ABSTRACT

KRUGER, M. J. Effects of thick-bar resistance training on strength measures in experienced weightlifters. MS in Exercise and Sport Science-Human Performance, May 1999, 51pp. (N. Triplett-McBride)

This investigation determined the efficacy of resistance training with thick-handled barbells and dumbbells. Twenty two experienced male weightlifters were randomly assigned to groups that exercised either with increased grip circumferences or normal grip circumferences. Each group performed an identical 6 week resistance training program. Body weight, forearm circumference, hand dynamometer, chinup repetition maximum, and standard 1 repetition maximum bench press and deadlift tests were administered pre- and posttraining. An alpha level of 0.1 was used after a power analysis of relevant literature. Results showed a significant increase ($p < 0.001$) in all variables as a result of the training in both groups. There was a significant ($p < 0.1$) interaction in left hand dynamometer and body weight variables in favor of the experimental condition. The results indicate that thick-bar resistance training is effective in improving grip strength and upper-body functional strength.

EFFECTS OF THICK-BAR RESISTANCE TRAINING ON STRENGTH MEASURES IN EXPERIENCED WEIGHTLIFTERS

A MANUSCRIPT STYLE THESIS PRESENTED

TO

THE GRADUATE FACULTY

UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

MASTER OF SCIENCE DEGREE

BY

MATTHEW J. KRUGER

MAY 1999

COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION

UNIVERSITY OF WISCONSIN-LA CROSSE

THESIS ORAL DEFENSE FORM

Candidate: Matthew James Kruger

We recommend acceptance of this thesis in partial fulfillment of this candidate's requirements for the degree:

Master of Science in Human Performance

The candidate has successfully completed the thesis final oral defense.

Thesis Committee Chairperson Signature	4-7-99 Date
Thesis Committee Member Signature	3 31 99 Date
Thesis Committee Member Signature	3-31-99 Date
Glenn Brice Thesis Committee Member Signature	3-31-99 Date

This thesis is approved by the College of Health, Physical Education, and Recreation.

Associate Dean, College of Health, Physical Education, and Recreation	4-15-99 Date
Director of University Graduate Studies	4-15-99 Date

ACKNOWLEDGEMENTS

I would to thank the following individuals for their support in the completion of my thesis:

Dr. N. Travis-Triplett McBride and Dennis Kline for their substantial investments of time and knowledge in the weight room and on this committee. The opportunity to work with these two individuals for my graduate assistantship has provided professional guidance, growth, and an experience for which I shall be forever indebted.

Dr. Glenn Brice and Dr. Richard Mikat for their valuable input and assistance in the areas of physiology, thesis protocol, and statistics.

The subjects of this study who were willing to train in this unusual manner for the sake of scientific progress.

Ben Crenshaw and Dan Stevenson, Information Technology Lab Assistants, for their help with computers, presentations, and professionalism.

Mike Burch, Wade Meyer, Bryan Beck, Brandon Marcello, Matt Condon, and others too numerous to mention for their patience and "viscious cycle" of friendship, always good for reality checks, humor, and direction, even when I don't deserve it.

My family, without whom none of this would be possible. Their unconditional support and love throughout the indecisiveness and confusion has led me to this point, probably despite myself.

TABLE OF CONTENTS

LIST OF APPENDICES

INTRODUCTION

Forearm and grip strength are arguably the most overlooked part of modern strength training. As evidenced by numerous excellent texts on the subject, the field of strength and conditioning has made vast improvements in identifying underlying factors of performance, periodized set/rep parameters, and incorporating Olympic lifts and plyometrics in order to maximize performance (3, 6, 13, 17). While these subjects are important to the advancement of the field of strength and conditioning, strength coaches often ignore the importance of forearm strength on functional strength and performance. Functional strength is the strength an individual is able to use during competition or everyday life, without artificial aids such as belts and straps. In sport competition and life, the body is only as strong as its weakest link. Modern resistance trainees often find that forearm and grip strength are their weakest links. In light of the massive grip strength of past athletes, some strength experts would argue that the field has regressed rather than advanced (4, 9).

Wrestling and the martial arts require tremendous forearm and grip strength in order to complete certain techniques and maximize performance. Forearm strength is necessary to generate power in any sport that requires swinging of an implement including tennis, racquetball, badminton, softball, baseball, and even ping-pong. Team sports like football, basketball, and hockey require forearm strength to tackle, move opponents, fight for position, and perform shots on goal. Optimal amounts of forearm strength will increase the functional strength during competition, thus increasing the chances for success. There is a gap in the strength and conditioning literature with respect to methods of increasing forearm/functional strength through dynamic resistance training. In the past, researchers investigated grip strength and forearm strength in a variety of ways. Examples are a static grip test for windsurfing (16), evaluation of hypertrophy and strength in the dominant arm of tennis players (18), and as a measurement of training status for elite rowers (12). In the most relevant study, researchers trained subjects for maximum grip strength on an isometric hand dynamometer for 6 weeks and found that grip strength, endurance, and peak blood flow increased significantly in both forearms (21). The importance of this study is that significant changes in grip strength can occur in 6 weeks or less.

The efficacy of thick-bar training and the subsequent effect on grip strength and functional strength has been discussed in several texts (4, 9). These authors theorize that training with barbells and dumbbells of increased handle circumference imposes greater stress on tendons and ligaments, creates an increased central nervous system response, and dramatically improves grip strength (4, 9). While these sources contain information on thick-bar resistance training, there are no scientific studies to support these claims. Rather, the efficacy of thick-bar training has relied on the anecdotal evidence of modern devotees and the lore of old-time strongmen, whose feats of enormous strength were supposedly built by using this method of training. Therefore, due to the lack of research on the subject, the purpose of this investigation was to determine if thick-bar resistance training is a valid method of increasing grip and functional strength.

METHODS

Subjects

Twenty-eight healthy male subjects (age range 19 to 24 years) began the study, with 22 completing the program. All subjects were experienced weightlifters with a minimum of 2 years training experience and were training on standard resistance training programs. In addition, all subjects were right handed. After receiving a detailed explanation of the study's protocol, the subjects signed an informed consent form (see Appendix A). The Institutional Review Board of the University of Wisconsin-La Crosse previously approved all study protocols.

Training Protocol

Each subject was provided a modified periodized strength training program designed to increase grip strength and functional strength (see Appendix B). The training program consisted of the typical periodized high volume to high intensity approach (3, 17) but also utilized time-under-tension considerations (13). The program was 6 weeks in duration and administered in a 3 day per week split routine as follows: Monday-Chest/Back, Tuesday-Legs/Low Back/Abdominals, and Friday-Shoulders/Biceps/Triceps (see Appendix B). With the exception of the abdominal and low back exercises, the subjects in the experimental group were required to perform all exercises with 0.75-inch thick pipe insulation around the handles of their barbells and dumbbells (see Appendix C). The pipe insulation was cut into 6-inch long sections and increased the circumference of the barbell/dumbbell handle from 10 cm to 20 cm. Subjects in the experimental group were required to use new pipe insulation handles during each workout to eliminate compression as much as possible. Subjects were not permitted to resistance train outside the study protocol and train aerobically on interim days due to the intensive nature of the program. The use of weightlifting belts, straps, and other artificial training aids were not allowed during training. All training sessions were performed under the direct supervision of the researcher.

Testing Protocol

Subjects were pretested prior to training and posttested after the 6 week training period for all variables. Body weight was a simple notation of scale weight in kilograms for all subjects. Forearm circumference was measured in an attempt to gauge hypertrophy of the forearm musculature in centimeters. Subjects stood with the shoulder abducted at 90 degrees, elbow flexed at 90 degrees, and wrist flexed at 90 degrees and rotated at 180 degrees. At this fixed position, a soft tape measure was wrapped around the base of the forearm, where the forearm touched the bicep.

