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# Effect of the Positions of Female Pro-Volleyball Players on the Stability of Shoulder Joints of the Dominant and Non-dominant Arms

The purpose of this study was to comparatively analyze the active stability of shoulder joints according to the frequency of overhead motions, such as serving and spiking, engaged in by female professional volleyball athletes who play different positions, and to provide the results as the basic data for developing exercise programs to prevent shoulder joint injuries. The subjects of this study were 50 Korean female professional volleyball players and positions were as follows: left and right attackers, centers, setters, and liberos. The external rotation and internal rotation muscle strength and muscle strength ratios of the dominant and non-dominant arms of all subjects were measured using Biodex. The results of this study are as follows: Frist, no significant differences were found in the internal and external rotation muscle strength of the dominant and non-dominant arms between positions. Second, for the shoulder joint muscle strength ratio of the dominant arm, by position, the setter showed significantly greater stability compared to the other positions. Third, for the shoulder joint muscle strength ratio of the non-dominant arm, by position, no significant difference in stability between positions was found. Fourth, it was found that the dominant arm had significantly greater instability of the shoulder joint than the non-dominant arm for attackers and centers, but no significant difference was found for setters and liberos.
This study comparatively analyzed the muscle strength ratios of the external/internal rotations and dominant/non-dominant arms, which can determine the stability of the shoulder joints between female professional volleyball playing positions that engage in jumps and spikes using only the dominant hand and positions that do not.

Key words: *Shoulder Joint; Dominant; Non-dominant; Isokinetic Exercise; Muscle Strength; Volleyball Player*

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## INTRODUCTION

Due to the nature of volleyball, injuries are frequent and injury factors increase from repeated jumps and the overuse of the dominant arm in such motions as spiking, blocking, receiving, and tossing. Injuries to players are keenly perceived as the cause of major problems, such as performance decline, absence from games, and increasing medical expenses(1, 2, 3). Motions, such as using the dominant arm, hinder the balance of the same joints of the dominant and non-dominant arms, and repeated performance of overhead motions cause strong efferent contraction of the external rotation muscles. This leads to micro-injuries of the external rotation muscles and limits the movement of the joints(4, 5). Furthermore, this type of motion also affects the joint capsules that provide passive stability of the shoulder joints and causes shoulder impingement syndrome and shoulder joint instability(2, 6, 7).

Previous studies that examined the ability of management programs to prevent sports injuries to knees and shoulders caused by jumping, serving, spiking, and other major volleyball motions, reported the importance of continuous tests and confirmations

of the efficient, normal muscle strength for the muscles that maintain active stability in the knee and shoulder joints(7, 8, 9).

The purpose of this study was to comparatively analyze the active stability of the shoulder joints according to the frequency of overhead motions, such as serving and spiking, engaged in by female professional volleyball athletes who play different positions, and to provide the results as the basic data for developing exercise programs to prevent shoulder joint injuries.

## METHODS

### Subjects

The subjects of this study were Korean female professional volleyball players who had joined pro teams after having played volleyball for at least 10 years. In total, the study consisted of 50 athletes who played different volleyball positions, as follows: 21 attackers, 13 centers, 7 setters, and 9 liberos. The age of the subjects ranged from 20 to 31, and their mean height and weight were 176.46±6.27cm and 68.60±6.69kg. They were elite professional volleyball players who belonged to the Korean Volleyball Federation (KOVO).

Those who were receiving treatment for orthopedic injuries or who had recovered from recent treatment of an orthopedic injury were excluded from this study. The characteristics of the subjects are listed in Table 1.

