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## Quadriceps Strengthening Daily Adjustable Progressive Resistance Exercise (Dapre) Technique versus Delorme's Progressive Resistive Exercises (Pre) Techniques

Paul R. Cleveland

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QUADRICEPS STRENGTHENING:  
DAILY ADJUSTABLE PROGRESSIVE RESISTANCE EXERCISE  
(DAPRE) TECHNIQUE  
VERSUS  
DELORME'S PROGRESSIVE RESISTIVE EXERCISES  
(PRE) TECHNIQUES

Paul R. Cleveland

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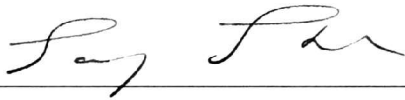
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BY  
PAUL R. CLEVELAND

A Thesis Submitted to the Faculty  
of the College of Graduate Studies  
At Georgia Southern University  
In Affiliation with Armstrong State College  
in Partial Fulfillment of the  
Requirements of the Degree  
Master of Health Science

Statesboro, Georgia

1994

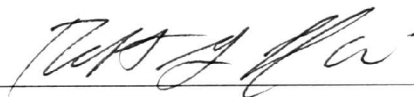
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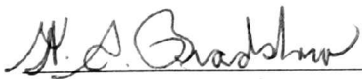


Chris Tuten



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Approved:



Vice President and Dean, College of Graduate Studies

5/25/94  
Date

## DEDICATION

To my loving wife, Judy, who spent endless hours  
by herself with our precious two children, Christina and Laura,  
while I was in class and for putting up with my constant  
procrastination finishing this thesis.

## ACKNOWLEDGMENT

A sincere word of appreciation to the following people for helping me to complete this thesis. Without their time and energy and constantly telling me my file was too thick, I would still be waiting to complete this paper.

Dr. Emma Simon

Dr. Sandy Streater

Dr. Chris Tuten

Dr. Bob Lefavi

Mrs. Susan Foster

THANK YOU!

## ABSTRACT

The purpose of this study was to determine if the DAPRE technique would significantly improve strength in the non dominant quadriceps muscle as opposed to Delorme's PRE technique for strengthening. Using a pretest posttest Cybex II strength test and applying a t-test for independent samples, it was found that after four weeks there was no significant difference between Group A (N=10) who exercised using Delorme's technique and Group B (N=10) who used the DAPRE technique. It was concluded that possibly because of the low sample number, the short length of the exercise intervention, and using normal healthy subjects instead of subjects with atrophied muscles as Knight (1985) had used, the outcome of the study was not what was expected.



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## DEFINITION OF TERMS

1. Cybex II: The name of the isokinetic device used to measure foot-pounds of torque.
2. normal healthy subjects: Subjects who were not under the care of a physician for any problem directly or indirectly related to their non dominant knee, did not have an injury to the non dominant knee within the last three months, nor were involved in and exercise program for strengthening of the lower extremity.
3. level of function: What someone is able to do physically. i.e.: Transfer independently, walk with an assistive device a distance of 200 feet with contact guard assistance of one person
4. normative data: The average time to rehabilitate a person with a certain diagnosis. i.e.: two months, 20 treatments
5. isokinetic strength: The amount of torque generated by the Cybex II measured in foot-pounds. Synonym - dynamic strength
6. foot-pounds of torque: The force generated by contraction of a muscle that results in the movement of a limb against a lever.
7. peak torque values (PTV): The foot-pounds of torque measured from the strip chart recorder
8. dynamometer: The instrument used to measure torque. A part of the Cybex II.

# QUADRICEPS STRENGTHENING: DAILY ADJUSTABLE PROGRESSIVE RESISTANCE EXERCISE (DAPRE) TECHNIQUE VERSUS DELORME'S PROGRESSIVE RESISTIVE EXERCISE (PRE) TECHNIQUE

## INTRODUCTION

Today's world of health care is in a state of uncertainty. Health care cost are skyrocketing. Everyday in the news media there are reports from different interest groups about their ideas to reform the health care industry. Everyone is looking at ways to cut spending of health care dollars.

The days when the physician was in complete control of their patient has all but vanished. Third party payers are beginning to drive the system. Insurance companies are telling patients where they can go for health care and what health care provider they can see. Physicians are now practicing medicine with more regulations imposed on them than ever before. Insurance companies are also telling physicians what they can do or what they can not do based on cost and data showing what the norms are for that particular diagnosis. For practitioners in health care to survive the rest of the 1990's they will have to be able to show third party payers that they can be effective and efficient by getting the patient well and meeting or exceeding the norms established for the diagnosis that they are treating.