A hand dynamometer, a Lafayette Instrument Co. Model 78010, was used to measure grip strength to the nearest kilogram (2, 14, 19). The hand dynamometer width was calibrated at 11.5 cm in circumference in an attempt to match the 10 cm circumference of the standard handles of barbells and dumbbells. After a brief warm up, subjects performed 3 maximal grips of 2 second duration with each hand. Since all subjects were right handed, these 3 values were then computed into a mean grip score for both the dominant and nondominant hand. The data were collected with the elbow at 90 degrees flexion, shoulder at 0 degrees flexion, and wrist between 0 and 15 degrees of ulnar and radial deviation (19).

Chinups were used in this study to measure relative functional strength (10, 15). Chinups were performed with arms pronated and hands placed slightly more than shoulder width apart. A full repetition consisted of pulling the body from a straight arm hang until the chin cleared the bar. Subjects were not allowed to readjust their hands or use straps during the test and performed repetitions until failure. The chinup bar used for pre- and posttesting of both groups had a grip circumference of 10 cm, matching the circumference of the handle size of normal barbells and dumbbells used during control group training.

The bench press and deadlift were used in this study to determine changes in absolute strength. The bench press has been used in almost every training study as an excellent indicator of overall upper body strength (5, 8, 20). The deadlift has been used in several studies as an indicator of total body strength (1, 7, 11). Subjects performed a standard 1-RM bench press and deadlift pre- and posttraining. Barbells used in the bench press and deadlift 1-RM tests had a 10 cm handle circumference, matching that of standard resistance training. Weightlifting belts, straps, and other artificial aids were not allowed during testing in order to assess functional strength.

Statistical Analyses

Data were analyzed using the SPSS 8.0 (1997) statistical computer program. Pre- and posttraining group means were computed for all variables. A 2 X 7 factorial ANOVA with repeated measures was performed on differences between pre and posttest means to determine if significant changes occurred between the control and experimental groups as a result of the training protocol. Sheffe post-hoc analyses were used to test for within group differences. Alpha was set at 0.1 after a power analysis of the relevant literature.

RESULTS

Subject Characteristics

Twenty-two male subjects between the ages of 19 and 24 years participated as either the control or experimental group subjects. The mean age for the experimental group was 21.5 years, with 21.8 years the mean for the control group. There were 28 subjects at the beginning of the study. One subject experienced an ankle injury during a flag-football game, one experienced a wrist injury at work, one did not complete 85% of the required lifting sessions, one was a complete beginner at resistance training, and two stopped lifting because of "exercise-induced migraine headaches". All precluded further participation and were not used in data analysis.

Variable Results

Results of this study are presented in Table 1. All variables were measured before and after the 6 week training program. Descriptive statistics on physiological variables include body weight, forearm circumference, nondominant hand dynamometer readings, dominant hand dynamometer readings, chinup repetition maximum, 1-RM bench press, and 1-RM deadlift. These results may be viewed in graph form in Appendices D through J, respectively. Descriptive statistics for the amount of change in each of these variables are also included in Table 1.

All variables increased significantly ($p < 0.001$) in both groups over time, as a result of the training program. In this respect, both training methods produced significant

TABLE 1 Mean training results (N = 11 for both groups)

	Experimental			Control		
	Pre	Post	Difference	Pre	Post	Difference
Body Weight (kg)	84.7	86.7	2.0 *	83.8	84.7	0.9
SD	16.2	15.9		11.5	11.3	
Dominant arm Forearm Circ. (cm)	31.9	33.5	1.6	31.6	33.9	2.3 **
SD	2.3	2.6		2.6	2.6	
Non-Dominant Hand Dyn. (kg)	45.0	54.0	9.0*	44.0	50.0	6.0
SD	3.7	6.1		8.6	8.2	
Dominant Hand Dyn. (kg)	49.0	58.0	9.0	52.0	56.0	4.0
SD	6.1	6.8		8.9	10.6	
Chinups (reps)	9.0	14.0	5.0	7.0	10.0	3.0
SD	4.6	8.0		3.5	3.9	
Bench Press (kg)	109.1	117.7	8.6	111.8	117.7	5.9
SD	11.9	14.8		25.7	25.8	
Deadlift (kg)	141.8	161.8	20.0	129.5	153.6	24.1
SD	29.5	27.9		31.3	36.2	

*significant for experimental group
**significant for control group

improvements. The body weight and nondominant hand dynamometer variables reveal significant ($p < 0.1$) interaction in favor of the experimental group. Dominant hand dynamometer, chinup repetition max, and 1-RM bench press tests reveal nonsignificant improvements of the experimental group over the control group. Forearm circumference interaction was significant ($p < 0.1$) in favor of the control group. Maximal deadlift test showed nonsignificant gains for the control group over the experimental group.

DISCUSSION

The results of this study indicate some statistical significance, and a trend of practical significance, that demonstrate the efficacy of thick-bar training on forearm and functional strength. Nondominant hand dynamometer testing revealed that thick-bar training caused significant improvements in nondominant hand grip strength over the control group (see Appendix F). In dominant hand dynamometer tests, the experimental group more than doubled the amount of gain of the control group in dominant hand grip strength (see Appendix G). A similar trend was seen in chinups (see Appendix H) and bench press (see Appendix I). While these changes were not statistically significant, the results show a great deal of practical significance to thick-bar resistance training for grip strength and measures of upper body functional strength. As a whole, the results show that thick-bar training is an excellent method for increasing grip strength and other measures of upper body strength.

The deadlift tests revealed that thick-bar resistance training did not improve one group's deadlift performance significantly more than the other (see Appendix J). However, the training program was not designed towards leg strength and the experimental condition was put at a serious disadvantage in this regard. The training program was designed to challenge the forearms, even when training the legs. Thus, the training poundages of the experimental group were always limited to 60-80% of normal because of the increased handle circumference of their barbells and dumbbells. The experimental group's limiting factor was their forearms and grip strength; whereas the control group's limiting factor were their larger and more powerful quadriceps, hamstrings, and gluteus maximus and minimus. Over the entire training period, the ability of the control group to use greater poundages may have led to increased muscle breakdown, increased muscle resynthesis, and increased deadlift gain.

The hypertrophy data are also interesting in light of the preceding argument. The control group improved significantly ($p < 0.1$) over the experimental group in forearm circumference. However, bodyweight of the experimental group improved significantly ($p < 0.1$) over the control group. Thus, thick-bar training in order to attain greater hypertrophy gain remains debatable. Body weight was simply a notation of scale weight in this study. While the researcher is convinced the body weight gain was primarily muscle, there were no official body composition tests performed in this study. In addition, the method of assessing forearm hypertrophy was highly experimental. Therefore, the conclusion from the results is that thick-bar training may result in hypertrophy, but not necessarily greater hypertrophy than normal resistance training.

PRACTICAL APPLICATION

This investigation provides evidence that thick-bar training for athletes is an effective and valid method for increasing grip strength and other measures of upper body strength. Forearm circumference and body weight measurements show that thick-bar training may be as effective for hypertrophy as standard resistance training. In the deadlift, the control group improved more than the experimental group. While this appears to discount the efficacy of thick-bar training for increasing deadlift strength, the experimental group was limited by grip strength when training legs. This resulted in the experimental group using 60-80% of their normal leg training poundages because of the increased handle circumferences of their barbells and dumbbells. The gain disparity between groups was relatively small (24.1 kg for control, 20.0 kg for experimental). Thus, thick-bar resistance training was effective in improving deadlift strength as well, especially in consideration of the reduced training poundages used in this study.