Table 1. Characteristics of subject

| Position | Number(n) | Age(yrs) | Height(cm) | Weight(kg) | Body fat(%) |
|---|---|---|---|---|---|
| Attack | 21 | 24.67±3.04 | 177.71±4.23 | 70.36±5.96 | 23.20±4.49 |
| Center | 13 | 24.46±2.60 | 181.46±5.01 | 70.77±5.35 | 21.79±3.02 |
| Setter | 7 | 25.43±3.60 | 173.89±5.28 | 65.81±8.65 | 22.30±3.45 |
| Libero | 9 | 24.22±2.33 | 168.31±3.47 | 63.39±5.64 | 22.86±3.39 |
| Sum | 50 | 24.64±2.83 | 176.46±6.27 | 68.60±6.69 | 2267±3.75 |

### Procedure

As subjects of this study, 50 female professional volleyball players, who belonged to the KOVO, were selected. A preliminary assessment included an examination of their physical characteristics, their age, height, weight, and body fat. The selected subjects were classified into their individual, primary volleyball positions. To objectively measure the internal and external rotation muscle strength of the shoulder joints in the dominant and non-dominant arms, measurements were taken three times at the angular velocity of 60 ° /sec using the Biodex System III(Biodex Medical, U.S.A). In accordance with the manufacturer's guidelines, the subjects warmed up by stretching each joint and they practiced the motions three times before each measurement was taken. One minute of resting time was given before changing the angular velocity, and the joint motion was performed within a range that did not cause pain.

### Data Analysis

For data analysis, the means and standard deviations were determined using SPSS software(Version 12). Furthermore, to test the statistical significance of the differences between the groups, the significance level was set to .05, and a t-test and a one-way ANOVA were performed. Statistical significance was determined when the p-value was lower than .05. The results were represented as mean SD.

