

## Standard Rehabilitation vs. Standard Plus Closed Kinetic Chain Rehabilitation for Patients with Shoulder Impingement: A Rehabilitation Outcomes Study

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### ABSTRACT

There currently is a lack of efficacy to support the use of closed kinetic chain (CKC) exercise in rehabilitation of the upper extremity. The purpose of this study was to examine rehabilitation outcomes of patients with a diagnosis of shoulder impingement that received a standard rehabilitation protocol or a standard plus CKC rehabilitation protocol. Thirteen males and 1 female referred to the Gundersen Sports Medicine Clinic with shoulder impingement were randomly assigned to either a standard rehabilitation group ( $n = 7$ ) or standard plus CKC rehabilitation group ( $n = 7$ ). The CKC exercise involves tilting a balance board in a quadruped or push-up position. The balance board is tilted for 30 seconds each in an anterior-posterior, lateral, and clockwise-counterclockwise direction. The set is repeated three times with 30 seconds of rest between each set. Pre/post-testing measurements included: 1) isokinetic power of shoulder internal/external rotators at  $60^\circ/\text{sec}$ ,  $180^\circ/\text{sec}$ , and  $300^\circ/\text{sec}$ , 2) the American Academy of Orthopaedic Surgeons - Arm, Shoulder, and Hand Outcomes Module survey and, 3) a pain medication use question. Dependent variables were analyzed using a  $2 \times 2$  ANOVA with repeated measure. Following  $6.6 \pm 2.3$  weeks of treatment, patients were significantly stronger ( $p \leq .05$ ) on four measures and strength improvements almost reached significance ( $p < .07$ ) on two additional measures. Patients' abilities to perform activities of daily living improved but not significantly ( $p < .08$ ). Pain medication use was reduced from an average of 1-2 times per day to a few times per week. There were no significant differences between the standard and standard plus CKC groups for any of these variables. In conclusion, following 6 weeks of PT treatment, patients with shoulder impingement are stronger, less limited in their activities of daily living, and appear to require less medication. Addition of CKC exercise to PT treatments does not appear to affect patient outcomes.

Key Words: functional outcomes, pain medication

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## INTRODUCTION

Closed kinetic chain (CKC) rehabilitation of the upper extremities (UEs) has become increasingly popular in clinics, due in part to its benefits in rehabilitation of the lower extremities (LEs) (5,6,10,12,16,21,22). Lower extremity CKC exercise has been recommended over open kinetic chain (OKC) exercise for numerous reasons, many of which can be applied to rehabilitation of the UEs. CKC exercise involves a system of joints similar to links of a chain where both ends of the chain are fixed and motion at one joint produces motion at all the other joints in the chain. Bunton et al. claim LE CKC training enhances the coordination of proprioceptive feedback mechanisms necessary for normal function (5). Numerous studies (10,12,16,22) have shown CKC exercise to have greatly reduced shear forces and increased muscular co-contraction as opposed to OKC exercise. In an analysis of the biomechanical events taking place in the LE kinetic chain, Rivera et al. suggest that CKC exercise facilitates the strengthening and integration of muscle groups and normal proprioceptive mechanisms needed for proper function. They maintain that peak performance is a result of the cooperation between all joints and muscles included in an activity and that this cannot be measured by a specific OKC exercise. They state that weight-bearing activities stimulate motor learning and neuromuscular control mechanisms (21).

It has been suggested that this type of exercise should be included in the rehabilitation program for shoulder joint pathologies for a number of reasons. First, the co-contraction of agonist and antagonist muscle groups (7,26) which occurs in a CKC position enhances the dynamic joint stability of the shoulder complex. Secondly, CKC exercise is usually safer for the patient, more functional, and more aggressive than OKC exercise. Finally, there are a number of sports in which athletes use the closed kinetic chain position either continuously or intermittently. These sports include cross country skiing, wrestling, gymnastics, swimming, and kayaking (23). Athletes in these sports could potentially benefit from rehabilitation exercises that resemble the activities they perform in their specific sport.

