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THE EFFECTS OF A GRIP STRENGTH DEVELOPMENT
PROGRAM ON THE ACCURACY OF THE
APPROACH SHOT IN GOLF

Thesis for the Degree of M. A.
MICHIGAN STATE UNIVERSITY
RICHARD C. CADIGAN
1968



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THE EFFECTS OF A GRIP STRENGTH DEVELOPMENT
PROGRAM ON THE ACCURACY OF THE
APPROACH SHOT IN GOLF

By

Richard C. Cadigan

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Health, Physical Education
and Recreation

1968

ABSTRACT

THE EFFECTS OF A GRIP STRENGTH DEVELOPMENT PROGRAM ON THE ACCURACY OF THE APPROACH SHOT IN GOLF

by Richard C. Cadigan

Statement of the Problem

To investigate the effect of a grip strength development program on the accuracy of the approach shot as used in golf.

Methodology

Eighteen male members of an intermediate golf class held at Michigan State University during the spring term of 1968 were used as subjects. All subjects were given a pre-test of grip strength as measured by the hand dynamometer and approach shot accuracy as measured by the number of balls, out of a possible twenty, landing in a prescribed target area from a distance of one hundred yards. Using the accuracy score, they were matched in two groups that were as close to being equal on accuracy as could be expected.

The two groups consisted of a control and an experimental group. The experimental group received the same instruction as did the control group but also participated in a grip strength development program.

The program was conducted for four weeks and consisted of progressive resistance exercises employing varied sets and repetitions. At the conclusion of the pre-arranged training program, the subjects were tested in the same manner as the pre-test.

Student's t tests were used to process the data which was then analyzed.

Conclusions

1. The grip strength development program significantly improved the grip strength of the subjects.

2. The grip strength development program did not significantly improve the accuracy of the approach shot as used in golf.

Approved Randolph W. Webster

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DEDICATION

This thesis is respectfully dedicated
to my wonderful parents

Mr. and Mrs. Thomas F. Cadigan

my beloved fiancée

Mary Elaine

and

"Tommy"

ACKNOWLEDGMENT

The writer wishes to extend his thankful appreciation to Dr. Randolph W. Webster for his advice and assistance during the course of this study and for his guidance and cooperation during the author's year at Michigan State University.

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R.C.C.

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CHAPTER I

INTRODUCTION

It has been shown in past studies that there is a positive relationship between general strength and athletic ability, and, likewise, it is generally accepted by coaches and physical educators that grip strength is a valid indication of general strength. In agreement with those statements is the belief that strength is an important factor in playing golf and that an effort should be made to develop the musculature of the body which is needed to play competently. These three concepts along with recognizing the grip as the most important fundamental of golf have prompted this study.

Interpretation of the Problem

Beginning golfers are said to have difficulty in mastering the vardon or overlap grip in golf. The major problem has been attributed to the lack of strength in the forearm, wrist and finger regions. For this reason golfers are often times reluctant to use the overlap grip. But no matter what grip is used there is a certain degree of "grip strength" needed to insure effective use of that grip.

It is the belief of the writer that by increasing his "grip strength" a golfer will have better control of his

golf club and will be more able to master the overlap grip. The ultimate objective is to improve upon the person's entire golf game.

Statement of the Problem

The problem of this study was to investigate the effect of a grip strength development program on the accuracy of the approach shot as used in golf.

Purpose of the Study

The purpose of this study was to determine if it were possible to improve upon the accuracy of the approach shot in golf through a grip strength development program, the purpose of which it was to increase the strength of the forearm, wrist, and fingers. The study was also intended to investigate the relationship between grip strength improvement and accuracy improvement.

Need of the Study

The game of golf has long been searching for a unique approach or procedure that would provide greater insurance of ones success in the sport and produce a more satisfying experience for the golfer. If this hypothesis were true, if accuracy could be improved by increasing "grip strength," then all golfers, physical educators, and golf coaches would be able to use a grip strength development program to their advantage.

The beginning golfer would more easily master the skill of correctly gripping the golf club while the intermediate golfer could improve upon his accuracy by increasing his "grip strength." The physical educator could produce a greater skill level and increase interest through his golf unit if he first prepared his students with a grip strength development program. In much the same manner a golf coach could improve the performance of his team.

Nothing can be more frustrating and dissatisfying than to have an interest suppressed by continuous failure. This has quite often been the case with novice golfers and perhaps can be avoided.