This study provides evidence that thick-bar training is an effective method of resistance training. Results indicate that thick-bar training provides significantly better grip strength than normal resistance training as well as increased upper body strength. However, it should probably be used in conjunction with standard lower body resistance training to maximize results. At the very least, this investigation shows thick-bar training to be a viable and effective alternative to standard resistance training.

REFERENCES

1. BALE, P., E. COLLEY, J. MAYHEW, F. PIPER, AND J. WARE. Anthropometric and somatotype variables related to strength in American football players. *Journal of Sports Medicine and Physical Fitness.* 34:383-389, 1994.

2. BOHANNON, R. Upper extremity strength and strength relationships among young women. *Journal of Orthopaedic and Sports Physical Therapy.* 8:128-133, 1986.

3. BOMPA, T. *Periodization of Strength.* Toronto, ON: Veritas Publishing, 1993.

4. BROOKFIELD, J. *Mastery of Hand Strength.* Nevada City, CA: IronMind Enterprises, 1995.

5. FITZIMMONS, P., D. LANDERS, J. THOMAS, AND H. VANDERMARS. Does self-efficacy predict performance in experienced w^ightlifters? *Research Quarterly for Exercise and Sport.* 62:424-431, 1991.

6. FLECK, S. AND W. KRAEMER. *Designing Resistance Training Programs.* Champaign, IL: Human Kinetics, 1987.

7. GATER, D., D. GATER, J. URIBE, AND J. BUNT. Impact of nutritional supplements and resistance training on body composition, strength and insulin-like growth factor-1. *Journal of Applied Sport Science Research.* 6:66-76, 1992.

8. HUNTER, G., J. HILYER, AND M. FORSTER. Changes in fitness of intercollegiate basketball. *Journal of Strength and Conditioning Research.* 7:26-29, 1993.

9. KUBIK, B. *Dinosaur Training.* Louisville, KY: Brooks Kubik, 1996.

10. LEGG, S., A. MILLER, D. SLYFIELD, P. SMITH, C. GILBERD, H. WILCOX, AND C. TATE. Physical performance of elite New Zealand olympic class sailors. *Journal of Sports Medicine and Physical Fitness.* 37:41-49, 1997.

11. MAYHEW, J., T. McCORMICK, F. PIPER, A. KURTH, AND M. ARNOLD. Relationships of body dimensions to strength performance in novice adolescent male powerlifters. *Pediatric Exercise Science.* 5:347-356, 1993.

12. McCULLY, K., B. BODEN, M. TUCHLER, M. FOUNTAIN, AND B. CHANCE. Wrist flexor muscle of elite rowers measured with magnetic resonance spectroscopy. *Journal of Applied Physiology*. 67:926-932, 1989.

13. POLIQUIN, C. *The Poliquin Principles*. Napa, CA: Dayton Writers Group, 1997.

14. PUHARIC, T. AND R. BOHANNON. Measurement of forearm pronation and supination strength with a hand-held dynamometer. *Isokinetics and Exercise Science*. 3:202-206, 1993.

15. ROMMICH, J. AND J. FRAPPIER. Physiological determinants of wrestling success in high school athletes. *Pediatric Exercise Science*. 5: 134-144, 1993.

16. SCHOENLE, C., S. BOTH, AND H. RIECKERT. Factors determining performance during static grip exercise on a simulated windsurfer – Part II: maximal grip strength, calculated forearm strength, heart frequency, and blood. *Leistungssport*. 12:280-284, 1982.

17. SIFF, M. AND Y. VERKHOSHANSKY. *Supertraining: Strength Training for Sporting Excellence*. Johannesburg, South Africa: Univerisity of Witwatersrsand Press, 1998.

18. STRIZAK, A., G. GLEIM, A. SAPEGA, AND J. NICHOLAS. Hand and forearm strength and its relation to tennis. *American Journal of Sportsmedicine*. 11:234-239, 1983.

19. WALDO, B. Grip strength testing. *Journal of Strength and Conditioning*. 10:32-35, 1996.

20. WILLIFORD, H., J. KIRKPATRICK, M. SCHARFF-OLSON, D. BLESSING, AND N. WANG. Physical performance characteristics of successful high school football players. *American Journal of Sports Medicine*. 22:859-862, 1994.

21. YASUDA, Y. AND M. MIYAMURA. Cross transfer effects of muscular training blood flow in the ipsilateral and contralateral forearms. *European Journal of Applied Physiology and Occupational Physiology* 51:321-329, 1983.

APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT

"PRACTICAL FOREARM STRENGTH"

TRAINING STUDY

I, ____________________________, volunteer to participate in a six-week training study examining the effects of increased barbell/dumbbell circumferences on forearm/practical strength. I have been informed that participating in this study requires two maximal bench press and deadlift repetitions, four hand dynamometer tests, four maximum pull-up tests, and four hang-for-time tests. I have been informed that I will be required to follow a weight-training program for the duration of the study. I will lift three days per week (Monday, Wednesday, Friday) in the strength center located in Room 164 Mitchell Hall at the University of Wisconsin-La Crosse. I consider myself to be in good health, and to my knowledge I am not infected with a contagious disease nor have any limiting physical condition or disability which would preclude my participation in this study. I also have been informed of the risks involved with weight training and exercise. As with any training protocol, muscle soreness, cramping, and muscle strains/tears are all potential risks. In addition, the possibility of being injured through extraordinary circumstances exists with a resistance training program (broken bones, ligament damage, disc ruptures, stroke, heart failure, etc.).

I have attended an informational meeting on the positives and negatives of weight training, and in particular, training with implements of increased circumference. I have been fully informed of the risks involved in the training and testing. Any questions have been answered to my complete satisfaction. Therefore, I voluntarily consent to be a subject in this study. Furthermore, I know I may withdraw at any time without any type of penalty.

I consent to publication of the study results so long as the information remains anonymous so that no identification of the individual subjects can be made. I further understand that although a record will be kept of my having participated in the experiment, all experimental data collected from my participation will be referred to by number only.

Questions regarding the use of human subjects may be referred to Dr. Garth Tymeson, Chairman of the Institutional Review Board, at 785-8155. Concerns about any aspects of this study may be referred to Matt Kruger (507-895-6511), Dr. Travis Triplett-McBride (785-6546), or Dennis Kline (785-6533).

Signed: ______________________________ Date: ____________

Signed: ______________________________ Date: ____________

APPENDIX B

TRAINING PROGRAM

WEEKS 1 & 2

Monday	Exercise	Sets	Reps	Tempo	Rest
	Chinups (pronated)	4	8-10	301	120 s.
	Incline DB Bench	4	8-10	301	120 s.
	Bent-Over Rows	4	8-10	401	120 s.
	Flat Bench DB Flys	4	8-10	401	120 s.
	Cable Row	4	8-10	401	120 s.
	EZ-Bar Pullovers	4	8-10	401	120 s.
Wednesday					
	DB Squats	4	8-10	401	180 s.
	DB Lunges	4	8-10	301	120 s.
	Lying Leg Curl	4	8-10	401	120 s.
	Crunches	4	8-10	401	60 s.
	Low Back Ext.	4	8-10	401	60 s.
	Reverse Crunch	4	8-10	401	60 s.
Friday					
	Seated DB Press	4	8-10	401	120 s.
	DB Side Raises	4	8-10	301	120 s.
	Parallel Dips	4	8-10	401	120 s.
	Incline DB Curls	4	8-10	302	120 s.
	Lying DB Tri. Ext.	4	8-10	401	120 s.
	Zottman DB Curls	4	8-10	302	120 s.

