

**Theraband Versus Cuff Weights
in the Strengthening of
the Internal and External
Rotator Muscles of the
Shoulder**

An Honors Thesis (HONRS 499)

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Introduction

Injuries to the rotator cuff muscles and the shoulder complex are a fairly common occurrence in overhead sports including swimming, baseball, and softball. These injuries must be address in some manner to insure that the athlete can return to competition with peak performance in a relative short amount of time. It is important that the athletes are returned safely to guard against reinjury to the rotator cuff. Methods of intervention for these shoulder injuries include both surgical and nonsurgical treatment. Hurley, et.al.(7), found that specific therapy directed at strengthening the muscles surrounding the glenohumeral joint should be the first step in the treatment of rotator cuff and other shoulder injuries. Pawlowski and Perrin (11) determined that specificity of exercise for the shoulder was important in maximizing performance. Surgical intervention should only be used when this initial treatment proves ineffective. There are many different modes of resistance exercise that can be used in an attempt to strengthen the rotator cuff muscles. These forms of exercises include isokinetic, isotonic, and isometric exercises.

Four muscles make up the rotator cuff complex. These muscles are the supraspinatus, the infraspinatus, teres minor and the subscapularis (6,15). The muscles of the rotator cuff have a

small cross sectional area and these muscles are quick to fatigue (12). These muscles act to stabilize the glenohumeral joint due to poor ligament structure and a lack of bony stability of this found in this joint (15). The subscapularis primary function is internal rotation while the infraspinatus and teres minor aid in external rotation of the shoulder. Wagner (17) also describes the supraspinatus as both an internal and external rotator. Other muscles of the shoulder complex that aid in internal rotation are the pectoralis major, anterior deltoid, teres major, and the latissimus dorsi. The muscle that aids the rotator cuff in external rotation is the posterior deltoid. The musculature surrounding the rotator cuff has a great deal more muscle mass than do the rotator cuff muscles while at the same time perform many of the same functions of those rotator cuff muscles (15). Substitution of these larger muscles is possible when the rotator cuff is not properly conditioned to perform endurance type work. It is obvious that it is necessary to strengthen these muscles in order to insure the stability of the glenohumeral joint.

Isokinetic exercise allows for a concentric or eccentric contraction at a set angular velocity. Any increase in force production by the muscle will not increase the velocity, but will provide an increased torque output (13). Isokinetic exercises usually involves the use of expensive devices or machines and may be impractical for the strengthening of the rotator cuff in many

instances. Isokinetics can also be a useful diagnostic device to determine a muscle group's ability to produce force.

Isometric exercises involve static contractions and will increase strength at the angle of the isometric contraction (13). This mode of exercise is effective early in rehabilitation when limited range of motion is desired, but is less effective in increasing strength through the entire range of motion of the joint. Isometric exercises also tend to increase systolic blood pressure during the contraction so they may be contraindicated for those with heart conditions (13).

Isotonic exercise, also known as progressive resistance exercise, allows for a contraction through a range of motion. These exercises can be performed using a variety of resistance methods including free weights, cuff weights, Theraband, or weight machines (12,13). Isotonics allow for both concentric and eccentric contractions. There is some debate as to the difference in effectiveness between these different modes of resistance commonly used in isotonic exercise.

Theraband is a common means of progressive resistance due to its low initial cost and the ability to exercise in a functional movement patterns. For greatest effectiveness, cuff weights must be used against gravity which is not true for Theraband. Resistance with the use of Theraband is provided through the elastic property of the band. For this reason, a wide variety of functional movements can be easily replicated against the resistance provided by the Theraband that are not possible with

the use of conventional cuff weights. Even though Theraband has many practical uses there is little research to support the overall effectiveness of this device as a means of progressive resistance.

The purpose of this study was to determine if there is a difference in overall strength gains between these modes of progressive resistance. This study concentrated on two widely used modes of resistance used in the rehabilitation of the rotator cuff, namely Theraband and cuff weights. It was hypothesized that the cuff weight group should produce a greater overall increase in peak torque production by the internal and external rotators, over the Theraband group following the four week training period. Cuff weights allow for more quantitative measurements of resistance and supply a relatively constant amount of resistance over the full desired range of motion. Theraband increases resistance as the length is increased. For this reason, the resistance supplied by the Theraband is greater at the end of the range of motion. With the use of Theraband, an amount of resistance that causes overload at the end of the range of motion may not produce enough resistance at the beginning of the range of motion.