While it appears that CKC training would be of benefit to athletes who engage in sports requiring activity in the CKC position, there are numerous reasons why this exercise is appropriate for other individuals as well. Although the weight bearing function is not common in the UEs, the structure of the glenohumeral (GH) joint requires stabilization and muscular co-contraction of surrounding structures during functional activity (26). In contrast to OKC exercise, CKC rehabilitation of the LEs has been shown to increase proprioception, decrease tibio-femoral shear forces, induce co-contraction of stabilizing musculature, and allow for optimal performance (5,6,10,12,16,21). During functional activities the shoulder also requires proprioceptive input and muscular coordination for stability. Upper extremity CKC exercise can be used to facilitate and enhance dynamic joint stability beginning early in rehabilitation programs because of decreased shear forces at the GH joint (7,27).

A few authors have examined the concept of UE CKC exercise. Stone et al. (23) outlined the use of CKC exercises in the shoulder rehabilitation of athletes who bear weight on their UEs or move their body over a stationary hand. Their treatment protocol included first addressing range of motion limitations. Once normal motion had been achieved, endurance exercises were started with dumb bells, sandbag weights, or lightweight surgical tubing as indicated. Later free weights were incorporated into the program, progress-

ing toward CKC exercises such as cariocas, slideboard, the Fitter®, the Stairmaster®, the Shuttle®, step-ups on the hands, and air circles (23).

Dillman et al. examined the differences in electromyographic (EMG) activity during exercises, which incorporated a fixed external and movable external load. They found similar EMG activity when comparable loads were used (11). Their study suggests that it is inappropriate to assume OKC and CKC exercises are completely separate entities. They feel that similar muscular activation can occur during exercises with a fixed external or movable external load if they incorporate similar biomechanics (11).

Wilk and Arrigo (26) suggested the early implementation of UE CKC exercise for rehabilitation of the unstable shoulder to promote muscular co-contraction and recruitment, and prevent rotator cuff shut down caused by pain and inflammation. They emphasized the importance of considering the biomechanical stresses of an activity when designing an UE weight bearing rehabilitation program that is specific to an individual patient's needs. Wilk et al. (27) have recommended that the absolute goal in shoulder rehabilitation is functional stability. They state that stability is a result of the combined contraction between dynamic and static stabilizers of the shoulder and claim this is promoted during CKC exercise because of joint approximation forces in the weight bearing position (27).

Although integration of CKC rehabilitation programs into UE rehabilitation programs has been recommended, there is little research to support its efficacy. Thus, the purpose of this study was to examine rehabilitation outcomes of patients with shoulder impingement who received either a standard rehabilitation protocol or a standard plus CKC exercise protocol.

## **EXPERIMENTAL DESIGN AND METHODS**

### **Subject Selection**

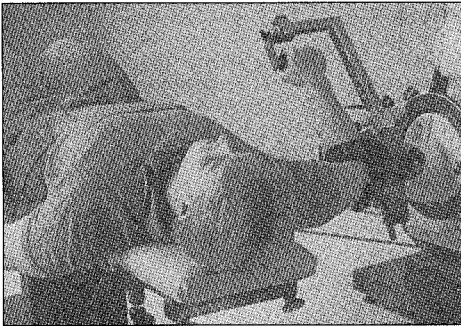
All male and female patients referred to Gundersen Sports Medicine Clinic, Onalaska, during the preceding year (January 1, 1997 to January 1998) with a diagnosis of shoulder impingement were asked to participate in this study. Exclusion criteria included: 1) patients from distant sites who were referred for evaluation but would be treated at hospitals in their hometown area, 2) patients with a shoulder impingement diagnosis possessing a type three acromion who could not tolerate isokinetic testing, 3) patients who could not read and would have been unable to complete the surveys, 4) patients with secondary shoulder diagnoses that would not allow them to complete the standard shoulder rehabilitation protocols, and 5) patients referred by a physician who indicated that the standard shoulder rehabilitation protocol was contraindicated. Patients who agreed to serve as subjects signed an informed consent form approved by both the UW-La Crosse and Gundersen Lutheran Medical Center Institutional Review Boards. Subjects were randomly assigned to receive either a standard rehabilitation protocol or a standard plus CKC exercise rehabilitation protocol.

