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A Comparison of Effectiveness of Three Methods of Throwing a Basketball for Accuracy

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A COMPARISON OF THE EFFECTIVENESS OF THREE METHODS OF THROWING A BASEBALL FOR ACCURACY

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This thesis, submitted by Richard L. Dehn in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota, is hereby approved by the committee under whom the work has been done.

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Date August 2, 1968

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ABSTRACT

The purpose of this study was to determine whether the overhand, sidearm or underarm throw was the most accurate. Twenty boys from the Grand Forks, North Dakota, Park Board Babe Ruth and Rookie League baseball programs participated in the study. The test activity included fielding ground balls from different angles and throwing for accuracy using the three methods mentioned. A retest involving seven of the subjects was administered later to determine whether any consistency existed in the methods of throwing being used.

Two statistical comparisons were: (1) a within group comparison involving the results of the means of the three types of throwing methods used, (2) a within group comparison between the results of the pre- and post-tests. The null hypothesis was tested with the "t" technique for the difference between means derived from correlated scores from small samples.

Based on the results of this study, it seems apparent that the use of the overhand throw resulted in the most skillful performance when fielding and throwing a baseball for accuracy regardless of direction from which the ball approached. Also, the treatment of the data with respect to the test-retest comparison indicated no significant difference at the .05 level indicating reasonable consistency in the test results.

CHAPTER I

INTRODUCTION

Today many boys are participating in baseball. Individuals who participate in an activity want to perform in the most successful manner. Therefore, it is important that the most effective methods be used to gain this success.

Physical education teachers have been constantly searching for ways to improve the ability of each performer in order to increase the success of the player. Baseball coaches, like other coaches, have attempted many methods in an effort to teach a boy how to perform the necessary skills more efficiently.

Statement of the Problem

The purpose of this study was to measure the accuracy of various procedures for throwing a baseball. Three different types of throwing were used including: (1) overhand throw, (2) sidearm throw, (3) underarm or submarine throw. The test activity consisted of throwing a regulation baseball for accuracy at a target ninety-feet distant.

Need for the Study

One of the first requisites for the development of motor skills has been the ability to recognize the elements of skillful performance. Teachers of physical education and therapists in the field of physical medicine have long been concerned, not merely with performance in various activities, but that performance be done in the most skillful manner. Therefore, teachers should be

able to teach kinesiological principles to enable students to learn, feel and recognize the qualities that distinguish between awkward and skillful movement.

Efficient motion has been one important characteristic of skillful performance. Another very important characteristic of skillful performance has been accuracy. An individual may have tremendous coordination and efficient motion, but these factors have very little value if a real goal has never been reached. Accuracy has been based on a combination of factors. These factors included judgment of direction, distance and force, proper timing, and good muscular control. Accuracy has been needed in simple acts of everyday life as well as in more complicated acts necessary for the skillful performance of activities.

Hence, it would seem to be of practical value for teachers, coaches and baseball players to learn the best method of throwing a baseball accurately. The three throws most commonly used could be tested. If a significant difference was found in favor of one method, it could be applied to students who play baseball. It could help them become more skillful performers and more successful in their participation.

Purpose of the Study

The purpose of the study was to determine whether the overhand, sidearm or underarm (submarine) throw was the most accurate. If there was no significant difference in the accuracy of the three different types of throwing procedures, it would seem

practical to use the method which proved the most successful to the participants themselves.

However, if one of the throwing procedures was significantly more accurate than any of the other procedures, it would seem most beneficial to incorporate that particular throwing procedure when applicable.

Delimitations of the Study

1. The subjects in this study were boys who participated in the Babe Ruth and Rookie baseball leagues in Grand Forks, North Dakota.

2. The ages of the subjects ranged from thirteen to fifteen years.

3. Subjects were limited to a throwing distance of ninety feet.

4. Conclusions drawn from the results of the study will be directly applicable to the individuals or members of the Babe Ruth and Rookie Leagues of Grand Forks, North Dakota, and to individuals who have like qualifications.

5. The balls were thrown to the infielders and were not all perfectly thrown. The author assumed that each individual received the same number of good and poor throws. This would be similar to a game situation.

6. All of the subjects tested were right handed.

Definition of Terms

Certain concepts are explained below in terms of their

meaning as used in this study.

Accuracy. Throwing a baseball at a target and hitting that target with precision and exactness.

Overhand throw. Throwing with the forearm above the shoulder and vertical with a backswing and foreswing to propel the ball.

Sidearm throw. The arm in the sidearm pattern was close to the horizontal and the elbow was more fully extended at release.

Underarm throw. Throwing with the arm below the horizontal with a backward to forward swing.

Rookie League. An organized baseball league for boys 13 years old.

Babe Ruth League. Boys from the ages of 14 to 16 who play baseball in an organized league. The organization is named after the famous baseball player, Babe Ruth.

Skillful performance. A combination of the following characteristics to perform a task: efficiency, accuracy, good judgment, adequate speed, strength and power.

Review of Related Literature and Research

This study was concerned with a baseball throw for accuracy which involved three different methods. The three throwing methods were the overhand throw, the sidearm throw, and the underarm or submarine throw. The following reports and studies were taken from books and articles written by prominent baseball personnel and from research studies which pertained to the problem of throwing

for accuracy.

Reports and Studies

All baseball players, especially infielders, needed to be able to throw as quickly and accurately as possible. The following sources recommended the overhand throw.

Daniel E. Jessee discussed the throwing methods of third basemen and shortstops. Jessee mentioned that a good shortstop must be able to throw from any and all positions in which he may receive the ball. It was imperative that he have a strong and accurate arm to enable him to make throws from the deep position, from the short position on the grass and from either side. It was advisable to throw the ball in an overhand manner whenever possible. The form was more accurate and the throw was a great deal easier for the receiving player to handle.[1]

The third baseman has longer and more difficult throws to make than any other infielder except the shortstop. Jessee felt he should throw overhand on all plays possible, since it was a more accurate throw and it was also easier to handle on the receiving end. It should be used chiefly with hard hit ground balls directly at him or to his right and on relay throws and double play balls whether he throws to first, second, or home plate. He should aim his throws, as should his teammates, about

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[1]Daniel E. Jessee, Baseball (New York: A. S. Barnes and Company, 1938), p. 48

letter or shoulder high on double plays, waist high on put-outs, and about a foot above the ground if the base runner was to be tagged.[2]

Ins and Outs of Baseball by Otto Vogel presented several interesting views on throwing. Vogel discussed the overhand throw, the sidearm throw, and the underarm throw and felt all should be made with a snap or full arm motion.

Vogel believed a five or six year old boy should learn to throw overhand. It was basic and was made from a more upright and natural position than other types of throws. This throw also had possibilities for more distance and was the most accurate. Once it had been learned, the other types of throws followed naturally.[3]

Infielders should use the snap overhand throw, whenever possible, with the full arm action on long throws. There were times, however, when they would have to make the sidearm or underarm throws. These would be used when making double plays or when a quick snap was necessary. For example, a third baseman, in fielding a slow ball close to the ground, would make this type of throw so that no time would be lost in getting the ball to the first baseman.[4]

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[2]Ibid., p. 55.

[3]Otto H. Vogel, Ins and Outs of Baseball (St. Louis: C. V. Mosby Company, 1952), p. 38.

[4]Ibid., p. 43.

James L. Miller studied the effect of instruction on the development of throwing accuracy of first grade children. The purpose of his study was to determine if instruction in the motor skill of throwing would improve the performance of first grade children over and above the effects produced by maturation and general practice.[5] His results were rather interesting.

Two experimental and two control groups, composed of boys and girls respectively, were studied. The experimental groups of boys (N-21) and girls (N-18) received instruction in the overhand throw for accuracy for a total of 26 twenty-minute periods. The control groups of boys (N-15) and girls (N-23) received 26 twenty-minute periods of play using games which involved throwing a ball. The control group received no instruction in throwing skills.