WEEKS 3 & 4

Monday	Exercise	Sets	Reps	Tempo	Rest
	Chinups	3	5-7	901	90 sec.
	Incline DB Bench	3	5-7	505	90 sec.
	Barbell Rows	3	5-7	505	90 sec.
	Flat DB Flys	3	5-7	505	90 sec.
	Cable Row	3	5-7	505	90 sec.
	EZ-Bar Pullovers	3	5-7	505	90 sec.
Wednesday					
	DB Squats	3	5-7	505	90 sec.
	DB Lunges	3	5-7	505	90 sec.
	Leg Curl	3	5-7	802	90 sec.
	Crunches	3	5-7	505	60 sec.
	Low Back Ext.	3	5-7	505	60 sec.
	Reverse Crunches	3	5-7	505	60 sec.
Friday					
	Seated DB Press	3	5-7	505	90 sec.
	Side Raises	3	5-7	505	90 sec.
	Parallel Dips	3	5-7	901	90 sec.
	Incline Curls	3	5-7	505	90 sec.
	Lying DB Ext.	3	5-7	802	90 sec.
	Zottman DB Curls	3	5-7	505	90 sec.

WEEKS 5 & 6

Monday (4 min. rest between all sets)

Chinups	Set #1: Max reps	Bench Press	Set #1: 85% of max X 5
	Set #2: Max reps + 5 lbs.		Set #2: 90% of max X 3
	Set #3: Max reps + 10 lbs.		Set #3: 94% of max X 2
	Set #4: Max reps		Set #4: 97% of max X 2
	Set #5: Max reps + 2.5 lbs.		Set #5: 100% of max X 2
	Set #6: Max reps + 5 lbs.		

Wednesday (4 min. rest between all sets)

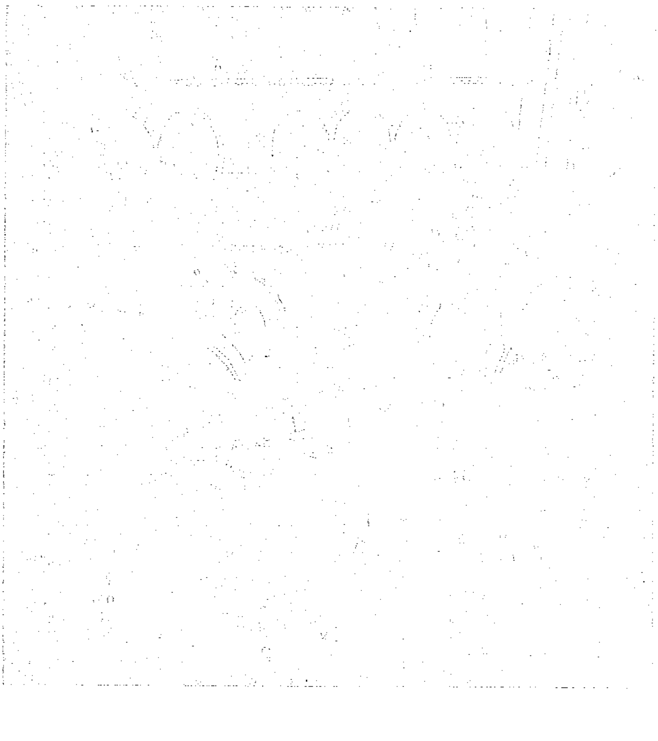
Deadlift	Set #1: 85% of max X 5	Lying Leg Curls	Set #1: 5 reps
	Set #2: 90% of max X 3		Set #2: 5 reps
	Set #3: 94% of max X 2		
	Set #4: 97% of max X 2		
	Set #5: 100% of max X 2		

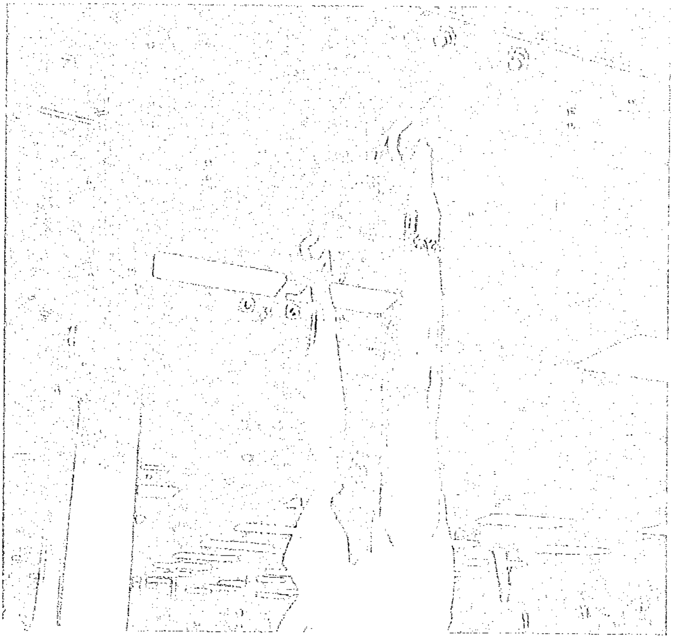
Friday

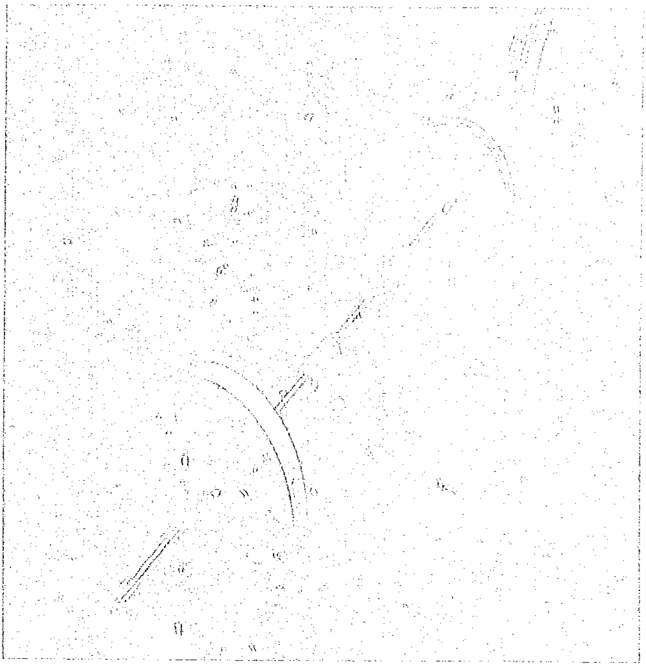
DB Shoulder Press	4 sets	2-4 reps	20X tempo	4 min.
Lying EZ Bar Tri. Ext.	4	2-4	20X	4 min.
Standing DB Curls	4	2-4	20X	4 min.