The field of physical therapy has not been exempt from the health care reforms. For third party payers, time and function seem to be the key words for successful rehabilitation. No longer are the insurance companies concerned with their clients range of motion of a joint and/or the strength of a particular muscle. Third party payers are

concerned with how quickly a patient can reach their maximal level of function for a given diagnosis. For example, what is the normal time it takes for a total knee patient to be independent in walking with an assistive device? This data termed normative data is being generated per diagnosis by different groups for the third party payers.

In rehabilitation the race is on. In negotiating with third party payers for the right to be part of their health care package, outcomes for the physical therapy practice will be part of the information needed. No longer will the lowest bid per treatment be selected. The rehabilitation group selected will be the group that can effectively and efficiently treat the patient with the fewest health care dollars. Practitioners will need to be looking for ways to cut treatment time and still have the same results.

#### PROBLEM STATEMENT

Strengthening of a muscle is an area of rehabilitation that is used everyday on nearly every patient. There are many different techniques for strengthening found in the literature, (Berger, 1962, 1967; Delorme & Watkins, 1948; Macqueen, 1954; Stone & Kroll, 1982, Zinovieff, 1951). Two such techniques are the daily adjustable progressive resistance exercise technique (DAPRE) and Delorme's progressive resistive exercise technique (PRE). Knight (1985) surmised that variations of Delorme's PRE technique had been the most widely used technique for strengthening in the field of rehabilitation for over 40 years. In 1979 Knight introduced a new strengthening protocol and titled it the DAPRE technique. The purpose of this investigation was to see if the DAPRE technique would build significantly more strength than the PRE technique in a certain period of time.

#### REVIEW OF LITERATURE

"The human body adapts and improves in direct relation to the type of stimuli to which it is exposed" (Sanders, 1990, p. 240). In 1945 Delorme published an article describing the progressive resistive exercise (PRE) technique for strengthening of a muscle.

Progressive resistive exercise is used to increase muscular strength and endurance in an orderly and progressive manner. This method permits an overload to be applied to the musculature and allows for the adaptation of bones, ligaments, tendons, and muscles so that the imposed overload is not applied too quickly and further damage incurred. (Harrelson, 1991, p. 177)

Delorme's (1945) technique called for finding the maximal weight a person could lift through a full range of motion for 10 repetitions. This was called the 10 repetition maximum and labeled 10 RM. The 10 RM was determined once a week from a 1 RM. The person building strength would then perform 7 to 10 sets of 10 repetitions using this 10 RM three times per week.

In 1948, Delorme and Williams revised the 1945 technique. They lowered the number of repetitions per exercise session from 70 - 100 repetitions to 30 repetitions. This revision led to the use of heavier weights resulting in quicker gains in strength and muscle volume. The protocol revision still required determining the 10 RM for the week. At each exercise session the first set of 10 repetitions was performed with 50% of the 10 RM. The second set of 10 repetitions was performed with 75% of the 10 RM. The third and final set of the exercise was performed with 100% of the 10 RM doing 10 repetitions of the exercise, (Harrelson, 1991).

The theory of PRE is that a situation is created wherein an individual muscle (or muscle group) must exercise to full capacity against an ever-increasing resistance. Until recently, with the introduction of the Daily Adjustable Progressive Resistance Exercise (DAPRE) technique, no formal method existed for objectively determining either the optimal time to increase resistance or the optimal amount of weight to increase resistance. The DAPRE technique claims to address these concerns and, as a consequence, to provide quicker strength development during rehabilitation. (Knight, 1985, p.646)

Knight (1979) took the PRE concept and modified it into the DAPRE technique. This new technique took into account the gains made in strength at each exercise session and built upon that strength gain. This made sure that work near optimal capacity was being performed. Knight also incorporated Berger's (1962) work that looked at the optimal number of repetitions per set. Berger found that subjects who exercised using four, six, and eight repetitions per set had significant gains in strength over those subjects who exercised using 2, 10 and 12 repetitions per set. Knight's (1979) DAPRE technique uses five to seven repetitions per set as the standard.