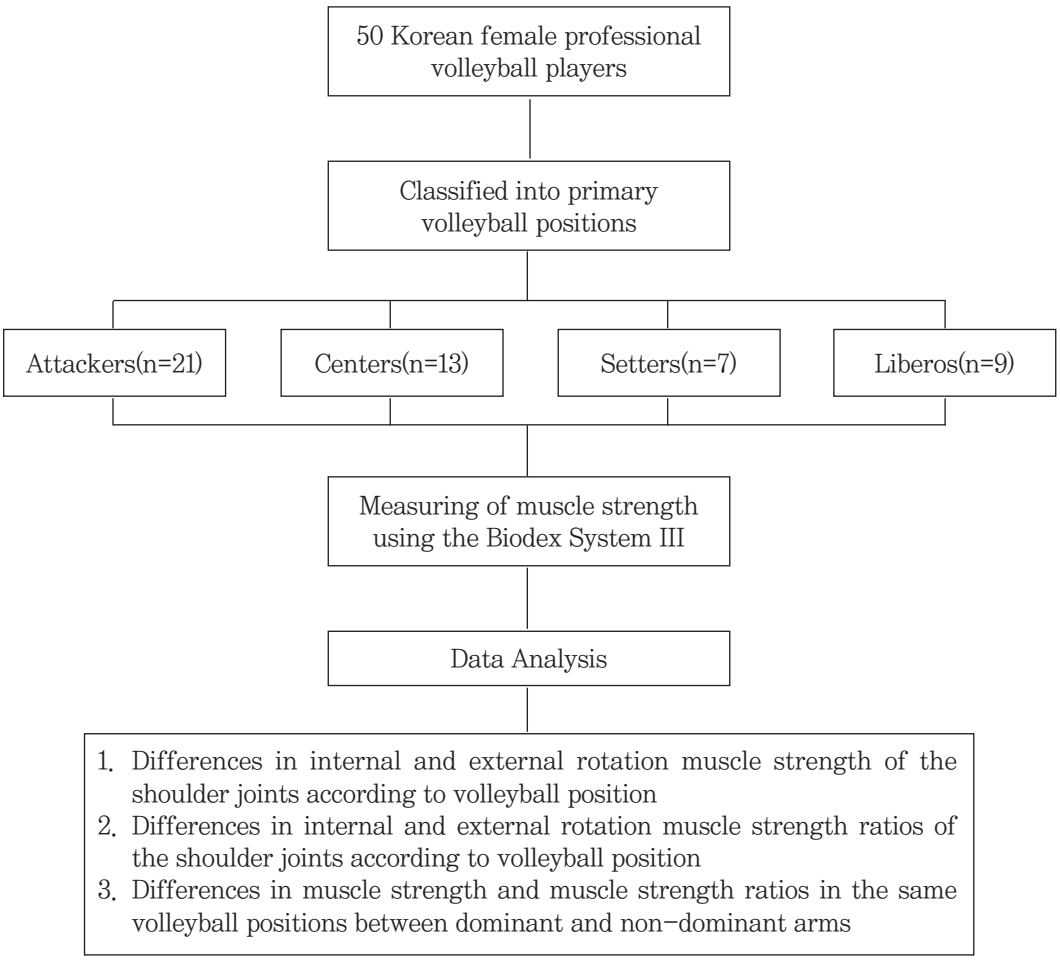



Fig. 1. Template of the research.

## RESULTS

### Differences in Internal and External Rotation Muscle Strength and Muscle Strength Ratios of the Shoulder Joints according to Volleyball Position

#### Differences in internal and external rotation muscle strength of the dominant arm according to volleyball position

The examination results for muscle strength in the internal and external rotations of the dominant arms for all subjects, classified as attackers, centers, setters, and liberos, are as follows. The internal rotation muscle strength was 27.22±8.60 ft-lbs for attackers, 26.30±7.63 ft-lbs for centers, 23.76±6.19 ft-lbs for setters, and 24.81±8.98 ft-lbs for liberos.

The difference in muscle strength between volleyball positions was found to be the greatest for attackers, followed by centers, setters, and liberos. The external rotation muscle strength was 13.70±3.69 ft-lbs for attackers, 12.94±2.88 ft-lbs for centers, 14.89±3.29 ft-lbs for setters, and 13.30±5.65 ft-lbs for liberos. The difference in muscle strength between volleyball positions was found to be the greatest for setters, followed by attackers, centers, and liberos. Furthermore, the internal rotation muscle strength was higher than the external rotation muscle strength in all the position groups. No significant difference was found in internal and external rotation muscle strengths between the position groups.

No significant differences were found in the internal and external rotation muscle strength of the dominant and non-dominant arms between all the volleyball positions. The results are listed in Table 2.

**Differences in internal and external rotation muscle strength of non-dominant arm according to volleyball position**

The muscle strength examination results for the internal and external rotations of the non-dominant arms for all the subjects, classified into attackers, centers, setters, and liberos, are as follows. The internal rotation muscle strength was 25.91±7.13 ft-lbs for attackers, 24.81±8.18 ft-lbs for centers, 24.77 ±5.72 ft-lbs for setters, and 24.67±7.47 ft-lbs for liberos. The difference in muscle strength between these volleyball positions was found to be the greatest for attackers, followed by centers, setters, and liberos. The external rotation muscle strength was 15.64±3.68 ft-lbs for attackers, 14.16±4.35 ft-lbs for centers, 13.37±3.44 ft-lbs for setters, and 12.18± 3.28 ft-lbs for liberos. The difference in muscle strength between these volleyball positions was found to be the greatest for attackers, followed by centers, setters and liberos. Furthermore, the internal rotation muscle strength was higher than the external rotation muscle strength in all position groups. No significant difference was found in the internal and external rotation muscle strength between the position groups(Table 2).