All the children were given the throwing test five times. They were tested twice on succeeding days at the beginning of the study, and twice on succeeding days at the end of the training period (tests 2A and 2B). Then they were tested once ten days after the end of the training period (test 3).

All of the subjects were first grade pupils at the Lock Haven Elementary School, Baltimore County, Maryland. Their ages ranged from six years-four months to seven years-two months.

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[5]James L. Miller, "Effect of Instruction on Development of Throwing for Accuracy of First Grade Children," Research Quarterly, XXVIII (1957), p. 132.

The study was conducted between the dates of February 3, and April 23, 1954.[6]

The difference between the mean gains of the boys in the experimental group and the boys in the control group was not significant for any period. The mean gains of the girls of the experimental and control groups were not statistically significant for any of the test periods.[7]

The findings of this study indicated that instruction of first grade children in a motor skill, such as throwing for accuracy, did not improve the skill of the child over and above what was to be expected to occur by practice without instruction. However, it should be noted that, the improvement in throwing for both the boys' and girls' groups was greater for those groups which received instruction. This suggested that, if the study has been carried out over a longer period of time, perhaps the results would have been statistically significant in favor of the groups receiving instruction.[8]

The Athletic Institute's instructor guide to baseball provided some interesting facts in regard to throwing a baseball. There were three types of throws discussed. It was suggested the underarm throw should be used only when it was important to get

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[6] Ibid., p. 133.

[7] Ibid., pp. 134-135.

[8] Ibid., p. 135.

the ball away fast from a crouch position. The sidearm throw was considered for short quick throws. It was recommended that most ball players should use the sidearm throw only in case of emergency. By far the most used and most valuable throw was the overhand throw. It was more accurate and had more "carry" than any other type of throw. This was the throw for power and control. It was wise for beginning baseball players to learn the overhand throw first and practice until all fundamentals were natural and speed and control had been achieved. However, regardless of the type of throw used, it was imperative that the thrower follow through since this added accuracy and speed to the throw.[9]

Another interesting article on throwing was presented by Don Weiskopf in the Athletic Journal. Third basemen should throw overhand to first base whenever possible. Weiskopf felt an overhand throw was generally faster and certainly more accurate. A ball thrown sidearm had a tendency to move away and down from the target. Young players should practice fielding grounders and bringing themselves into position immediately to throw overhand.[10]

Because of the variety of plays he has to handle, the third baseman must be proficient in the following ways of throwing:

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[9]Otto H. Vogel and Dick Siebert, Baseball: Instructor's Guide (Chicago: Athletic Institute, 1958), p. 22.

[10]Don Weiskopf, "Third Base Play," Athletic Journal XLIII (February, 1963), p. 69.

1) Overhand (on balls hit directly to him, to the right or deep third)

2) Sidearm (making a throw for a double play on the shortstop side)

3) Underarm (fielding bunts with two hands)[11]

According to "Yogi" Berra, a third baseman should throw overhand rather than sidearm, although most third basemen can throw both ways. An overhand throw usually proved to be more accurate than any other kind, and the third baseman often has more time to make the play to first. Sometimes the third baseman may be called upon to throw underarm, especially on a charge in for a bunt or a "topped" ground ball. In that case the player moved forward so swiftly there was no time to straighten up and throw. It was necessary to get the ball away from the crouched position. If nothing else, a third baseman's throwing must be versatile.[12]

A study by James L. Webb on the effect of no warm-up, related warm-up, and unrelated warm-up on the performance of the baseball throw for accuracy and distance provided some interesting results. The purpose of the study was to determine the relative effects of no warm-up, unrelated warm-up, and a related warm-up upon physical performance as measured by a baseball throw for distance and a baseball throw for accuracy. The subjects utilized

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[11] Ibid., p. 70.

[12] Yogi Berra, Yogi Berra's Baseball Guide (New York: Sayre Ross Company, 1966), p. 36.

in the study were thirty-six "Midget League" baseball players whose ages ranged from ten to twelve years. Each test was taken a total of three times by each subject. The subjects took the test after each of the different warm-up methods.[13]

Statistical comparisons were made between results obtained using the three types of warm-up procedures for both accuracy and distance tests. It was concluded that there were no statistically significant differences between the means obtained through the use of the three warm-up methods in either the throw for accuracy or the throw for distance.

Comparisons were made between the initial test data and retest data of a group of ten of the subjects by establishing the significance of the coefficient of correlation. The data indicated that the distance test was reliable as a measuring instrument while the accuracy test was not.[14]

Investigation of the basic patterns of the three methods of throwing a baseball for accuracy produced the following results. In the basic underarm pattern, the joints which moved levers in the direction of the throw normally occurred in the following sequence: hip rotation, spinal rotation, shoulder adduction and flexion, and wrist flexion. For the most effective participation,

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[13]James L. Webb, "The Effect of No Warm-Up, Related Warm-Up and Unrelated Warm-Up on the Performance of the Baseball Throw for Accuracy and Distance" (Master's Thesis, Department of Physical Education, University of North Dakota, 1963), pp. 1-36.

[14]Ibid., p. 37.

all should be moving as the object is released. As the trunk rotated backward, the arm was raised to the back in a combined abducting and extending shoulder joint action. As the arm moved forward, it was kept in the sagittal plane by a combination of shoulder adduction and flexion. The underarm throw and pitch were much alike in joint and lever action.[15]

The pattern of the overhand throw utilized the two joint actions which appeared to have the highest speeds, wrist flexion and shoulder medial rotation. The sequence of joint actions may be seen in the football pass and in the baseball pitch. Both show the step forward with the left foot, hip and spinal rotation, and medial rotation of the humerus. As the torso rotated forward by hip and spinal actions, the humerus was laterally rotated. This timing was an important feature of complex movement patterns. The slower joints began their forward movement as the faster joints, the more distal, completed their backswings. The muscles responsible for the forward swing can begin contraction to stop the backswing. The combination of backward movement and beginning contraction stretched the tendons and connective tissue in the muscles, and thus the forward movement could be more forceful.

It can be noted in the overhand throw that the elbow has extended somewhat before the ball has been released. This

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[15]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louis: The C. V. Mosby Company, 1963), p. 63.

shortened the "moment" arm for shoulder medial rotation. It appeared that this action developed its greatest linear velocity before release and that this velocity had to be utilized by the joints acting at release.[16]

The basic sidearm pattern, in which the shoulder and elbow joints are fixed, was rarely used in throwing light objects. In a study of the sidearm and overhand throwing patterns of a highly skilled man and woman, the preliminary parts of the movements were found to be much alike. The differences were in the position of the arm and in the degree and timing of elbow extension. The arm in the sidearm pattern was close to the horizontal as hip rotation began, and the elbow was more fully extended at release. These arm positions would lengthen the "moment" arm for hip and spinal levers and shorten the "moment" arm for shoulder rotation. The hip action in both subjects contributed a greater proportion of the velocity in the sidearm throw than it did in the overhand pattern.[17]

Basic patterns may be observed at the time the hand, or extension of it (bat or racquet), transmits force developed by body levers to the object which has to be moved. These are the underarm, overhand, and sidearm patterns. The basic joint action of each and the similarities and differences between them may be

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[16] Ibid., p. 74.

[17] Ibid., p. 84.

seen in the following table.

Basic Patterns and Their Joint Actions[18]

Patterns	Hip	Spine	Shoulder	Elbow	Wrist
Underarm	Rotation	Rotation	Flexion	Fixed	Flexion
Overhand	Rotation	Rotation	Medial Rotation	Fixed	Flexion
Sidearm	Rotation	Rotation	Fixed	Fixed	Flexion

The joint actions of the body in the basic patterns of movement are therefore very much alike except for the joint action of the shoulder. The graphic information presented would seem to indicate similarity in basic patterns except for the joint action of the shoulder. Physical educators should be aware of this fact when instructing students to throw a ball.

