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A 12-week rehabilitation program improves body composition, pain sensation, and internal/external torques of baseball pitchers with shoulder impingement symptom

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The aim of this study was to investigate the effects of a 12-week rehabilitation program on body composition, shoulder pain, and isokinetic internal/external torques of pitchers with impingement syndrome. A total of 30 pitchers were divided into 2 groups: experimental group (EG, n=16) and control group (CG, n=14). The rehabilitation program consisted of physical therapy, warm-up, work-out, and cool-down. As results, body weight and fat mass of EG were decreased whereas muscle mass of EG was significantly increased after the experiment. The pain degrees in resting, normal daily activity, and strenuous activity on the numeric pain rating scale were significantly decreased in the EG. The internal and external peak torques (PTs) of uninvolved and involved sides of EG were increased in EG after 12 weeks. Such results provide a deficit ratio of both sides in EG close to normal values. The ratios of internal/external PTs in EG were also close to the reference values. The internal and external total works of both sides in EG were similar to the values of PT. The fatigue indices of internal and external rotators of both sides in EG were decreased. As a conclusion, a 12-week rehabilitation program reduced the shoulder pain, improved the body composition and enhanced the isokinetic shoulder internal/external rotators in EG with impingement symptoms. Also the study suggested that the rehabilitation program evened out the ratio between internal and external rotators and lowered the fatigue level after the experiment.

Keywords: Numeric pain rating scale, Shoulder internal rotators, Shoulder external rotators, Muscle mass

INTRODUCTION

Shoulder injuries are responsible for the majority of injuries in baseball players. Most of these injuries occur during the throwing motion and due to overuse. Dale et al. (2007) reported that overhead throwing motion requires an intricate balance between the static and dynamic structures of the shoulder. Such integration requires muscular strength and endurance, flexibility and neuromuscular control (Dillman et al., 1993; Escamilla et al., 2001; Fleisig et al., 1995; Murray et al., 2001). If any one of these factors is compromised, a functional instability results, the performance diminishes and shoulder injuries are more likely to occur (Dale et al., 2007; Lee et al., 2003; Warner et al., 1990). Especially, overhead athletes can show shoulder impingement symptoms due to overload from repetitive throwing (Heyworth and Williams, 2009). Pappas et al. (1985) reported that professional baseball pitchers played over 30 games in a season. They might throw at high velocity as many as 200 pitches in a game. It is not surprising that shoulder pain, inflammation and dysfunction are frequently complaints among baseball pitchers. Fongemie et al. (1998) also reported that the rotator cuff muscle tendons pass through a narrow space between the acromion process of the scapula and the head of the humerus, in which anything which causes further narrowing of this space can result in an impingement syndrome. This can be caused by bony structures such as subacromial spurs, osteoarthritic spurs on the acromioclavicular joint and variations in the

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shape of the acromion. Thickening or calcification of the coracoacromial ligament can also cause impingement. A loss of function of the rotator cuff muscles, due to injury or loss of strength, may cause a superior movement of the humerus which subsequently results in impingement. Inflammation and subsequent thickening of the subacromial bursa may also cause impingement (Fongemie et al., 1998).

Actually, a shoulder joint is unstable because of its normal configuration and the composition of the geometry and ligamentous restraints of the joint (Jobe and Kvitne, 1989). The geometry of the joint, which is composed of the large humeral head in the relatively smaller glenoid fossa, affords the shoulder to a tremendous mobility at the expense of osseous stability. Additionally, the ligamentous restraints normally provide a moderate degree of static stability. However, these restraints are compromised in the thrower because of the tremendous forces which are placed across the joint and the excessive motions which are required during throwing. Ferrara et al. (2000) investigated the injury rates on the basis of such mechanisms. The shoulder joint injury rate was 12.8% in baseball pitchers. Although this rate was smaller than the lumbar injury rate, these rates were not statistically different. Therefore, since the on the shoulder joint injured pitchers experienced an inflammation and healing phase, a specific rehabilitation therapy must be needed. The goals of the exercise therapy were to stabilize the shoulder joint and the thoracoscapulohumeral joint complex and to support their flexibility. Also the functions of shoulder joint should be strengthened and normalized. Especially, the modalities of rehabilitation programs and protocols have been used and were performed on shoulder extension/flexion, shoulder abduction / adduction in baseball pitchers. However, the internal/external rotation is very important for baseball pitchers. Hinton (1988) suggested that the rotator cuff imbalances, decreased internal and external rotators, exhibited in the pitching shoulder of participants, may draw the attention to the need for structured exercise to prevent and correct the deficit of internal and external rotators. It can act as a predisposing factor for injury in the throwing athlete also. Recently, Zanca et al. (2013) reported that a higher torque fluctuation of shoulder internal rotation in athletes with asymptomatic impingement syndrome may point to neuromuscular adaptations related to the throwing training. They also confirmed that there was torque steadiness of shoulder internal and external rotations in the regularly training of overhead athletes with and without impingement symptoms. Namely, the syndrome of this deficit may not be found easily.

Thus, the purpose of this study was to investigate the deficit part of an injured shoulder in isokinetic shoulder internal/external rotators and to assess the changes of pain degrees and body composition in baseball amateur pitchers after a 12-week rehabilitation program.

