

Isokinetic Shoulder Joint Characteristics by Position: Professional Korean Female Volleyball Players

The purpose of the study was to investigate the strength of isokinetic muscle by the position of a volleyball players. Analysis and comparison of shoulder dynamic stability will be conducted according to rotational movement of the shoulder during spiking and serving amongst the various positions. Fifty professional Korean female volleyball players (age: 20~30), all different positions – attacker (left and right), center, setter, and libero were The concentric peak torque, strength ration of the internal and external rotation of the shoulder girdle for both dominant and non-dominant arms. Firstly, there were significant differences found for the strength ratio between the setter and the other positions in the dominant arm. On a second note, there was a significant decrease in shoulder dynamic stabilization for both the attacker and center in the dominant arm. However, there were no significant differences for the setter or the libero. This study suggests that the isokinetic muscle strengths of the volleyball players are different from each other.

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INTRODUCTION

In volleyball, both left and right attackers, the center who carries out rapid and time difference attacks, the setter that reads the flow of the game and sets an attack direction accordingly by tossing, as well as the libero that works to receive and focus on defense all have individual roles. Serves, spikes, as well as attacks, blocks, and receiving are repeated until the upper hand is gained^{1,2,3}. The most common motion in volleyball involves strong movement of the arms above the head referred to as an 'overhead swing' which is the culprit behind frequent shoulder injuries^{4,5,6}.

The shoulder joint has the largest range of

movement in the human body and is held together by the supraspinatus, infraspinatus, teres minor, and subscapularis muscles. The surrounding ligaments also play a crucial role in stabilization and movement. A significant percentage of volleyball players experience shoulder injuries during their career and many are reported to become chronic. The excessive external rotation associated with the primary techniques of volleyball is known to overload the surrounding muscles and ligaments causing eventual injury^{7,8}. Joint cartilage and rotator cuff injuries are common in volleyball players, and repetitive injuries cause chronic joint instability to which female athletes are known to be more susceptible⁹.

Muscle strength assessment using isokinetic exercise provides the most objective and scientific results. Identifying the muscle strength ratio of the agonist and antagonist muscles according to the movement of the specific joint and the degree of muscle strength have proven useful for preventing injury as well as the development and improvement of intervention programs in many studies¹⁰.

Most studies regarding volleyball focus on gender and participatory characteristics^{3,7}. There are many studies available regarding volleyball players comparing gender and characteristics based on level of participation. However it is difficult to find research comparing the isokinetic muscle strength based on player position.

As such, this study aims to compare the differences in muscle strength between positions for women due to women being more vulnerable to shoulder injuries than men. Therefore this study investigates the isokinetic muscle strength of internal and external rotator muscles of the shoulder joints on both sides according to player position in professional domestic female volleyball players.

METHODS

Subjects

The research subjects were professional female volleyball players currently part of the Korean Volleyball Federation. Of 50 total subjects, 21 were attackers, 13 were centers, 7 were setters, and 9 were liberos. All subjects were medically cleared for participation by an orthopedic specialist. Furthermore, before participation, all subjects were thoroughly informed of the intervention and aims of the study. The general characteristics of

the subjects are as appears in (Table 1).

Method

The steps taken in this study are as appears in (Figure 1). The measurements were taken before the start of the 2016 pro volleyball season.

In order to measure the muscle strength of the external and internal rotation of the shoulder joint by varying positions, an isokinetic device (Biodex, USA) was used. Before measurement, a calibration of 0 points was obtained. Practice sessions were conducted before the actual measurement in order to familiarize the subject with the device. During measurement, subjects were verbally instructed to maximally contract muscles so the maximum muscle strength could be expressed. The joint range of motion of the shoulder joint was performed starting from 0° to 90° of internal rotation with the torso and waist of the subject fixed. With the subject seated in the isokinetic device, the elbow joint and axis of the dynamometer were aligned. The cuff was then fixed at the proximal area of the carpal joint. The measurement was conducted whilst the subject performed maximal external rotation from internal rotation, and then moved back to internal rotation. This measurement was conducted a total of 4 times with each measurement set at the pace of 60°/sec.

Data Analysis

The SPSS version 24 was used for technical analysis of the data obtained in this study. In order to analyze isokinetic strength by position, the one-way ANOVA was conducted. Pre- and post-examinations were conducted using the Tukey test. The level of statistical significance was set $\alpha=0.05$.

Table 1. Characteristics of subject

Position	No.	Age(yr)	Height(cm)	Weight(kg)	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	22.67 ± 3.75

*Statistically significant ($p<0.05$) compared with all other group.

Statistically significant ($p<0.05$) compared with Attack and Center group.

Statistically significant ($p<0.05$) compared with Center and Liebero group.

RESULTS

The results of the measurement of the isokinetic muscle strength are as appears in (Table 2). For shoulder external joint rotation, difference in muscle strength appeared highest in order from setter, attacker, center, to libero. For internal

joint rotation, difference in muscle strength appeared highest in order from attacker, center, setter, to libero. Additionally, in all position groups, the external muscle strength appeared lower than the internal rotation muscle strength. There were no significant differences between the groups regarding rotation muscle strength.

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

	External Torque(ft-lbs)		Internal torque(ft-lbs)		External · Internal ratio(%)	
	D-S	ND-S	D-S	ND-S	D-S	ND-S
Attack	13.70±3.69	15.64±3.68	27.22±8.60	25.91±7.13	51.36±8.20	61.49±9.01#
Center	12.94±2.88	14.16±4.35	26.30±7.63	24.81±8.18	50.27±5.60	58.07±9.39#
Setter	14.89±3.29	13.37±3.44	23.76±6.19	24.77±5.72	63.52±10.34*	53.83±5.69
Libero	13.30±5.65	12.18±3.28	24.81±8.98	24.67±7.47	47.64±9.03	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.