Summary

Available literature in the form of articles on athletics, studies reported in the Research Quarterly and the textbooks on baseball instruction favored the overhand throw as the most accurate method of throwing a baseball. Most of the articles agreed that all three types of throwing procedures were necessary for participation in baseball. There did not seem to be conclusive evidence however, that the overhand throw had been tested with the other types of throwing procedures and found to be more accurate. The literature on the joint actions of the body indicates the basic

[18] Ibid., p. 53.

patterns of movement among the three throws. It also points out the similarity of movements between the joint actions except for the joint action of the shoulder.

CHAPTER II

METHOD OF RESEARCH

The purpose of this study was to compare and analyze three different throwing methods in the specific activity of throwing a regulation baseball for accuracy to determine if a significant difference existed among them. The subjects were each tested in the overhand throw, the sidearm throw, and the underarm throw.

Subjects

The subjects in this study were members of the Grand Forks, North Dakota, Park Board baseball teams. They were players from the Babe Ruth and Rookie Leagues. Their ages ranged from thirteen to fifteen years. The testing procedures were initiated during the summer of 1967. The testing period ran for a period of three weeks. The subjects in this study may be considered as experienced to a certain degree, since all of the subjects had been participating in organized baseball for several years.

Testing

All participants in this study were requested to attend an orientation meeting before the testing period began. At this time, general information concerning the test and the procedures to be used by the subjects was discussed and explained. The subjects were to field ground balls thrown to them and then throw as quickly and as accurately as possible at a target ninety

feet away. The subjects were first to make 15 overhand throws, then 15 sidearm throws, and finally 15 underarm throws, all for accuracy. Each subject threw a total of 45 throws. To make the procedure as game-like as possible, the subjects were required to field ground balls thrown to their right, to their left, and straight at them before making their throws for accuracy. Each subject, therefore, had five overhand throws to make from the right, five from the left, and five from the center. The subjects also used the same procedure with the sidearm throw and the underarm throw. The author threw the ground balls to the subjects who had no knowledge from which side the ball had to be fielded and thrown. This was an attempt to provide a game-like situation. Each subject made only 15 throws during one testing period. This minimized the possibility of fatigue which may have occurred if a subject made all 45 throws in one testing period.

The target was a hoop with a diameter of three feet. The hoop, which faced the subjects and was perpendicular to the ground, was placed on a base two and one half feet from the ground and ninety feet from the subject's position. Attached to the top of the hoop was a thin piece of colored cloth which extended downward to cover the entire hoop area. The purpose of the cloth was to make the target easier for the subjects to sight. It also made it easier for the scorers to determine if the ball penetrated the accuracy area. Two points were scored if the ball went through the hoop without hitting the outer edge. One point was scored if

the ball hit the hoop surface. No points were awarded if the ball missed the hoop area or surface completely. There was a possibility of scoring 30 points for each type of throwing method used.

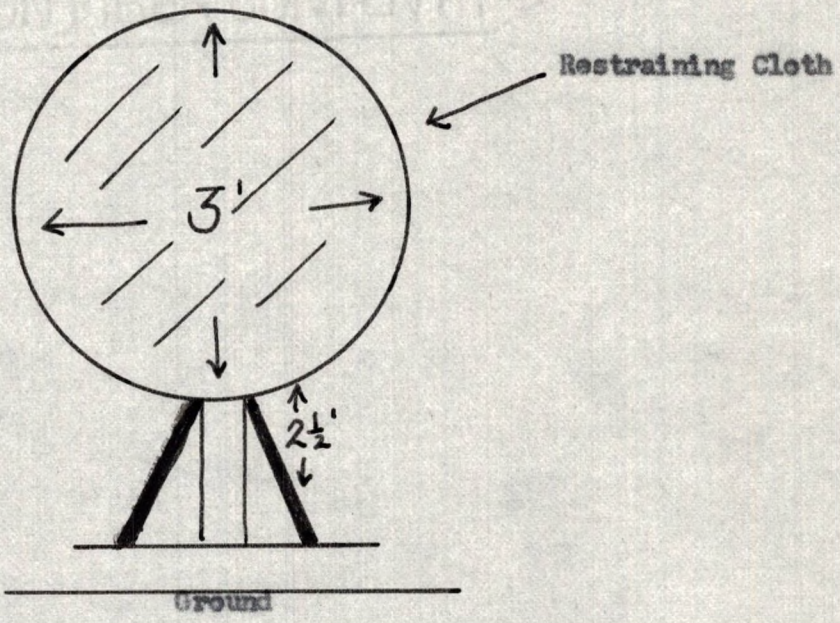

Figure 1. -- Target Specifications

Two judges aided the author in administering and scoring. One judge was used to watch the subjects make their throws and determine whether the subjects used the throwing method prescribed for them. The other judge recorded scores made by the subjects. The judges used in this study were Grand Forks, North Dakota, Park Board coaches. Each had many years of baseball experience along with several years of coaching experience.

Investigation of several tests of the null hypothesis indicated that the "t" technique for testing the significance of the difference between means derived from correlated scores from small samples was suitable for a within group comparison

in this study. This test determined the ratio between the mean difference and the standard error of the mean difference. This ratio was expressed as "t" and was checked for significance in a "t" table. The value of "t" was proportional to the degree of freedom (N-1) allowed in determining the relationship between the mean difference and the estimate of sampling error of the mean difference.[1]

A random sample of subjects was later retested using the same testing device. Again the "t" technique was used to analyze the data. The purpose of the retest was to establish if any consistency existed between the test-retest data. The investigator decided to reject the null hypothesis at the .05 level of significance at which "t" equals 2.09 with 11 degrees of freedom. Complete data, including raw scores and mean differences, together with details of the mathematical process employed in the analysis for each testing area have been presented in Appendix A, pp. 38-65.

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[1]Quinn McNemar, Psychological Statistics (New York: John Wiley and Sons, Inc., 1955), p. 108.

CHAPTER III

ANALYSIS OF THE DATA

The purpose of the testing in this study was to determine whether significant differences might result among the three different throwing procedures tested. This study assumed the null hypothesis in analyzing the results of performance involving three types of throwing procedures. That hypothesis asserts that there are no true differences between the mean scores, and that the differences found between the sample means are chance differences and are accidental and unimportant.

Results of Comparisons

Throws from the left side

The results of the overhand throw from the left side produced a mean score of 3.50 while the mean for the underarm throw from the left side was 2.00. This represented a mean difference of 1.50. The estimate of sampling error of the mean difference was .52. The "t" value of 2.88 with 19 degrees of freedom indicated significance at the .05 level, and the null hypothesis was therefore rejected.

The results of the overhand throw from the left side produced a mean score of 3.50 while the mean for the sidearm throw from the left side was 2.65. This represented a mean difference of .85. The estimate of sampling error of the mean difference was .42. The "t" value of 2.02 with 19 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was

therefore retained.

The results of the sidearm throw from the left side produced a mean score of 2.65 while the mean for the underarm throw from the left side was 2.00. This represented a mean difference of .65. The estimate of sampling error of the mean difference was .49. The "t" value of 1.32 with 19 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

Throws from the center

The results of the overhand throw from the center and the underarm throw from the center showed that the overhand throw produced a mean score of 3.30 while the mean for the underarm throw was 2.20. This represented a mean difference of 1.10. The estimate of sampling error of the mean difference was .34. The "t" value of 3.23 with 19 degrees of freedom indicated significance at the .05 level, and the null hypothesis was therefore rejected.

The results of the overhand throw from the center produced a mean score of 3.30 while the mean for the sidearm throw from the center was 3.00. This represented a mean difference of .30. The estimate of sampling error of the mean difference was .32. The "t" value of .93 with 19 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the sidearm throw from the center produced

a mean score of 3.00 while the mean for the underarm throw from the center was 2.20. This represented a mean difference of .80. The estimate of sampling error of the mean difference was .39. The "t" value of 2.05 with 19 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

Throws from the right side

The results of the overhand throw from the right side produced a mean score of 3.55 while the mean for the underarm throw from the right side was 2.40. This represented a mean difference of 1.15. The estimate of sampling error of the mean difference was .54. The "t" value of 2.12 with 19 degrees of freedom indicated significance at the .05 level, and the null hypothesis was therefore rejected.

