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A Comparison of Reaction Time Changes in Freshman Baseball Players Elicited by Practive With the Variable Speed Rotating Pitching Machine

William G. Trenbeath

A COMPARISON OF REACTION TIME CHANGES IN FRESHMAN BASEBALL PLAYERS ELICITED BY PRACTICE WITH THE VARIABLE SPEED ROTATING PITCHING MACHINE

by

William G. Trenbeath

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This thesis submitted by William G. Trenbeath 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.

W. C. Koenig
Chairman

John L. Quaday

Clyde W. Marks

William Johnson
Dean of the Graduate School

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ABSTRACT

The purpose of this study was to determine the differences, if any, which might occur in the reaction time of two groups, one of which took part in a training program using the Variable Speed Rotating Pitching Machine and another group which did not.

The participants in this study consisted of eighteen freshman baseball candidates at the University of North Dakota. A Meylan Reaction-Action Timer was used to test all participants in reaction time before and after a six week experimental period using the matched pairs technique. Nine subjects were placed in the control group and nine subjects were placed in the experimental group.

The experimental group participated in a systematic training program three days a week for a period of six weeks using the Variable Speed Rotating Pitching Machine. The control group participated in normal daily activities.

Two statistical comparisons were made: (1) a within group comparison between the test and retest means of each group, and (2) a comparison between the means on the retests of each group. The null hypothesis was assumed in analyzing the significance of the difference between means at the .05 level.

The results of the comparison showed an improvement, although not significant, by the experimental group in reaction time. The control group evidenced a significant difference in reaction time at the .05 level.

It was concluded that at the end of the six week training period, the experimental group was significantly faster in reaction time (at the .05 level) than was the control group. The final conclusion was that: participation in a systematic Variable Speed Rotating Pitching Machine could improve the reaction time of college freshman baseball players, at least in the manner tested in this study.

CHAPTER I

INTRODUCTION

Since the beginning of baseball, players and coaches have been searching for the magic formula for success in hitting. This search has led to the invention of many different "hitting aids," ranging from the conventional pitching machine to the simple batting tee. However, little attention has been paid to the improvement of reaction time as it affects hitting a baseball.

Opinions differ among baseball coaches as to whether or not the reaction time of a hitter can be improved. Research studies have indicated that there is a difference in reaction times of baseball players and that this reaction time does play an important part in the hitting of a baseball.

Statement of the Problem

The problem of this study was to determine whether or not participation in a program using the Variable Speed Rotation Pitching Machine for a period of six weeks would improve reaction time significantly.

The writer tested the reaction times of eighteen freshman baseball aspirants using the Meylan Reaction-Action Timer.

Need for the Study

Baseball is a great sport, as demonstrated by the number of participants. The intense competition involved in inter-scholastic, intercollegiate and professional baseball emphasizes the challenge confronting the present day baseball player.

Because of the demands confronting the baseball coach, this writer became interested in the hitting aspect of the game of baseball, and in particular, those factors which influence hitting. It is these factors which are discussed by coaches, players and fans alike. It is generally agreed that reaction time plays a very important part in the role of hitting. The question therefore arises, how, if at all, can reaction time be improved?

If there were a definite method of improving reaction time of the baseball player, it would be advantageous for players and their coaches to know about it. This knowledge would be beneficial to both coaches and players since they could better utilize their time in preparation for actual competition.

Limitations

The participants in this study consisted of potential members of the 1967 Freshman Baseball Team at the University of North Dakota.

The number of "Variable Speed Rotating Pitching Machines" used was limited to one because of the personal expense involved.

Definition of Terms

The experimental group refers to the nine potential members of the 1967 University of North Dakota Freshman Baseball team who participated in a program using the Variable Speed Rotating Pitching Machine.

The control group refers to the nine potential members of the 1967 University of North Dakota Freshman Baseball team who participated in a normal routine of daily activities.

A swing refers to the action taken by the batter in attempting to strike the ball with the bat.

The reaction time, for the purposes of this study, refers to the time elapsing between the initial application of the stimulus and the beginning of the individual's reaction to it.

The Variable Speed Rotating Pitching Machine refers to a mechanical motor driven device which propels a rope-tied baseball through a horizontal orbit. This device was used by the experimental group during their six week training program.

Review of Related Literature

Literature directly related to the topic selected by the writer was very limited. However, much research has been conducted in other areas of baseball. Perhaps, the numerous factors that influence the hitting of a baseball and the resulting difficulty of controlling these factors have kept the number of investigations in this area to a minimum. An attempt was made to gather as much pertinent information as possible referring to the topic of this study.