### **Pre-rehabilitation Tests**

#### *Isokinetic Strength*

Testing was completed for patients using the Cybex 340 (Cybex, Ronkonkoma, NY). The Cybex 340 was set according to recommendations in the user's manual (pp 3-28,

3-29) for measurement of internal and external rotation with the patient supine and the shoulder positioned in 90° of abduction and 90° of elbow flexion. The internal and external rotators were selected as the muscle groups to be tested and trained due to their role as static stabilizers and as power generators during dynamic movements such as throwing (2,4,7,19). The testing was performed on both upper extremities. Measurements of concentric power were recorded between 80° of external rotation and 50° of internal rotation. The testing procedure began with four-gradient sub-maximal to maximal warm-up repetitions followed by five testing repetitions (9) at each of three speeds: 60°/sec, 180°/sec, and 300°/sec. These speeds sample muscle force through the velocity spectrum (8,14,20). Values of peak torque and peak torque normalized to body weight were obtained. Patients were encouraged to apply maximal effort and were reinforced with positive verbal feedback during the testing session (18).



*Figure 1.* Patient positioned on Cybex isokinetic dynamometer to test strength of shoulder internal and external rotators at three speeds.

#### *Functional Outcomes Measure*

Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire is an upper extremity specific orthopedic outcomes assessment tool developed by the Institute for Work and Health in Toronto (13,24). It has been adopted by the American Academy of Orthopaedic Surgeons as an outcome data collection instrument. The questionnaire is self-administered and contains 30 questions on a Lichert scale. The subject is asked to rate his/her difficulty, from 1-5, in completing activities of daily living. Examples of some of the questions asked include placing an object on an overhead shelf, washing or blow-drying hair and, carrying a shopping bag. It also addresses the psychological impact injury has on patients by asking if they feel less capable because of their shoulder pain.

#### *Use of Pain Medication*

Also included with the DASH questionnaire was an additional question related to use of pain medication. The question was worded as follows: "During the past week, how often have you taken pain medication, including narcotics and over-the-counter medications?" The patient had the option of choosing: 1) 3 or more times a day, 2) once or twice a day, 3) once every couple of days, 4) once a week or, 5) not at all.

#### **Rehabilitation Protocols**

Patients assigned to the standard rehabilitation group received the standard

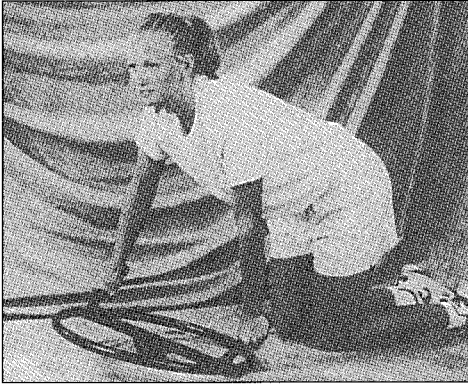
Gundersen Lutheran Sports Medicine protocol for the treatment of shoulder impingement. The standard shoulder rehabilitation is summarized in Table 1.