MATERIALS AND METHODS

Subjects

A total of 30 young men participated in this study. All of the subjects were baseball players with impingement symptoms without any previous shoulder or neck surgery. The subjects underwent a physical examination including medical history and orthopedic evaluation by an orthopedic surgeon. The inclusion criteria for baseball players with impingement symptoms were as follows: complaints of posterosuperior shoulder pain during the throwing motion; pain during the apprehension test and pain relief during the relocation test; or a positive response in one of the above-mentioned tests associated with another of the following diagnostic indicators: Neer, Hawkins, or Jobe (Zanca et al., 2011). An impingement syndrome can be usually diagnosed by subjects' history and due to physical examination. During the physical examination, a researcher twisted or elevated the player's arm to test for reproducible pain (Neer's sign and Hawkin's sign).

After the physical examination, the subjects were randomly divided into two groups: the experimental group (EG, n = 16) with rehabilitation exercise and the control group (CG, n = 14) without rehabilitation exercise. No dropouts were noticed during this study. For all subjects an informed consent form was provided before the study. The informed consent form was approved by the Ethic Committee of Hanseo University Institute and the Korean Academy of Medical Sciences for Health, Korea. The exclusion criteria were as follows: generalized joint laxity according to the Beighton and Horan score; 17 systemic or neurological illnesses; previous shoulder dislocation; previous shoulder or neck surgery or physical therapy treatment in the 12 months prior to the study (Zanca et al., 2013). Complete subject characteristics are presented in Table 1.

Experimental design

All subjects came to the hospital on the 1st day to sign an informed consent form and to complete the self-report questionnaires (Numeric Pain Rating Scale) which were designed to identify subjects with syndrome. After the procedure, each subject returned to the physical care center in the hospital to measure the body composition and for the shoulder isokinetic test. All subjects started with the rehabilitation program accompanied by test re-

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Table 1. Physical characteristics of the subjects

Groups*	CG	EG	Z (*P*)†
Age (yr)	22.57±1.79	21.31±1.74	-2.009 (0.052)
Height (cm)	171.57±4.38	176.50±5.11	-2.400 (0.015)
Weight (kg)	67.79±5.90	68.50±8.18	-0.229 (0.822)
Muscle mass (kg)	32.07±2.86	31.64±4.55	-0.312 (0.759)
Percent mass (kg)	13.95±4.97	13.48±4.26	-0.187 (0.854)
Pain (months)	5.64±1.22	6.06±1.44	-0.640 (0.552)

All values are expressed as mean±standard deviation.
*CG and EG represent groups control group and experimental group, respectively; †Results from non-parametric Mann-Whitney U test.

sults. After 12 weeks, the subjects were examined again with the same measurements as before the treatment. The results of body composition, pain degrees and isokinetic shoulder internal/external rotation tests were selected for this study.

Body composition

To measure weight, fat mass, and muscle mass of the subjects, we used the bioelectrical impedance analysis method assessed by InBody 320 Body Composition Analyzer (BioSpace, Korea), and measured height using BMS 330 anthropometer (BioSpace, Korea). The Body Composition Analyzer is a segmental impedance device measuring the voltage drop in the upper and lower body. The electrodes were made of stainless steel and the electrical interfaces were created as the subject stood upright while gripping hand electrodes and stepping onto foot electrodes. Eight tactile electrodes were placed in contact with the surfaces of both hands and feet: thumb, palm and fingers, front sole, and rear sole (Pil-Byung et al., 2011).

Numeric pain rating scale

All subjects completed the numeric pain rating scale (NPRS) to measure self-reported their pain. The scale was broken down into centimeters and was numerically expressed from 0 to 10 cm. This is a reliable pain assessment tool that requires the subject to place a *V* on a 10 cm long straight line with stops on each end. The left stop equals no pain and the right stop equals the worst pain imaginable (Divir, 2013; Michener et al., 2011). The distance marked on the NPRS was then measured twice. The NPRS was assessed each at rest, with normal daily activities and with strenuous activities. The mean value of these conditions was considered as representative score. The pain scale was translated from English into Korean and was verified to investigate the questions' homogeneity by Korean sports medicine experts. The coefficient from Cronbach' α values calculated by an internal consistency for this question (item inter consistency) was $\alpha = 0.943$. It appeared to show a higher level of trust that has been identified. The pain score was applied to the study of the course of treatment.

Musculo-articular function: internal/external rotations

An isokinetic dynamometer (HUMAC®/NORM™ Testing & Rehabilitation System, CSMI, MA, US) was used for this study. All subjects were submitted to a warm up program including stretching before the test. Subjects were placed on the shoulder internal/external rotation modular component in a standing position. Initial testing of the shoulder typically involved the modified neutral position. This position was obtained by tilting the dynamometer approximately 70° from a horizontal base position. To install the wrist/shoulder adapter on the dynamometer input arm, an investigator inserted the wrist/shoulder adapter into the long end of input arm and secured the handgrip at shoulder position and then installed elbow stabilizer pad on the short end of input arm. To confirm the test position for sure, the subjects were asked from monorail deck. To lock hips, the subjects were asked to stand with the opposite leg slightly forward and with the hand resting on their thigh. The dynamometer height was then adjusted to the position of subject's test arm with elbow flexed to 90° and shoulder slightly abducted.