The DAPRE technique starts with a person doing 10 repetitions of an exercise at one-half the estimated working weight. The second set of the exercise is performed at three fourths the working weight only performing six repetitions. The third set is performed with the full working weight doing as many repetitions as can be done. The working weight for the last set of exercises is adjusted based on the number of repetitions performed during the third set. As many repetitions as can be performed are done with the adjusted working weight for the fourth and last set. Based on the number of repetitions performed during the fourth set, the working weight is adjusted again for the start of the next exercise session, (Knight, 1979).

In rehabilitation the quicker the strength can be regained the faster the functional activity can be performed. As stated earlier, functional activity or outcome is becoming the objective measurement that third party payers are looking for. In order to cut health care dollars, strengthening a muscle in the quickest way could help to reduce the time involved in getting a patient to a particular functional level.

### HYPOTHESIS

Subjects who exercise for four weeks using the DAPRE technique for strengthening of the non dominant quadriceps muscle will have significantly greater gains

in strength than those subjects who exercise the non dominant quadriceps using the PRE technique for four weeks.



## METHODOLOGY

### SUBJECTS

Subjects were a convenience sample of volunteers. All subjects for this research were from Chatham County. Each volunteer was able to bend (flex) and straighten (extend) the non dominant knee without pain. The range of motion of the subject's non dominant knee was at least 90 degrees of bend (flexion) to 10 degrees or less from the knee being straight (extension). None of the subjects had an injury to the non dominant knee within the last three months, were under the care of a physician for any problem directly or indirectly related to their non dominant knee, or were actively involved in an exercise program for strengthening the lower extremity. All of the subjects signed an informed consent form (Appendix A).

### INSTRUMENT

Elliott in 1978 stated the following:

The Cybex II, a device for testing isokinetic strength , has gained increasing acceptance in the field since its development in 1970. Today it not only plays an integral part in the functioning of most professional football clubs and sports medicine clinics in the country, but also promises to assume an important role in occupational injury evaluation, athletic screening and rehabilitation, and verification of treatment results (p. 2408).

The Cybex II was used to objectively determine the strength of the quadriceps muscle. The quadriceps muscle is the muscle responsible for straightening (extending) the knee. The Cybex measures the dynamic strength of a muscle about a joint at every point

within its range of motion. The dynamic strength is measured in foot-pounds of torque as generated against a lever arm moving at a set angular velocity.

Thigpen (1990) concluded that when using the strip chart recorder (SCR) to obtain the peak torque values (PTV), the information gathered was reliable. Moffroid (1969) found the Cybex to be both reliable and valid for measuring the torque values of the quadriceps.

### PROCEDURE

A convenience sample of 20 volunteers was assembled. The 20 subjects were randomly assigned, by drawing, to two groups of ten subjects each. Group A was assigned Delorme's strengthening protocol while Group B was assigned the DAPRE technique for strengthening.

Both groups used a standard warm up protocol prior to the pretest, exercise session, and posttest. The standard warm up procedure (Appendix B) consisted of muscle warm up and stretching so as not to injure the joint or muscles when lifting heavy weights. Positioning of the subjects on the Cybex exercise chair for the pretest and posttest was critical for objective measurements. Each subject was positioned and stabilized on the Cybex exercise chair by means of Velcro straps about their non dominant thigh, their hips, and their chest. Removable pads were used to adjust the backrest so as to position the knee axis in correct alignment with the dynamometer. The axis of rotation for the knee was considered to be a point at the center of a line which runs transversely through the femoral condyles. The axis of rotation of the dynamometer for the Cybex was aligned with the axis of rotation of the knee. The bottom of the shin pad was positioned as close as possible to two centimeters proximal the lateral malleolus. To ensure that the posttest was administered with the same set up as the pretest, the number of pads used for the back rest and the number of holes showing on the lever arm to which the shin pad was attached was recorded.

The pretest for both Group A and Group B was the same. Standardized verbal instructions ( Appendix C) were given to the subject. Following the verbal instructions the strip chart recorder (SCR) was adjusted for the test. The subject then exercised the knee briefly using submaximal effort after the speed selector had been adjusted to 60 revolutions per minute (RPM). The test consisted of three maximal kicks (extension) of the non dominant knee. The knee extension was recorded in foot pounds of torque by the SCR. The foot pounds of torque was the measurement that was used for the strength of the quadriceps.