Patients assigned to the standard plus CKC rehabilitation group received the standard protocol in addition to a series of CKC exercises. The CKC exercises were performed in a quadruped position (hips and knees flexed to 90°) using a balance board, the Cuff Link (Integrated Functions, Elk Rapids, MI) (Figure 2). When tolerated, the patient was progressed to the push-up position with hip and knees in full extension. The patient assumed a position above the board with the arms in full extension at the elbow joint, and 90° flexion at the shoulder with the hands placed directly below the shoulders on opposite sides and in the middle of the Cuff Link. Subjects were encouraged to maintain a position of scapular protraction which promotes serratus anterior strengthening while maintaining shoulder flexion of 90° (7,16). This position of increased stability balances both compression and shear forces at the GH joint. It also allows for co-contraction of dynamic stabilizing structures, which enhances static stability and trains the proprioceptors to balance muscles of the shoulder during dynamic activity (7). Three CKC exercises were performed on a timed count: tilting the Cuff Link until it reached the ground in an anterior-posterior direction for 30 seconds, a lateral direction for 30 seconds, a clockwise direction for 15 seconds, and a counter-clockwise direction for 15 seconds. This sequence was completed three times with a 30-second rest period in between.

All subjects in both groups were treated by the same physical therapist, George Davies.

*Table 1.* Standard treatment protocol for Impingement Syndrome at Gundersen Lutheran Sports Medicine Clinic.

<b>ROM</b>	<b>Pain free</b>
Modalities	Ultra Sound, Phonophoresis, Iontophoresis, Microcurrent Electrical Neuro Stimulation, Spray and Stretch, Myofascial, Biofeedback, Electrical Stimulation, Cryotherapy
Passive Range Of Motion	Glenohumeral and Scapulo-thoracic joint mobs if indicated
Flexibility	Stretches for Pectoralis Minor and Major, Infraspinatus, and Teres Minor
Active Range Of Motion	Pain free, posture alignment, scapulo-thoracic setting and timing
Upper Body Ergometer Cycling	High seat, 90-120 RPM
Isometrics	Trunk, scapulo-thoracic, glenohumeral: internal and external rotation, flexion, extension, abduction, and scaption
Proprioceptive Nueromuscular Facilitation	Scapulo-thoracic and glenohumeral muscles
Progressive Resisted Exercises	Decline bench press, rower, biceps, triceps, external and internal rotation, lateral raise, scaption, shoulder horn, and trunk flexion and extension
Isokinetics	Scapulo-thoracic, modified neutral internal and external rotation, flexion, extension, abduction, adduction, scaption, diagonals D1 and D2, and prone external rotation
Cardiovascular Endurance	Fitron®, Concept Rower®, Versa Climber®
Functional	Sport specific, upper extremity plyometrics, Impulse®, Body Blade®, and Fitter®



*Figure 2.* Patient in modified push-up position using the Cuff Link to move in three directions for the Closed Kinetic Chain exercise.

### **Post-rehabilitation Tests**

The isokinetic tests described in the pre-rehabilitation procedure were repeated approximately six weeks later. The DASH and pain medication question were also repeated at that time.

### **Data Analysis**

Pre/post isokinetic measures and DASH scores were analyzed using a 2x2 ANOVA (group-by-time) with the second factor being considered a repeated measure. The SPSS for Windows packages was used for statistical analysis. An  $\alpha$  level of  $< .05$  was considered significant.

## **RESULTS**

The authors will continue to collect data for this study until the end of the 1998 calendar year. This final report summarizes the findings from patients seen during the time period of January 1, 1997 to March 1998. Fourteen subjects met the inclusion criteria and consented to participate in the study. One of the fourteen subjects missed more than 20% of his scheduled treatments and was dropped from the study. Two of the remaining thirteen subjects were unable to complete isokinetic pre-testing due to pain and four of the thirteen subjects were missing post-DASH questionnaires. Thus, data analysis included eleven subjects for isokinetic strength variables and nine subjects for the DASH and the pain medication question.

Descriptive characteristic of the 13 subjects completing the study are included in Table 2.

*Table 2.* Descriptive characteristics of 13 subjects with a diagnosis of shoulder impingement completing a standard or standard plus closed kinetic chain (CKC) rehabilitation program.

Variable	Standard Group	CKC Group	Total
N	7	6	13
Weight	249.0 ± 93.8	175.0 ± 27.8	184.4 ± 31.5
Age	38.9 ± 13.9	33.0 ± 12.0	36.4 ± 12.9
Weeks of Treatment	6.4 ± 2.3	6.2 ± 2.6	6.3 ± 2.3

The average age of subjects was 37 years with a range of 17-62 years. There were 13 males and 1 female. Subjects were treated for an average of 6.6 ± 2.3 weeks. There were no significant differences between groups for any of the variables listed.

