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The Effect of Game Participation by a Professional Pitcher on Isokinetic and Isometric Muscle

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Abstract

This study was conducted to identify the isokinetic muscular strength during the season in professional baseball pitchers. By medical and clinical tests of medical specialist (doctor), 21 players were selected for this study. Total results of 21 players were used as data. All variables were measured in pre-season, in-season, and post-season. Isokinetic and isometric muscle strength was measured by CSMi (Humac Co., U.S.A). Repeated measure MANOVA was used to verify differences between the groups. LSD (Least Significant Difference) was carried out when significant difference is appeared among times and independent T-test was used to analyze significant differences between groups. Significant level was $p<.05$. The results of this study were as follows: In isokinetic muscle strength test, ER/IR ratio of dominant shoulder was significantly lower than in non-dominant. Peak muscle strength (180°/sec) in dominant was significantly lower. In isometric muscle strength test, isometric - 25° ER muscle strength in dominant was significantly lower than in non-dominant. In conclusion, Isometric muscle strength of external rotators in dominant was lower and also decreased during the season. Therefore, further researches will be necessary for identifying effects of pitching on muscle strength in baseball players.

Keywords: Component, Formatting, Isometric Muscle Strength, Isokinetic Muscle Strength, Baseball Player

1. Introduction

Players who repeatedly pitch balls experience a change in the muscle strength of their glenohumeral joint as the season progresses[17]. The reason for this is because for patients whose rotator has ruptured, the muscle strength of the glenohumeral joint tends to weaken. Therefore recovering this weakened muscle strength is a critical method for recovering the function of the muscles[8]. Isokinetic exercises apply constant resistance in proportion to the muscle strength that is exerted due to the subject's spontaneous movement at an angular velocity that is fixed. By doing so, a maximum level of contraction can be maintained within the total range of movement. Because it is highly efficient in reinforcing muscle strength, it is often used as part of a rehabilitation program or athlete management program in sport medicine[18]. Generally, it is known that when it comes to exercise injury, the ratio of muscle strength (the ratio of agonist muscle and antagonistic muscle) rather than the size of the muscle strength has a bigger impact. Many reference points for each joint's muscular strength ratio have been reported[4,11]. Many assessments are being reported on measuring and analyzing the muscle strength of the glenohumeral joint through isometric, isokinetic and isotonic exercises. In particular, isokinetic exercises are defined as exercises

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that artificially change the resistance in accordance to the applied peak torque to maintain a constant speed. This allows a more objective measurement and analysis[10].

For injury prevention and functional recovery of muscle balance and range of movement of the joint is important, particularly in the shoulder rotator cuff muscle is very important in the rehabilitation process and prophylactic examination of dynamic muscle strength, power, endurance and performance of the damage. Force couple of rotator cuff in the shoulder joint plays an important role to stabilize the humerus[7]. When the shoulder is close to the supraspinatus, infraspinatus and teres minor and subscapularis lead to humeral head slide to inferior. And the humeral head by the action of the deltoid muscle is possible to ensure stability for the positioning of the humeral shoulder blade when made fossa raising operation[9]. Humeral joint instability and impingement syndrome is that patients with the target muscle imbalances to check the results of the posterior rotator cuff problems that appeared to be[12]. In particular, the rotator cuff injury portion of the study examined the relevance of a rotator cuff muscle imbalance was pointed out that the main cause of muscle imbalance[13]. Isokinetic equipment play an important role in scientifically and clinically checking of Muscle balance, strength measurement, assessment, therapeutic exercise, improved performances of the players. It is used to test the agonist and antagonist balance surrounding the shoulder joint. Evaluation of the strength was much is used in the process of checking for the prevention and rehabilitation of the shoulder portion due to this balance of strength are in a position to effect changes in the bone. Test result data using isokinetic equipment is laying the basis for shoulder training and help to provide data[3]. Thus, the stability and mobility of the shoulder is closely related to the ability of the pitcher performances, can be referred to as ways to improve the performances of it with the stability and mobility at the same time a pitcher. So, a high level of safety for a variety of previous studies that show the sport to give a scientific basis for the exercise of the players were going to perform.

However, factors individually or been done by research papers to date was showing that only limited trend observed for clinical signs, so I think need a comprehensive understanding about the pitching motion of the shoulder joint related in muscle strength.

Accordingly, this study seeks to provide scientific data for shoulder injury prevention and performance enhancing their pitching strength by observing the changes in season lapse targeted at professional baseball pitcher.