The results of the overhand throw from the right side produced a mean score of 3.55 while the mean for the sidearm throw from the right side was 2.85. This represented a mean difference of .70. The estimate of sampling error of the mean difference was .60. The "t" value of 1.16 with 19 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the sidearm throw from the right side produced a mean score of 2.85 while the mean for the underarm throw from the right side was 2.40. This represented a mean difference of .45. The estimate of sampling error of the mean difference

was .47. The "t" value of .95 with 19 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

Cumulative Comparison Involving Fielding Balls from Three Directions

Overhand-Sidearm-Underarm

The results of the total number of overhand throws from all directions led to a mean score of 10.35 while the results of the sidearm throws produced a mean score of 8.50. This represented a mean difference of 1.85. The estimate of sampling error of the mean difference was .67. The "t" value of 2.76 with 19 degrees of freedom indicated significance at the .05 level, and the null hypothesis was therefore rejected.

The results of the total number of sidearm throws produced a mean score of 8.50 while the mean for the underarm throws was 6.60. This represented a mean difference of 1.90. The estimate of sampling error of the mean difference was .64. The "t" value of 2.96 with 19 degrees of freedom indicated significance at the .05 level, and the null hypothesis was therefore rejected.

The results of the total number of overhand throws produced a mean score of 10.35 while the results of the underarm throws produced a mean score of 6.60. This represented a mean difference of 3.75. The estimate of sampling error of the mean difference was .78. The "t" value of 4.80 with 19 degrees of freedom indicated significance at the .05 level, and the null

hypothesis was therefore rejected.

Test-Retest Comparisons

Overhand Throws

The results of the overhand throws from the left side produced a mean score of 3.86 on the pre-test and a mean of 4.00 on the post-test. This represented a mean difference of .14. The estimate of sampling error of the mean difference was .74. The "t" value of 0.19 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the overhand throws from the center produced a mean score of 4.28 on the pre-test and a mean of 4.00 on the post-test. This represented a mean difference of .28. The estimate of sampling error of the mean difference was 1.10. The "t" value of .25 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the overhand throws from the right side produced a mean score of 3.86 on the pre-test and a mean of 4.14 on the post-test. This represented a mean difference of .32. The estimate of sampling error of the mean difference was .89. The "t" value of .31 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

Sidearm Throws

The results of the sidearm throws from the left side produced a mean score of 3.14 on the pre-test and a mean of 2.71 on the post-test. This represented a mean difference of .43. The estimate of sampling error of the mean difference was .64. The "t" value of .67 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the sidearm throws from the center led to a mean score of 3.42 on the pre-test and a mean of 2.28 on the post-test. This represented a mean difference of 1.14. The estimate of the sampling error of the mean difference was .50. The "t" value of 2.28 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the sidearm throws from the right side produced a mean score of 2.71 on the pre-test and a mean of 3.00 on the post-test. This represented a mean difference of .29. The estimate of the sampling error of the mean difference was .36. The "t" value of .77 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

Underarm Throws

The results of the underarm throws from the left side produced a mean score of 3.14 on the pre-test and a mean of 2.57

on the post-test. This represented a mean difference of .57. The estimate of the sampling error of the mean difference was .36. The "t" value of 1.58 with 6 degrees of freedom indicated no significance at the .05 level, and the null hypothesis was therefore retained.

The results of the underarm throws from the center produced a mean score of 2.57 on the pre-test and a mean of 2.57 on the post-test. This represented a mean difference of .00 The estimate of the sampling error of the mean difference was .92. The "t" value of .00 with 6 degrees of freedom indicated no significance at the .05 level and the null hypothesis was therefore retained.

The results of the underarm throws from the right side led to a mean score of 2.14 on the pre-test and a mean of 3.14 on the post-test. This represented a mean difference of 1.00 The estimate of the sampling error of the mean difference was .68. The "t" value of 1.47 with 6 degrees of freedom indicated no significance at the .05 level and the null hypothesis was therefore retained.

Summary

The results of this study indicated that the overhand throw was significantly more accurate than the underarm throw from the three different positions. In the cumulative comparison the sidearm throw was also found to be more significant than the underarm throw. The test-retest data provided reasonable consistency with no significant difference being found between the

pre-test and post-test results.

TABLE I

COMPARISON OF RESULTS OF THE OVERHAND, SIDEARM AND UNDERARM THROWS

	Mean Score for Results of Throws from Left Side	Mean Difference	Estimate of Sampling Error of the Mean Difference	"t" Value and Significance *
Overhand	3.50	.85	.42	2.02 not significant at the .05 level
Sidearm	2.65			
Sidearm	2.65	.65	.49	1.32 not significant at the .05 level
Underarm	2.00			
Overhand	3.50	1.50	.52	2.88 significant at the .05 level
Underarm	2.00			

* "t" value with 19 degrees of freedom. 2.09 at the .05 level.

TABLE I (Cont.)

COMPARISON OF RESULTS

	Mean Score for Results of Throws from the Center	Mean Difference	Estimate of Sampling Error of the Mean Difference	"t" Value and Significance
Overhand	3.30	.30	.32	.93 not significant at the .05 level
Sidearm	3.00			
Sidearm	3.00	.80	.39	2.05 not significant at the .05 level
Underarm	2.20			
Overhand	3.30	1.10	.34	3.23 significant at the .05 level
Underarm	2.20			

TABLE I (Cont.)

COMPARISON OF RESULTS

	Mean Score for Results of Throws from Right Side	Mean Difference	Estimate of Sampling Error of the Mean Difference	"t" Value and Significance
Overhand	3.55	.70	.60	1.16 not significant at the .05 level
Sidearm	2.85			
Sidearm	2.85	.45	.47	.95 not significant at the .05 level
Underarm	2.40			
Overhand	3.55	1.15	.54	2.12 significant at the .05 level
Underarm	2.40			

TABLE I (Cont.)

TOTAL COMPARISON OF RESULTS

	Mean Score for Total Results of the Three Throws	Mean Difference	Estimate of Sampling Error of the Mean Difference	"t" Value and Significance
Overhand	10.35	1.85	.67	2.76 significant at the .05 level
Sidearm	8.50			
Sidearm	8.50	1.90	.64	2.96 significant at the .05 level
Underarm	6.60			
Overhand	10.35	3.75	.78	4.80 significant at the .05 level
Underarm	6.60			

TABLE II

TEST-RETEST COMPARISON
(MEAN SCORE)

Overhand Throw	Pre-test	Post-test	Mean Difference	"t" Value
Left Side	3.86	4.00	.14	.19*
Center	4.28	4.00	.28	.25*
Right Side	3.86	4.14	.32	.31*

Sidearm Throw	Pre-test	Post-test	Mean Difference	"t" Value
Left Side	3.14	2.71	.43	.65*
Center	3.42	2.28	1.14	2.28*
Right Side	2.71	3.00	.29	.77*

Underarm Throw	Pre-test	Post-test	Mean Difference	"t" Value
Left Side	3.14	2.57	.57	1.64*
Center	2.57	2.57	.00	.00*
Right Side	2.14	3.14	1.00	1.47*

* Not significant at the .05 level.

CHAPTER IV

DISCUSSION

While conducting this investigation, the writer discovered certain facets which should be considered in trying to develop skillful performance in students during physical activity. It is important for the individual performers to be successful in the activities they are attempting to perform. Skillful performance of an activity is one very important factor in reaching this success. Physical education instructors, therefore, must know which throwing procedure will produce the best results so they can initiate that procedure into the activity. It also seems necessary that physical educators and coaches know the basic kinesthetic patterns and movements of an activity in order to give students a better understanding of the different methods of throwing for accuracy.