The range of motion (ROM) of internal/external rotation was nearly from 80° to 60°. However, if the subjects did not fit into a normal ROM, an expert tried to give as much as possible according to their ROM. Subjects performed 4 maximal warm-up repetitions and 4 maximal test repetitions at 60°/sec, and then performed 4 maximal warm-up repetitions and 15 maximal test repetitions at 180°/sec. The rest time between the test velocities was 60 sec. All tests were supervised by only one trained researcher. The peak torque (PT) of shoulder internal and external rotation was analyzed at 60°/sec and then the ratio of internal and external rotation of PT was calculated as well as the deficit ratio on the right and left sides in internal and external rotations, respectively. Furthermore, the measured results of isokinetic torques at 180°/sec have been analyzed by total work (TW) and then the ratio of internal and external rotation of TW were calculated as well as the deficit ratio on the right and left sides in internal and external rotations, respectively.

Rehabilitation program

The study subjects participated in a supervised progressive rehabilitation program for 12 weeks (Table 2). All subjects agreed not to change their daily activity patterns and not to change their

Table 2. Rehabilitation programs for the subjects

Types	Program types	Intensity/Time	Period
Warm-up	Ultrasonic wave	5 min	1d-12 wk
	Laser therapy	10 min	
	Stationary cycling at 60% VO_2max	15 min	
	Standing stretching	10 min	
Work-out 1st phase (Monday)	Prone horizontal abduction at 90°-100° with external rotation (ER)	10 reps × 3 sets	1d-12 wk
	Prone extension with ER	10 reps × 3 sets	
	Prone horizontal abduction at 90°/elbow flexion with ER	10 reps × 3 sets	
	Forward flexion	12 reps × 3 sets	
	Abduction	12 reps × 3 sets	
	Shrug	15 reps × 3 sets	
Work-out 2nd phase (Wednesday)	Internal rotation scaption	10 reps × 3 sets	1d-12 wk
	ER scaption	10 reps × 3 sets	
	Military press	12 reps × 3 sets	
	Internal horizontal abduction	10 reps × 3 sets	
	External horizontal abduction	10 reps × 3 sets	
	Triceps extension	15 reps × 3 sets	
	Biceps curl	15 reps × 3 sets	
	Shoulder rowing	15 reps × 3 sets	
Work-out 3rd phase (Friday)	Horizontal abduction	10 reps × 3 sets	1d-12 wk
	Straight arm press	15 reps × 3 sets	
	Internal rotation	15 reps × 3 sets	
	ER	15 reps × 3 sets	
	Press-ups	12 reps × 3 sets	
Cool-down	Stretching on met	20 min	1d-12 wk
	Icing	10 min	
	Electrotherapy	10 min	
	Air compressor	15 min	

dietary habits during the conduct of study. The rehabilitation program was classified as warm-up, work-out (1st-3rd phase) and cool-down. The warm-up for the rehabilitation program consisted of two therapeutic modalities. First, subjects began physical therapy with ultrasonic wave (5 min) and laser therapy (10 min). Then they performed an exercise session with warm-up including stationary cycling (15 min) and standing stretching for 5 min. Stationary cycling was performed at 60% VO_2max.

The work-out was performed on Monday, Wednesday and Friday depending on the program schedule and was followed by the 1st work-out phase (from 1 day to 12 weeks). It involved prone horizontal abduction at 90°-100° with external rotation, prone extension with external rotation, prone horizontal abduction at 90° elbow flexion with external rotation, forward flexion, abduction, and shrug on floor at an intensity of less than 13 (somewhat difficult) on the rating of perceived exertion (RPE) scale. This stage focused on the pain reduction, the tolerance of weight bearing and the ROM improvement. Following this, all subjects performed the 2nd work-out phase, which included internal rotation scaption, external rotation scaption, military press, internal horizontal abduction, external horizontal abduction, triceps extension, biceps curl and shoulder rowing. Finally the 3rd phase included horizontal abduction, straight arm press, internal rotation, external rotation and press-ups. Both phases focused on the tolerance of full weight bearing, on the passive ROM improvement and on the neuromuscular control. The cool-down after the rehabilitation program consisted of two therapeutic modalities. First, all subjects performed the static and dynamic stretching on mattress for about 20 min. Then they were managed by icing (10 min), electrotherapy (10 min) and air compression (15 min). The rehabilitation exercises and their repetitions and sets used in this study were extracted from the contents of several former studies and applied as the means to manage the shoulder condition and to prevent re-injuries (Griffith, 1997).

Statistical analyses

Data were analyzed using the SPSS program (version 18.0; SPSS Inc, Chicago, IL, USA). Values reported are means ± standard deviation. The descriptive statistics were calculated for all dependent variables prior to the comparison of measurements including NPRS, body composition, and isokinetic torque variables in 60°/sec and in 180°/sec. The data were analyzed using non-parametric

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tests, because the data for this study were not normally distributed. Details of statistical methods were as follows; Firstly, the delta values were analyzed to control the effects of pre-time on post-time score using the formula: (variables at post-time–variables at pre-time)/ variables at pre-time×100. Secondly, the Mann-Whitney U test was performed to examine the difference between both groups using the delta value. Lastly, the significance level for all analyses was set a priori at $P \leq 0.05$.

RESULTS

Changes of body composition

The data derived from 2 groups were analyzed regarding differences in pre- and post-exercise after 12 weeks (Table 3). Baseline characteristics of the subjects with full data at baseline and follow-up examinations are summarized in Table 1. No differences were observed in baseline characteristics among groups, indicating homogeneity in anthropometric characteristics.

Table 3 displays the changes observed in the body weight of the 2 groups. The body weight values of the delta percent were significantly (Z=-2.910; $P=0.003$) different between 2 groups. Especially, the body weights were decreased in the EG. Similarly to the changes of body weight, the fat mass were significantly (Z=-2.411; $P=0.015$) decreased in the EG after 12 weeks. However, the muscle mass of the EG was significantly (Z=-3.533; $P=0.000$) increased after the experiment.