APPENDIX C

PICTURES OF RESEARCH PROTOCOL

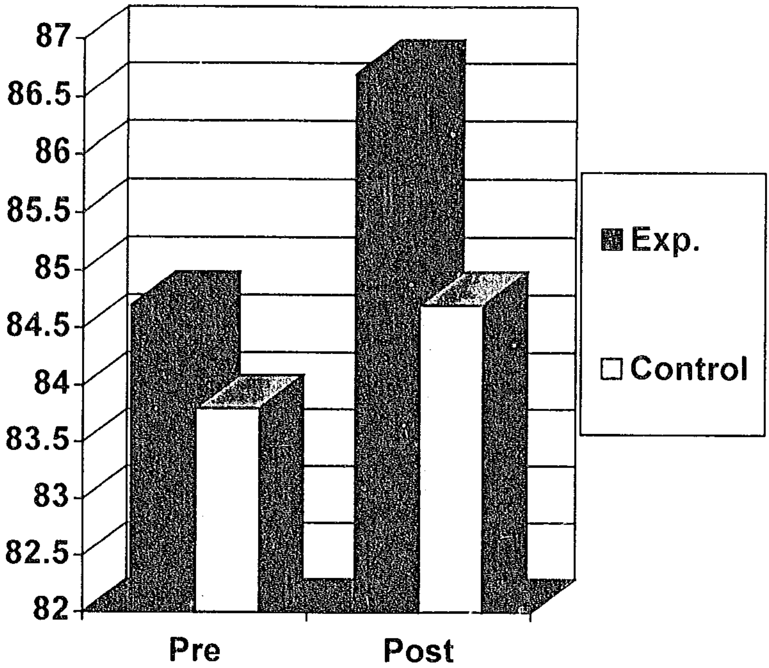






APPENDIX D

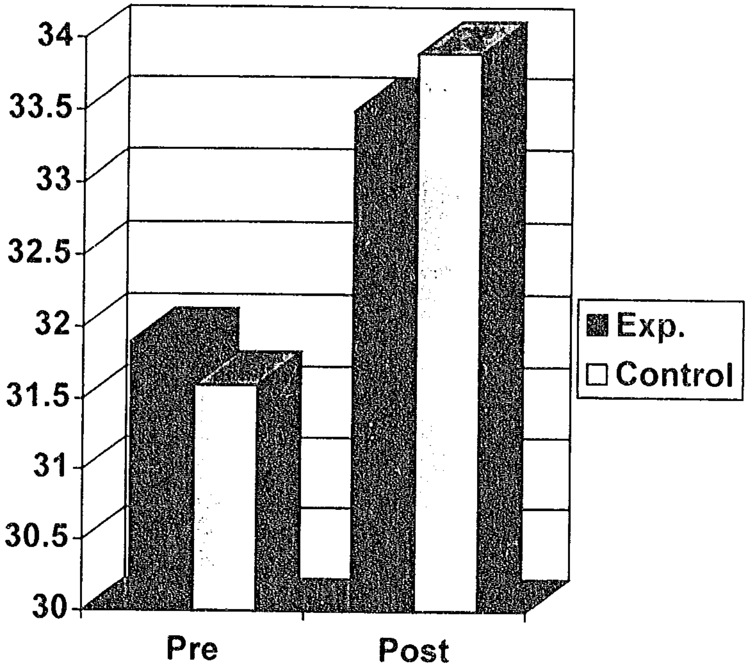
GRAPH OF BODYWEIGHT RESULTS



Mean bodyweight differences following 6 weeks of training.

APPENDIX E

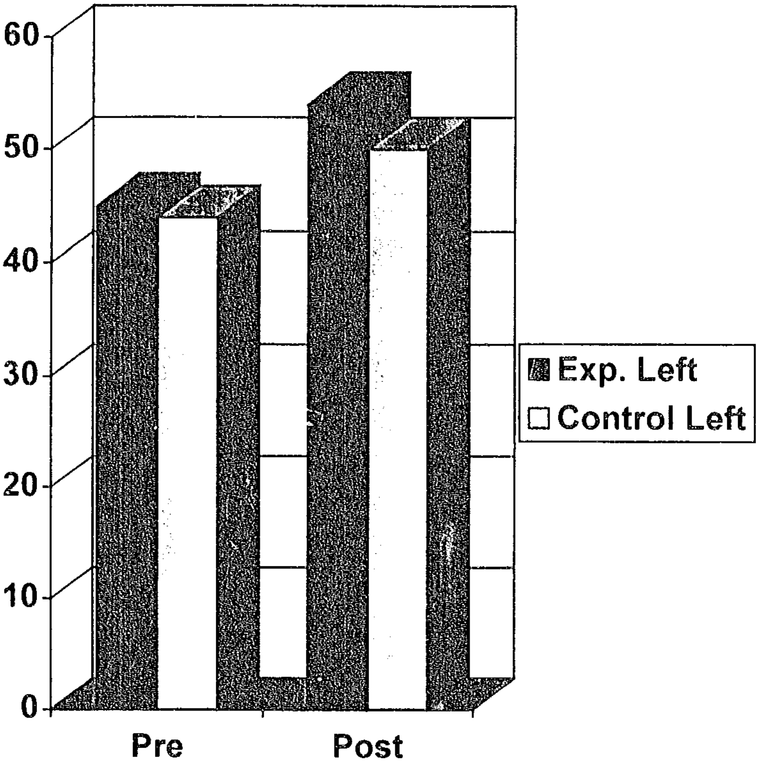
GRAPH OF FOREARM CIRCUMFERENCE RESULTS



Mean forearm circumference differences following 6 weeks of training.

APPENDIX F

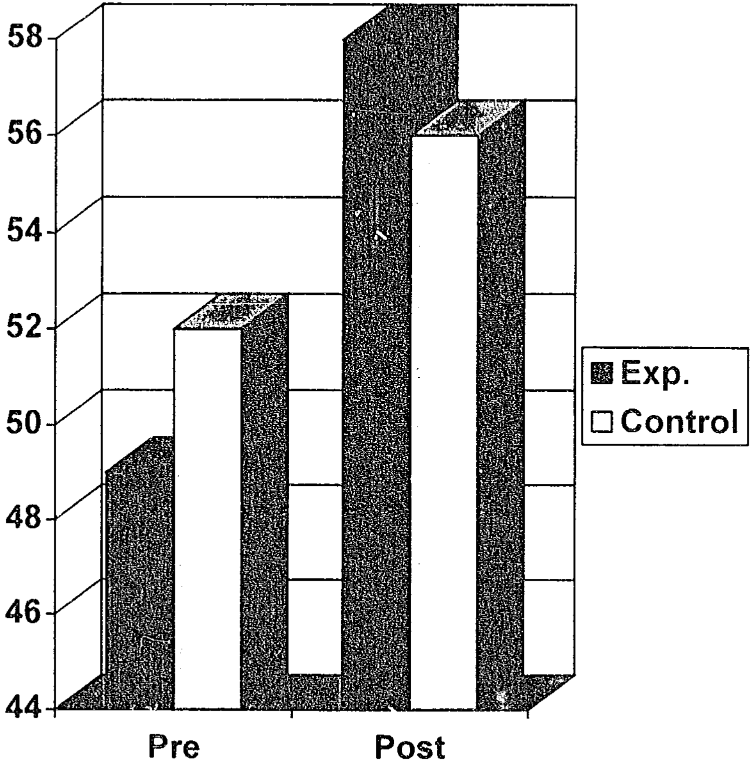
GRAPH OF NONDOMINANT HAND DYNAMOMETER RESULTS



Mean differences in nondominant hand dynamometer following 6 weeks of training.