Methods

Subjects

Subjects in this study were males from Ball State University between the ages of 18 and 24. Twenty subjects were originally recruited to participate in this study. All subject were screened to determine the presence of any current shoulder pathology that might affect the outcome of the study. Following this initial screening, fourteen subjects met the criteria and agreed to participate in the study. Subjects were informed of potential risks and benefits involved with participation in the study and signed an informed consent form. All activity involving the subjects were carried out within the guidelines as set forth by the Institutional Review Board.

The fourteen participants were randomly divided into two groups. One group (N=7) was to train one shoulder using Theraband and the other group (N=7) was to train one shoulder using cuff weights. In both groups the shoulder that was not trained served as a control so that each individual acted as their own control. The study was randomly counter balanced with equal number of dominant and non-dominant shoulders being trained over the course of the study.

All subjects were pre and post tested using the Cybex 6000 isokinetic dynamometer to determine peak torque production for

internal and external rotation at 60 and 180 degrees per second. Subjects trained one shoulder for a period of four weeks using their assigned means of resistance. During this four week period the subjects trained their shoulder internal and external rotators three times per week to point of overload. Participants performed appropriate warm-up exercises to stretch the internal and external rotators prior to exercise bouts in order to avoid injury.

Isokinetic Testing

All subjects were pre and post tested bilaterally using the Cybex 6000 isokinetic dynamometer. Isokinetic testing was used to determine gains in peak torque production throughout the four week strengthening protocols. Subjects were instructed to warm-up prior to testing on the Cybex UBE to avoid injury to the shoulder during the testing bouts. The subjects were tested concentrically in internal and external rotation of the shoulder. Testing was conducted at 60 and 180 degrees per second.

The Cybex modified internal/external rotation protocol was used. In this position, the subject's shoulder was slightly abducted with anatomical zero being located at zero degrees of internal and external rotation. The subject's elbow was bent to 90 degrees of flexion. The subject's body was parallel to the dynamometer during testing. The dynamometer's height was set to a level that allowed the subject's shoulders to be parallel to the ground. This position was chosen because of its similarity to the position used during the training protocol. Range of motion stops

were placed at approximately 55 degrees of external rotation which was a point at which most subjects felt they were able to initiate a solid contraction for the beginning of the internal rotation. Internal rotation stops were placed at a point slightly less than the natural block that was incurred as the lower arm came in contact with the torso. The subjects were not allowed to substitute other muscles by using leverage of the hips and torso as this involvement could influence the peak torque production and provide false data.

The isokinetic testing protocol was set up as follows:

1. The subject was instructed to warm-up for a period of 5 minutes on the UBE.
2. The subject performed 4 sub-maximal concentric contractions at 60 degrees per second to acclimatize themselves to the testing speed.
3. The subjects performed 5 maximal concentric contractions in internal and external rotation at 60 degrees per second followed by a 20 second resting period.
4. The subjects performed 4 sub-maximal concentric contractions at 180 degrees per second.
5. The subjects performed 5 maximal concentric contractions at 180 degrees per second.
6. The test was then performed as described in steps 1-5 on the other shoulder.

During the testing protocol, the subjects were given no verbal encouragement that might influence results of the test. This could be a factor if the same encouragement was not congruent throughout the entire pre and post testing procedure. The subjects were also not allowed to see the monitor since this might also affect their performance on the tests.

Training Protocols

The training protocol lasted for four weeks. During this time the subjects in both groups exercised the internal and external rotators muscles of their experimental shoulder three times per week. Subjects were instructed to only perform training on the test shoulder and to perform on normal daily activities with the other shoulder. The subjects in both groups performed three sets of eight repetitions using the maximum amount of resistance that could be repeated 10 times. Each participant's maximal ten repetitions was determined to be the amount of resistance that could be repeated with the muscle nearly at the point of fatigue by the completion of the tenth repetition. Throughout the four week training period, the amount of resistance was increased as the subject's internal and external rotators became accustomed to previous maximal resistance. The group using cuff weights increased resistance in increments of 1.5 pounds. The Theraband group increased resistance by first increasing the tension of the Theraband by moving away from the point of the band's attachment until maximal effective length had been achieved. Once the maximal effective length of the Theraband had been reached the subject progressed to the next level of resistance in Theraband's progression of colored resistance.