Changes of numeric pain rating scale

To ascertain the effects of the rehabilitation program on pain degree, the values were gained using NPRS, which involved points felt at resting, normal daily activity and strenuous activity. The data from 2 groups were analyzed for differences in pre- and post-exercise after 12 weeks (Table 4).

Table 4 displays the changes observed in the pain degree of the 2 groups. At pre-status, there was no significant difference in three group values. However, there significant differences were shown in three group values after 12 weeks. The values of the delta percent in resting status were significantly different between both groups. In other words, the pain degree in the resting status was significantly (Z=-4.122; $P=0.000$) decreased in the EG. Similar to the changes of pain degree in the resting status, the pain values of normal daily activity (Z=-4.545; $P=0.000$) and strenuous activity (Z=-4.122; $P=0.000$) status were significantly decreased in the EG after 12 weeks.

Changes of shoulder internal/external rotators at 60°/sec

Table 5 displays the changes observed in the PT of internal/external rotators of the 2 groups.

At pre-status, no significant difference was shown in the uninvolved and involved sides of the groups. However, there were significant differences in internal/external PT of the uninvolved and involved sides of the groups after 12 weeks. The delta percent values in internal PT of uninvolved and involved sides of CG were significantly decreased, however, the delta percent values in internal PT of the uninvolved (Z=-2.620; $P=0.008$) and involved (Z=-2.224; $P=0.025$) sides of EG were significantly increased after 12 weeks. Such results showed a deficit ratio of both shoulder sides of EG close to normal values (±10%). The ratios of internal/external PT of EG were also close to reference values (±60%) after 12 weeks. The results of external rotator were similar to the results in the internal rotators in both sides after 12 weeks.

Changes of internal/external rotators at 180°/sec

Table 6 displays the changes observed in the TW of internal/

Table 3. Changes of body composition between 2 groups after 12 weeks

Items	Groups*	Pre	Post	Δ%
Body weight (kg)	CG	67.79±5.90	69.34±5.29	2.41±2.54
	EG	68.50±8.18	68.21±7.87	-0.38±1.92
	Z (*P*)**	-.229 (.822)	-.229 (.822)	-2.910 (.003)
Muscle mass (kg)	CG	32.07±2.86	31.72±2.70	-0.99±3.73
	EG	31.64±4.55	33.81±4.20	7.41±8.54
	Z (*P*)**	-.312 (.759)	-1.414 (.166)	-3.533 (.000)
Fat mass (kg)	CG	13.95±4.97	14.60±4.97	5.57±9.41
	EG	13.48±4.26	12.53±3.23	-4.70±11.26
	Z (*P*)**	-.187 (.854)	-1.123 (.275)	-2.411 (.015)

All values are expressed as mean±standard deviation.
*CG and EG represent control group and experimental group, respectively; **Results from non-parametric Mann-Whitney U test.

Table 4. Changes of pain degrees between 2 groups after 12 weeks

Items	Groups*	Pre	Post	Δ%
Resting	CG	5.64±1.22	5.36±1.01	-2.13±21.38
	EG	6.06±1.44	2.13±1.09	-61.32±26.60
	Z (*P*)**	-0.640 (.552)	-4.586 (.000)	-4.122 (.000)
Normal daily activity	CG	6.50±0.76	6.64±1.01	3.20±17.98
	EG	7.13±1.15	3.44±1.03	-49.86±18.91
	Z (*P*)**	-1.821 (.085)	-4.632 (.000)	-4.545 (.000)
Activity strenuous activity	CG	7.71±0.83	8.00±0.88	4.32±12.27
	EG	7.88±1.02	3.56±1.31	-53.00±20.61
	Z (*P*)**	-0.616 (.580)	-4.694 (.000)	-4.672 (.000)

All values are expressed as mean±standard deviation.
*CG and EG represent control group and experimental group, respectively; **Results from non-parametric Mann-Whitney U test.

Table 5. Changes of peak torque (PT) in shoulder internal and external rotators at 60°/sec

Items	Groups	Uninvolved			Involved			Deficit ratio		
		Pre	Post	Δ%	Pre	Post	Δ%	Pre	Post	Δ%
Internal PT (Nm)	CG	48.29±8.53	47.21±8.82	-0.95±16.51	43.43±7.56	42.64±8.97	-1.09±16.97	15.07±8.97	15.93±12.90	29.39±61.40
	EG	54.06±1.54	62.13±13.13	15.87±16.00	47.63±12.04	53.69±12.47	13.75±14.86	16.63±8.48	10.06±6.04	-37.61±32.40
	Z (*P*)**	-1.397 (0.166)	-3.163 (0.001)	-2.620 (0.008)	-0.917 (0.377)	-2.417 (0.015)	-2.224 (0.025)	-0.021 (0.984)	-2.461 (0.013)	-3.535 (0.000)
External PT (Nm)	CG	31.29±7.28	29.29±5.04	-1.78±26.95	28.50±8.00	26.79±8.29	-3.77±23.24	19.79±5.47	21.14±5.93	8.63±20.56
	EG	28.31±5.76	34.63±7.81	22.78±16.26	24.75±5.93	31.81±8.37	28.76±17.92	21.50±9.58	14.31±6.65	-25.17±37.15
	Z (*P*)**	-1.084 (0.294)	-2.024 (0.043)	-2.682 (0.006)	-1.356 (0.179)	-1.833 (0.070)	-3.410 (0.000)	-.292 (0.790)	-2.727 (0.005)	-2.370 (0.017)
Internal/External PT ratio (%)	CG	66.79±6.05	50.79±7.47	-33.98±22.56	67.07±11.57	51.14±7.63	-33.02±25.00			
	EG	61.56±10.63	62.31±9.78	0.30±16.79	66.06±13.38	62.31±15.79	-8.50±20.25			
	Z (*P*)**	-1.229 (0.224)	-2.977 (0.002)	-3.741 (0.000)	-.333 (0.759)	-2.082 (0.038)	-2.453 (0.013)			

