiner.

The general characteristics of the participants and survey variables are presented as the medians and ranges for continuous variables and as numbers or percentages for categorical variables. All statistical analyses were performed using IBM SPSS for Windows, version 20 (IBM Corp.), and the p-values of <0.05 were considered significant. The Wilcoxon signed ranked test was used to confirm the right-left difference.

Results

Eight junior elite tennis players were recruited, of whom six were male and two were female. Their average age was 13.1 years. All participants were right-handed.

The average duration of tennis experience was 3.5 years, while the average duration of player experience was 1.6 years. The average number of training hours per day was 3.6 hours and 21.9 hours per week. The average number of competitive games played in the past year was seven. The playing style of all players was baseliner, and the backhand stroke style was two-handed (Table 1).

Table 2. Athletes' thoughts on causes of pain

Cause	Data
Hit by ball or collision	3 (37.5)
Lack of warm-up or preventive conditioning program	4 (50.0)
Insufficient rest	0 (0)
Inappropriate training environments	0 (0)
Extended training time	2 (25.0)
Repetition of specific motion	0 (0)
Improper posture	3 (37.5)
Psychological factors	0 (0)
Continuation of training without proper treatment	3 (37.5)
Reduced stamina	0 (0)
Equipment problem	0 (0)

Values are presented as number (%).
Multiple responses permitted.

Table 1. Participants' characteristics

Characteristic	Total	Boy	Girl
Participants	8 (100)	6 (75.0)	2 (25.0)
Age (yr)	13.0 (12–14)	13.5 (12–14)	12.5 (12–13)
Height (cm)	166.5 (158.1–176.0)	168.5 (160.3–176.0)	159.1 (158.1–160.0)
Weight (kg)	55.9 (47–75)	57.0 (47–75)	50.0 (48–52)
Right-handed	8 (100)	6 (100)	2 (100)
Tennis experience (yr)	3.5 (1–6)	3.5 (1–6)	3.5 (3–4)
Player experience (yr)	1.5 (1–3)	1.5 (1–2)	2.0 (1–3)
Training time			
Hours/day	3.5 (3.5–4.5)	3.3 (3.0–4.5)	4.0 (4.0–4.0)
Days/week	6.0 (6.0–7.0)	6.0 (6.0–7.0)	6.0 (6.0–6.0)
Hours/week	21.0 (18.0–31.5)	19.5 (18.0–31.5)	24.0 (24.0–24.0)
Competition game (time/yr)	4.0 (2.0–15.0)	7.0 (2.0–15.0)	3.5 (3.0–4.0)
Playing style, baseline:SV	8:0	6:0	2:0
Backhand stroke style, one hand:two hands	8:0	6:0	2:0

Values are presented as number (%) or median (range).
SV: serve and volley.

At the time of the examination, no players complained of musculoskeletal pain; however, six players complained of experiencing shoulder pain during and after games. Among them, three answered that the pain they experienced had a frequency of less than 25%, and the other three players answered a frequency of between 25.0% and 75.0%.

The association between shoulder pain and parameters including duration of tennis experience and player experience, training hours per day and week, number of competitive games played per year, and ranking could not be determined due to the small number of participants. A lack of warm-up exercise was the most common factor proposed by the athletes as the cause of pain (Table 2). Rehabilitation was the most preferred pain management method (Table 3). All players answered that they required training to prevent musculoskeletal pain. Six players answered that musculoskeletal pain affected performance, one player answered that she experienced frustration due to pain, and one player answered that he had previously avoided a match due to pain.

Physical examination revealed no left-right difference in shoulder flexion, while it was found that the three players (37.5%) had a slightly decreased ROM in the dominant arm shoulder extension by 5.0°, with a mean right shoulder extension ROM of 52.5° and mean left shoulder extension ROM of 53.8°. Four players (50.0%) showed a decrease in ROM in IR of 5° to 10°, with a mean right IR ROM of 40.6° and mean left IR ROM of 43.1°. No differences were found in the shoulder ER (Table 4).