Following the pretest the subject was then scheduled for the exercise portion of the research. Each subject was seen three times per week for four weeks. A period of four weeks was chosen for several reasons. The first and foremost reason was to see if in fact there was a difference in the strength between the two techniques in just four weeks. For the area of rehabilitation this could mean a jump start on the functional training of a patient. It could mean the discharging of a patient in less time than the normative data shows thereby cutting treatment cost. A secondary factor was the time involved in getting the research done and the compliance factor of the subjects involved in a longer project.

Sanders (1990) wrote the following:

To enhance the individual's adaptation to training as well as regeneration following demanding training sessions the specific cycle length must be determined. In order to avoid overtraining and stagnation the specific cyclical alternations of high- and low-intensity stimuli must be followed so that fatigue and rest are partners. There exists a wide variation in frequency patterns of workout, from as many as five per week to as few as two per week. Those physiological properties associated with protein turnover and the glycogen restoration appear to be the most important factors in returning muscle glycogen to the preexercise levels and restoring

functional ability. This suggests that the ideal pattern would be alternate days of training and rest. (p. 245)

The above statement is suggestive of exercising three times per week, therefore the frequency of the exercise sessions that each group would do was chosen to be three times per week.

The pretest, exercise portion, and the posttest were scheduled for the same time of day each session. Appointment times did not vary more than one hour from the scheduled time because of Hislop's (1963) observation of the diurnal effects of strength.

Group A subjects used the Delorme PRE technique for strengthening. All exercise sessions started with a warm up per Appendix B. During their first exercise session the 10 repetition maximum (10 RM) weight for the non dominant quadriceps had to be calculated. "A repetition maximum is the greatest amount of weight (load) a muscle can move through the range of motion a specific number of times" (Kisner, 1985, p.85). A 10 RM is the greatest amount of weight that a person can lift through the range of motion 10 times. This was done with the subject sitting on the Cybex exercise chair lifting an amount that had been selected by the researcher through the full range of knee extension. Weights were either adjusted up or down until the subject was able to lift the weight only 10 times. This weight was considered to be the 10 RM. Once the 10 RM had been calculated, the subject did 10 repetitions of knee extension using 50 % of the 10 RM weight. The subject rested three minutes and did 10 more repetitions of knee extension lifting 75% of the 10 RM weight. The last set of 10 repetitions was done after three minutes of rest with 100% of the 10 RM weight. In summary, the subject exercised the non dominant quadriceps at each exercise session at 50%, 75%, and 100% of the 10 RM. That 10 RM was used for the remainder of the week with a new 10 RM being set at the end of the week for the next week. The setting of a new 10 RM went on for three consecutive weeks.

Group B subjects used the DAPRE technique as their strengthening protocol. All exercise sessions started with the standard warm up per Appendix B. The subjects in Group B exercised three times per week for four weeks like Group A. To get started for the first session the subject had the working weight estimated. The working weight was adjusted according to the charts found in Appendix D. During each exercise session four sets of exercises were performed for knee extension. The first set was performed using 1/2 of the working weight doing 10 repetitions. The second set was performed using 3/4th of the working weight doing only 6 repetitions. The third set was performed using the full working weight doing as many repetitions as the subject can. The weight was then adjusted according to Table 2 of Appendix D. With the adjusted working weight the subject performed as many repetitions as he could. The working weight was again adjusted according to Table 2 in Appendix D. The new working weight was the working weight for the next session.

When the subjects in Group A and Group B finished their 12th scheduled exercise appointment, the next appointment made was for their posttest. The posttest was scheduled for the same standing appointment time as their exercise session. The posttest was administered in the same manner as the pretest. Care was taken to make sure that the number of back pads were the same as well as the length of the lever arm with the shin pad attached was the same for each subject as per their pretest. Once the recording from the SCR was taken, the maximum foot pounds of torque generated by the quadriceps was calculated.

### DATA ANALYSIS

A mean and standard deviation was calculated for the age, pretest, and the posttest scores for each group. T-tests for pretest means and posttest means as well and the mean

of the difference between Group A and Group B were calculated. The t-test was also calculated for paired differences within Group A and Group B.

## RESULTS

Subjects had a mean age of 38 years for Group A and 35.6 years for Group B as shown in Table 1. All subjects were Caucasian females from Chatham County, Effingham County and Bryan County. Each group had 10 subjects that were randomly assigned to the groups by drawing. Pretest and posttest strength for the non dominant quadricep muscle was recorded by the Cybex II in foot-pounds. Table 2 shows that the mean for the pretest in foot-pounds was 83.3 for Group A and 76.3 for Group B. The posttest mean in foot-pounds for Group A was 84.8 and for Group B was 78.7 as found in Table 3.