All values are expressed as mean±standard deviation.
*CG and EG represent control group and experimental group, respectively; **Results from non-parametric Mann-Whitney U test.

Table 6. Changes of total work (TW) in shoulder internal and external rotators at 180°/sec

Items	Groups	Uninvolved			Involved			Deficit ratio		
		Pre	Post	Δ%	Pre	Post	Δ%	Pre	Post	Δ%
Internal TW (J)	CG	619.79±182.12	537.64±144.42	-10.98±19.46	541.14±87.85	528.21±136.98	-2.93±16.16	16.86±7.29	18.21±8.13	14.37±52.27
	EG	665.63±182.04	763.38±215.23	15.90±18.89	605.56±157.86	684.13±174.50	14.51±18.66	17.06±6.86	10.56±6.10	-33.86±38.23
	Z (*P*)**	-0.748 (0.473)	-2.912 (0.003)	-3.326 (0.001)	-1.019 (0.313)	-2.266 (0.022)	-2.432 (0.013)	-0.188 (0.854)	-2.456 (0.013)	-2.474 (0.012)
External TW (J)	CG	357.07±113.47	304.64±125.93	-14.23±28.02	315.71±115.38	291.00±115.00	-5.41±20.47	17.36±11.59	18.21±11.36	10.52±39.36
	EG	328.06±88.57	382.06±117.75	17.64±22.40	267.00±104.10	342.56±149.47	29.26±36.20	25.25±10.93	12.69±5.13	-37.92±41.40
	Z (*P*)**	-0.582 (0.580)	-1.622 (0.110)	-3.159 (0.001)	-1.434 (0.154)	-1.227 (0.224)	-3.118 (0.001)	-1.811 (0.070)	-2.625 (0.008)	-3.160 (0.001)
Internal/External TW ratio (%)	CG	51.07±6.53	46.00±8.61	-9.21±16.97	41.43±9.48	53.21±9.69	32.02±26.88			
	EG	55.88±14.49	55.25±9.76	2.14±21.52	50.50±12.80	52.38±10.35	6.44±19.08			
	Z (*P*)**	-0.583 (0.580)	-2.477 (0.012)	-1.268 (0.208)	-1.873 (0.064)	-.708 (0.498)	-2.411 (0.015)			

All values are expressed as mean±standard deviation.
*CG and EG represent control group and experimental group, respectively; **Results from non-parametric Mann-Whitney U test.

Table 7. Changes of fatigue index (FI) in shoulder internal and external rotators at 180°/sec

Items	Groups	Uninvolved			Involved		
		Pre	Post	Δ%	Pre	Post	Δ%
Internal FI	CG	17.43±12.01	20.29±12.11	30.89±39.41	12.14±9.32	16.29±9.68	46.80±78.01
	EG	11.44±18.58	6.63±10.92	-43.34±23.84	14.25±17.86	6.81±8.28	-45.31±38.03
	Z (*P*)**	-0.999 (0.334)	-3.329 (0.001)	-3.972 (0.000)	-0.770 (0.448)	-2.727 (0.005)	-3.639 (0.000)
External FI	CG	16.14±9.35	12.07±11.95	-11.26±111.34	11.93±9.80	15.57±10.20	30.93±45.55
	EG	18.00±12.13	12.25±7.03	-37.32±42.61	20.19±9.71	11.50±7.52	-43.36±32.92
	Z (*P*)**	-0.708 (0.498)	-.208 (0.854)	-0.707 (0.498)	-2.601 (0.008)	-1.483 (0.142)	-3.659 (0.000)

All values are expressed as mean±standard deviation.
*CG and EG represent control group and experimental group, respectively; **Results from non-parametric Mann-Whitney U test.

external rotators of the 2 groups.

At pre-status, there were no significant differences in the uninvolved and involved sides of both groups. However, there were significant differences in the internal/external TW of the uninvolved and involved sides of both groups after 12 weeks. The delta percent values in internal TW of uninvolved and involved sides of CG were significantly decreased, however, the delta percent values in internal TW of uninvolved (Z=-3.326; $P=0.001$) and involved (Z=-2.432; $P=0.013$) sides of EG were significantly increased after 12 weeks. Such results showed a deficit ratio of both shoulder sides of EG close to the normal value (±10%). Although the ratios of internal/external TW of CG were not close to reference values (±60%), those of EG were close to those values after 12 weeks. The results of external rotator were similar to the results of the internal rotator in both sides after 12 weeks. Meanwhile, Table 7 displays the changes observed in the fatigue degrees of in-

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ternal/external rotators in both groups.