APPENDIX G

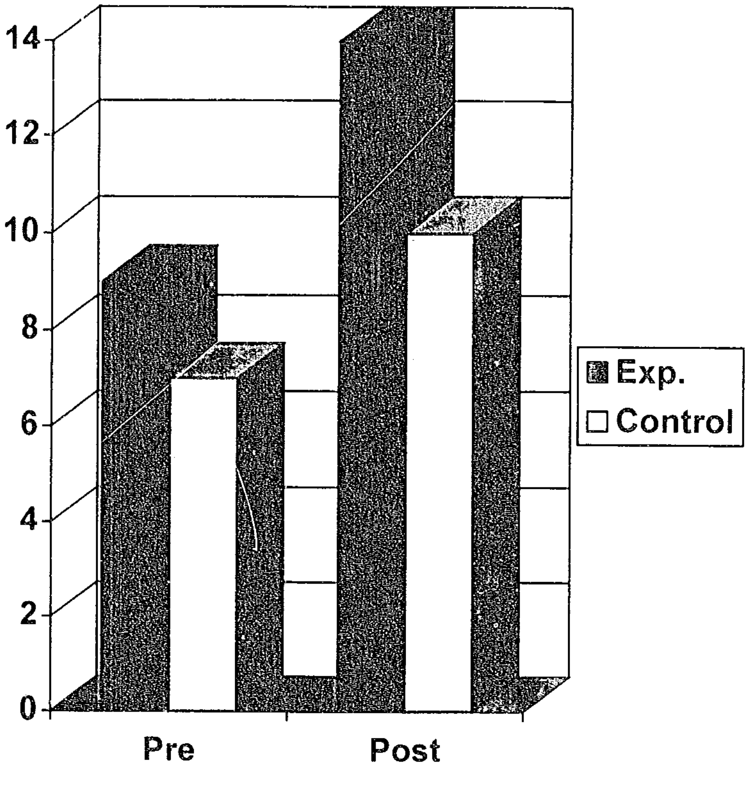
GRAPH OF DOMINANT HAND DYNAMOMETER RESULTS



Mean differences in dominant hand dynamometer results following 6 weeks of training.

APPENDIX H

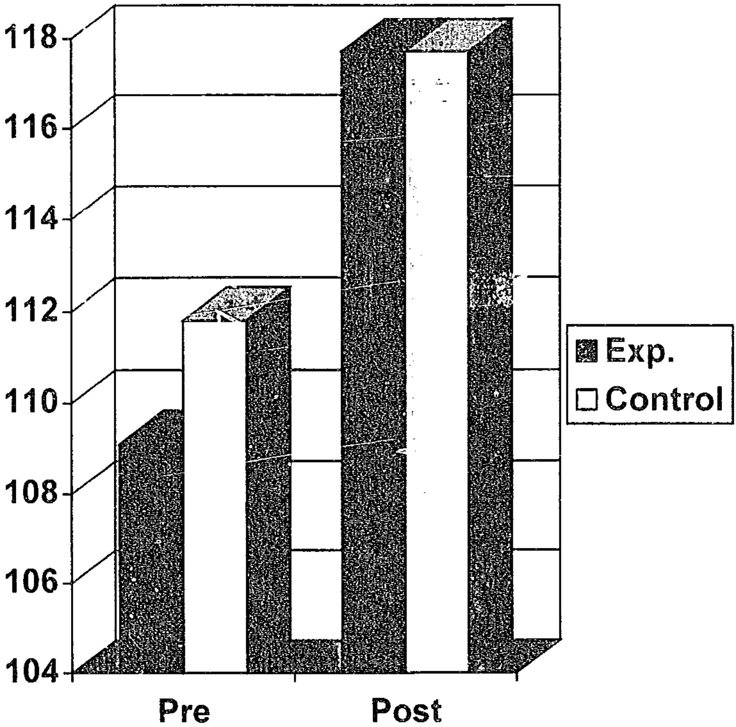
GRAPH OF CHINUP RESULTS



Mean differences in chinups following 6 weeks of training.

APPENDIX I

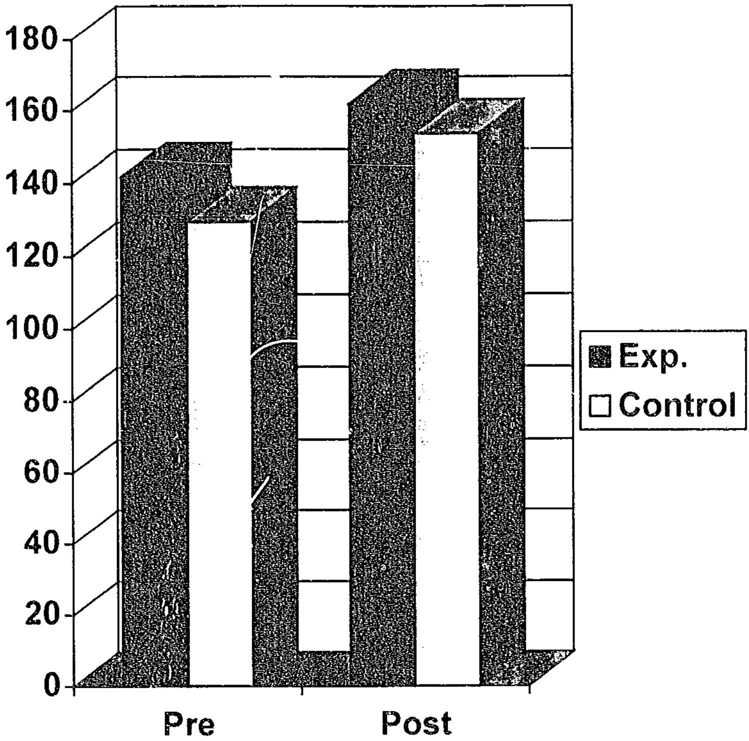
GRAPH OF BENCH PRESS RESULTS



Mean differences in 1-RM bench press (kg) following 6 weeks of training.

APPENDIX J

GRAPH OF DEADLIFT RESULTS



Mean differences in 1-RM deadlift (kg) following 6 weeks of training.

APPENDIX K

REVIEW OF RELATED LITERATURE

REVIEW OF RELATED LITERATURE

Introduction

The following review of related literature discusses the relevant information and research behind forearm strength, grip strength, and resistance training protocols. This study is the first to combine information from these three areas. Research from each area is necessary to justify the inclusion of various aspects in this study.

Forearm Anatomy

A detailed discussion of forearm anatomy is required to understand how the forearm muscles were trained during this program. The primary extrinsic muscles of the forearm include the biceps brachialis and brachioradialis which serve to flex the forearm (19). The anconeus opposes this flexion (19). The brachialis, brachioradialis, and anconeus were the three major forearm muscles trained through dynamic resistance training. While the program consisted of isotonic exercises, the other extrinsic muscles were trained isometrically because no specific wrist flexion/extension or abduction/adduction exercises were performed. The extrinsic muscles were trained through the flexor mechanism of the hand and through stabilization of other movements (38). These extrinsic muscles include the flexor carpi ulnaris, flexor carpi radialis, palmaris longus, extensor carpi radialis, extensor carpi ulnaris, pronator teres, supinator, and pronator quadratus (19). An argument could be made that the pronator teres, pronator quadratus, and supinator were trained isotonically, but the pronation/supination action of Zottman curls occurs in conjunction with forearm flexion/extension. Many intrinsic muscles of the hand and fingers were also trained isometrically during this study. These muscles include the flexor digitorum profundus and superficialis, flexor pollicus longus and brevis, abductor pollicus brevis, and flexor digiti minimi just to name a few (19). These muscles, and many others, were required to grasp the barbells/dumbells during training. Therefore, they affected the outcome of all tests and measurements in this study.

Grip/Forearm Strength Research

While never studied in a resistance training format, grip and/or forearm strength have been evaluated for a variety of other reasons. There is evidence of using grip/forearm strength as a valid measure of fitness. Pitetti, Fernandez, Pizarro, and Stubbs (29) measured forearm strength by a hand isometric dynamometer in an attempt to determine the fitness status of individuals with mental retardation. Maximal grip strength, calculated forearm strength, and other variables were examined in determining successful performance on a simulated windsurfing static grip exercise (33). The training status of elite rowers was examined by forearm strength and mitochondrial density of the forearms as determined by magnetic resonance spectroscopy during various rowing exercises (22). Adams, Bangerter, and Roundy (1) placed subjects on a 12 week strength training program, with one group performing additional wrist and finger flexion, in an attempt to improve baseball throwing velocity. Results from this study (1) were inconclusive, stating that the effects of strengthening the wrist and finger flexors and baseball throwing velocity remain to be established.