On ultrasonographic examination, AC joint widening was observed in seven of the players (Table 4). The Wilcoxon signed ranked test confirmed that there was a difference in the widths of the left and right AC joints ($p<0.05$). No abnormalities were found in the biceps long head tendon and sheath, rotator cuff tendons, or posterior GH joint. There was no statistically significant difference in the thicknesses of the left and right upper trapezius and supraspinatus muscles (Table 5). None of the participants showed subacromial impingement.

Discussion

This pilot study investigated basic data regarding shoulder pain in junior elite tennis players by conducting a survey, physical examination, and ultrasonographic examination. To the best of our

Table 3. Current pain management techniques adopted by athletes

Method	Data
Nothing	1 (12.5)
Rest	3 (37.5)
Personal training (stretching, sports massage)	3 (37.5)
Alternative medicine (yoga, meditation, chiropractic, acupuncture)	1 (12.5)
Rehabilitation treatment (physical therapy, injection)	4 (50.0)
Medication	0 (0)
Operation	0 (0)

Values are presented as number (%).
Multiple responses permitted.

Table 4. Measured ROMs and acromioclavicular joint width

Measure	Subjects No.							
	1	2	3	4	5	6	7	8
Shoulder extension ROM (°)								
Left	45	40	60	60	60	60	55	50
Right	40	45	60	60	55	60	50	50
Right-left difference	−5	5	0	0	−5	0	−5	0
Internal rotation ROM (°)								
Left	50	45	35	40	50	35	40	50
Right	50	55	25	35	45	35	40	40
Right-left difference	0	10	−10	−5	−5	0	0	−10
ACJ width (mm)								
Left	12.5	6.7	7.0	8.9	8.7	6.6	6.6	8.1
Right	12.6	8.9	10.0	11.4	9.5	6.2	8.5	10.2
Right-left difference	0.1	2.2	3.0	2.5	0.8	-0.4	1.9	2.1

ROM: range of motion, ACJ: acromioclavicular joint.

Table 5. Muscle thickness measured by ultrasonography

Measure	Subjects No.							
	1	2	3	4	5	6	7	8
Upper trapezius thickness (mm)								
Left	4.7	5.7	7.8	5.4	5.9	5.6	4.5	6.3
Right	4.4	6.6	7	6.4	6.4	6.1	4.5	4.9
Right-left difference	−0.3	0.9	−0.8	1.0	0.5	0.5	0	−1.4
Supraspinatus thickness (mm)								
Left	20.1	17.9	20.6	23.3	18.7	19.6	20.2	20.4
Right	18.7	16.3	20.6	22	18.6	17.3	21.5	20.3
Right-left difference	−1.8	−1.6	0	−1.3	−0.1	−2.3	1.3	−0.1

knowledge, this is the first study on shoulder pain and ultrasonographic findings in junior elite tennis players in Korea. There have been several studies on injuries in junior elite tennis players; however, most were epidemiological studies. Few studies have investigated shoulder conditions using imaging devices; however, there have been no studies on Korean players[2,3,7,8,12,13]. Korean junior elite players are more likely to have been exposed to excessive training time than in foreign countries because tennis rankings are related to college admissions[8]. In previous studies, the entire upper extremity (shoulder, elbow, and wrist) of players was evaluated; however, in this study, we focused on the shoulder because shoulder pain was shown to be the most common complaint while shoulder injury had the highest incidence in previous studies[5,10,12,13].

According to the survey, the average number of training hours per week was 21.9 hours, which is less than the 30 hours that have been revealed in a previous study in Korea[8]; however, 21.9 hours is still significantly higher than the results of foreign studies[5,8]. This may be due to a law passed by the Korean Ministry of Education that has made it mandatory for junior athletes to not miss school classes unless they are participating in a competition.