2. Method

2.1 General Characteristics of Subjects

The subjects were baseball players registered with the Korea Baseball Association, who had been diagnosed by a medical doctor that there were no abnormalities in the glenohumeral joint and who had voluntarily agreed to the purpose of this study. Given the dropouts of the subjects that will inevitably occur during the study, a total of 21 subjects were selected. Those with no clinical abnormalities in any of the tests were selected as study subjects. A dominant shoulder was set, with the other shoulder being non-dominant or less frequently used. Measurements were taken three times; Pre-season, In-season, and Post-season. Players who had an injury and could not play in games were excluded from the study. The physical characteristics of the subjects are as shown in Table 1.

Table 1. Characteristics of subjects (n = 21)

No	Age (yr)	Career (yr)	Height (cm)	Weigh t(kg)	BMI (cm/kg)
21	24.31	11.32	185.13	85.91	23.72

Values are M ± SD

2.2 Method of Measurement

Measurement of isokinetic muscle strength was conducted internal rotation and external rotation of the glenohumeral joint. To measure the isokinetic muscle strength of internal rotation and external rotation of the glenohumeral joint, the subject took the supine position as seen in Figure 1. Then rotated externally the humerus joint by 90° with the elbow flexed by 90° with the handle touching the palm, the location was fixed. The axis of the dynamometer was made to pass the middle part between the joint and the torso and forearms were fixed using a belt. Using CSMi (humac Co., U.S.A.) which is an isokinetic equipment, the test was conducted three times each after three times of preparation exercise at angular velocities of 60°/sec, 120°/sec, and 180°/sec[17]. The range of movement of the joint was limited to, for IR -30°, and for ER 90°. After being fixed, the dominant side was tested after which the non-dominant side was tested. In order to increase the reliability of the test, the subjects were taught to not lift their pelvis or scapula on both sides from the bed.

The test was prepared in the same method as the isometric test, with both internal and external rotations tested for 5 seconds each at angles of 85°, 30° and 25°. There was a 20 second intermission during the test and in order to increase the reliability of the test, the subjects were taught to not lift their pelvis or scapula on both sides from the bed.

Figure 1. Measurement of internal rotation and external rotation isokinetic strength.

2.3 Statistics

Repeated measure MANOVA was used to verify differences between the groups. LSD (Least Significant Difference) was carried out when significant difference is appeared among times and independent T-test was used to analyze significant differences between groups. Significant level was p<.05.

3. Result

3.1 Changes in the Isokinetic Muscle Strength of the Glenohumeral Joint

3.1.1 Changes in Maximum Isokinetic Muscle Strength in Accordance with Angular Velocity

An analysis of the difference across measurement period and part shows that in all categories of internal rotation and external rotation for maximum isokinetic muscle strength had no significant difference.

Table 2. Changes of isokinetic strength by period and side

		Pre-season	In-season	Post-season
60 PT IR	Dominant	32.00 ± 5.54	33.33 ± 5.95	31.61 ± 4.49
	Non-dominant	37.39 ± 21.18	29.83 ± 3.35	28.89 ± 3.76
60 PT ER	Dominant	28.67 ± 4.04	30.78 ± 3.69	30.89 ± 3.89
	Non-dominant	37.39 ± 21.18	29.83 ± 3.35	28.89 ± 3.76
120 PT IR	Dominant	39.56 ± 29.24	31.83 ± 4.36††	29.89 ± 4.97††
	Non-dominant	26.72 ± 3.88	27.22 ± 3.61	24.22 ± 4.61
120 PT ER	Dominant	39.22 ± 30.34	27.94 ± 6.67	32.11 ± 11.51
	Non-dominant	37.22 ± 20.83	29.67 ± 3.09	32.28 ± 14.52
180 PT IR	Dominant	42.11 ± 25.34*†	34.00 ± 3.46†††	31.28 ± 4.96†
	Non-dominant	29.67 ± 3.69	28.94 ± 3.00	27.94 ± 3.90
180 PT ER	Dominant	43.17 ± 41.91	29.11 ± 3.32	31.83 ± 13.17
	Non-dominant	35.44 ± 20.07	28.72 ± 2.80	32.61 ± 16.33

†p<.05 vs. Non-dominant, ††p<.01 vs. Non-dominant, †††p<.001 vs. Non-dominant. *p<.05 vs. Post-season. PT: peak torque, IR: internal rotation, ER: external rotation.

3.1.1.1 Changes in Maximum Isokinetic Muscle Strength at 60°

An analysis by measurement period and side shows that there was no significant difference in all categories of isokinetic muscle strength for internal rotation and external rotation at 60°.