The exercise protocol of repetitions for both study groups was:

1. The subjects were encouraged to stretch the shoulder musculature prior to bouts of exercise.

2. The subject was placed in the position for internal rotation determined by their assigned group's protocol.
3. The subjects performed 3 sets of eight repetitions of internal rotation.
4. The subjects rested for a period of approximately 30 seconds between sets of internal rotation.
5. The subjects were then placed in position for external rotation exercise as determined by their assigned group's protocol.
6. The subjects then performed 3 sets of 8 repetitions of external rotation.
7. The subjects rested for approximately 30 seconds between sets.

The first group performed their training using Theraband as a means of resistance. The position of the shoulder for the subjects for in group 1 consisted of the shoulder being in zero degrees of abduction with the elbow bent to 90 degrees of flexion. The subjects were instructed to lock the elbow against their side to isolate the internal and external rotators. The Theraband was anchored at waist level and the subject stood at approximately 8 feet from the point at which the Theraband was anchored. This distance offered a sufficient amount of tension and resistance for the exercise. The beginning position for both internal and external rotation exercises was zero degrees of internal rotation. The subjects were then instructed to perform internal and external rotation exercise as described earlier in this section as described by Aronen (2) and by Thein (14).

Group two performed their training using cuff weights as a form of resistance. The positioning for training is as follow for

group two. Internal rotation was performed with the subject supine with their shoulder at zero degrees of abduction. The subject was instructed to move as close as possible to the edge of the table so that their arm was touching the edge of the table. The elbow was then bent to 90 degrees of flexion and externally rotated to 90 degrees. The cuff weight was placed just proximal to the wrist. The subject was then instructed to internally rotate the shoulder through a full range of motion against gravity. Internal rotation exercises were conducted as described earlier in this section. External rotation was conducted with subject lying on the side not being trained. The shoulder was in zero degrees of abduction and the elbow was bent to 90 degrees of flexion. The cuff weights were placed just proximal to the wrist. Starting position for external rotation was full internal rotation as allowed by the anatomical block of the torso. Subjects were then instructed to perform external rotations exercise as described by the protocol earlier in this section. This position was described by Aronen (2) and by Waggoner (17).

Results

The results of this study revealed many unexpected trends in strength gains by both groups. Demographic information for all subjects participating in this study can be seen in table 4. The average baseline peak torques were greater for the control shoulder for both experimental groups at all testing speeds, as noted in Table 2. Both groups exhibited higher peak torque values for internal rotation than external rotation. Percent gains in peak torque were greater for the control group at all testing speeds except for internal rotation at 180 degrees per second in which the peak torque in the control group decreased by 5.4 percent which can be seen in Table 3. In both experimental situations and the control group, greater increases in peak torque production were seen at 180 degrees per second for both internal and external rotation. When comparing group 1 and group 2, the group using cuff weights showed a greater percent increase in peak torque production over the four week training period in external rotation. During the training period the group using Theraband showed an increase in percent improvement in internal rotation. Even though the cuff weight's mean values were greater than the Theraband in external rotation and greater for the Theraband in internal rotation, the control shoulder still showed a greater degree of increase in peak torque production in both directions except for internal rotation at 180 degrees per second, as noted in table 4.

Demographic Information of Study Subjects			
No. of subjects	Mean Ht. in Inches	Mean Wt.	Mean Age
14	71.33	194.06	20.67

Table 1

Mean (SD) Values for Peak Torque Production in ft/lbs				
	Pre test trained	Pre test control	Post test trained	Post test control
ER 60 deg/sec	22.57 (5.9)	24.00 (6.6)	23.39 (6.6)	24.85 (6.7)
ER 180 deg/sec	17.21 (3.5)	18.79 (4.3)	18.50 (4.2)	20.43 (4.3)
IR 60 deg/sec	34.07 (7.1)	35.07 (8.2)	34.54 (7.7)	34.77 (7.0)
IR 180 deg/sec	29.93 (9.5)	31.43 (6.6)	31.36 (7.7)	32.71 (7.6)