None of the participants complained of shoulder pain at the time of the investigation, and only three players (37.5%) answered that they experienced it “sometimes,” indicating a frequency of 25.0% to 75.0% during or after a game. Six of eight players (75.0%) answered that musculoskeletal pain affects performance. One player was frustrated and one avoided competition (12.5%, respectively) due to shoulder pain, which was lower than previous results[8]. Similar to previous studies, players most often thought that insufficient warm-up was the cause of musculoskeletal pain and that the preferred pain prevention method was personal solving (stretching and massage), while rehabilitation management was chosen rather than rest[8]. This is thought to be because the participants were relatively young healthy athletes with short careers, and none of the participants had a significant history of injury. All players responded that pain prevention education was necessary. Compared with a previous study in which 53.3% responded that pain prevention education was mandatory, we concluded that pain prevention education has been widely expanded over the past 7 years[8].

Physical examination showed that the IR of the shoulder was reduced in the dominant arm in four players (50.0%). The definition of GH IR deficit (GIRD) varies in prior papers. Some papers have defined it as a condition in which the IR difference between both arms is 15°, while some have stated the difference to be 20°, and others have stated that any difference between the IR of both arms classifies as GIRD[4,14,15]. This is a common finding in previous studies on throwing sports, and a similar trend was observed in this study, although the difference was not statistically significant[9,16-18]. Three out of four players who showed IR deficits participated in more than 10 matches over the past year. Considering the tendency of IR deficit as the number of matches increases, it can be inferred that stretching is important to prevent GIRD[19]. Furthermore, it was suggested that exercise to prevent GIRD is necessary to prevent this reduction in shoulder IR, which was confirmed in junior elite tennis players from progressing to GIRD.

Ultrasound examination revealed no abnormalities in the biceps long head tendon and sheath, rotator cuff tendons, or posterior GH joint, and there was no statistically significant difference in the thickness of the left and right upper trapezius and supraspinatus muscles. This is likely due to the fact that this study only included healthy junior players with relatively short careers. Interestingly, AC joint widening was observed in seven players

(87.5%). AC joint widening is known to occur mainly because of trauma in contact sports[20-22]. Therefore, it was strange to observe this in elite junior tennis players. To the best of our knowledge, this is the first reported observation of AC joint widening in racket sports without a history of trauma, suggesting that this issue has been underestimated. The mechanism of AC joint widening in this study is as follows; in junior tennis players with ligament laxity, the rapid and repeated swing of the racket beyond ROM may lead to the widening of the AC joint[10]. Alternatively, it may be caused by excessive movement of the AC joint during ER due to GIRD.

This was a pilot study with eight participants, therefore, there were limitations to reaching a definitive conclusion due to the small number of participants. In seven out of eight participants (87.5%), there was a tendency to decrease the IR of the shoulder; however, we could not confirm statistical significance due to the small sample size. In future large studies, we will verify the statistical significance of the reduction of shoulder IR. As all eight players were taught by the same coach, the results may not be representative of all junior elite tennis players. Nevertheless, the present study is meaningful as it outlines the shoulder problems experienced by junior elite tennis players as identified through a comprehensive survey, physical examinations, and ultrasonographic examination.

In conclusion, in junior elite tennis players, it appears that weekly training hours are gradually decreasing but are still significantly higher than those in other countries. Furthermore, pain prevention education has widely expanded over the past 7 years. Interestingly, we observed AC joint widening in the dominant arm of the participants. In the future, the exact incidence and mechanism of AC joint widening in noncontact racket sports and the association between AC joint widening and shoulder pain and injury should be investigated.

Conflict of Interest

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

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Conceptualization: HP. Data curation, Investigation: all authors. Formal analysis, Methodology: HP, BR. Project administration: SH. Resources, Supervision: BR. Writing–original draft: HP. Writing–review & editing: BR.

Supplementary Materials

Supplementary Materials can be found at https://doi.org/10.5763/kjsm.2023.41.2.83.

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