The results of the study from the three different positions indicated that the overhand throw was significantly better than the underarm throw. Thestudy also revealed no significant difference between the overhand and sidearm throws, or between the sidearm and underarm throws. Two reasons may be assumed for these findings: 1) that the difference in the kinesthetic patterns and movements of the shoulder caused these results, 2) the subjects may have used the overhand throw more than the other types of throws in their past experience with throwing. This dose not mean that the underarm throw should never be utilized or taught to students. There may be times in a game situation when the underarm throw may be the only method to achieve success and

should therefore be used. The same is true of the sidearm throw. The overhand throw should be recommended for use whenever possible, since it was found to be the better throw. This does not mean, however, that the other types of throws should be neglected.

Best scores seemed to occur when the subjects were throwing from the right side with the overhand and underarm throws. With the sidearm throws the best scores occurred from the center. Because all the subjects were right handed, it may be assumed that the best scores would come from the right side and the center because it takes a greater adjustment to get into position to throw the ball from the left side. In the test-retest results, it was found that all three throws were consistent, however, the overhand throw was the most consistent of the three.

The results of the study may have been affected by many variables including attitudes, health status, weather and field conditions. Skillful performance is dependent upon a good mental attitude. Therefore, it is important that physical educators and coaches have a favorable attitude toward an activity despite and adversity. The enthusiasm and importance coaches place on an activity and on the desired results may have an effect on the performance of an individual. It may be assumed that an individual's mental attitude toward an activity undoubtedly will be among the variables that cannot be measured accurately in an activity.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to determine and compare three different throwing methods in the specific activity of throwing a regulation baseball for accuracy. The subjects were each tested on their ability to execute the overarm, sidearm, and underarm throws.

The subjects selected for this investigation were twenty boys from the Grand Forks, North Dakota, Park Board Baseball Program. They were players from the Babe Ruth and Rookie Leagues. The subjects had to field ground balls thrown to the left, right and front and then throw for accuracy. A random sample was later retested to establish whether there was consistency among the throwing methods used for this test.

The scores of the throws were statistically compared to determine whether any significant differences existed between the results of the three types of throws. The null hypothesis was assumed with respect to the differences and this hypothesis was tested with the "t" technique for the difference between means derived from correlated scores of small samples. Comparisons were also made between the initial test data and retest data of a group of seven subjects. The "t" technique was used to determine if there was consistency between trials. This hypothesis was

tested with the "t" technique at the .05 level of significance.

Findings

The following findings seemed warranted on the basis of the data collected in this study:

1. In fielding and throwing ground balls from the left side, the results indicated that the overhand throw was significantly better at the .05 level than the underarm throw from the same side. No other significant differences were found in comparisons of throws from the left.

2. The results from ground balls thrown from the center, again indicated that the overhand throw was significantly better at the .05 level than the underarm throw. In further comparisons of throws from the center no other significant differences were found.

3. From the right side, the results indicated a significant difference in favor of the overhand throw over the underarm throw at the .05 level. Again there were no significant differences between the other two comparisons.

4. In comparing the results of the totals from all positions, both overhand and sidearm throws were significantly better than the underarm throw at the .05 level. Also, the overhand throw was significantly better than the sidearm in comparing the total results.

5. Test-retest data indicated that the accuracy test, as administered in this study, was consistent. There were no

significant differences in the test-retest results at the .05 level, although the overhand throw did produce the most consistent results.

Conclusions

1. When making throws from all three positions, the overhand throw was the most consistently accurate throw.

2. Regardless of direction, the sidearm throws were more accurate than the underarm throws.

Recommendations

Based on the results of this investigation it is recommended that:

1. Continuous research in the area of fundamental baseball skill performance be made.

2. The number of subjects be increased in any future investigations of a similar nature.

3. Additional studies be conducted in this area in which the subjects be of college age.

4. A similar study be made with an experimental group and a control group to determine significant or non-significant gains in skillful performance.

5. The overhand throw be emphasized by physical education instructors and coaches for more efficient and skillful performance.

6. A similar study be done using left-handed subjects.

7. A study be done to determine the degree of difficulty among the three throwing methods used in this study.

Raw Data

Accuracy Throw
Overhand
(Score)

Subject	Left	Center	Right
1.	4	4	4
2.	3	1	2
3.	2	1	4
4.	4	6	2
5.	2	3	4
6.	8	5	1
7.	1	5	8
8.	6	4	4
9.	2	3	4
10.	3	4	4
11.	2	1	4
12.	3	1	2
13.	6	4	5
14.	6	6	3
15.	2	3	4
16.	5	3	3
17.	4	2	2
18.	1	4	2
19.	2	3	3
20.	4	3	6

Raw Data

Accuracy Throw
Sidearm
(Score)

Subject	Left	Center	Right
1.	2	4	2
2.	1	0	2
3.	1	2	0
4.	4	4	2
5.	1	4	3
6.	4	3	6
7.	2	2	3
8.	3	4	4
9.	3	4	2
10.	2	2	2
11.	2	2	0
12.	1	2	5
13.	6	3	1
14.	2	5	2
15.	6	4	4
16.	3	5	6
17.	2	2	4
18.	2	2	4
19.	2	4	0
20.	4	2	5

Raw Data

Accuracy Throw
Underarm
(Score)

Subject	Left	Center	Right
1.	2	0	0
2.	0	0	0
3.	2	0	1
4.	3	6	0
5.	6	2	0
6.	6	0	4
7.	3	4	6
8.	4	5	6
9.	2	4	1
10.	1	1	2
11.	0	0	1
12.	0	1	3
13.	0	2	4
14.	2	2	2
15.	3	2	4
16.	0	4	7
17.	1	2	4
18.	1	3	0
19.	2	2	2
20.	2	4	1

Raw Data

Test-Retest

Accuracy Throw
Overhand
(Score)

I. Test

Subject	Left	Center	Right
1.	4	4	4
2.	8	5	1
3.	1	5	7
4.	2	3	4
5.	4	6	2
6.	6	4	5
7.	2	3	4

II. Retest

Subject	Left	Center	Right
1.	3	4	5
2.	6	3	3
3.	2	2	7
4.	2	5	4
5.	4	3	6
6.	5	3	5
7.	6	8	0

Raw Data

Test-Retest

Accuracy Throw
Sidearm
(Score)

I. Test

Subject	Left	Center	Right
1.	2	4	2
2.	4	3	6
3.	2	2	3
4.	3	4	2
5.	4	4	2
6.	6	3	1
7.	1	4	3

II. Retest

Subject	Left	Center	Right
1.	0	4	4
2.	4	4	2
3.	2	1	3
4.	2	2	2
5.	3	1	3
6.	4	2	3
7.	4	2	4

Raw Data

Test-Retest

Accuracy Throw
Underarm
(Score)

I. Test

Subject	Left	Center	Right
1.	2	0	0
2.	6	0	4
3.	3	4	6
4.	2	4	1
5.	3	6	0
6.	0	2	4
7.	6	2	0

II. Retest

Subject	Left	Center	Right
1.	2	0	1
2.	4	4	5
3.	2	3	4
4.	1	3	2
5.	2	2	4
6.	1	3	4
7.	6	3	2

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand (Left Side) vs. Underarm (Left Side)

	Overhand	Underarm	D	D^2
1.	4	2	-2	4
2.	3	0	-3	9
3.	2	2	0	0
4.	4	3	-1	1
5.	2	6	4	16
6.	8	6	-2	4
7.	1	3	2	4
8.	6	4	-2	4
9.	2	2	0	0
10.	3	1	-2	4
11.	2	0	-2	4
12.	3	0	-3	9
13.	6	0	-6	36
14.	6	2	-4	16
15.	2	3	1	1
16.	5	0	-5	25
17.	4	1	-3	9
18.	1	1	0	0
19.	2	2	0	0
20.	4	2	-2	4
	$\Sigma 70$	$\Sigma 40$	$\Sigma -30$	$\Sigma 150$

$N = 20$

$\Sigma D = -30$

$\Sigma D^2 = 150$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{150 - \frac{900}{20}}{\frac{20-1}{\sqrt{20}}}} = \frac{150 - \frac{900}{20}}{} = 105.00$$

$$= \frac{105}{19} = 5.52 = \frac{\sqrt{5.52}}{\sqrt{20}} = \frac{2.349}{4.472} = .52 = S_{\bar{D}}$$