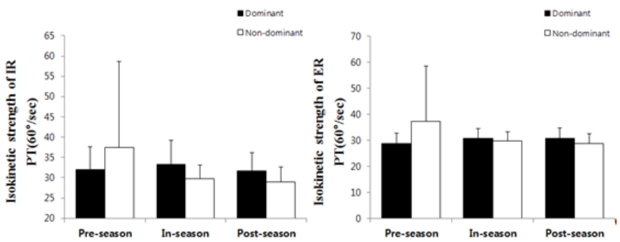

Figure 2. Differences of isokinetic 60° PT IR and ER to Period.

3.1.1.2 Changes in Maximum Isokinetic Muscle Strength at 120°

For 120° internal rotation, the dominant side was 31.83 ± 4.36 which is significantly higher than the Non-dominant figure of 27.22 ± 3.61 at p<.01. For Post-season, the dominant side was 29.89 ± 4.97 which was significantly higher than the Non-dominant side of 24.22 ± 4.61 at p<.01.

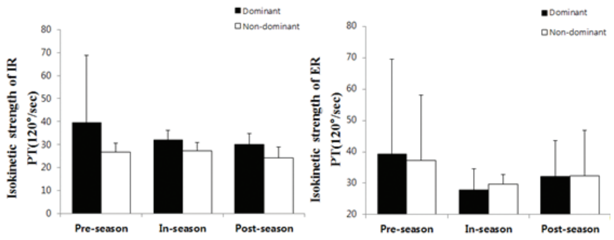

Figure 3. Differences of isokinetic 120° PT IR and ER to Period.

3.1.1.3 Changes in Maximum Isokinetic Muscle Strength at 180°

For 180° internal rotation Pre-season, the dominant side was 42.11 ± 25.34 which is significantly higher than the Non-dominant side of 29.67 ± 3.69 at p<.05. For In-season, the dominant side was 34.00 ± 3.46 which is significantly higher than the Non-dominant side of 28.94 ± 3.00 at p<.01. For In-season, the Dominant side was 31.28 ± 4.96 which is higher than the Non-dominant side of 27.94 ± 3.90 at p<.05. An analysis of the difference across periods show that Pre-season Dominant internal rotation was 42.11 ± 25.34 which is significantly higher than the Post-season Dominant internal rotation of 31.28 ± 4.96 at p<.05.

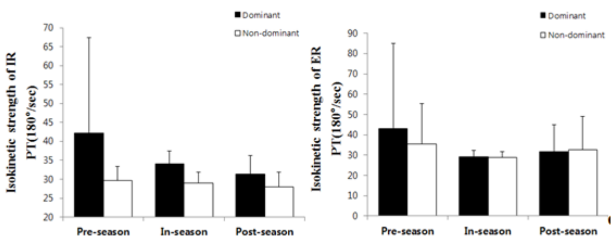

Figure 4. Differences of isokinetic 180° PT IR and ER to Period.

3.1.1.4 Changes in isokinetic tatal work strength in accordance with angular velocity

There was a significant difference in internal rotation between parts for isokinetic work at 60°, 120° and 180°.

Table 3. Changes of isokinetic total work strength by period and side

		Pre-season	In-season	Post-season
60 TW IR	Dominant	127.33 ± 47.13	146.39 ± 30.42†††	136.44 ± 20.03††
	Non-dominant	118.56 ± 27.49	114.94 ± 25.71	108.39 ± 33.65
60 TW ER	Dominant	134.67 ± 23.86	143.22 ± 18.04	142.06 ± 20.76
	Non-dominant	136.17 ± 22.78	136.72 ± 18.24	133.78 ± 20.75
120 TW IR	Dominant	103.44 ± 40.14	122.67 ± 20.91†††	110.56 ± 31.62††
	Non-dominant	97.78 ± 22.45	94.11 ± 20.18	82.22 ± 27.50
120 TW ER	Dominant	118.72 ± 22.48	125.61 ± 11.83	115.94 ± 27.47
	Non-dominant	121.06 ± 16.02	120.11 ± 13.90	111.28 ± 24.03
180 TW IR	Dominant	96.61 ± 39.05	109.78 ± 23.26††	105.00 ± 23.52†
	Non-dominant	84.44 ± 21.91	85.94 ± 17.15	84.72 ± 22.74
180 TW ER	Dominant	96.83 ± 19.43	101.50 ± 10.91	98.22 ± 15.76
	Non-dominant	94.44 ± 18.46	99.61 ± 11.04	98.78 ± 10.32

†p<.05 vs. Non-dominant, ††p<.01 vs. Non-dominant, †††p<.001 vs. Non-dominant PT: peak torque, IR: internal rotation, ER: external rotation.