Table 4 shows that Group A and Group B were not significantly different groups, in strength, when comparing the means of the pretest. The probability level was determined to be 0.328. When comparing the means of the posttest for Group A and Group B's strength, the two groups were found to have no significant difference between them. The posttest probability was calculated to be 0.352.

Table 5 shows that there was no significant difference in strength gains between the mean of the differences for Group A and the mean of the differences for Group B. The probability level was calculated to be 0.420.

Table 6 shows that there was no significant difference in strength gains between the increase in Group A's pretest mean foot-pound and posttest mean foot-pound. This probability level was determined to be 0.124. There was a significant difference in strength gains between the pretest mean foot-pound and the posttest mean foot-pound of Group B. This probability level was significant at the 0.004 level.

Table 1

Mean Age by Groups

Variable	Mean	SD	Minimum	Maximum	Valid N
Group A	38.00	10.20	25.00	61.00	10
Group B	35.60	7.04	25.00	45.00	10

Table 2

Mean Pretest Foot-pounds by Groups

Variable	Mean	SD	Minimum	Maximum	Valid N
Group A	83.30	16.55	61.00	119.00	10
Group B	76.30	14.55	54.00	99.00	10

Table 3

Mean Posttest foot-pounds by Groups

Variable	Mean	SD	Minimum	Maximum	Valid N
Group A	84.80	15.04	64.00	115.00	10
Group B	78.70	13.48	60.00	100.00	10



Table 4

t-test for Equality of Means

Variiances	t Value	Degrees of Freedom	2-Tail Probability
pretest: Group A to Group B			
Equal	1.00	18.00	.328
Unequal	1.00	17.71	.329
posttest: Group A to Group B			
Equal	.96	18.00	.352
Unequal	.96	17.79	.352

Note. Comparing pretest means and posttest means.

Table 5

t-test for Equality of Means

Variiances	t Value	Degrees of Freedom	2-Tail Probability
Equal	.83	18.00	.420
Unequal	.83	16.34	.421

Note. Comparing mean of the difference posttest to pretest Group A to mean of the difference posttest to pretest Group B.

Table 6

t-test for Paired Differences

	Mean	SD	SE of Mean	t-value	df	2-tail sig
Group A	1.500	2.799	.885	1.69	9	.124
Group B	2.400	2.011	.636	3.77	9	.004

Note. Comparing pretest mean to posttest mean for each group.

## DISCUSSION

In Knight's (1985) article he stated, "strength gains with the DAPRE technique have been impressive and appear to be more rapid than those reported using the Delorme technique" (p. 648). The study just conducted did not find that the DAPRE technique for strengthening was significantly different than Delorme's PRE technique. Knight's 1985 study of the DAPRE technique was with subjects that had quadriceps atrophy because they had been immobilized with plaster casts for three to six weeks post surgery to repair torn collateral ligaments or meniscus problems or because of a similar non operative problem. The results that the DAPRE technique was not significantly different from the PRE technique could have been because normal healthy individuals were used as subjects where subjects with atrophy of the quadriceps were used in Knight's (1985) study. Further study between the two different populations would have to be carried out to see if this was significant.

Both Group A and Group B were not significantly different from each other by the t-test calculated for the groups pretest. Because the t-test showed no significance difference between the pretest for each group the t-test could be used for the posttest calculations (Gay, 1987). The posttest t-test for the means also showed that there was no difference between the two groups. The t-test for the mean of the gains (difference) was calculated. The t-test showed that there was no difference between the mean gains in foot-pounds for Group A and Group B. Therefore the hypothesis that the DAPRE technique would make a significant difference in strength gain in four weeks had to be rejected.

The design using four weeks may need to be extended to six or even eight weeks to really show strength gains on normal healthy individuals. Knight (1985) reported that Fuglsang-Frederiksen and Scheel (1978) noticed that there was an increase in force exerted by atrophied quadriceps muscle from 40% to 80% of the force of the opposite quadriceps muscle within one week and Ikai and Fukunaga (1970) reported a 93% increase in force generated by a muscle that only increased 23% in cross-sectional size after 100 days of exercise. Knight speculated that the changes in strength in his study suggested a neurological change rather than a morphological change. Whether a neurological change or a morphological change took place was beyond the scope of this research. Further research would be needed to make this determination.