Limitations of the Study

This study was limited to:

1. Eighteen male members of an Instructional Physical Education class in intermediate golf held during the spring term of 1968 at Michigan State University.
2. The data which was collected on March 28 and April 25.
3. The grip strength measured on the subjects' dominant hand by the hand dynamometer.
4. The approach shot accuracy measured by a pre-determined and marked target area.
5. The lack of control of the training program.
6. The limited length of the training program.

Definition of Terms

1. Approach Shot: A stroke to the putting green. Reference to it in this paper was to indicate a shot of one hundred yards from the center of the target area to the teeing area.

2. Grip: The technique used to hold the golf club while hitting the ball.

3. Grip Strength: The degree of strength that can be exerted by the forearm, wrist and fingers as measured by a hand dynamometer.

4. Accuracy: Consisted of the subjects' ability to land the ball in a prescribed target area from a distance of one hundred yards.

5. Vardon Grip or Overlapping Grip: It consists of the grip end of the golf club crossing diagonally from the fingers of the left hand through the palm to the heel of the left hand. The V's formed by the thumb and index finger of each hand point approximately toward the right shoulder. The small finger of the right hand is then placed between the index finger and the middle finger of the left hand.

6. Interlocking Grip: Same as the overlapping grip only the index finger of the left hand is interlocked with the little finger of the right hand.

7. Baseball or Spread Grip: The thumb and all the fingers of both hands are wrapped around the club end of the golf club with none of the fingers or thumbs overlapping or interlocking.

CHAPTER II

REVIEW OF RELATED LITERATURE

Golfers have long known the importance of the grip in golf as being "the basis of the swing" and realize that it "must be mastered before proceeding" to any other aspect of the game (11:163). Tommy Armour in discussing the grip mentions that one of the first things which determines how well an individual is going to play is the way in which the golf club is held. He states that "the hands must be fitted compactly together to coordinate the essential factors of left hand control and right hand power" (4).

The golf grip forms a basis upon which the many other phases of the game are built. The swing, for example, is highly dependent upon the way the club is gripped. According to Armour, "the correct grip is the first basic skill of a sound swing" (4). He is backed up by Reese who believes that to establish a strong swing one must start with a strong grip and that the most important feature of the grip is that it enables the golfer to hit the ball with maximum power at impact (53:118). Because the grip determines the swing it will also determine to some extent how the ball is hit. Crogen contends that most professional golfers and teachers of golf agree that a correct grip is essential in

order to learn the complete game of golf. She states, ". . . of all fundamentals, perhaps, the grip is most important. How the club is held determines to a great extent how squarely the ball will be hit" (21:11).

Although it has been established that the "correct grip" is essential in golf there does not seem to be agreement as to which method is superior. Perhaps the most popular grip is the overlapping grip which according to Crogen is preferred by most golf professionals, professional golfers and good amateur golfers since ". . . it promotes powerful wrist action" (21:11). In his book, Fundamentals of Golf, Finsterwald advocates the overlapping grip as the "surest way of acquiring genuine coordination of the two hands while offering a minimum of difficulty in learning the rudiments" (27:20). A study was done by Stallard at the University of Washington which compared the overlapping grip and the baseball (ten-finger) grip in regards to power and accuracy for college women beginning golfers. She found that although there was a difference in the results which favored the overlapping grip, this difference was not statistically significant. She concluded ". . . it appears that using the overlapping grip was more effective in increasing power and accuracy than was the ten finger grip" (58).

The biggest drawback in using the overlapping grip seems to be the amount of strength needed to coordinate

the technique and provide proper control over the club. Bunn felt that unless an individual had terrific wrist power, the overlapping grip should not be used. He was referring to women and young beginning golfers in particular and felt they lacked sufficient strength in the wrists and ". . . lose needed power by shortening the force arm when using the overlap grip" (15:230).

Other studies by Dana, at the University of Iowa, and Alderman, at the University of British Columbia, found no significant differences with either the overlapping, interlocking or spread grip (23, 1). It should be noted, however, that the spread grip appeared superior for accuracy in teaching the golf swing to beginners in the latter study. The author feels that the most extensive study was done by Walker at Springfield College. Again the results showed that there was no statistically significant difference in the distance or accuracy of the golf drive when using the three most favored golf grips. He concluded that there was no grip superior in either distance or accuracy and therefore no reason why one golf grip should be taught over another. Selection of a golf grip, he believes, should be based on individual preference and best results (64).

These individual preferences may be due to physical characteristics such as small hands or short fingers in which case Finsterwald recommended they use either the interlocking or baseball grip in order to enable them to

have their hands closer together so that the hands will work as a unit (26).