Table 2. Shoulder strength and strength ratio by D-S and ND-S

A

| | External torque | Internal torque | Ext/Int strength ratio |
|---|---|---|---|
| Attack | 13.70±3.69 | 27.22±8.60 | 51.36±8.20 |
| Center | 12.94±2.88 | 26.30±7.63 | 50.07±5.60 |
| Setter | 14.89±3.29 | 23.76±6.19 | 63.52±10.34* |
| Libero | 13.30±5.65 | 24.81±8.98 | 47.64±9.03 |

B

| | External torque | Internal torque | Ext/Int strength ratio |
|---|---|---|---|
| Attack | 15.64±3.68 | 25.91±7.13 | 61.49±9.01# |
| Center | 14.16±4.35 | 24.81±8.18 | 58.07±9.39# |
| Setter | 13.37±3.44 | 24.77±5.72 | 53.83±5.69 |
| Libero | 12.18±3.28 | 24.67±7.47 | 50.33±8.96 |

* Statistically significant($p<.05$) compared with all other position group.
\# Statistically significant($p<.05$) compared between D-S and ND-S in position.
A; in dominant side, B; in non dominant side, D-S; dominant side, ND-S; non dominant side.

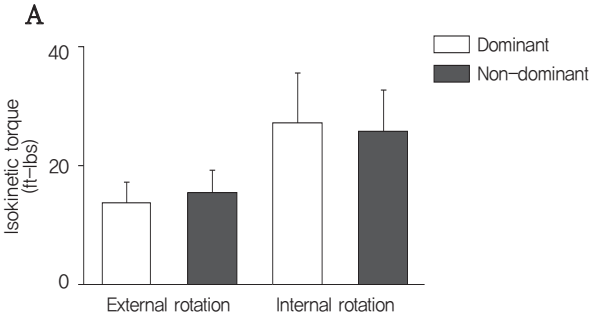
## Differences in Muscle Strength and Muscle Strength Ratios in the Same Volleyball Positions between Dominant and Non-dominant Arms

**Difference in muscle strength and muscle strength ratios between dominant and non-dominant arms in attackers**

The muscle strength differences in the external rotation and internal rotation motions and the ratio of the external/internal rotation muscle strength between dominant and non-dominant arms in the attacker position were as follows. In the external rotation, the non-dominant arm(15.64±3.68 ft-lbs) showed a higher muscle strength than the dominant arm(13.70±3.68 ft-lbs). In the internal rotation, the dominant arm(27.22±8.60 ft-lbs) showed a higher muscle strength than the non-dominant arm(25.91± 7.13 ft-lbs). In the ratio of external/internal rotation muscle strength, the non-dominant arm(61.49±9.01 ft-lbs) showed a significantly higher ratio than the dominant arm(51.36±8.20 ft-lbs)(Fig. 2).

**Difference in muscle strength and muscle strength ratios between dominant and non-dominant arms in centers**

The muscle strength differences in external rotation and internal rotation motions and the ratio of external/internal rotation muscle strengths between dominant and non-dominant arms in the center position were as follows. In the external rotation, the non-dominant arm(14.16±4.35 ft-lbs) showed a higher muscle strength than the dominant arm(12.94 ±2.86 ft-lbs). In the internal rotation, the dominant arm(26.30± 7.63 ft-lbs) showed a higher muscle strength than the non-dominant arm(24.81±8.18 ft-lbs). In the ratio of external/internal rotation muscle strength, the non-dominant arm(58.07±9.39 ft-lbs) showed a significantly higher ratio than the dominant arm(50.27±5.60 ft-lbs)(Fig. 2).