3.1.1.5 Changes in Isokinetic Total Work Strength at 60°

The total work strength of internal rotation isokinetic muscle strength at 60° In-season showed that the Dominant side recorded 146.39 ± 30.42Nm which was significantly higher than the Non-dominant side of 114.94 ± 25.71NM at p<.01. For Post-season, the dominant side's muscle strength was 136.44 ± 20.03Nm which is significantly higher than the Non-dominant side of 108.39 ± 33.65Nm.

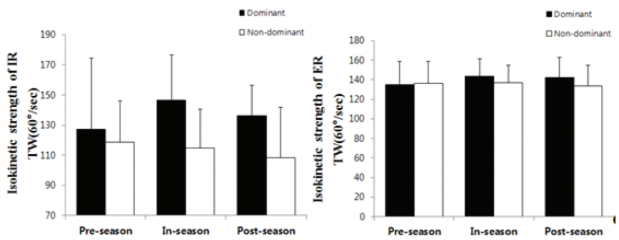

Figure 5. Differences of Isokinetic 60° TW IR and ER to Period.

3.1.1.6 Changes in Isokinetic Total Work Strength at 120°

The total work strength of internal rotation isokinetic muscle strength at 120° In-season showed that the Dominant side was 122.67 ± 20.91 NM which is significantly higher than the Non-dominant side of 94.11 ± 20.18 NM at p<.001. For Post-season, the muscle strength of the Dominant side was 110.56 ± 31.62 NM which is significantly higher than the Non-dominant side's 82.22 ± 27.50 NM at p<.01.

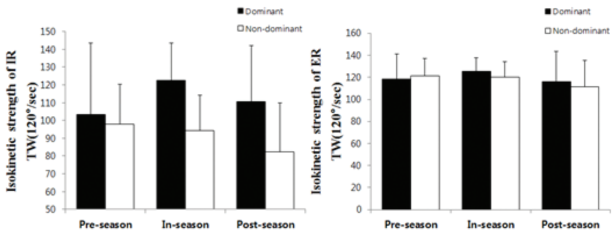

Figure 6. Differences of Isokinetic 120° TW IR and ER to Period.

3.1.1.7 Changes in Isokinetic Total Work Strength at 180°

The total work strength of internal rotation isokinetic muscle strength at 180° In-season showed that the Dominant side was 109.78 ± 23.26 NM which is significantly higher than the Non-dominant of 85.94 ± 17.15 NM at P<.01. For Post-season, the dominant side's muscle strength was 105.00 ± 23.52 NM which is significantly higher than the Non-dominant side's 84.72 ± 22.74 NM at p<.05.

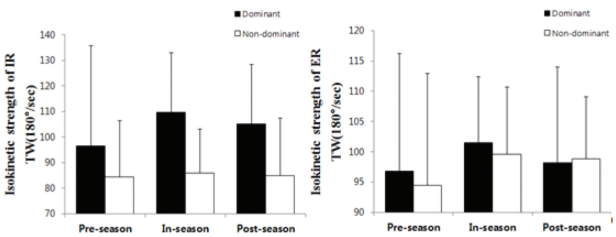

Figure 7. Differences of Isokinetic 180° TW IR and ER to Period.

3.1.1.8 Changes in maximum peak torque ratio in accordance with angular velocity

There were no significant differences

Table 4. Changes of isokinetic total work strength by period and side

		Pre-season	In-season	Post-season
60° PT Ratio	Dominant	92.58 ± 22.48	95.09 ± 20.25	98.95 ± 14.38
	Non-dominant	134.91 ± 56.89	108.48 ± 18.94	113.49 ± 22.75
120° PT Ratio	Dominant	101.74 ± 23.86	89.47 ± 26.31	109.93 ± 43.64
	Non-dominant	137.52 ± 62.31	110.71 ± 17.98	137.80 ± 67.32
180° PT Ratio	Dominant	94.35 ± 25.27	86.71 ± 14.60	104.74 ± 52.14
	Non-dominant	118.46 ± 57.95	100.45 ± 16.03	119.53 ± 65.51

PT: peak torque

3.1.1.9 Changes of Isokinetic Total Work Ratio by Period and Side

There was no significant difference in any of the categories of total work ratio across measurement periods or parts. An analysis of differences across measurement periods and parts showed no significant difference in the change of isokinetic work amount ratio at 60° 120° or 180°.