There is no way to measure the psychological aspect involved in the preference of one grip over another. Perhaps a person has had continued success with one grip and does not wish to experiment with another. In many cases the opposite is true and an unfavorable experience resulted in the individual not using that grip again. The author feels that the most common reason for using one particular grip all of the time is that the person has been advised to do so from someone whose opinion is respected or is imitating a favorite professional.

Arnold Palmer, who is considered to be the foremost authority on golf today, in his book Palmer on Power, treats the grip as something that depends on the individual but should also be experimented on. He believes ". . . it doesn't make much difference which [grip] is employed. Any of these grips, if used right, is as good as the other" (46). By experimenting he means the feel and comfort as well as the actual results. This is especially true of the beginner who Nelson believes must learn to have a "firm grip without tenseness" (43:20). A conclusion as to which grip was more effective was best summed up by Boros in his article "Getting the Most from Your Hands" in which he states, ". . . actually there is no 'one' proper way to grip the club--there are many" (10:21).

The use of strength tests as indicators of athletic or motor ability is by no means new. McCloy (37), in a 1934 article quotes from Jay W. Scavers as follows:

The Intercollegiate Strength Test was introduced into eastern colleges about 1880 and was used in many institutions for the purpose of determining whether or not a student was fit for participation in major sports. The test consisted of the strengths of the right and left grip, the back lift, the leg lift (56)

McCloy also states in his book Tests and Measurements in Health and Physical Education, ". . . strength is the most important element in motor performance" (38:27).

Hutto conducted an extensive study in which he investigated six previously done studies which used factor analysis to determine tests of motor abilities, and he mentions that each study found strength to be a common factor (31). In Hutto's study the first common factor was found to be general strength and the fifth common factor was arm or shoulder strength. Shay, at Syracuse University, found that success in learning the upstart movement on the horizontal bar was related to strength and fitness (57).

Through studies such as the ones previously mentioned it became apparent that there was a positive relationship between grip strength and general strength and physical condition. With this in mind studies were conducted to substantiate the idea that a single grip strength test could be substituted for the complex batteries of tests in determining motor ability and physical fitness. Rogers

believes in this substitution and states, "A recent study indicates that grip strength alone responds remarkably well to changes in general physical condition" (55:44). His study and work by Stanbury, Phillips and Larson during the early forties helped increase the acceptance of the predicative characteristics of the grip strength test (59, 48, 34).

Strength and grip strength were soon investigated for their relationship to athletic ability. Burke found grip strength to be a reliable measure of athletic ability while Cureton found muscular strength to have the same relationship with general athletic ability (16, 22). These pioneering studies opened the door to the many studies which were to follow in search of any accurate prediction of ability in specific sports, activities, and many other areas.

Not all investigations, however, warrant grip strength as being an accurate indicator of general strength or a predictor of athletic ability. In a study by Rasch it was stated that:

the importance of grip strength as an indicator of general bodily strength is a matter of controversy . . . others have contended that it does not give a satisfactory indication of this factor. The present finding of a non-significant correlation ($r = .15$) between hand grip and wrist flexion strength adds support to the latter view. (52:508)

Cozens, too, found no predicative value in arm strength tests given to college men (20). Nor did Phillips

et al. find that grip strength had any relationship to success on the Kraus-Weber Test (49). A study was conducted by Owens at the Air Force Academy to determine the relationship between grip strength and the physical education grade earned by selected fourth class cadets. He also failed to find a significant relationship between grip strength and physical education grades (45). It is interesting to note, however, that in similar studies by Tinkle and Montoye (60) and Wessel and Welson (67), both of which were conducted at Michigan State, a positive and significant relationship was found between grip strength and physical education grades received in both men's and women's programs. Wessel and Welson added in conclusion:

The fact that the correlation between grades in physical education and grip strength substantiates the results of the college man's study is still not proof that increasing strength will result in higher grades (67).

In the studies by Tinkle and Montoye (60) and Wessel and Welson (67) it was also determined that grip strength was directly related to and probably dependent upon body weight and only indirectly related to height in college men and women. A more extensive study was conducted by Pierson and O'Connell investigating this same relationship. Analysis of the data collected on 299 healthy adult males showed that for men in condition and within the limits of the study, grip strength is significantly related to weight but not to height or age (50). Bookwalter feels

that age, weight and Classification Index I are all factors influencing grip strength (9).

A great deal of research has been conducted in an attempt to find possible relationships between grip strength and more specific motor and athletic performance. As early as 1936 Blakeman, Jackson, and Rogers concluded from a study they conducted that grip tests are likely to prove invaluable to athletic coaches in selecting players and substitutes for any game involving large muscle activity and in deciding when and whether or not to return tired players to games (8). In determining what factors lead to success in the athletics at Southern Illinois University it was discovered by DiGiovanna that linemen in football, gymnasts, field event men in track and athletes who competed in more than one sport had much greater right and left grip strength (24:199).