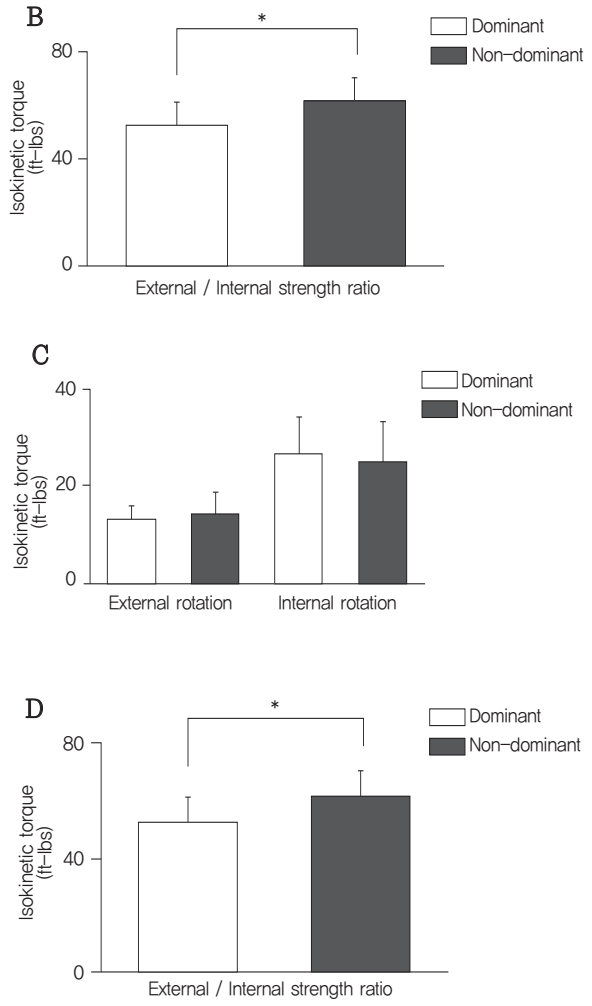



Fig. 2. Shoulder strength and strength ratio by D-S and ND-S in attack and center position

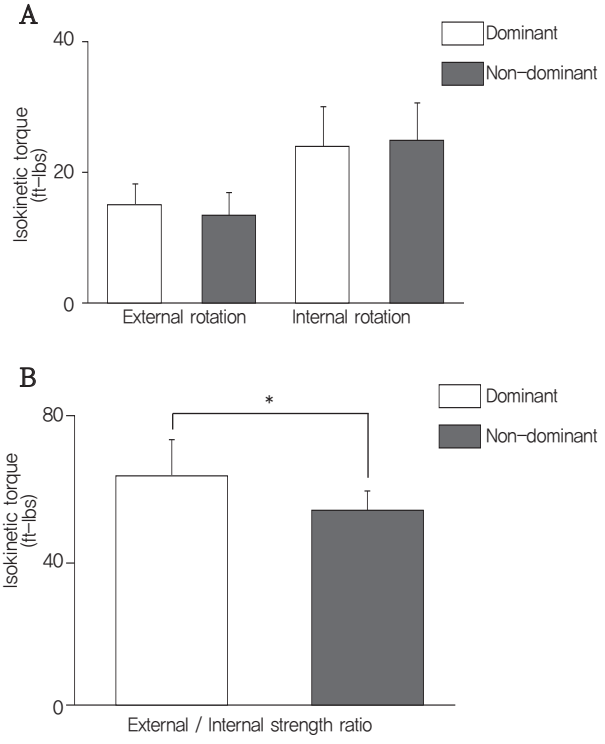
* Statistically significant ($p<.05$) compared with all other group.
A; shoulder strength in external and internal rotation by D-S and ND-S in attackers
B; shoulder strength ratio by D-S and ND-S in attackers
C; shoulder strength in external and internal rotation by D-S and ND-S in centers
D; shoulder strength ratio by D-S and ND-S in centers

**Difference in muscle strength and muscle strength ratios between dominant and non-dominant arms in setters**

The muscle strength differences in the external rotation and internal rotation motions and the ratio of external/internal rotation muscle strengths between dominant and non-dominant arms in the setter position were as follows. In the external rotation, the dominant arm(14.89±3.29 ft-lbs) showed a higher muscle strength than the non-dominant arm(13.37±3.44 ft-lbs). In the internal rotation, the non-dominant arm(24.77±5.71 ft-lbs) showed a higher muscle strength than the dominant arm(23.76 ±6.19 ft-lbs). In the ratio of external/internal rotation muscle strength, the dominant arm(63.52±10.34 ft-lbs) showed a significantly higher ratio than the non-dominant arm(53.83±5.69 ft-lbs)(Fig. 3).