Table 5. Changes of isokinetic total work ratio by period and side

		Pre-season	In-season	Post-season
60 TW Ratio	Dominant	135.98 ± 99.08†	101.20 ± 21.13††	105.08 ± 14.26
	Non-dominant	120.49 ± 30.62	122.79 ± 22.93	132.60 ± 35.70
120 TW Ratio	Dominant	145.15 ± 105.88	105.50 ± 22.21	107.22 ± 18.39
	Non-dominant	130.27 ± 32.30	133.07 ± 31.24	145.65 ± 49.35
180 TW Ratio	Dominant	124.70 ± 83.46†	96.61 ± 23.51	95.76 ± 15.75
	Non-dominant	117.83 ± 33.68	120.27 ± 27.27	126.06 ± 40.97

†p<.05 vs. Non-dominant, ††p<.01 vs. Non-dominant TW: total work

3.1.1.10 Changes in the Isometric Muscle Strength of the Glenohumeral Joint

- Changes of Isometric Muscle Strength

There were significant differences across periods for 25°

internal rotation and across sides for 85 internal rotation and external rotation and 30° internal rotation.

Table 6. Changes of isometric strength by period and side

		Pre-season	In-season	Post-season
85° IR	Dominant	28.67 ± 6.60†††	30.61 ± 8.51†††	28.94 ± 8.21†††
	Non-dominant	20.39 ± 6.29	18.44 ± 6.45	20.44 ± 7.87
85° ER	Dominant	29.11 ± 5.14†	28.61 ± 5.17	29.89 ± 4.13††
	Non-dominant	23.39 ± 7.41	25.61 ± 5.70	25.00 ± 5.76
30° IR	Dominant	32.72 ± 5.92††	32.94 ± 6.64†	28.56 ± 5.79
	Non-dominant	26.67 ± 6.38	27.33 ± 5.63	25.56 ± 5.25
30° ER	Dominant	33.89 ± 5.42	33.44 ± 7.33	33.61 ± 5.20
	Non-dominant	30.72 ± 6.55	31.61 ± 6.23	31.78 ± 6.16
-25° IR	Dominant	33.56 ± 6.61	33.39 ± 4.79	28.06 ± 5.43
	Non-dominant	29.72 ± 6.21	31.28 ± 5.58	28.28 ± 5.11
-25° ER	Dominant	24.44 ± 8.71**	22.00 ± 5.68**	21.94 ± 5.93
	Non-dominant	23.39 ± 6.68	22.50 ± 5.65	22.44 ± 5.83

†p<.05 vs. Non-dominant, ††p<.01 vs. Non-dominant, †††p<.001 vs. Non-dominant. *p<.05 vs. Post-season, **p<.01 vs. Post-season, ***p<.001 vs. Post-season. IR: internal rotation, ER: external rotation.

- Changes in Isometric Muscle Strength at 85°

For Pre-season and for internal rotation, dominant side's muscle strength was 28.67 ± 6.60 which was significantly higher than the Non-dominant side's 20.39 ± 6.29. For In-season, the Dominant side recorded 30.61 ± 8.51, which is significantly higher than the Non-dominant side's record of 18.44 ± 6.45. For Post-season, the muscle strength of the Dominant side was 28.94 ± 8.21, which is significantly higher than the Non-dominant side's 20.44 ± 7.87.

The isometric muscle strength for external rotation at 85° was, for Pre-season, 29.11 ± 5.14 on the dominant side and for the Non-dominant side 23.39 ± 7.41, with the dominant side being significantly higher. For In-season, the muscle strength of the Dominant side was 28.61° ± 5.17 which is significantly higher than the Non-dominant side's 25.61 ± 5.70, and for Post-season, the Dominant side's muscle strength was 29.89° ± 4.13 which is significantly higher than the Non-dominant side's 20.44 ± 7.87.

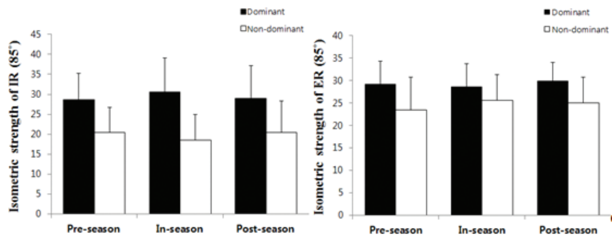

Figure 8. Differences of Isometric 85° IR and ER to Period.