At pre-status, there were no significant differences in the uninvolved and involved sides of both groups. However, there were significant differences in the internal/external fatigue index of uninvolved and involved sides of both groups after 12 weeks. The delta percent values in the fatigue index of internal rotator of the uninvolved and involved sides of CG were significantly increased, however, the delta percent values in the fatigue index of internal rotator of the uninvolved ($Z = -3.972$; $P = 0.000$) and involved ($Z = -3.639$; $P = 0.000$) sides of EG were significantly decreased after 12 weeks. The results of external rotator were similar to the results of the internal rotator in both shoulder sides after 12 weeks.

DISCUSSION

The principal findings of this study represented the 12-weeks rehabilitation program improved the body composition, reduced shoulder pain and enhanced the isokinetic shoulder internal/external rotators in the EG group with shoulder impingement symptoms compared to the CG group. And it was also found that a 12-weeks rehabilitation program balanced between internal rotator and external rotator and eventually lowered the fatigue level of the involved and uninvolved shoulder sides after the experiment.

Prior to the entry in the rehabilitation program, the subjects of the EG were transferred to the physical therapy for the reduction of shoulder pain. In this study, the work-out performed in the present study depended on the program schedule for the baseball pitchers after this procedure. This was followed by the 1st work-out phase, which included prone horizontal abduction at 90°-100° with external rotation, prone extension with external rotation, prone horizontal abduction at 90°/elbow flexion with external rotation, forward flexion, abduction, and shoulder shrug on floor at an intensity of less than 13 (somewhat difficult) on the rating of perceived exertion scale. This stage focused on the reduction of pain, the tolerance of weight bearing and the improvement of motion range. The pain degrees of EG were decreased in three conditions of NPRS due to the rehabilitation program. In other words, there were no significant differences between three pain conditions in the both groups at pre-status, while there were significant decreases in three pain conditions in the EG after 12 weeks. Especially, almost all of the baseball pitchers in EG reported that the pain values of normal daily activity and strenuous activity conditions were gradually decreased during the course of time. As results of the present study, the NPRS of EG were significantly decreased $-61.32 \pm 26.60\%$ in resting condition, $-49.86 \pm 18.91\%$ in normal daily activity, and $-53.00 \pm 20.61\%$ in strenuous activity after the experiment.

Actually, a lot of baseball pitchers played not only a few games in a season and throw many pitches in a game at a high velocity (Pappas et al., 1985). Thus, the glenohumeral stabilization is inadequate and an injury or a disability may be the consequence (Janda et al., 1988). These disabilities include neurological entrapments, compression syndromes, acromioclavicular joint degeneration, impingement due to instabilities, superior labrum anterior to posterior lesions, subdeltoid bursitis, biceps tendinitis, subluxing bicipital tendon, under surface tears of the rotator cuff, full thickness tears of the rotator cuff, lesions of the humeral head, fracture of the humerus, fracture of the coracoid, posterior capsular syndrome, and muscle imbalances (Andrews and Carson, 1985; Black and Lombardo, 1990; Branch and Partin, 1992; Gainor and Piotrowski, 1980; Garth et al., 1987; Jobe and Kvitne, 1989; Ringel et al., 1990; Schachter et al., 1992; Simon and Hill, 1989). Namely, the patients with these abnormal conditions felt a pain in their shoulder joint or shoulder around muscles. However, such an injured or disabled shoulder may be treated or recovered as before the healthy status (Dale et al., 2007; Park et al., 2013) as like the results of the present study.

In regards of usefulness and reliability of NPRS, Michener et al. (2011) reported that at initial stage, the patients with shoulder pain ($n = 136$) completed the Penn Shoulder Score, which included pain, satisfaction and function sections. The pain was measured using an 11-point NPRS for 3 conditions of pain: at rest, with normal daily activities and with strenuous activities such like in this present study. The average score of NPRS was calculated by averaging the scores of that scale for 3 conditions of pain. The final Penn Shoulder Score was completed after 3-4 weeks of rehabilitation (Michener et al., 2011). The score was 2.17 points decreased in the minimal clinically important difference, which this changes of slightly more than 2 points. This means around 20% of the full scale and was the smallest difference value associated with a clinically meaningful change (Dvir, 2013). van Meeteren et al. (2006) also conducted a study to determine the responsiveness to the change of isokinetic dynamometry of the shoulder and to compare this responsiveness with outcome measures of pain and activity level. The subjects were 10 patients with a unilateral capsulitis of the shoulder. In this study the involved/uninvolved ratios of the maximal PT of abduction, adduction, external and internal rotation, active ROM of abduction and external rotation were calculated. In addition, the pain was scored using the NPRS and the activity level was scored using the Shoulder Disability Questionnaire. According to their study results, there was a significant correlation between the change scores of numeric rating scale and Shoulder Disability Questionnaire. No significant correlations were found between the change scores of the numeric rating scale and Shoulder Disability Questionnaire on the one hand and the involved / uninvolved ratios of PT and active ROM on the other hand. Concretely, they suggested that a variety of parameters of isokinetic dynamometry might provide additional information as compared with the usual outcome measures of pain and functional level.