Studies have also investigated the relationship of grip strength to specific sports or motor activities. Buckwald studied the relationship between grip strength and the performance of basketball players at Syracuse University. His findings showed improved basketball performance as grip strength improved (13). Coons, in a similar study, used football players and found a slight positive relationship correlation between grip strength and offensive performance and a slight negative correlation between grip strength and defensive performance (18).

Werling, in testing grip strength against the ability to swing a baseball bat, found some relationship between the velocity of the swing and grip strength, but not enough to be significant (66).

A low positive correlation was found by Alexander between dominant hand grip strength and the velocity of wrist and slap shots in hockey, whereas accuracy was uncorrelated with dominant hand grip strength. Neither of these results were statistically significant (2). In still another study, Watters was unable to find any statistical significance between grip strength and the forehand drive in tennis with college women at the University of Florida. She found that initial grip strength was not a determining factor in the final level of skill attained and also that there were no major gains in grip strength as a result of the tennis course (65). A somewhat different approach was used by Vogt at North Carolina when she used eighteen college women tennis players of intermediate skill or better and strengthened their grips and measured the effect on playing ability. The subjects' failure to show improvement in grip strength forced an end to the study (63). The author would like to point out that the basic procedure followed by Vogt (63) is similar to his own.

A study to determine the relationship between grip strength and cross country running performance was conducted by Augusta at Springfield College which failed to

produce a significant correlation (5). Jackson conducted a study at the University of Florida that was of great interest to the author. Grip strengths of the right and left hand were measured before and after an eleven week course in golf. He found that although right and left hand grip strengths increased significantly over the eleven weeks, the correlation between final skill level and grip strength were not significant (32). In opposition to the findings of many of the studies mentioned is the positive relationship between grip strength and fast reaction time found by Parker at Springfield College (47).

Hoffman, in his book Weight Training for Athletes, defines the purpose of physical training as ". . . preparing the body for instant response to physical demands and to strengthen it for efficient activity during a reasonable length of time" (30:3). He continues to support the beliefs of the author as to the importance of strength when he states that an athlete should ". . . possess above average strength in all the muscles of his body, and have superior strength in all the muscles used most often in his sport" (30:3). For this reason Hoffman advanced two ways of arranging the sequences of exercises. One, the single sequence, was a concentration on one major muscle, or on one group of small muscles. The second method was aimed at the development of large muscle groups.

Strength is merely one of the outcomes we are interested in as a result of physical training. A number of other essential qualities have been associated with physical training. Co-ordination, according to Fallon in his Weight-Training for Sport and Fitness, is dependent upon "educating" the muscles and bringing them under control." If the muscles are trained to be not only tough but elastic, greater agility will result" (25). Hoffman summed up the advantages of physical training by stating the two principles upon which it is based:

1. Healthy muscles will increase in their ability to operate the levers of the body as reasonable demands are placed upon them.
2. The organs of the body, including the muscles, will retain a degree of operating ability that is equal to normal demands. An exception is the cardiac muscle, which continuously contracts under maximum effort (30:21).

In regards to the time interval needed to accomplish these objectives we find that Nulton was convinced that even a small amount of weight training could produce measurable results (44). This theory was also advanced by Hoffman who maintained that strength could be gained with surprising speed through weight training.

Through an intelligently designed program of resistance exercises all voluntary muscles can be strengthened. At the same time the involuntary muscles and the entire system of organs of the body can be conditioned to operate at peak efficiency (30).

Berger investigated the effect of varied weight training programs on strength and found that training with

three sets each session produced a greater improvement than training with one or two sets. Also that progressive resistance exercise with six repetitions per set improved strength more than training with two repetitions. He concluded that a combination of six repetitions performed for three sets was more effective in improving strength than any other combination of sets and repetitions per set (7). Progressive resistance by sets and repetitions is the execution of an exercise with a particular weight for a number of repetitions followed by a short pause for rest. Then a second execution is performed with the same amount of weight for the same number of repetitions. As the number of repetitions becomes greater the amount of resistance is increased. Buck, at the University of Washington, found that heavy weight and few repetitions produced better results than lighter weight and more repetitions (14).

Although there is an accepted procedure which will bring about an increase in strength through physical training we must consider that individuals, regardless of exercise frequency, react in a manner peculiar to themselves (36). This was best expressed by the American Association for Health, Physical Education and Recreation in Weight Training in Sports and Physical Education. It stated that:

Individuals respond differently to weight training. Within almost every group working with weights there will be some individuals who do not become stronger, and occasionally one or more may actually lose

strength. There is no "sure fire" weight training program for all and continual changes in procedures and techniques may be necessary to elicit strength gains (3:19).