**Difference in muscle strength and muscle strength ratios between dominant and non-dominant arms in liberos**

The muscle strength differences in the external rotation and internal rotation motions and the ratio of external/internal rotation muscle strengths between dominant and non-dominant arms in the libero position were as follows. In the external rotation, the dominant arm(13.30±5.65 ft-lbs) showed a higher muscle strength than the non-dominant arm(12.18±3.28 ft-lbs). In the internal rotation, the dominant arm(24.81±8.98 ft-lbs) showed a higher muscle strength than the non-dominant arm(24.67± 7.47 ft-lbs). In the ratio of external/internal rotation muscle strength, the non-dominant arm(50.33±8.96 ft-lbs) showed a significantly higher ratio than the dominant arm(47.64±9.03 ft-lbs)(Fig. 3).



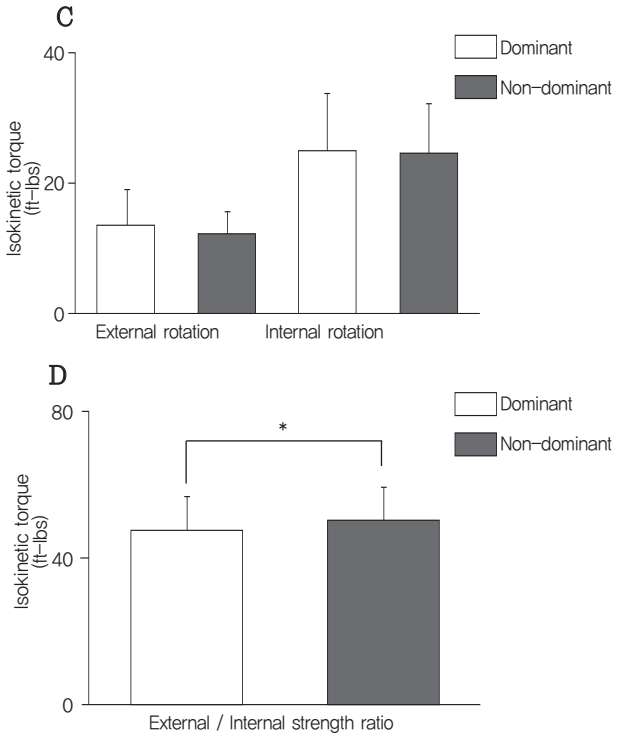



Fig. 3. Shoulder strength and strength ratio by D-S and ND-S in setter and libero position

* Statistically significant($p<.05$) compared with all other group.
A; shoulder strength in external and internal rotation by D-S and ND-S in setters
B; shoulder strength ratio by D-S and ND-S in setters
C; shoulder strength in external and internal rotation by D-S and ND-S in liberos
D; shoulder strength ratio by D-S and ND-S in liberos

## DISCUSSION

Due to the nature of volleyball games, players frequently engage in characteristic postures, such as overhand motions for jumping, serving, and spiking, finger motions to push the ball over the head for tossing, and defensive diving(dig)(10, 11, 12). Previous studies, which compared the physical activities between different volleyball positions, reported that the highest frequency of motion was found in jumping and spiking for attackers, in jumping and blocking for centers, in jumping and tosses for setters, and in receives for liberos(11, 13). Regarding shoulder joints, which are representative of noncontact injury areas, many studies reported on the injury mechanism due to motions such as spikes and serves and comparisons were made by sex or performance. However, very few studies have examined changes to the structural or active stability of shoulder joints according to specific volleyball positions.

For powerful striking of the volleyball, players perform as much internal rotation of the shoulder joint as possible, which generates an afferent contraction of the internal rotation muscles. Thus, attackers and centers who engage in a great deal of overhead motion, such as spiking, serving, and blocking, showed greater muscle strength of the dominant arm than setters and liberos. This study found that the internal rotation muscle strength of attackers, who used a great deal of overhead motion of the dominant arm, was greater although the difference was not significant. The muscle strength of the non-dominant arm also increased most significantly in attackers, followed by centers, setters, and liberos.