Table 2

Percent Change in Peak Torque Production				
	ER 60 deg/sec	ER 180 deg/sec	IR 60 deg/sec	IR 180 deg/sec
Trained	3.5 (.1)	6.2 (.1)	1.3 (.1)	5.1 (.2)
Untrained	4.6 (.1)	7.9 (.1)	2.3 (.1)	-5.4 (.1)

Table 3

Percent Change (SD) in Peak Torque Production by Group				
	Theraband trained	Control	Cuff Weight trained	Control
ER 60 deg/sec	2.9 (.1)	1.8 (.1)	4.2 (.1)	7.8 (.1)
ER 180 deg/sec	4.7 (.1)	6.9 (.1)	7.6 (.1)	9.0 (.1)
IR 60 deg/sec	2.3 (.1)	2.5 (.1)	0.0	2.1 (0)
IR 180 deg/sec	12.3 (.2)	-7.5 (.2)	-2.1 (.2)	8.1 (0)

Table 4

Discussion

The data compiled from this study revealed many unexpected trends and predicted trends, that sometimes supported the initial hypothesis that there would be greater increases in peak torque production by the group using cuff weights versus cuff weights. There were increases observed in peak torque production in both experimental groups as suspected, but there was a greater increases in peak torque production seen in the control group at all speeds except internal rotation at 180 degrees per second.

Baseline data was constant with previous findings by Ivey, Calhoun, and Ruscke (8), Day (4), and Brown (3). These same trends were also noted by Alderink and Kuch (1). The values were slightly lower in this study when compared with the Ivey's findings, but this difference could be attributed to the positioning of the shoulder during isokinetic testing as described by Alderink and Kuch (1). Alderink and Kuch (1) determined that greater peak torque could be produced with the shoulder abducted to 90 degrees than could be produced with the shoulder at zero degrees of abduction due to surrounding musculature involvement.

Even though Theraband is commonly used mode of progressive resistance exercise in the rehabilitation of shoulder injuries, there have been few studies to document its actual effectiveness. There are many researchers (2,9,10,13,14) that describe potential

exercises and the muscle groups that are exercises using Theraband, yet its effectiveness is difficult to prove. For this reason it is difficult to compare results of this with current trends in research.

Increases in strength during a short time period is typically attributed to increased motor unit recruitment (12,13). This increase will be seen after approximately four weeks. The second major gain in force production will be seen following approximately 8 to 10 weeks of training (13). At this point increases in cross sectional area of the muscle tissue can be observed. Since the subjects trained for only four weeks it can be assumed that increases in peak torque production must be attributed to increased motor unit recruitment. Even though it was known that increases in force production at the conclusion of the study would be mainly from motor unit recruitment, this time span seemed acceptable since many times rehabilitation compliance ceases after a relatively short time period after beginning the use of therapeutic exercises.

However, the control group performed better on the isokinetic post test compared to the experimental groups. One possible answer to this question would be that the study groups exhibited overtraining during the four week training period. Overtraining can lead to a decrease in observed performance and strength production (12). Both of the experimental groups exercised their internal and external rotators three times per week to the point of overload. For this reason, it is possible that the

experimental groups performance was inhibited by this factor. The control shoulder only carried out daily activity and would have been "fresh" for the post-test on the Cybex.

Another unexpected trend was a decrease in performance on the post-test at 180 degrees per second of internal rotation in the control shoulder. In the isokinetic protocol, this test was the last test performed for each shoulder. The study was counter balanced with equal number of dominant and non-dominant shoulder. Because of this, it is not possible to assume that the subjects merely decided to perform more poorly on their last test, since for half of the subjects this test would have been performed at the middle of the testing protocol. When comparing the frequency distribution of peak torque production in the control shoulder there was a greater accumulation of values at the upper end of the distribution seen in the pretest. This suggests that there was a sub-maximal effort by some subjects during the post-test.