- Changes in Isometric Muscle Strength at 30°

The isometric muscle strength for internal rotation at 30° for Pre-season showed that the Dominant side was 32.72 ± 5.92 which is significantly higher than the Non-dominant side's 26.67 ± 6.38. For In-season, the Dominant side was 32.94 ± 6.64 which is significantly higher than the Non-dominant side's 27.33 ± 5.63. For Post-season, the Dominant side was 28.56 ± 5.79 which is significantly higher than the Non-dominant side of 25.56 ± 5.25.

There was no significant difference in the isometric muscle strength of external rotation at 30° across measurement periods or parts.

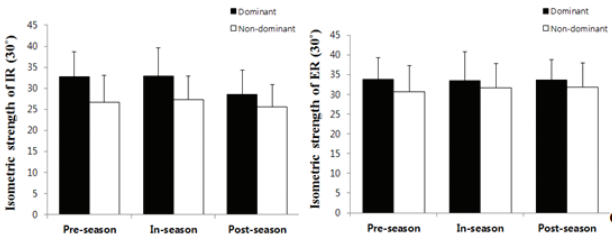

Figure 9. Differences of Isometric 30° IR and ER to Period.

- Changes in Isometric Muscle Strength at -25°

For Pre-season-25° external rotation, the muscle strength of the Dominant side was 24.44 ± 8.71 which is significantly higher than the Post season's Dominant side of 21.94 ± 5.93. The In-season -25° external rotation muscle strength of the Dominant side was 22.00 ± 5.68 which is significantly higher than the Post season's Dominant value of 21.94 ± 5.93 at p<.01. An analysis of differences across measurement period shows that there is no significant difference in any categories of isometric muscle strength for internal rotation and external rotation at -25°.

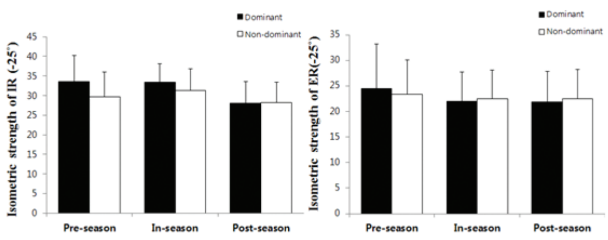

Figure 10. Differences of Isometric -25° IR and ER to Period.

- Changes of Isometric Strength Ratio

At 85°, there was a significant difference across parts by measurement period, the ratio of isometric strength ratio at 85° for Pre-season showed that the Dominant side recorded 104.15 ± 19.20° which is significantly higher than the Non-dominant side's 121.97 ± 45.56°. For In-season, the ratio of the Dominant side was 98.09 ± 25.68° which is higher than the Non-dominant side's 153.92 ± 59.67°. For Post-season, the muscle strength of the Dominant side was 110.11 ± 29.49° which is significantly higher than the Non-dominant side's 137.72 ± 54.41°.

An analysis of the differences in parts across measurement periods show that there was no significant difference in any categories of isometric muscle strength for internal rotation and external rotation at 30° and -25°.

Table 7. Changes of isometric strength ratio by period and side

		Pre-season	In-season	Post-season
85°	Dominant	104.15 ± 19.20	98.09 ± 25.68††	110.11 ± 29.49
	Non-dominant	121.97 ± 45.56	153.92 ± 59.67	137.72 ± 54.41
30°	Dominant	106.39 ± 23.13	106.25 ± 31.90	122.11 ± 30.10
	Non-dominant	119.80 ± 28.61	118.80 ± 27.67	128.29 ± 31.12
-25°	Dominant	72.78 ± 21.83	66.55 ± 16.51	79.23 ± 20.53
	Non-dominant	80.50 ± 25.31	74.18 ± 22.67	82.31 ± 27.57