CHAPTER III

METHODOLOGY

The Problem

The problem of this study was to investigate the effect of a grip strength development program on the accuracy of the approach shot in golf.

Source of the Data

The study was initiated during the spring term of 1968 at Michigan State University. Eighteen male members of an instructional physical education class in intermediate golf were divided into two groups, one of which received a four week grip strength development program, and were compared as to the improvement of accuracy in the approach shot.

Methods of Procedure

The subjects were administered the pre-test for grip strength and approach shot accuracy by the author on March 28 at the practice green of Michigan State University.

Grip strength was tested first and was measured by a hand dynamometer using the method prescribed by Clarke (17:158). They had the hand dynamometer placed securely in their dominant hand and were asked to squeeze, giving

their maximum effort, without allowing the gripping hand to touch their body or anything else. The dominant hand was tested because it plays the major role in the golf grip and golf swing. Armour states ". . . Your left hand guides the club and keeps the face in the desired position for the hit and the power pours through the coupling of the right hand and the club" (4, 57). (The opposite, of course, would be true in the case of a left handed golfer.)

Each subject was allowed two attempts if he felt that his first effort had not been his best, and he was allowed to take his trials when he felt he was ready. Instruction in the use of the hand dynamometer was given to all subjects before the test was given.

The accuracy test measured the subjects ability to land twenty shots in a prescribed target area from a distance of one hundred yards using either a seven, eight or nine iron. This distance was decided on because of the finding of Crogen and Miller and Ley which showed that success is more quickly attained with the short irons and short swing (21, 40). A tee area of ten yards allowed the subjects a little additional freedom and meant that the distance from where the ball was hit to the middle of the target could range from one hundred to one hundred ten yards.

The target area (see Figure 1) consisted of a large practice green marked by white yarn with three consecutive

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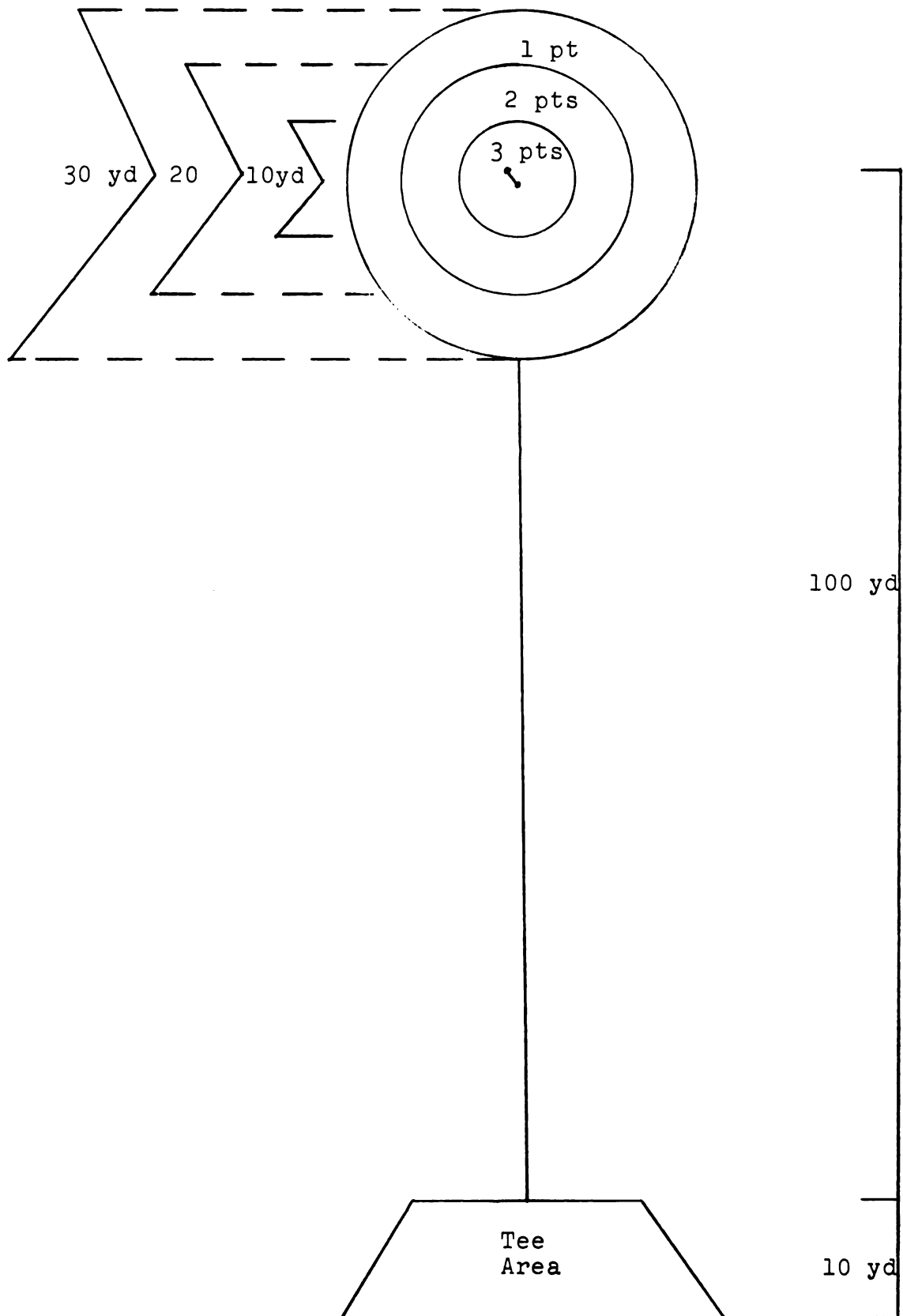