Forearm strength is a popular topic in tennis related articles. Holland (12) found that forearm strength is essential in protection from lateral epicondylitis, or tennis elbow. Strizak and colleagues (35) found that dominant arm forearm strength was much greater than the nondominant arm, which was thought to be an adaptation to prevent tennis elbow. Overload of the wrist and finger extensor muscles is proposed to be the mechanism behind lateral epicondylitis (34).

Forearm/grip strength has been recognized as essential to sporting performance by various authors. While none of these articles recommend training with barbells and dumbbells of increased handle circumference, they usually make other recommendations for forearm training or functional strength. The sports that have recognized the potential of grip strength and/or functional strength in sport are football (16), Australian football (17), ice hockey (11), golf (27), and gymnastics (28). In addition, functional strength training has also been addressed in the rehabilitation process of athletes (23).

The most relevant study was authored by Yasuda and Miyamura (40). These Japanese researchers trained subjects for maximum grip strength on an isometric hand dynamometer for 6 weeks and found that grip strength, endurance, and peak blood flow increased significantly in both the right and left arms. The importance of this study is that it shows significant changes in grip strength can occur in 6 weeks or less.

Brooks Kubik (14) outlined the efficacy of "thick bar training" and the importance of grip strength and functional strength in his text Dinosaur Training. Kubik theorizes that training with barbells/dumbells of increased circumference imposes greater stress on tendons and ligaments, creates better focus, and dramatically improves grip strength. While this text contains the most information about this type of training, it is typical of many strength texts. It does not rely on scientific studies. It relies on the evidence of the massive strength of the old time strongmen, whose feats of enormous strength were supposedly built by using this method of training. Currently, there is a great deal of anecdotal evidence, but no scientific evidence, to back up his theories.

Forearm strength, finger flexor strength, and similar constructs have been examined with magnetic resonance imaging, isometric training, motor learning activities, and in routines outlined in popular bodybuilding magazines. These studies and/or articles are not mentioned here. It would be difficult to draw lines of comparison between the aforementioned studies/articles and an applied strength and conditioning study such as this. This study focuses on dynamic resistance training, practical strength, and their relationship to barbells and dumbbells of increased circumference.

Resistance Training Program Research

The resistance training program used in this study was somewhat unconventional, aggressive, and designed to challenge forearm/grip strength. The following sections will attempt to explain and/or justify the inclusion of certain parts of the resistance training program.

Program Length

A 6 week training period was chosen for a variety of factors. First, 6 weeks is the longest uninterrupted period of time that students encounter in a university setting. Unsupervised training over holidays and vacations would compromise the quality of results and legitimacy of the program. Second, numerous other authors have used 6 week training programs in peer-reviewed studies. In a closely related study, Yasuda and Miyamura (40) trained the right forearms of subjects on an isometric hand dynamometer for 6 weeks. This study is important because it examined the effects of 6 weeks of training on grip strength. Other studies with 6 week durations have focused on hamstring strength/agility (6), time to fatigue (3), vertical jump height (36), and cycling performance (18). Third, 6 week resistance training programs have been shown to ensure maximal progress. The human body is incredibly adept at adapting to training regimes. Recognized strength experts such as Poliquin (30), Zatsiorsky (41), and Fleck and Kraemer (9) all endorse periodized training in which resistance training programs change dramatically every 6 weeks or less.

Program Frequency

A 3 day per week frequency was chosen for numerous reasons. The most obvious is the feasibility for both subjects and the author. Second, resistance programs that train 3 days per week are fairly typical and commonplace. While the subjects in the study trained 3 days per week, each body part was only trained once per week because of the split programming. Frequency is dependent on recovery, muscle groups trained, exercises performed, and various other factors (30). Research has shown that maximum strength in a particular exercise is achieved 5 to 9 days post-workout (7). Due to the aggressive nature of the program, the subjects needed a full week for a body part to recover.

Volume/Intensity Manipulations

Initially, the resistance training program used in this study was high volume (24 sets per workout) with low intensity (8-10 reps per set). After the first 2 weeks, volume decreased (18 sets per workout) and intensity rose (5-7 reps per set), but the tempo of each lift was slowed down. As a result, volume remained high. In addition to counting sets, volume can be measured as the amount of time under tension during a workout. Thus, while the number of sets dropped, workout volume remained high because the lifting tempo of each set was slowed to adjust the total time-under-tension. During the last 2 weeks of training, the program switched to low volume (10 sets per workout) and high intensity (1-5 reps per set). The tempo of the lifts was largely ignored in the last 2 weeks as the focus shifted to maximum strength. This type of high volume to high intensity programming is used in nearly all periodization texts, including Poliquin (30), Zatsiorksky (41), and Fleck and Kraemer (9).

Strength Testing Research

Hand dynamometry has been established as a valid measure for measuring hand strength. Waldo (38) outlined the effectiveness of hand dynamometer testing on athletics and rehabilitation. In other studies, reliability and validity of hand dynamometer testing has been established in rotator cuff rehabilitation (20), forearm pronation/supination strength (31), and upper extremity strength relationships (4). Hand dynamometer testing was used in this study to measure changes in grip strength and followed recommended protocol set by Waldo (38).

Chinups were used to measure changes in relative strength (i.e., strength dependent on bodyweight). Chinups have been established as a legitimate test of relative strength in numerous studies ranging from Olympic class sailors (15) to physical fitness norms in youth (24). Clark (5) used chinups to measure functional muscular strength in young adult females. Chinups were found to be a major determinant of wrestling success in high school athletes (32). In many sports where grip strength and relative strength are essential for success, chinups are a valid measurement of functional strength and successful performance.

One RM bench press and deadlift were used as indices of absolute strength. One RM bench press has been measured in EMG studies (25), biomechanical analysis of joint angles (26), and feedback efficacy (37). In related studies, one RM bench press has measured absolute upper body strength in high school football players (39), college basketball players (13), and experienced weightlifters (8). These are a few examples of the common practice of using a single RM bench press as a measure of absolute upper body strength. The one RM deadlift measured absolute total body strength because hamstrings, gluteus maximus & minimus, erector spinae, trapezius, latissimus dorsi, and many other muscles are needed to complete the lift. Two examples of published studies using the one RM deadlift to measure absolute strength are American football players (2) and adolescent powerlifters (21). One RM deadlifts have also been used in collegiate studies (10) as an index of absolute strength.

Summary

In the American literature, there has never been a resistance training study evaluating methods of improving grip strength by using barbells and dumbbells of different grip circumferences. While grip and functional strength have been recognized and looked at in a variety of ways, the strength and conditioning field has largely ignored methodology for improving grip/forearm strength. However, there is evidence for significant increases in forearm strength in 6 weeks or less. The resistance program for this study was written on solid theoretical foundation with the intent of producing significant results. However, the efficacy of training with increased barbell/dumbbell grip circumference can only be established through valid scientific research.

REFERENCES

1. ADAMS, T., B. BANGERTER, AND E. ROUNDY. Effect of toe and wrist/finger flexor strength training on athletic performance. *Journal of Applied Sport Science Research*. 2:31-34, 1988.