The results of the isokinetic testing are listed in Table 3. The time effect (pre- to post-testing) was significant ( $p < .05$ ) for both the standard and CKC groups, suggesting that there was a strength increase for both shoulder internal rotation measured at 60°/sec and external rotation measured at 180°/sec and 300°/sec. The time effect did not quite reach significance ( $p < .07$ ) for both groups for the variables of internal rotation measured at 180°/sec and 300°/sec. The group-by-time interaction was not significant for any of the six strength variables tested, suggesting that groups did not change differently over time on these measures.

Results of the DASH questionnaire are summarized in Table 4 and visualized in figure 3. Although the scores for both groups decreased over time, suggesting an improvement in ability to perform activities of daily living, this difference did not quite reach significance ( $p < .08$ ).

The results of the pain medication question are listed in Table 5. The frequency at which patients were using pain medication decreased from two or more times per day pre-rehabilitation to once every couple of days post-rehabilitation. The number of patients taking no medication at all increased from one person pre-rehabilitation to three individuals post-rehabilitation.

*Table 3.* Results of isokinetic testing both pre- and post-rehabilitation for the standard and closed kinetic chain (CKC) groups.

Variable	Standard		CKC		Total	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
ER 60°/sec *	11.7 ± 1.9	14.1 ± 2.7	11.0 ± 3.4	15.0 ± 5.0	11.5 ± 2.4	15.0 ± 3.5
ER 180°/sec *	10.1 ± 2.1	12.9 ± 2.3	11.0 ± 2.9	14.3 ± 3.4	10.5 ± 2.3	13.0 ± 2.9
ER 300°/sec *	8.6 ± 2.0	10.6 ± 2.1	9.7 ± 3.8	13.3 ± 5.1	9.0 ± 2.6	11.5 ± 3.0
IR 60°/sec *	18.1 ± 4.5	21.0 ± 4.4	18.3 ± 5.1	20.5 ± 6.1	18.2 ± 4.4	20.8 ± 4.8
IR 180°/sec	15.4 ± 4.1	17.4 ± 2.8	15.8 ± 3.2	18.3 ± 6.3	15.5 ± 3.6	17.7 ± 4.1
IR 300°/sec	12.0 ± 4.2	15.0 ± 3.8	13.8 ± 3.3	15.8 ± 4.6	12.6 ± 3.8	15.3 ± 3.9

\* significant at  $p < .05$

Table 4. Results of the Disability of Shoulder, Arm and Hand (DASH) questionnaire both pre- and post-rehabilitation for the standard and closed kinetic chain (CKC) groups.

Group	Pre-test	Post-test
Standard	25.8 ± 21.8	6.0 ± 4.3
CKC	15.0 ± 5.1	4.7 ± 3.5

### DASH Scores

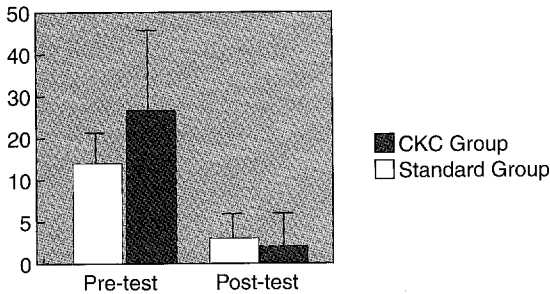


Figure 4. Graph of DASH scores pre-rehabilitation to post-rehabilitation for the CKC and Standard Groups.

Table 5. Results of the question, “During the past week, how often have you taken pain medication, including narcotics and over-the-counter medications?”