One other area of concern was the inconsistency of the increased peak torque production between the two experimental groups. In the Theraband group, they exhibited greater increases in peak torque production in both testing speeds of internal rotation. In the cuff weight group, they demonstrated greater peak torque increases in both speeds of external rotation. This can be attributed to the positioning of the cuff weight group during internal rotation. During the execution of the exercises, the group contracted concentrically against gravity for approximately the first 90 degrees of motion. After this point,

the remainder of the contraction was aided by gravity and then became an eccentric contraction of the external rotators as these muscles attempted to decelerate the motion against gravity. During the internal and external rotation exercises performed by the Theraband group, the contraction was always against the line of resistance so all eccentric forces incurred would have been equal for both internal and external rotation.

All groups performed better at 180 degrees per second during the post-test. The percent increase in peak torque production was higher at this speed than was produced at 60 degrees per second. This finding is contrary to the findings by Page(10) who noticed greater increases at 60 degrees per second. It is not evident why this increase was seen. Most subjects indicated that they preferred the 180 degree per second testing speed to the 60 degree per second test. It is possible that the 180 degree per second produced less fatigue to the internal and external rotators since this speed required less time to complete. Trendinnick and Duncan (16) reported that their the reliability was not as good at 180 degrees per second when compared with results at 60 degrees per second.

Another concern was whether the muscles of the rotator cuff were actually isolated during the training protocol. It was necessary to overload the internal and external rotators to produce in increase in peak torque production. Due to the size of the muscles of the rotator cuff, substitution of the surrounding musculature probably occurred because of the inability of the

rotator cuff muscles to endure the stress put on them in an attempt to over load the muscle group.

Isolation of the rotator cuff is important when relating this study to practical applications. The rotator cuff muscles play a larger role in providing stability for the glenohumeral joint than does the surrounding musculature (7,14). If the rotator cuff muscles are fatiguing quickly, then substitution by the surrounding musculature occurs and the rotator cuff was not trained maximally. If the rotator cuff muscles are not correctly trained, then there is no increase in glenohumeral stability, which is the major goal for increasing the strength of the rotator cuff.

Suggestions for Further Research

As noted previously there are many extrinsic factors that may have affected the outcome of this study. In this study, there are several changes that should be made to insure more valid data. These changes include greater number of subjects, better control with exercise compliance, reevaluation of training protocols, and reevaluation of isokinetic testing.

It would be beneficial to have a greater number of subjects. In this study, only 7 subjects participated in each group. An increase to 20 subjects would provide more results. Screening individuals for height and weight along with activity level and previous participation in overhead sporting activity could improve

the homologousness of the data. This may prevent large ranges in peak torque values. Compliance was a problem with the subjects. It was difficult to enforce compliance as there was no reward system in place to reinforce positive behavior.

Also, the effects of gravity with the cuff weights may have had a greater effect on strength increases. One possible solution to this effect would be to use a pulley system that would remove the gravitational effects. The use of a weighted pulley system as described by Einhorn (5) would closely replicate the exercise performed by the Theraband group.

It is also important to determine a more objective means of determining when increases in weight or resistance is needed to insure the muscles of the rotator cuff are being exercised to the point of overload. In this study the decision was based on reports of the subject along with subjective observations on the part of the investigator. A predetermined schedule for increase of resistance might alleviate this problem and enable the muscles to be overloaded during each and every exercise session. Another possibility would be to make the last set in both internal external rotation a "burn out" set. This would make sure that the muscle group was overloaded consistently.