2. BALE, P., E. COLLEY, J. MAYHEW, F. PIPER, AND J. WARE. Athropometric and somatotype variables related to strength in American football players. *Journal of Sports Medicine and Physical Fitness*. 34:383-389, 1994.

3. BISHOP, D. AND D. JENKINS. The influence of resistance training on the critical power function and time to fatigue at critical power. *Australian Journal of Science and Medicine in Sport*. 28:101-105, 1996.

4. BOHANNON, R. Upper extremity strength and strength relationships among young women. *Journal of Orthopaedic and Sports Physical Therapy*. 8:128-133, 1986.

5. CLARK, T. *The relationship between physical self-perceptions and functional muscular strength in young adult females*. Unpublished master's thesis, University of Wisconsin-La Crosse, La Crosse, WI, 1996.

6. CLARKE, R. *Effects of a six week slideboard training program as part of a preseason conditioning program on hamstrings strength and agility*. Unpublished master's thesis, University of Oregon, Eugene, OR, 1997.

7. COLGAN, M. *Optimum Sports Nutrition*. Ronkonkoma, NY: Advanced Research Press, 1993.

8. FITZIMMONS, P., D. LANDERS, J. THOMAS, AND H. VANDERMARS. Does self-efficacy predict performance in experienced weightlifters? *Research Quarterly for Exercise and Sport*. 62:424-431, 1991.

9. FLECK, S. AND W. KRAEMER. *Designing resistance training programs*. Champaign, IL: Human Kinetics, 1987.

10. GATER, D., D. GATER, J. URIBE, AND J. BUNT. Impact of nutritional supplements and resistance training on body composition, strength and insulin-like growth factor-1. *Journal of Applied Sport Science Research*. 6:66-76, 1992.

11. HERMISTON, R. Functional strength and skill development of young ice hockey players. *Journal of Sports Medicine and Physical Fitness*. 15:52-256, 1975.

12. HOLLAND, D. *Effects of forearm strength on lateral epicondylitis*. Unpublished master's thesis, Indiana State University, Evanston, IL, 1979.

13. HUNTER, G., J. HILYER, AND M. FORSTER. Changes in fitness of intercollegiate basketball. *Journal of Strength and Conditioning Research*. 7:26-29, 1993.

14. KUBIK, B. *Dinosaur training*. Louisville, KY: Brooks Kubik, 1996.

15. LEGG, S., A. MILLER, D. SLYFIELD, P. SMITH, C. GILBERD, H. WILCOX, AND C. TATE. Physical perfcımance of elite New Zealand olympic class sailors. *Journal of Sports Medicine and Physical Fitness*. 37:41-49, 1997.

16. LEISTNER, K. Hand and forearm training for football. *Athletic Journal*. 67:38-39, 1986.

17. MARTIN, I. Functional strength for football. *Coaching Update*. 9:18-19, 1996.

18. MARTIN, D., SCIFRES, J., ZIMMERMAN, S., AND J. WILKINSON. Effects of interval training and a taper on cycling performance and isokinetic leg strength. *International Journal of Sports Medicine*. 15:485-491, 1994.

19. MARTINI, F. AND M. TIMMONS. *Human Anatomy*. Englewood Cliffs, NJ: Prentice Hall, 1995.

20. MAY, L., R. BURNHAM, AND R. STEWARD. Assessment of isokinetic and hand-held dynamometer measures of shoulder rotator strength among individuals with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*. 78: 251-255, 1997.

21. MAYHEW, J., T. McCORMICK, F. PIPER, A. KURTH, AND M. ARNOLD. Relationships of body dimensions to strength performance in novice adolescent male powerlifters. *Pediatric Exercise Science*. 5:347-356, 1993.

22. McCULLY, K., B. BODEN, M. TUCHLER, M. FOUNTAIN, AND B. CHANCE. Wrist flexor muscle of elite rowers measured with magnetic resonance spectroscopy. *Journal of Applied Physiology*. 67:926-932, 1989.

23. McEVOY, K., B. RAWSON, AND P. RIDLEY. The role of functional strength training in the rehabilitation process of athletes. *Sport Health*. 11:16-19, 1993.

24. MEKOTA, K. AND R. KOVAR. *UNIFITTEST (6-60): Tests and Norms of Motor Performance and Physical Fitness in Youth and in Adult Age.* Olomouc, CZ: Palacky University, 1995.

25. MURPHY, A. AND G. WILSON. The assessment of human dynamic muscular function: a comparison of isoinertial and isokinetic tests. *Journal of Sports Medicine and Physical Fitness.* 36:169-177, 1996.

26. MURPHY, A., G. WILSON, J. PRYOR, AND R. NEWTON. Isometric assessment of muscular function: the effect of joint angle. *Journal of Applied Biomechanics.* 11:205-215, 1995.

27. MURRAY, P. AND W. COONEY. Golf-induced injuries of the wrist. *Clinics in Sports Medicine.* 15:85-109, 1996.

28. NEAL, R., V. KIPPERS, D. PLOOY, AND M. FORWOOD. The influence of hand guards on forces and muscle activity during giant swings on the high bar. *Medicine and Science in Sports and Exercise.* 27:1550-1556, 1995.

29. PITETTI, K., J. FERNANDEZ, D. PIZARRO, AND N. STUBBS. Field testing asessing the physical fitness of mildly mentally retarded individuals. *Adapted Physical Activity Quarterly.* 5:318-331, 1988.

30. POLIQUIN, C. *The Poliquin Principles.* Napa, CA: Dayton Writers Group, 1997.

31. PUHARIC, T. AND R. BOHANNON. Measurement of forearm pronation and supination strength with a hand-held dynamometer. *Isokinetics and Exercise Science.* 3:202-206, 1993.

32. ROEMMICH, J. AND J. FRAPPIER. Physiological determinants of wrestling success in high school athletes. *Pediatric Exercise Science.* 5:134-144, 1993.

33. SCHOENLE, C., S. BOTH, AND H. RIECKERT. Factors determining performance during static grip exercise on a simulated windsurfer – Part II: maximal grip strength, calculated forearm strength, heart frequency, and blood. *Leistungssport.* 12:280-284, 1982.

34. SNIJDERS, C., A. VOLKERS, K. MECHELESE, AND A. VLEEMING. Provocation of epicondylalgia lateralis (tennis elbow) by power grip or pinching. *Medicine and Science in Sports and Exercise.* 19:518-523, 1987.

35. STRIZAK, A., G. GLEIM, A. SAPEGA, AND J. NICHOLAS. Hand and forearm strength and its relation to tennis. *American Journal of Sportsmedicine*. 11:234-239, 1983.

36. TIMMONS, S. *Increasing vertical jump: a comparison between two training programs*. Unpublished master's thesis, Ball State University, Muncie, IN, 1996.

37. VONGJATURAPAT, N. *Effect of false positive and false negative feedback on self-efficacy and performance of low and high self-esteem experienced weightlifters*. Unpublished doctoral thesis, Oregon State University, Corvallis, OR, 1994.

38. WALDO, B. Grip strength testing. *Journal of Strength and Conditioning*. 10:32–35, 1996.

39. WILLIFORD, H., J. KIRKPATRICK, M. SCHARFF-OLSON, D. BLESSING, AND N. WANG. Physical and performance characteristics of successful high school football players. *American Journal of Sports Medicine*. 2_:859-862, 1994.

40. YASUDA, Y. AND M. MIYAMURA. Cross transfer effects of muscular training blood flow in the ipsilateral and contralateral forearms. *European Journal of Applied Physiology and Occupational Physiology*. 51:321-329, 1983.

41. ZATSIORSKY, V. *Science and Practice of Strength Training*. Champaign, IL: Human Kinetics, 1995.