Recently, several clinicians and investigators are becoming an increasing interest in isokinetic exercise and assessment of the upper extremity as shown in the previous documentation. In fact, the shoulder joint consists of the articulation of the humerus head and the glenoid cavity of the scapula. The glenohumeral joint is a complex multiaxial articulation which is capable of movement through each of the cardinal planes and through a variety of diagonal and horizontal patterns. The Joint stability is primarily provided by capsular and muscular soft tissue structures rather than by the configuration of this rather shallow ball-and-socket articulation (Perrin, 1993). The shoulder joint provides a variety of movements which are centered to the glenoid fossa. Through a lot of motions, the internal rotator and external rotator of the shoulder may influence the relative contribution from the involved musculature. Especially, the shoulder musculature during the act of pitching or throwing indicates significant activity of the pectoralis major and latissimus dorsi muscles during the acceleration phase. In contrast, the subscapularis muscle remains relatively silent during this phase of throwing (Jobe et al., 1983; 1984). In here, internal rotation is produced by the subscapularis, teres major, pectoralis major, latissimus dorsi and anterior deltoid muscles, with the relative contribution from these muscles related to variations in their respective length-tension relationships as the glenohumeral joint moves from the neutral to a 90° abducted position. External rotation is produced by the infraspinatus, teres minor and the posterior deltoid muscles.

To develop the internal and external rotators as well as other rotational functions, this study provided the subjects of EG with the 2nd work-out phase, which included internal rotation scaption, external rotation scaption, military press, internal horizontal abduction, external horizontal abduction, triceps extension, biceps curl and shoulder rowing. Thereafter the study provided the EG also with the 3rd work-out phase which included horizontal abduction, straight arm press, internal rotation, external rotation and press-ups. As shown in the results above and if compared to the pre-status, the 2nd and 3rd work-out from the rehabilitation program for EG significantly decreased the fat mass -4.70±11.26% along with and decreasing pain sensation of the involved shoulder site, while the muscle mass significantly increased 7.41±8.54% after 12 weeks. By improving the body composition almost all of isokinetic PT and TW were increased in EG. In detail, at pre-status, there was no significant difference in the uninvolved and involved sides of the groups. The delta percent values in internal PT of uninvolved and involved sides of CG were significantly decreased, however, the delta percent values in internal PT of uninvolved (15.87±16.00%) and involved (13.75±14.86%) sides of EG were significantly increased after 12 weeks. Such results provide a deficit ratio of both shoulder sides of EG close to normal values (±10%). The ratios of internal/external PT of EG were also close to reference values (±60%) after 12 weeks. The results of the external rotator were similar to the results of the internal rotator in both sides after 12 weeks. In regards to this result, Ivey et al. (1985) conducted a study to find a ratio between internal and external rotators. They tested the isokinetic muscles in the shoulders of 31 normal volunteers and found no statistical differences between dominant and non-dominant shoulders, even though there was a consistent pattern of greater strength in the dominant shoulder. In this study the internal rotation strength was greater than the external rotation by the ratio of 3:2 for both the fast and slow torque arm speed.

In general, the external rotator muscles produce approximately 60% to 80% of the torque values generated by the internal rotator muscles, and a comparison of the bilateral strength values of these muscle groups indicates a dominant/non-dominant relationship usually within 10% (Perrin, 1993). However, Perrin (1993) suggested that most of clinicians should consider the neuromuscular demands of a variety of athletic activities and their potential effect on the reciprocal and bilateral muscle group relationships of the shoulder rotator musculature. Anyway, by enhancing PT and TW during the rehabilitation program in this study, the fatigue index of internal rotator of uninvolved (-43.34±23.84%) and involved (-45.31±38.03%) sides of EG were significantly decreased after 12 weeks. The results of external rotator (-37.32±42.61% in uninvolved; -43.36±32.92% in involved) were similar to the results of the internal rotator in both shoulder sides after 12 weeks.

In conclusion, it was found that the rehabilitation program balanced between internal and external rotators and lowered the fatigue level after the study. Detail results are as follows; Firstly, the body weight and fat mass of body composition were increased in CG. However, those of EG were decreased after 12 weeks. The

 http://dx.doi.org/10.12965/jer.140087

muscle mass of CG was significantly decreased, whereas that of EG was increased after the study. Secondly, the pain degree in the resting status of NPRS was significantly decreased in the EG compared to CG. Similar to the changes of pain degree in the status of rest, the pain values of normal daily activity and strenuous activity status were significantly decreased in EG after 12 weeks. Thirdly, the internal and external PT of uninvolved and involved sides of CG were significantly decreased, however, those of both sides of EG were significantly increased after 12 weeks. Such results show a deficit ratio of both sides of EG close to normal values. The ratios of internal/external PT of EG were also close to reference values after 12 weeks. Lastly, the internal and external TW of uninvolved and involved sides of CG were significantly decreased, however, those of both sides of EG were significantly increased after 12 weeks. Such results show a deficit ratio of both sides of EG close to normal values. Although the ratios of internal/external TW of CG were not close to reference values, those of EG were close to that values after 12 weeks. Meanwhile, the fatigue indices of internal and external rotators of uninvolved and involved sides of CG were higher than in the pre-status, however, those of internal and external rotators of both sides of EG were significantly lower than in the pre-status after 12 weeks.

CONFLICT OF INTEREST

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

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REFERENCES

Andrews, JR, Carson WG. Glenoid labrum tears related to the long head of the biceps. Am J Sports Med 1985;13:337-341.

Black KP, Lombardo JA. Suprascapular nerve injuries with isolated paralysis of the infraspinatus. Am J Sports Med 1990;18:225-228.

Branch T, Partin C. Spontaneous fractures of the humerus during pitching: a series of 12 cases. Am J Sports Med 1992;20:468.

Dale RB, Kovaleski JE, Ogletree T, Heitman RJ, Norrell PM. The effects of repetitive overhead throwing on shoulder rotator isokinetic work-fatigue. N Am J Sports Phys Ther 2007;2:74-80.