Figure 1.--Target Area

circles having diameters of ten, twenty and thirty yards respectively. A white flag marked the middle of the target. It was the belief of the author that using an actual golf green gave the subjects a psychological advantage and made the testing as realistic as possible to the skill as it applies to the game of golf. It should be noted that the obstructions (sand traps, etc.) which hindered performance in testing were the same obstructions the golfer is faced with on the golf course and therefore allowed for a better indication of his ability.

Each subject took twenty successive shots and did so at his own rate. He was allowed to adjust his location if he so desired and could also change the club he was using. The subjects used their own golf clubs but the same new golf balls were used by all the subjects (and replaced if damaged) to insure that they met the specific requirements of the Professional Golfers Association of America (62).

The subjects' accuracy score depended on the number of balls he could land on the green and their location in regards to the white flag and the three consecutive circles. A ball landing in the inner circle was awarded three points, while a ball in the middle area received two points and a ball resting in the outer area got only one point. No points were allowed any balls outside the three circles.

Grip strength and accuracy were retested on the following day, March 29, by the author using exactly the same procedures as had been used on the original tests.

The subjects were placed into two groups of nine each according to the results of their accuracy tests. The method used to group the subjects was an attempt to produce two approximately equal groups for the purpose of comparison in regards to their improvement.

One group, the control, attended class for three hours one day a week but received no training program. The experimental group attended the same three hour class as the control group but also took part in a grip strength development program whose purpose it was to increase the strength of the forearm, wrist and fingers. The program was participated in for four weeks and consisted of progressive resistance exercises using a specified number of sets and repetitions. The weight training was carried on three times a week while finger push-ups and ball squeezing were done everyday. The author supplied a list of exercises, that had been found to be effective in developing grip strength, to each of the subjects (see Appendix I). The subjects were instructed to choose the exercise which they felt would produce the greatest strength increase over the four week period. It was asked that ball squeezing and use of the wrist roller (35, 30, 51) be two exercises used by all subjects.

On April 25, both groups were administered the post-test for grip strength and approach shot accuracy. The post-tests were conducted at the same place and in the same manner

as were the pre-tests. The author would like to point out that the same hand dynamometer was used in all tests and was calibrated each time to insure accurate measurement. Also that the target area was marked identically for both tests.

Methods of Analysing Data

To investigate the reliability of the grip strength and approach shot accuracy tests, a Pearson Product-Moment Coefficient of Correlation was determined between the pre-test and the retest. A student's t test of the hypothesis that the difference between the means of the two tests was equal to zero was also conducted for both grip strength and approach shot accuracy (28).

In order to determine if the experimental group (grip strength development program) had a statistically significant improvement over the control group in grip strength and approach shot accuracy, students' t tests were run with the hypothesis that the difference between the mean changes in the two groups were not greater than zero. It should be noted that the mean changes refers to the difference of the group means on the pre-test and the post-test.

CHAPTER IV

ANALYSIS AND PRESENTATION OF DATA

The purpose of this study was to determine if it were possible to improve upon the accuracy of the approach shot in golf by increasing the strength of the forearm, wrist and fingers.

The grip strength development program was conducted for four weeks and was participated in by the experimental group. A pre-test was given before the program and a post-test after it. A test-retest correlation was also run.