$\bar{D}$ (Mean difference) $= \frac{30}{20} = 1.50$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{1.50}{.52} = 2.88$

df $= N-1 = 19$

"t" at the .05 level $= 2.09$ Difference is significant at the .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand (Left Side) vs. Sidearm (Left Side)

	Overhand	Sidearm	D	D^2
1.	4	2	-2	4
2.	3	1	-2	4
3.	2	1	-1	1
4.	4	4	0	0
5.	2	1	-1	1
6.	8	4	-4	16
7.	1	2	1	1
8.	6	3	-3	9
9.	2	3	1	1
10.	3	2	-1	1
11.	2	2	0	0
12.	3	1	-2	4
13.	6	6	0	0
14.	6	2	-4	16
15.	2	6	4	16
16.	5	3	-2	4
17.	4	2	-2	4
18.	1	2	1	1
19.	2	2	0	0
20.	4	4	0	0
	Σ70	Σ53	Σ -17	Σ83

$N = 20$

$\Sigma D = -17$

$\Sigma D^2 = 83$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$$= \sqrt{\frac{83 - \frac{289}{20}}{20 - 1}} \Big/ \sqrt{20} = 83 - \frac{289}{20} = 68.55$$

$$= \frac{68.55}{19} = 3.60 \quad \sqrt{3.60} = \frac{1.897}{4.472} = .42 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{17}{20}$ .85

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{.85}{.42} = 2.02$

df $= N - 1 = 19$

"t"at the .05 level $= 2.09$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Sidearm (Left Side) vs. Underarm (Left Side)

	Sidearm	Underarm	D	D^2
1.	2	2	0	0
2.	1	0	-1	1
3.	1	2	1	1
4.	4	3	-1	1
5.	1	6	5	25
6.	4	6	2	4
7.	2	3	1	1
8.	3	4	1	1
9.	3	2	-1	1
10.	2	1	-1	1
11.	2	0	-2	4
12.	1	0	-1	1
13.	6	0	-6	36
14.	2	2	0	0
15.	6	3	-3	9
16.	3	0	-3	9
17.	2	1	-1	1
18.	2	1	-1	1
19.	2	2	0	0
20.	4	2	-2	4
	Σ 53	Σ 40	Σ -13	Σ 101

$N = 20$

$\Sigma D = -13$

$\Sigma D^2 = 101$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N - 1}}$

$= \sqrt{\frac{101 - \frac{169}{20}}{20 - 1}} = \frac{101 - \frac{169}{20}}{\sqrt{20}} = 92.55$

$= \frac{92.55}{19} = 4.867 = \frac{\sqrt{4.86}}{\sqrt{20}} = \frac{2.204}{4.472} = .49 = S_{\bar{D}}$

$\bar{D}$ (mean difference) $= \frac{13}{20} = .65$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{.65}{.49} = 1.32$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand (Center) vs. Underarm (Center)

	Overhand	Underarm	D	D^2
1.	4	0	-4	16
2.	1	0	-1	1
3.	1	0	-1	1
4.	6	6	0	0
5.	3	2	-1	1
6.	5	0	-5	25
7.	5	4	-1	1
8.	4	5	1	1
9.	3	4	1	1
10.	4	1	-3	9
11.	1	0	-1	1
12.	1	1	0	0
13.	4	2	-2	4
14.	6	2	-4	16
15.	3	2	-1	1
16.	3	4	1	1
17.	2	2	0	0
18.	4	3	-1	1
19.	3	2	-1	1
20.	3	4	1	1
	Σ 66	Σ 44	Σ -22	Σ 77

$N = 20$

$\Sigma D = -22$

$\Sigma D^2 = 77$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}}$

$= \sqrt{\frac{77 - \frac{484}{20}}{20-1}} = \frac{77 - \frac{484}{20}}{\sqrt{20}} = 52.80$

$= \frac{52.80}{19} = 2.77 = \frac{\sqrt{2.77}}{\sqrt{20}} = \frac{1.646}{4.472} = .34 = S_{\bar{D}}$

$\bar{D}$ (mean difference) $= \frac{22}{20} = 1.10$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{1.10}{.34} = 3.23$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand (Center) vs. Sidearm (Center)

	Overhand	Sidearm	D	D^2
1.	4	4	0	0
2.	1	0	-1	1
3.	1	2	1	1
4.	6	4	-2	4
5.	3	4	1	1
6.	5	3	-2	4
7.	5	2	-3	9
8.	4	4	0	0
9.	3	4	1	1
10.	4	2	-2	4
11.	1	2	1	1
12.	1	2	1	1
13.	4	3	-1	1
14.	6	5	-1	1
15.	3	4	1	1
16.	3	5	2	4
17.	2	2	0	0
18.	4	2	-2	4
19.	3	4	1	1
20.	3	2	-1	1
	Σ 66	Σ 60	Σ -6	Σ 40

$N = 20$

$\Sigma D = -6$

$\Sigma D^2 = 40$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}}$

$= \sqrt{\frac{40 - \frac{36}{20}}{20 - 1}} = 40 - \frac{36}{20} = 38.20$

$\sqrt{20}$

$= \frac{38.20}{19} = 2.01 = \frac{\sqrt{2.01}}{\sqrt{20}} = \frac{1.417}{4.472} = .32 = S_{\bar{D}}$

$\bar{D}$ (mean Difference) $= \frac{6}{20} = .30$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{.30}{.32} = .93$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Sidearm (Center) vs. Underarm (Center)

	Sidearm	Underarm	D	D^2
1.	4	0	-4	16
2.	0	0	0	0
3.	2	0	-2	4
4.	4	6	2	4
5.	4	2	-2	4
6.	3	0	-3	9
7.	2	4	2	4
8.	4	5	1	1
9.	4	4	0	0
10.	2	1	-1	1
11.	2	0	-2	4
12.	2	1	-1	1
13.	3	2	-1	1
14.	5	2	-3	9
15.	4	2	-2	4
16.	5	4	-1	1
17.	2	2	0	0
18.	2	3	1	1
19.	4	2	-2	4
20.	2	4	2	4
	Σ60	Σ44	Σ-16	Σ72

$N = 20$

$\Sigma D = -16$

$\Sigma D^2 = 72$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{72 - \frac{256}{20}}{20-1}} = \frac{72 - \frac{256}{20}}{\sqrt{20}} = 59.2$$

$$= \frac{59.2}{19} = 3.11 \quad \frac{\sqrt{3.11}}{\sqrt{20}} = \frac{1.763}{4.472} = .39 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{16}{20} = .80$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{.80}{.39} = 2.05$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is not significance at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand (Right Side) vs. Underarm (Right Side)

	Overhand	Underarm	D	D^2
1.	4	0	-4	16
2.	2	0	-2	4
3.	4	1	-3	9
4.	2	0	-2	4
5.	4	0	-4	16
6.	1	4	3	9
7.	8	6	-2	4
8.	4	6	2	4
9.	4	1	-3	9
10.	4	2	-2	4
11.	4	1	-3	9
12.	2	3	1	1
13.	5	4	-1	1
14.	3	2	-2	1
15.	4	4	0	0
16.	3	7	4	16
17.	2	4	2	4
18.	2	0	-2	4
19.	3	2	-1	1
20.	6	1	-5	25
	Σ 71	Σ 48	Σ -23	Σ 141

$N = 20$

$\Sigma D = -23$

$\Sigma D^2 = 141$

$$S_{\bar{D}} \text{ (estimate of sampling error of } \bar{D}) = \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}} \Bigg/ \sqrt{N}$$

$$= \sqrt{\frac{141 - \frac{529}{20}}{20-1}} \Bigg/ \sqrt{20} = 141 - \frac{529}{20} = 114.15$$

$$= \frac{114.15}{19} = 6.00 = \frac{\sqrt{6.00}}{\sqrt{20}} = \frac{2.449}{4.472} = .54 = S_{\bar{D}}$$

$$\bar{D} \text{ (mean difference)} = \frac{23}{20} = 1.15$$

$$\text{"t"} = \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{1.15}{.54} = 2.12$$