The low sample number in each group (N=10) was another factor that could have led to the results not turning out as predicted. It is quite possible that if the research was run again with a larger sample size the outcome might be different. More research would bear this out.

Based on this research it matters not whether a therapist uses the DAPRE technique or the Delorme's PRE technique for strengthening the non dominant quadriceps. Both techniques showed strength gains in the quadriceps based on Table 6 where Group A had a mean gain of 1.5 foot-pounds and Group B had a mean gain of 2.4 foot-pounds.

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## Appendix A

### Informed Consent

Dear Volunteer,

You have volunteered to help in a study to compare two particular strengthening techniques for the quadriceps muscle of the non dominant knee. Several items you need to know are:

1. You will have the results of this study shared with you.
2. All information obtained from you will be held in strict confidence.
3. There will be no emotional or physical harm inflicted on you before, during, or after this study.
4. You are at liberty to withdraw from this study at any time you wish.

By signing below, you agree to participate in this study.

Thank you,

Paul R. Cleveland

---

Signature

---

Date

## Appendix B

### Standard Warm Up Procedure

1. The subjects walks or rides a stationary bicycle without resistance for three minutes.
2. The subject then performs 10 repetitions of hamstring stretches by lying on their backs with the non dominant hip and knee flexed to 90 degrees. The subject grabs their non dominant leg behind the knee keeping the hip at 90 degrees of flexion. The subject leg is extended straight up in the air placing a stretch on the hamstring muscle. This is held for a count of 10 seconds and then lowered to the starting position. This represents one repetition.
3. The subject then stretches the quadriceps muscle of the non dominant knee by standing and grabbing hold of their non dominant foot behind them. To do this the subject has to bend their knee as much as possible keeping their hip extended. This places a stretch on the quadriceps which is maintained for a count of 10 seconds. This is done for 10 repetitions.



## Appendix C

### Cybex Testing Verbal Instructions

The following instructions were read to the subject after they had been positioned in the exercise chair.

1. This is a test to determine the strength of your non dominant knee. In a moment you will be asked to give me three kicks just as hard and as fast as you can. The strip chart recorder will be measuring your strength in foot pounds of torque. I will only be looking at the strength of your quadriceps muscle. That muscle is the muscle that straightens your knee. It is found on top of your thigh.

To get yourself familiar with the Cybex, I want you to warm up your knee on this device. Do not give maximal effort at this time. Start by just straightening your knee out as far as it will go and then bend your knee until it hits the heel pad below. Do this over and over until I ask you to stop. You will have to put some effort into the kicking out in order to get any resistance.

## Appendix D

TABLE 1  
The DAPRE technique\*

Set	Portion of Working Weight Used	No. of Repetitions
1	1/2	10
2	3/4	6
3	Full	Maximum†
4	Adjusted	Maximum‡

\* Adapted from Knight (17)

† The number of repetitions performed during the third set is used to determine the adjusted working weight for the fourth set according to the guidelines in Table 2.

‡ The number of repetitions performed during the fourth set is used to determine the adjusted working weight for the next day according to the guidelines in Table 2.

TABLE 2  
General guidelines for adjustment of working weight\*

No. of Repetitions Performed During Set	Adjustment to the working weight for the:	
	Fourth set†	Next day‡
0-2	Decrease 2-5 kg and repeat the set	
3-4	Decrease 0-2 kg	Keep the same
2-7	Keep the same	Increase 2-5 kg
8-12	Increase 2-5 kg	Increase 2-7 kg
13+...	Increase 5-7 kg	Increase 5-10 kg

\* Adapted from Knight (17).

† The number of repetitions performed during the third set is used to determine the adjusted working weight for the fourth set according to the guidelines in column 2.

‡ The number of repetitions performed during the fourth set is used to determine the adjusted working weight for the next day according to the guidelines in column 3.

## Appendix E

### Test Results for Thesis

Group A			Group B		
Age	Pretest	Posttest	Age	Pretest	Posttest
38	119	115	36	54	60
25	75	79	43	83	86
37	82	83	29	72	71
29	79	84	45	63	65
45	65	65	31	62	67
42	92	90	39	72	74
61	97	100	43	87	89
29	81	83	28	99	100
35	82	85	25	94	95
39	61	64	37	77	80

Note. Pretest and posttest numbers are in foot-pounds of torque.