Test Results

Table 1 shows the pre-test and retest scores for both grip strength and accuracy for all eighteen subjects. It also indicates the differences between these tests.

A Pearson Product-Moment Coefficient of Correlation was found between the pre-test and the retest for both grip strength and accuracy to determine the reliability of the two tests. A correlation (r) of .956 was found on the grip strength tests while a test-retest correlation of $r = .864$ was found on the accuracy tests.

The mean of the grip strength pre-test was found to be 113.6 which was identical to the mean of the retest.

TABLE 1.--Grip strength and accuracy pre-test and retest.

Subject	Grip Strength			Accuracy		
	Pre-Test	Retest	Difference	Pre-Test	Retest	Difference
1	90	96	6	23	20	-3
2	122	120	-2	21	24	3
3	120	116	-4	19	18	-1
4	120	124	4	18	20	2
5	110	110	0	14	16	2
6	148	140	-8	12	14	2
7	104	110	6	8	12	4
8	140	136	-4	8	10	2
9	122	120	-2	3	15	12
10	120	124	4	27	25	-2
11	110	110	0	21	20	-1
12	104	106	2	20	20	0
13	98	100	2	18	16	-2
14	104	100	-4	17	16	-1
15	114	110	-4	8	10	2
16	96	100	4	19	16	-3
17	112	110	-2	7	10	3
18	110	114	4	6	12	6
TOTAL	2044	2046	2	269	294	25
MEAN	113.6	113.6	.11	14.9	16.3	1.4

A pre-test mean of 14.9 was found for accuracy with a retest mean of 16.3.

Students' t tests were also run on the results of the accuracy and grip strength pre-tests and retests to determine if the differences between the means of the two tests were equal to zero. A $t = .10$ was found for the difference of the means of the grip strength tests. The difference between means was not significant at the .01 level.

The difference of accuracy tests means produced a $t = 1.6$ and was not significant at the .01 level.

Table 2 shows the pre-test and post-test grip strength scores for both the control group and the experimental group. It also indicates the differences between these tests.

The control groups mean grip strength of the pre-test was found to be 119.5, with a mean of 122.4 on the post-test resulting in the mean difference of 2.9 for control group subjects.

A pre-test mean of 107.5 was found for grip strength in the experimental group with a mean of 124.2 on the post-test producing a mean difference of 16.7 for experimental group subjects.

A t test of the difference between the mean changes in grip strength for the control group and experimental group produced a $t = 1.82$. The difference between mean changes was significant at the .05 level.

TABLE 2.---Grip strength pre-test and post-test.

Subject	Control Group			Experimental Group		
	Pre-Test	Post-Test	Difference	Pre-Test	Post-Test	Difference
1	90	95	5	120	135	15
2	122	125	3	110	125	15
3	120	122	2	104	120	16
4	120	120	0	98	123	25
5	110	125	15	104	125	21
6	148	140	-8	96	120	24
7	104	110	6	114	125	11
8	140	140	0	112	120	8
9	122	125	3	110	125	15
TOTAL	1076	1102	26	968	1118	150
MEAN	119.5	122.4	2.9	107.5	124.2	16.7

Table 3 shows the pre-test and post-test accuracy scores for both the control group and the experimental group. It also indicates the differences between these tests.

The mean accuracy score for the pre-test was found to be 14 for the control group with a mean of 20.3 on the post test resulting in the mean difference of 6.3 for control group subjects.

The experimental group had a mean of 14.7 on the pre-test, 22.8 on the post-test and had a mean difference of 8.

A value of $t = 1.06$ was found on the t-test of the difference between the mean changes in accuracy score for the control group and the experimental group. This value was not significant at the .05 level.

Interpretation of Results

Grip Strength Test

The test-retest correlation to determine the reliability of the grip strength test produced an $r = .956$. This was considered a "very high" correlation and yielded a coefficient of determination of $r^2 = .913$. This figure indicated that 91% of the variability of the retest could be determined (predicted) by the variability of the pre-test.

TABLE 3.--Accuracy pre-test and post-test.

Subject	Control Group			Experimental Group		
	Pre-Test	Post-Test	Difference	Pre-Test	Post-Test	Difference
1	23	27	4	27	30	3
2	21	29	8	21	27	6
3	19	26	7	20	25	5
4	18	25	7	18	26	8
5	14	14	0	17	27	10
6	12	20	8	9	16	7
7	8	14	6	8	20	12
8	8	12	4	7	16	9
9	3	16	13	6	18	12
TOTAL	126	183	57	133	205	72
MEAN	14	20.3	6.3	14.7	22.8	8

A value of $t = .10$ for the difference of means of the grip strength pre-test and retest was not significant at the .01 level. The pre-test and retest would therefore produce similar means 99% of the time.