$df = N - 1 = 19$

"t" at the .05 level = 2.09 Difference is significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand (Right Side) vs. Sidearm (Right Side)

	Overhand	Sidearm	D	D^2
1.	4	2	-2	4
2.	2	2	0	0
3.	4	0	-4	16
4.	2	2	0	0
5.	4	3	-1	1
6.	1	6	5	25
7.	8	3	-5	25
8.	4	4	0	0
9.	4	2	-2	4
10.	4	2	-2	4
11.	4	0	-4	16
12.	2	5	3	9
13.	5	1	-4	16
14.	3	2	-1	1
15.	4	4	0	0
16.	3	6	3	9
17.	2	4	2	4
18.	2	4	2	4
19.	3	0	-3	9
20.	6	5	-1	1
	Σ 71	Σ 57	Σ -14	Σ 148

$N = 20$

$\Sigma D = -14$

$\Sigma D^2 = 148$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{148 - \frac{196}{20}}{20 - 1}} = \frac{148 - \frac{196}{20}}{\sqrt{20}} = \frac{138.2}{19} = 7.27 = \frac{\sqrt{7.27}}{\sqrt{20}} = \frac{2.696}{4.472} = .60 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{14}{20} = .70$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{.70}{.60} = 1.16$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Sidearm (Right Side) vs. Underarm (Right Side)

	Sidearm	Underarm	D	D^2
1.	2	0	-2	4
2.	2	0	-2	4
3.	0	1	1	1
4.	2	0	-2	4
5.	3	0	-3	9
6.	6	4	-2	4
7.	3	6	3	9
8.	4	6	2	4
9.	2	1	-1	1
10.	2	2	0	0
11.	0	1	1	1
12.	5	3	-2	4
13.	1	4	3	9
14.	2	2	0	0
15.	4	4	0	0
16.	6	7	1	1
17.	4	4	0	0
18.	4	0	-4	16
19.	0	2	2	4
20.	5	1	-4	16
	Σ57	Σ48	Σ -9	Σ91

$N = 20$

$\Sigma D = -9$

$\Sigma D^2 = 91$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$$= \sqrt{\frac{91 - \frac{81}{20}}{20 - 1}} \Big/ \sqrt{20} = \frac{91 - \frac{81}{20}}{19} = \frac{86.95}{19} = 4.57 = \frac{\sqrt{4.57}}{\sqrt{20}} = \frac{2.137}{4.472} = .47 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{9}{20} = .45$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{.45}{.47} = .95$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Total Comparison of Overhand vs. Sidearm

	Overhand	Sidearm	D	D^2
1.	12	8	-4	16
2.	6	3	-3	9
3.	7	3	-4	16
4.	12	10	-2	4
5.	9	8	-1	1
6.	14	13	-1	1
7.	14	7	-7	49
8.	14	11	-3	9
9.	9	9	0	0
10.	11	6	-5	25
11.	7	4	-3	9
12.	6	8	2	4
13.	15	10	-5	25
14.	15	9	-6	36
15.	9	14	5	25
16.	11	14	3	9
17.	8	8	0	0
18.	7	8	1	1
19.	8	6	-2	4
20.	13	11	-2	4
	Σ 207	Σ 170	Σ -37	Σ 242

$N = 20$

$\Sigma D = -37$

$\Sigma D^2 = 242$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N - 1}}$

$$= \sqrt{\frac{242 - \frac{1369}{20}}{20 - 1}} = \frac{242 - \frac{1369}{20}}{\sqrt{20}} = \frac{173.55}{\sqrt{20}}$$

$$= \frac{173.55}{19} = 9.13 = \frac{\sqrt{9.13}}{\sqrt{20}} = \frac{3.021}{4.472} = .67 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{37}{20} = 1.85$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{1.85}{.67} = 2.76$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Total Comparison of Sidearm vs. Underarm

	Sidearm	Underarm	D	D^2
1.	8	2	-6	36
2.	3	0	-3	9
3.	3	3	0	0
4.	10	9	-1	1
5.	8	8	0	0
6.	13	10	-3	9
7.	7	13	6	36
8.	11	15	4	16
9.	9	7	-2	4
10.	6	4	-2	4
11.	4	1	-3	9
12.	8	4	-4	16
13.	10	6	-4	16
14.	9	6	-3	9
15.	14	9	-5	25
16.	14	11	-3	9
17.	8	7	-1	1
18.	8	4	-4	16
19.	6	6	0	0
20.	11	7	-4	16
	Σ 170	Σ 132	Σ -38	Σ 232

$N = 20$

$\Sigma D = -38$

$\Sigma D^2 = 232$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$= \sqrt{\frac{232 - \frac{1444}{20}}{20-1}} \Big/ \sqrt{20} = 232 - \frac{1444}{20} = 159.8$

$= \frac{159.8}{19} = 8.41 = \frac{\sqrt{8.41}}{\sqrt{20}} = \frac{2.900}{4.472} = .64 = S_{\bar{D}}$

$\bar{D}$ (mean difference) $= \frac{38}{20} = 1.90$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{1.90}{.64} = 2.96$

df $= N - 1 = 19$

"t" at the .05 level $= 2.09$ Difference is significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Total Comparison of Overhand vs. Underarm

	Overhand	Underarm	D	D^2
1.	12	2	-10	100
2.	6	0	-6	36
3.	7	3	-4	16
4.	12	9	-3	9
5.	9	8	-1	1
6.	14	10	-4	16
7.	14	13	-1	1
8.	14	15	1	1
9.	9	7	-2	4
10.	11	4	-7	49
11.	7	1	-6	36
12.	6	4	-2	4
13.	15	6	-9	81
14.	15	6	-9	81
15.	9	9	0	0
16.	11	11	0	0
17.	8	7	-1	1
18.	7	4	-3	9
19.	8	6	-2	4
20.	13	7	-6	36
	Σ 207	Σ 132	Σ -75	Σ 485

$N = 20$

$\Sigma D = -75$

$\Sigma D^2 = 485$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{485 - \frac{5625}{20}}{20-1}} = \frac{485 - \frac{5625}{20}}{\sqrt{20}} = 203.75$$

$$= \frac{203.75}{19} = 10.72 = \frac{\sqrt{10.72}}{\sqrt{20}} = \frac{3.426}{4.472} = .78 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{75}{20} = 3.75$

"t" $= \frac{\bar{D} \text{ (mean difference)}}{S_{\bar{D}} \text{ (estimate of sample error of } \bar{D})} = \frac{3.75}{.78} = 4.80$

df $= N - 1 = 19$

"t" at the .05 level = 2.09 Difference is significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand Throw (Left Side)

	Pre-Test	Post-Test	D	D^2
1.	4	3	-1	1
2.	8	6	-2	4
3.	1	2	1	1
4.	2	2	0	0
5.	4	4	0	0
6.	6	5	-1	1
7.	2	6	4	16
	Σ 27	Σ 28	Σ 1	Σ 23

$N = 7$

$\Sigma D_2 = 1$

$\Sigma D^2 = 23$

$$S_{\bar{D}} \text{ (estimate of sampling error of } \bar{D}) = \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}} \Big/ \sqrt{N}$$

$$= \sqrt{\frac{23 - \frac{1}{7}}{7-1}} \Big/ \sqrt{7} = 23 - \frac{1}{7} = 22.86$$

$$= \frac{22.86}{6} = 3.86 = \sqrt{\frac{3.86}{7}} = \frac{1.96}{2.64} = .74 \; S_{\bar{D}}$$

$\bar{D}$ = (mean difference) = $\frac{1}{7}$ = .14

"t" = $\frac{\bar{D}}{S_{\bar{D}}} = \frac{.14}{.74} = 0.19$

df = N - 1 = 6

"t" at the .05 level = 2.44 Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand Throw (Center)