††p<.01 vs. Non-dominant

4. Discussion

Isokinetic exercises apply constant resistance in proportion to the muscle strength that is exerted due to the subject's spontaneous movement at an angular velocity that is fixed. By doing so, a maximum level of contraction can be maintained within the total range of movement. Because it is highly efficient in reinforcing muscle strength, it is often used as part of a rehabilitation program or athlete management program in sport medicine[18]. Generally, it is known that when it comes to exercise injury, the ratio of muscle strength (the ratio of agonist muscle and antagonistic muscle) rather than the size of the muscle strength has a bigger impact. Many reference points for each joint's muscular strength ratio have been reported[4]. In a preceding study that investigated the appropriate muscle strength balance[15], it was shown that external rotation had to be at least 65% compared to internal rotation. In another study[5], the most appropriate ratio of external rotation muscle strength and internal rotation muscle strength is said to be 66~75%. In a preceding study that investigated the correlation between the ball speed of a professional baseball player, his glenohumeral joint, lower back, isokinetic muscle strength and power at a 90 degree rotation of the glenohumeral joint the 180°/sec internal muscle strength (per unit body weight; BW%) was 42.9Nm, external rotation muscle strength was 37.3Nm, and muscle strength ratio was 87%. The 210°/sec internal rotation muscle strength (per unit body weight) was 41.8Nm, external rotation muscle strength was 35.2Nm, and muscle strength ratio was 84%. In a preceding study that investigated the internal and external rotations of professional baseball players' glenohumeral joint using an isokinetic device[14], the maximum muscle strength ratio at 180°/sec for internal rotation was 65% for the dominant side and 64% for the non-dominant side. The maximum muscle strength ratio at 210°/sec for internal rotation was 64% for the dominant side and 74% for the non-dominant side. Also, in a preceding study that used isokinetic devices on the rehabilitation and testing of the glenohumeral joint[3], 147 professional baseball players were used as subjects. At 210°/sec, the muscle strength of internal rotation on the dominant side (peak torque) was 21Nm, and 19Nm for external rotation, with the muscle strength ratio being 90%. The muscle strength for internal rotation on the non-dominant side (per unit body weight;

%BW) was 19Nm, and 14Nm for external rotation, with the muscle strength ratio being 74%. In a preceding study that investigated the dominant side and non-dominant side of university baseball players and the isokinetic muscle strength, operating power and the characteristics of the humerus inferior, at 90°/sec the muscle strength for internal rotation on the dominant side (per unit body weight; %BW) was 60.8Nm and 34.4Nm for external rotation, with the muscle strength ratio being 57%. The muscle strength for internal rotation on the non-dominant side (per unit body weight; %BW) was 64.1Nm, and 35.2Nm for external rotation, with the muscle strength ratio being 55%. At 180°/sec, the muscle strength of internal rotation on the dominant side (per unit body weight; %BW) was 59.9Nm and 36.6Nm for external rotation, with the muscle strength ratio being 64%. For the non-dominant side, the internal rotation muscle strength was 66.9Nm and 33.5Nm for external rotation, with the muscle strength ratio being 50%. In a preceding study that used an isokinetic device to investigate the ratio between the muscle strength in glenohumeral joint's internal rotation and external rotation in professional baseball players [10], at 180°/sec the muscle strength for internal rotation on the dominant side (per unit body weight; %BW) was 28.3Nm and 18.7Nm for external rotation, with the muscle strength ratio being 67%. For the non-dominant side, the muscle strength for internal rotation (per unit body weight; %BW) was 25.4Nm and 18.6Nm for external rotation, with the muscle strength ratio being 73%. In a preceding study using isokinetic devices to investigate the balance of the rotator[2], at 60°/sec the muscle strength of internal rotation on the dominant side (peak torque) was 65.38Nm and 39.92Nm for external rotation, with muscle strength ratio being 57%. For the non-dominant side, the muscle strength for internal rotation was 55.49Nm, and 39.84Nm for external rotation, with muscle strength ratio being 72%. At 180°/sec the muscle strength for inner rotation on the dominant side was 59.93Nm, 34.12Nm for external rotation with a muscle strength ratio of 60%. For the non-dominant side, the muscle strength for inner rotation was 51.04Nm, 34.28Nm for external rotation, and muscle strength ratio at 67%. The study results show that there was a significant difference between left and right for peak torque internal rotation at 120° and 180°. For total work internal rotation, there was a significant difference between left and right at 60°, 120° and 180°. The muscle strength ratio on the non-dominant side, too was in the range of 108~137% and out of the normal range, indicating a high risk of injury. Therefore, mechanical training while the muscle strength ratio is aligned will be required. The work amount ratio was 95~145% for the dominant side, and the peak torque ratio was 92~109%, showing the work amount ratio having a worse ratio balance than peak torque. Therefore, when isokinetic muscle strength is measured and assessed using a ratio, the ratio of work amount would have to be considered together. The isokinetic muscle strength on the dominant side and the non-dominant side for pitchers that were playing in games in season and post-season, there was a significant difference between in-season and post-season for maximum torque internal rotation at 120°/sec and between pre-season, in-season and post-season of maximum torque internal rotation at 180°/sec. Differences across time periods showed that there was a significant decrease in muscle strength for pre-season and in-season at 180°/sec maximum torque internal rotation, compared to post-season. Therefore, an exercise program that can prevent this decrease in muscle strength with the progress of the season will be needed. The reason many scholars' muscle strength figures differ may be due to an issue with the test method For example, when testing for the internal rotation muscle strength, if the scapula is lifted from the bed, the glenohumeral joint is mobilized, leading to a higher muscle strength observed. An injury to the glenohumeral joint can lead to a huge variation in muscle strength, too. Preceding studies have proved that isometric tests have a high reliability in testing and assessing issues of the rotator[6]. Another study[1,14] noted that the factors related to the speed of the pitcher's ball, such as the internal rotation muscle strength of the glenohumeral joint, are important. Therefore in this study internal and external rotation isometric muscle strengths were tested at 85 degrees, 30 degrees, and -25 degrees. There were significant differences between the left and right for pre-season and in-season in the -25 degree external rotation test, for pre-season and in-season in the 30 degree internal rotation test, and for pre-season and post-season internal rotation of the dominant side at 85 degrees, and for pre-season and post-season external rotation of the dominant side. There was also a significant difference in the dominant side's external rotation muscle strength between pre-season and in-season. It is estimated that the muscle strength for external rotation as the season progresses declined at -25 degrees, indicating that training through exercise programs to prevent this decline in isometric muscle strength would be required to prevent injury and improve performance. The ratio of isometric muscle strength by angle shows that at 85 degrees of the dependent side it was 98~110%, 106~122% at 30 degrees and 66~79% at -25 degrees, showing a week internal rotation muscle strength at 85 degrees and 30 degrees. The figure for -25 degrees was within normal range. On the non-dominant side at 85 degrees it was recorded 121~153%, 118~128% at 30 degrees, 74~82% at -25 degrees, showing a weak internal rotation muscle strength at 85 degrees and 30 degrees, while the figure for -25 was within normal range. This results shows that training and rehabilitation is needed for muscle balance on the dominant side and that the non-dominant side showed more imbalance, calling for the need for management on the non-dominant side to prevent injury and improve performance.