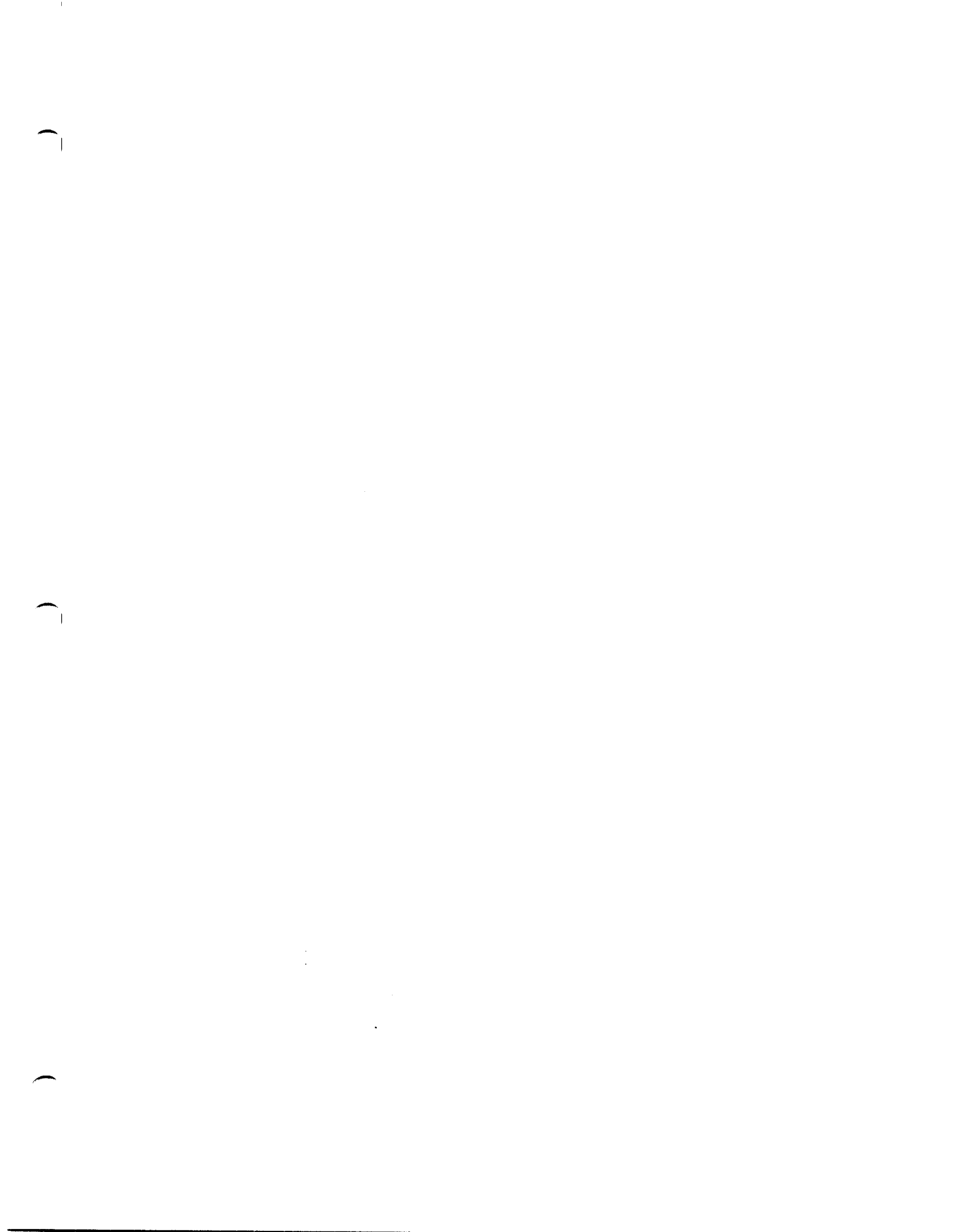
Problems with the isokinetic testing must be corrected in order to insure the validity of the data collected. One suggestion would be to provide verbal encouragement throughout the testing process. The verbal encouragement would be directed at making sure the subject was providing a maximal effort throughout

all sets an repetitions of the testing procedure. This would help to alleviate sub-maximal efforts on certain speeds and add to the homologousness of the data collected.

Conclusion

This study demonstrates that Theraband and cuff weights can be an effective means of progressive resistance exercise. The initial hypothesis was not sufficiently supported by the data collected. The group using cuff weights did not show a significant increase in peak torque production than did the group using Theraband. While both test groups demonstrated increases in peak torque production, the control group showed a greater increase following the training period. It should also be noted that limitations of the study make it difficult to draw many concrete conclusions from the data collected. Many unexpected trends in the data were observed that could be directly related to the methods and procedures used during the investigation. Many of these "problems" were addressed in the discussions and suggestions for their correction were provided. With changes in the research protocol may result in different results.

Further investigations into the effectiveness of Theraband as a mode of progressive resistance exercise should be conducted. Theraband is often used in the rehabilitation of shoulder injuries, but the effectiveness of this exercise modality has not been adequately documented. This study can serve as a model for future research.



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