	Pre-Test	Post-Test	D	D^2
1.	4	4	0	0
2.	5	3	-2	4
3.	5	2	-3	9
4.	3	5	2	4
5.	6	3	-3	9
6.	4	3	-1	1
7.	3	8	5	25
	Σ 30	Σ 28	Σ -2	Σ 52

$N = 7$

$\Sigma D = -2$

$\Sigma D^2 = 52$

$S_{\bar{D}}$ (estimate of the sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{52 - \frac{4}{7}}{7-1}} = \frac{52 - \frac{4}{7}}{\sqrt{7}} = 51.43$$

$$= \frac{51.43}{6} = 8.47 = \frac{\sqrt{8.47}}{\sqrt{7}} = \frac{2.91}{2.64} = 1.10 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{2}{7} = .28$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{.28}{1.10} = .25$

df $= N - 1 = 6$

"t" at the .05 level = 2.44 Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Overhand Throw (Right Side)

	Pre-Test	Post-Test	D	D^2
1.	4	5	1	1
2.	2	6	4	16
3.	1	2	1	1
4.	7	7	0	0
5.	4	4	0	0
6.	5	5	0	0
7.	4	0	-4	16
	Σ 27	Σ 29	Σ 2	Σ 34

$N = 7$

$\Sigma D = 2$

$\Sigma D^2 = 34$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$= \sqrt{\frac{34 - \frac{4}{7}}{7-1}} \Big/ \sqrt{7} = 34 - \frac{4}{7} = 33.43$

$= \frac{33.43}{6} = 5.57 = \frac{\sqrt{5.57}}{\sqrt{7}} = \frac{2.36}{2.64} = .89 = S_{\bar{D}}$

$\bar{D}$ (mean difference) $= \frac{2}{7} = .28$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{.28}{.89} = .31$

df $= N - 1 = 6$

"t" at the .05 level $= 2.44$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Sidearm Throw (Left Side)

	Pre-Test	Post-Test	D	D^2
1.	2	0	-2	4
2.	4	4	0	0
3.	2	2	0	0
4.	3	2	-1	1
5.	4	3	-1	1
6.	6	4	-2	4
7.	1	4	3	9
	Σ 22	Σ 19	Σ -3	Σ 19

$N = 7$

$\Sigma D_2 = -3$

$\Sigma D^2 = 19$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{19 - \frac{9}{7}}{7-1}} = \frac{19 - \frac{9}{7}}{\sqrt{7}} = 17.72$$

$$= \frac{17.72}{6} = 2.95 = \frac{\sqrt{2.95}}{\sqrt{7}} = \frac{1.71}{2.64} = .64 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{3}{7} = .43$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{.43}{.64} = .67$

df $= N - 1 = 6$

"t" at the .05 level = 2.44 Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Sidearm Throw (Center)

	Pre-Test	Post-Test	D	D^2
1.	4	4	0	0
2.	3	4	1	1
3.	2	1	-1	1
4.	4	2	-2	4
5.	4	1	-3	9
6.	3	2	-1	1
7.	4	2	-2	4
	Σ 24	Σ 16	Σ -8	Σ 20

$N = 7$

$\Sigma D_2 = -8$

$\Sigma D^2 = 20$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}}$

$$= \sqrt{\frac{20 - \frac{64}{7}}{7-1}} = \frac{20 - \frac{64}{7}}{\sqrt{7}} = 10.9$$

$$= \frac{10.9}{6} = 1.81 = \sqrt{\frac{1.81}{7}} = \frac{1.34}{2.64} = .50 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{8}{7} = 1.14$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{1.14}{.50} = 2.28$

df $= N - 1 = 6$

"t" at the .05 level $= 2.44$ Difference is not significant at .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Sidearm Throw (Right Side)

	Pre-Test	Post-Test	D	D^2
1.	2	4	2	4
2.	6	2	-4	16
3.	3	3	0	0
4.	2	2	0	0
5.	2	3	1	1
6.	1	3	2	4
7.	3	4	1	1
	Σ 19	Σ 21	Σ 2	Σ 26

$N = 7$

$\Sigma D = 2$

$\Sigma D^2 = 26$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$= \sqrt{\frac{26 - \frac{4}{7}}{7-1}} \Big/ \sqrt{7} = 26 - \frac{4}{7} = 25.43$

$= \frac{25.43}{6} = 4.23 = \frac{\sqrt{4.23}}{\sqrt{7}} = \frac{2.05}{2.64} = .77 = S_{\bar{D}}$

$\bar{D}$ (mean difference) $= \frac{2}{7} = .28$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{.28}{.77} = .36$

df $= N - 1 = 6$

"t" at the .05 level = 2.44 Difference is not significant at the .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Underarm Throw (Left Side)

	Pre-Test	Post-Test	D	D^2
1.	2	2	0	0
2.	6	4	-2	4
3.	3	2	-1	1
4.	2	1	-1	1
5.	3	2	-1	1
6.	0	1	1	1
7.	6	6	0	0
	Σ 22	Σ 18	Σ -4	Σ 8

$N = 7$

$\Sigma D = -4$

$\Sigma D^2 = 8$

$$S_{\bar{D}} \text{ (estimate of sampling error of } \bar{D}) = \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}}$$

$$= \sqrt{\frac{8 - \frac{16}{7}}{7-1}} = \frac{8 - \frac{16}{7}}{\sqrt{7}} = 5.72$$

$$= \frac{5.72}{6} = .95 = \frac{\sqrt{.95}}{\sqrt{7}} = \frac{.97}{2.64} = .36 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{4}{7} = .57$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{.57}{.36} = 1.58$

df $= N - 1 = 6$

"t" at the .05 level = 2.44 Difference is not significant at the .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Underarm Throw (Center)

	Pre-Test	Post-Test	D	D^2
1.	0	0	0	0
2.	0	4	4	16
3.	4	3	-1	1
4.	4	3	-1	1
5.	6	2	-4	16
6.	2	3	1	1
7.	2	3	1	1
	Σ 18	Σ 18	Σ 0	Σ 36

$N = 7$

$\Sigma D = 0$

$\Sigma D^2 = 36$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma(D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$= \sqrt{\frac{36 - \frac{0}{7}}{7-1}} \Big/ \sqrt{7} = \frac{36 - \frac{0}{7}}{6} = \frac{36}{6} = 6 = \frac{\sqrt{6}}{\sqrt{7}} = \frac{2.44}{2.64} = .92 = S_{\bar{D}}$

$\bar{D}$ (mean difference) $= \frac{0}{7} = 0$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{0}{92} = 0$

df $= N - 1 = 6$

"t" at the .05 level $= 2.44$ Difference is not significant at the .05 level

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

Area of Comparison Underarm Throw (Right Side)

	Pre-Test	Post-Test	D	D^2
1.	0	1	1	1
2.	4	5	1	1
3.	6	4	-2	4
4.	1	2	1	1
5.	0	4	4	16
6.	4	4	0	0
7.	0	2	2	4
	Σ 15	Σ 22	Σ 7	Σ 27

$N = 7$

$\Sigma D = 7$

$\Sigma D^2 = 27$

$S_{\bar{D}}$ (estimate of sampling error of $\bar{D}$) $= \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \frac{\Sigma (D)^2}{N}}{N-1}} \Big/ \sqrt{N}$

$$= \sqrt{\frac{27 - \frac{49}{7}}{7-1}} \Big/ \sqrt{7} = 27 - \frac{49}{7} = 20$$

$$= \frac{20}{6} = 3.33 = \frac{\sqrt{3.33}}{\sqrt{7}} = \frac{1.82}{2.64} = .68 = S_{\bar{D}}$$

$\bar{D}$ (mean difference) $= \frac{7}{7} = 1.00$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{1.00}{.68} = 1.47$

df $= N - 1 = 6$

"t" at the .05 level $= 2.44$ Difference is not significant at .05 level

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