In conclusion, this study shows that Korean professional baseball players had more decline in flexibility of internal rotation of the dominant side glenohumeral joint, decline in internal rotation muscle strength and issues with the scapula compared to foreign baseball players. As the season progressed, a decline in external rotation isometric muscle strength at -25° and a decline in isokinetic muscle strength for internal rotation at 180° appeared, indicating the need for constant management through a combination of isometric and isokinetic exercises. However, since it is difficult to prevent injuries and improve performance through rehabilitation exercises alone, a thorough management of the number of games participated, number of balls pitched, limit to the number of balls pitched, level of exhaustion and rest days would be needed.

The limit of this study lies in the fact that there may be errors due to the expertise of the test conductor operating the tests on the range of movement of joints or muscle strength. If the techniques and methods used for measurement are not maintained consistently, reliability may fall. Therefore, for more accurate results in follow-up studies, the same study should be conducted by a practiced trainer using an accurate test method to increase reliability. Moreover, this study is only limited to professional baseball players in one team and therefore a broader inclusion of subjects from various teams will be helpful in developing training methods that can improve performance and prevent injuries.

In the isometric muscle strength test (external rotation of 90 degrees) during the professional baseball season, significant differences were discovered between pre-season, in-season and post-season on dominant and non-dominant sides at 85° internal rotation, between pre-season and post-season for 85° external rotation, and between pre-season and in-season at 30° internal rotation. The muscle strength ratio of the dominant side at 85° showed that there was a significant difference in In-season values and an analysis across periods showed that there was a significant difference between pre-season, in-season and post-season for -25° external rotation.

5. Conclusion

During the professional baseball season a test on isokinetic muscle strength of the glenohumeral joint was conducted for pitchers. The result showed that there was a significant difference between the dominant and non-dominant sides in-season and post-season at 120° peak torque internal rotation and between pre-season, in-season and post-season at 180° peak torque internal rotation. An analysis of differences across time periods showed that the pre-season and in-season of internal rotation at 180° peak torque had more significance than the post-season. In the test for isokinetic muscle strength (90 degrees external rotation) there was a significant difference in in-season and post-season on dominant and non-dominant sides at 60°, 120°, and 180° work amount internal rotation. When the muscle strength ratio at angular velocity of 180° was measured, there was a significant difference in Pre-season, but no significant difference across time periods.

6. References

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