D-S: dominant side, ND-S: non-dominant side.

In the results of the external rotation of the non-dominant side, the difference in muscle strength appeared highest in order from attacker, center, setter, to libero. For internal rotation, the difference in muscle strength appeared highest in order from attacker, center, setter, to libero.

Analysis by position of the shoulder joint external and internal rotation muscle strength ratio showed that on the dominant side, difference in muscle strength appeared highest in order from setter, libero, attacker to center. Furthermore, in comparison to the other positions, the setter displayed a higher statistical significance. For the non-dominant side, the difference in muscle strength appeared highest in order from attacker, center, setter, to libero. There were no significant differences between the groups. In the non-dominant side, there was a significant difference between the attacker and the center regarding the rotational ratio (p<.05).

DISCUSSION

In volleyball, the overhand position meant for serving and spiking as well tossing which involves pushing the ball with the finger occur frequently^{2,3,11)}. When comparing the physical activity involved for each playing position, the attacker is

shown to jump and spike, the center is shown to jump and block, the setter is shown to jump and toss, while the libero is shown to receive the most¹²⁾. There are other characteristics that result from the frequency of technique performance in each position and these aspects are most likely reflected on physical activity²¹⁾. In this study, the muscle strength and muscle ratio of the shoulder joint during internal rotation and external rotation are observed based on position. These movements are crucial to the main volleyball techniques of spiking and serving and as such, in order to develop a scientific training program this study is an important source of evidence.

The attacker performs the most spikes which involves frequent and repeated motion of the dominant arm in the overhand position and thus increases the possibility of damage to the contractile structure^{5, 13)}. The mechanical explanation for this can be understood as the internal rotator muscle strength increases and the external rotator muscle strength decreases there emerges an imbalance in muscle strength^{14,15)}. Strong centrifugal contractile force in the shoulder shortens the non-contractile structures such as the the posterior capsule of the shoulder, resulting in micro-damage occurring in the external rotator muscles¹⁶⁾. Among the technical repertoire of the attackers, strikes have the highest score rate.

In order to perform a strong spike, strong afferent contraction of the internal rotation of the shoulder muscles is required and as such, the muscle strength of the main arm is higher than that of the other player positions. Copeland¹⁷ reported that volleyball players who experienced injury had weakening of the external rotator muscle strength due to frequent overhead movements. However, in this study, the strikers showed higher tendency to score using external rotation muscles than the other player positions and the indicated results were therefore not consistent with this theory. Yet, as the participants of this study had been cleared by an orthopedic specialist for un-hindering participation in this study, it may be explained that the muscle strength of the external rotator muscle had not suffered any damage from frequent overhead movements.

During a spike maneuver, a series of shoulder motions cause a change in the pattern of muscle strength and activity of the rotator cuff muscles and the repetition of these movements cause excessive loosening of the posterior capsule of the shoulder and physical stress is accumulated in order to prevent dislocation of the humerus^{10,18}. Efferent contractions require strong external rotational force which in repetition causes micro-damage and coupled with the antagonistic relationship of the internal rotator muscles further exacerbate the imbalance of muscle strength¹⁹. It can be expected that such characteristics would indicate a higher muscle strength ratio and active stability in the shoulder joint for positions such as attackers and centers that involve frequent overhead motions in comparison to positions such as setters and liberos. However, in this present study, in the case of the dominant arm, all attackers were at 51.36% and all centers were at 50.27%, which in comparison to the setters who had 63.52%, indicated that there was a significantly lower ratio. Furthermore, the libero showed a result as low as 47.64%, which shows that liberos are not able to perform overhead movements such as spiking or blocking and therefore the possibility of difference in torque ratio in the shoulder joint from other positions cannot be excluded and subsequent research is needed.

The difference between the internal and external rotation muscle strength in the non-dominant shoulder joints of the strikers and the center is significantly reduced¹⁰. In this study, the results

of comparative analysis conducted within the groups for the non-dominant and dominant arms showed that in the attacker and center groups where there is frequent overhead movement, the dominant side internal rotation muscle strength appeared superior and was similar to the results of previous studies. In the non-dominant side, the external rotation muscle strength appeared more superior^{7,19}.

Unlike the center and attacker, the setter appeared to have superiority in external rotation for the dominant side and internal rotation for the non-dominant side. The results however, were not of statistical significance. The main action performed by setters is tossing. While tossing also involves the overhead action, there is no application of rotational force as during spiking, which lowers the possibility of causing pain²⁰.

Finally, in the case of libero, there was no significant difference in the muscle strength and ratio of both arms and it is considered that the cause is due to a lack of overhead motions that may cause injury to the shoulder joint muscle strength in the dominant arm. Further studies are needed to clarify the characteristics of isokinetic muscle strength of the positions for professional Korean female volleyball players by expanding the number of subjects.

CONCLUSIONS

Identifying the effect of positioning in professional female Korean volleyball players on the internal and external rotation muscle strength as well as muscle strength ratio lead to the following conclusions.

For the dominant side, the shoulder joint muscle strength ratio of the center position had a difference of more significance compared to the other position. In the attacker and center positions, the dominant side had a higher difference in muscle strength ratio than the non-dominant side. However, there were no significant differences in the setter and libero positions. As this study has a limited subject pool, it is necessary during the interpretation of the results to keep in mind that the data is not to be generalized to all pro female volleyball players, and a secondary study is planned with a focus on expanding the number of subjects.

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