Response	Pre-test	Post-test
3 or more times /day	0	0
Once or twice a day	4	1
Once every couple of days	3	4
Once a week	1	1
Not at all	1	3

## DISCUSSION

A major finding of this study is that patients became stronger after receiving physical therapy treatment. Strengthening the shoulder movements of internal and external rotation undoubtedly contributes to an increase in static GH stability and enhances the muscles’ ability to generate sufficient force to achieve normal mechanics at the GH joint (2,4,7,18).

Functional outcomes, as measured by the DASH, were markedly improved. Although pre-rehabilitation to post-rehabilitation changes did not reach the critical level of  $p < .05$ , the improvement in function that the patients experienced approached significance ( $p < .08$ ). The failure to reach significance is most likely due to the large standard deviation found in the pre-rehabilitation standard group (Figure 2). The large amount of variability in combination with the small number of subjects ( $n = 9$ ) having completed both pre and post-questionnaires contributed to the insignificant findings.



The pain medication data were not statistically analyzed at this time due to the small number of subjects in the study. Analyzing categorical data of this type requires an  $n$  larger than nine. However, in comparing the frequency of answers, it appears that patients are using less pain medication after receiving physical therapy treatment. This is significant to reducing narcotic dependence, gastrointestinal irritation, and the patient's perception of wellness.

## **STUDY LIMITATIONS**

One of the major limitations of this study is the small number of subjects at the time the data were analyzed. The authors believe that the pre- to post- differences on the isokinetic strength measures, DASH questionnaire and pain medication use will all be significant when the number of subjects enrolled in the study increases.

A couple of factors contributed to the limited subject number in this study. First, allowing only one physical therapist to treat all subjects assured that subjects were treated consistently but it also limited the number of subjects that could enter the study. Secondly, conducting the study in the clinic made it difficult to control collection of post-rehabilitation data. Once patients start to feel better, they often discharge themselves regardless of whether they have completed their rehabilitation program. It was not possible to obtain post-rehabilitation strength measures on patients who did not return for their final treatments.

The authors tried to increase the number of patients that were post-tested by offering these patients the post-rehabilitation strength tests at no additional charge. No patients accepted this offer. Questionnaires were mailed with a stamped self-addressed envelope to subjects who did not return for treatment. Some subjects did return these questionnaires. In future studies subjects could be asked to complete the DASH on a weekly basis. The most recent DASH questionnaire could then be used as the post-rehabilitation measure. However, this approach may make it more difficult to recruit subjects due to the additional paper work required.

Another disadvantage of conducting the study in a clinical environment is that treatment durations ranged from 4 to 9 weeks. Patients do not achieve rehabilitation goals at the same rate. It would be unethical and poor use of health care dollars to continue treating a patient that is recovering quickly and is ready for discharge. Conversely, treatment outcomes will appear less significant after a set period of time (such as six weeks) for a patient whose progression is slower and is not ready for discharge.

## **SUMMARY**

Patients with shoulder impingement syndrome experienced an increase in strength of both the shoulder internal and external rotator musculature following six weeks of physical therapy treatment. Although there was a large change in scores obtained from the DASH questionnaire, suggesting that subjects were more functional in activities of daily living following treatment, these changes did not quite reach statistical significance. Subjects required less pain medication following treatment. Most patients used pain medication once or twice a day prior to treatment and this was reduced to a few times per week following treatment. There were no significant differences between groups for any of the variables measured. Thus, the addition of CKC exercise to the standard rehabilitation protocol does not enhance recovery of patients with shoulder impingement.

This study will be continued for an additional eight months following the submission of this report. As the number of subjects increases, so too will the statistical power. With an increased power, we anticipate that the pre- to post-treatment changes in functional status (as measured by the DASH) will become significant. Many insurers do not want to re-imburse health care providers for treatment if the only outcome of the treatment is an improvement in the patient's strength. This attitude may change if the results of this study demonstrate that treatment leads to an increase in the patient's function.

At the conclusion of this study, a manuscript will be prepared and submitted for publication in a physical therapy related journal. In addition, we intend to present our findings at the state and national physical therapy association conferences.

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