Because of these findings it was concluded that the grip strength test was a reliable test.

Accuracy Test

The test-retest correlation to determine the reliability of the accuracy test produced an $r = .864$. This was considered a "high" correlation and yielded a coefficient of determination of $r^2 = .746$. This figure indicated that 75% of the variability of the retest could be determined (predicted) by the variability of the pre-test.

A value of $t = 1.6$ for the difference of means of the accuracy pre-test and retest was not significant at the .01 level. The pre-test and retest would therefore produce similar means 99% of the time.

Because of these findings it was concluded that the accuracy test was a reliable test.

Grip Strength Improvement

Table 2 shows that the average improvement in grip strength over the four weeks between the pre-test and the post-test was 2.9 pounds for the subjects of the control group. The experimental group subjects, over the same period of time, had an average improvement of 16.7 pounds.

A t-test of the difference between the mean changes in the pre-test and post-test, of grip strength for the control group and the experimental group produced a value of $t = 1.82$. This value was significant at the .05 level. The mean changes in the grip strength pre-test and post-test would be significant 95% of the time. You could be 95% confident that the experimental group, which took part in the training program, would increase their grip strength significantly more than the control group which had no training program.

Because of these findings it was concluded that the grip strength development program produced a significant improvement in grip strength.

Accuracy Improvement

Table 3 shows that the average improvement in accuracy over the four weeks between the pre-test and the post-test was 6.3 for the subjects of the control group. The experimental group subjects, over the same period of time, had an average improvement of 8. Although the experimental group improved more, it was not significant at the .05 level.

A value of $t = 1.06$ for the difference of the mean changes, in the accuracy pre-test and post-test for the control group and experimental group, was not significant at the .05 level. The mean changes in the accuracy pre-test and post-test would not be significantly different 95% of the time. You could not be 95% confident that the

experimental group, which took part in the training program, would increase their accuracy score significantly more than the control group which had no training program.

Because of these findings it was concluded that the grip strength development program did not produce a significant improvement in accuracy.

It should be noted that the experimental group, which had the training program, did improve their accuracy score more than the control group but it was not a significant improvement.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study was conducted to determine if it was possible to improve upon the accuracy of the approach shot in golf by increasing the strength of the forearm, wrist and fingers.

Summary

Eighteen male members of an intermediate golf class held at Michigan State University during the spring term of 1968 were used as subjects for this study. All subjects were given a pre-test of grip strength as measured by the hand dynamometer and approach shot accuracy as measured by the number of balls, out of a possible twenty, landing in a prescribed target area from a distance of one hundred yards. Using the accuracy score, they were matched in duplicate, resulting in two groups that were as close to being equal on accuracy as could be expected using this method.

The two groups consisted of a control and an experimental group. The experimental group received the exact same instruction as did the control group but also participated in a grip strength development program.

The program was conducted for four weeks and consisted of progressive resistance exercises employing sets and repetitions. At the conclusion of the pre-arranged training period, the subjects were tested in the same manner as on the pre-test. The data was processed and then analyzed.

Conclusions

The evidence obtained from the analysis of the data leads to the following conclusions.

1. The grip strength development program, in this limited study, did significantly improve the grip strength of the subjects as measured by a hand dynamometer.
2. The grip strength development program, in this limited study, did not significantly improve the accuracy of the approach shot as used in golf.

Recommendations

The investigator desires to make the following recommendations.

1. The grip strength development program should be conducted with great control over the subjects.
2. The grip strength development program should be limited to only a few good strength producing exercises.
3. Power, as measured by distance, should be investigated for its relationship to grip strength.

4. The relationship of grip strength to accuracy and distance should be investigated for women.

APPENDIX I

GOLF TRAINING PROGRAM--GRIP STRENGTH IMPROVEMENT

This program has been developed for the player who desires to become stronger and more efficient. Past experience has proven that participation in this program will make you a stronger player.

In all exercises you should complete 3 sets of ten repetitions and this should be done at least 3 times a week. Certain exercises should be done every day (sponge ball grip, push-ups) at your own convenience while the others may be performed in weight room at the Men's I.M. Building or the Adapted Room--225 Jenison.

Exercise	Sets	Reps
1. Wrist--rotator both directions	3	10
2. Wrist curl bar or 25-lb plate	3	10
3. Hand grips	3	10
4. Hang by towels	3	10 sec
5. Push-ups--fingers	3	10
6. Supination-pronation	3	10
7. Wrist-roll	3	3
8. Sponge ball grips	as much as possible	

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