Dillman CJ, Fleisig GS, Andrews JR. Biomechanics of pitching with emphasis upon shoulder kinematics. J Orthop Sports Phys Ther 1993;18:402-408.

Escamilla RF, Fleisig GS, Zheng N, Barrentine SW, Andrews JR. Kinematic comparisons of 1996 Olympic baseball pitchers. J Sports Sci 2001;19:665-676.

Ferrara MS, Palutsis GR, Snouse S, Davis RW. A Longitudinal study of injuries to athletes with disabilities. Int J Sports Med 2000;21:221-224.

Fleisig GS, Andrews JR, Dillman CJ, Escamilla RF. Kinetics of baseball pitching with implications about injury mechanisms. Am J Sports Med 1995;23:233-239.

Fongemie AE, Buss DD, Rolnick SJ. Management of shoulder impingement syndrome and rotator cuff tears. Am Fam Physician 1998;57:667-682.

Gainor BJ, Piotrowski G. The throw: biomechanics and acute injury. Am J Sports Med 1980;8:114.

Garth WP, Allman FL, Armstrong WS. Occult anterior subluxations of the shoulder in noncontact sports. Am J Sports Med 1987;15:579.

Griffith HW. Complete guide to sports injury. New York: The Body Press/Perigee Books 1997;451-470.

Heyworth BE, Williams RJ 3rd. Internal impingement of the shoulder. Am J Sports Med 2009;37:1024-1037.

Hinton RY. Isokinetic evaluation of shoulder rotational strength in high school baseball pitchers. Am J Sports Med 1988;16:274-279.

Ivey FM Jr, Calhoun JH, Rusche K, Bierschenk J. Isokinetic testing of the shoulder strength: Normal values. Arch Phys Med Rehabil 1985;66:384-386.

Janda DH, Wojtys EM, Hankin FM, Benedict MA. Softball sliding injuries: a prospective study comparing standard and modified bases. JAMA 1988;259:1848-1850.

Jobe FW, Kvitne RS, Giangarra CE. Shoulder pain in the overhand or throwing athlete. Orthop Rev 1989;18:963-975.

Jobe FW, Moynes DR, Tibone JE, Perry J. An EMG analysis of the shoulder in pitching-A second report. Am J Sports Med 1984;12:218-220.

Jobe FW, Tibone JE, Perry J, Moynes D. An EMG analysis of the shoulder in throwing and pitching: A preliminary report. Am J Sports Med 1983;11:3-5.

Lee HM, Liau JJ, Cheng CK, Tan CM, Shih JT. Evaluation of shoulder proprioception following muscle fatigue. Clin Biomech 2003;18:843-847.

Michener LA, Snyder AR, Leggin BG. Responsiveness of the numeric pain rating scale in patients with shoulder pain and the effect of surgical status. J Sport Rehabil 2011;20:115-128.

Murray TA, Cook TD, Werner SL, Schlegel TF, Hawkins RJ. The effects of extended play on professional baseball pitchers. Am J Sports Med 2001;29:137-142.

Park JS, Oh HW, Park EK, Ko IG, Kim SE, Kim JD, Jin JJ, Jee YS. Effects of rehabilitation program on functional scores and isokinetic torques of knee medial plica-operated patients. Isokinet Exerc Sci 2013;21:19-28.

Pappas AM, Zawack RM, Sullivan TJ. Biomechanics of baseball pitching: a preliminary report. Am J Sports Med 1985;13:216-22.

Perrin DH. Isokinetic exercise and assessment. Human Kinetics Publishers. 1993;75-114.

Pil-Byung C, Shin-Hwan Y, Il-Gyu K, Gwang-Suk H, Jae-Hyun Y, Han-Joon L, Sung-Eun K, Yong-Seok J. Effects of exercise program on appetite-regulating hormones, inflammatory mediators, lipid profiles, and body composition in healthy men. J Sports Med Phys Fitness 2011; 51:654-663.

Ringel SP, Treihaft M, Carry M, Fischer R, Jacobs P. Suprascapular neuropathy in pitchers. Am J Sports Med 1990;18:80-86.

Schachter CL, Canham PB, Mottola MF. Biomechanical Factors Affecting Dave Dravecky's Return to Competitive Pitching: A Case Study: a case study. J Orthop Sports Phys Ther 1992;16:2-5.

Simon ER, Hill JA. Rotator cuff injuries: an up-data. J Orthop Sports Phys Ther 1989;10:394-398.

van Meeteren J, Roebroeck ME, Selles RW, Stam HJ. Responsiveness of isokinetic dynamometry parameters, pain and activity level scores to evaluate changes in patients with capsulitis of the shoulder. Clin Rehabil 2006;20:496-501.

Warner JJ, Micheli LJ, Arslanian LE, Kennedy J, Kennedy R. Patterns of flexibility, laxity, and strength in normal shoulders and shoulders with instability and impingement. Am J Sports Med 1990;18:366-375.

Zanca GG, Oliveira AB, Saccol MF, Ejnisman B, Mattiello-Rosa SM. Functional torque ratios and torque curve analysis of shoulder rotations in overhead athletes with and without impingement symptoms. J Sports Sci 2011;29:1603-1611.

Zanca GG, Saccol MF, Oliveira AB, Mattiello SM. Shoulder internal and external rotations torque steadiness in overhead athletes with and without impingement symptoms. J Sci Med Sport 2013;16:433-437.

 http://dx.doi.org/10.12965/jer.140087