Furthermore, just as other studies hypothesized that attackers and setters, who perform a great deal of overhead motion, would have a lower muscle strength ratio associated with the active stability of shoulder joints compared to setters and liberos, this study also found that, for the dominant arm, the muscle ratios of attackers and centers was 51% and 50%, respectively, and these were significantly lower than that of setters(63%). Additionally, the muscle strength ratio of liberos(52%) was significantly lower than the normal ratio of 66%. It seems that the shoulder joints that contribute to the stability of the upper limbs could be injured in the process of receiving, with one hand or two, a ball that is forcefully hit and returned by the opponent, in players engaged in stable postures with fixed lower limbs or in players engaged in unstable postures, such as diving. In accordance with the results of previous studies, this study found no significant differences in muscle strength ratio between positions with regard to the use of the non-dominant arm due to the nature of the volleyball(how forcefully it was hit and returned by the opposing team) in players that use the dominant arm more frequently.

The muscle strength examination of left and right shoulder joints, according to volleyball positions, also showed that attackers and centers, who perform a great deal of overhead motion, showed a higher internal rotation muscle strength of the dominant arm, a higher external rotation muscle strength of the non-dominant arm, and a significantly better stability of the non-dominant arm. These findings are similar to the results of previous studies. The reason that no significant differences were found in muscle strength between the volleyball positions seemsto be that the subjects of this study were professional players who compete in games rather than

players who complain of pain or who have limited range of motion.

For the volleyball setters, unlike attackers and centers, the dominant arm showed greater external rotation muscle strength, whereas the non-dominant arm showed a greater internal rotation muscle strength. Although the results were not significant, the dominant arm was stronger by about 18% and showed a muscle strength ratio of 63%, which was close to the normal ratio of 66%. It is estimated that this study derived these results for setters because setters perform almost no spiking motions that cause pain. They toss the ball to attackers using their thumb and index finger to pass the ball more accurately and quickly, which requires repeated performance of external rotation and extension of the upper limbs.

Finally, for the liberos, the muscle strength and muscle strength ratios were similar between the dominant and non-dominant arms. Liberos perform few overhead motions characteristic of volleyball that could affect the body, but they showed shoulder joint instability that was similar to attackers and centers, and instability was also suspected in the non-dominant arm. Thus, more accurate studies on the postures of liberos and the dynamic and physical changes resulting from those postures are necessary. In the future, more advanced studies are needed regarding the joint stability and sports injury ratios of volleyball positions that require frequent, high vertical jumping and positions that require frequent high horizontal jumping as well as studies on the knee, which is another representative injury area for this sport.

## CONCLUSION

This study investigated the effects of a volleyball player's position on the internal and external rotation muscle strength and the ratio of external/internal rotation muscle strength of domestic female, professional volleyball players. This study arrived at the following conclusions. First, no significant differences were found in internal and external rotation muscle strength of the dominant and non-dominant arms between the volleyball positions. Secondly, for the shoulder joint muscle strength ratio of the dominant arm, by position, the setter showed significantly higher stability compared to the other positions. Thirdly, for the shoulder joint muscle strength ratio of the non-dominant arm, by position, no significant difference in stability between volleyball positions was found. Fourthly, this study found that the dominant arm had significantly greater instability of the shoulder joint than the non-dominant arm for attackers and centers; however, no significant difference was found for setters and liberos.

The findings from this study suggest the need for exercise or management programs to reduce or remove shoulder joint injuries and the factors of instability due to overuse, which are characteristic differences between volleyball positions in which players engage in a significant number of overhead motions and other volleyball positions, thus preventing injuries.

This study investigated the active instability of shoulder joints as being among the causes of injuries that result from the overuse of shoulder joints, which are characteristic of motions engaged in when playing volleyball.

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