In an investigation conducted by Slater-Hammel and Stumpner,[1] there was evidence that the importance of the "last fraction of a second" or the "last few feet of home base" was greater than commonly imagined. Furthermore, even if the reaction time was of the order of a simple hand response to a visual stimulus, it would amount to between .150 and .225 of a second, and constitute a considerable interval of time. In view of the fact that a baseball travels from pitcher to home base in approximately one-half of a second, it became evident to the authors that a ball must be more than a few feet from home plate if the batter was to have time to react to it.

In their study, using twenty-five male physical education majors at Indiana University, they found that the mean starting reaction time was approximately .21 seconds. From their observations, it was concluded that it would be advantageous for a batter to withhold, somewhat, his reaction to a ball in flight to enable him to observe the ball a little longer, and this would, presumably, lead to greater batting success.

To attain an estimate of the maximal limits of batting reaction time, a second investigation by Slater-Hammel and Stumpner[2] was undertaken. This study was concerned with choice batting reaction time. The visual stimulus to which the subjects reacted consisted of four neon glow lamps. These lamps were mounted on a

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[1]A. T. Slater-Hammel and R. L. Stumpner, "Batting Reaction Time," Research Quarterly, (Vol. XXI, No. 4, December, 1950), pp. 353-356.

[2]A. T. Slater-Hammel and R. L. Stumpner, "Choice Batting Reaction-Time," Research Quarterly, (Vol. XXII, No. 3, October, 1951), pp. 377-380.

vertical panel to give a pattern of two vertical lights and two horizontal lights. At the signal "Ready," the subject concentrated on the light panel and the reaction to be made. Choice starting reaction time was measured by having the subject swing the bat forward only when the horizontal lights appeared.

The choice batting reaction time of twenty-five physical education majors was found to be .29 seconds. A comparison of the choice reaction times found in this experiment with the simple reaction time reported in an earlier study reveals that the latter was considerably shorter.

However, Hubbard and Seng[3] concluded that batting was not primarily a reaction time problem. They stated that the stimulus object (ball) is continuously visible during its flight, not suddenly presented. Consequently, the problem is one of tracking a moving object, predicting its course and, at some point in its flight, deciding to swing or not.

Slater-Hammel,[4] in comments made concerning the study conducted by Hubbard and Seng,[5] indicated that practically all instances of apparent head and eye movements occurred after commencements of the central processes. He further concluded that the central processes presumably could not do much in the way of

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[3]Alfred W. Hubbard and Charles N. Seng, "Visual Movements of Batters," Research Quarterly, (Vol. XXV, No. 1, March, 1954), pp. 42-57.

[4]A. T. Slater-Hammel, "Comments," Research Quarterly, (Vol. XXVI, No. 3, October, 1955), pp. 365-366.

[5]Hubbard and Seng, loc. cit.

predicting the ball's course. Therefore, any evidence of tracking was essentially eliminated.

Winograd[6] directed a study to determine the relationship of timing and vision to successful batting in baseball. He also attempted to indicate that groups who did not play baseball were different from groups who did, in terms of the abilities measured by the vision and timing tests employed. He concluded that there were definite differences reliably distinguishable between baseball players and non-athletes in choice timing.

Miller and Shay[7] made an investigation to determine the relationship of the speed of a pitched softball to the reaction time of selected individuals. The subjects utilized for the measurement of reaction time were 258 Springfield College undergraduate male students. The mean reaction time of the subjects was found to be .215 of a second. Nine softball pitchers were used and tested for speed. The average velocity of the subjects' pitches was 59.95 mph. Calculations showed that the ball would have been 29.33 feet from home plate before 116 of the subjects would have begun their swing. From these averages, the conclusion was that reaction time was a very significant factor in hitting and that pitchers with greater velocity would decrease the success of the batter if the reaction time remained the same.

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[6]Samuel Winograd, "The Relationship of Timing and Vision to Baseball Performance," Research Quarterly, (Vol. XIII, No. 4, December, 1942), pp. 481-493.

[7]Robert G. Miller and Clayton T. Shay, "Relationship of Reaction Time to the Speed of a Softball," Research Quarterly, (Vol. XXXV, No. 3, October, 1964), pp. 433-437.

Wilkinson,[8] studied the reaction times of fifty non-athletes and 100 athletes at Southern Illinois University. The athletes consisted of four groups: 25 wrestlers, 25 baseball players, 25 football players and 25 basketball players. Wilkinson found that wrestlers and baseball players had significantly shorter reaction times to visual stimuli than did the other two groups.

Parker,[9] undertook a study to determine the effect of progressive resistance exercises on reaction time. Twenty-three subjects, ten of whom were women, engaged in a concentrated five week training program using twelve progressive resistance exercises. He concluded that such a program did bring about a faster reaction time in all the subjects and, in addition, the subjects having the strongest grip strength were found to have the fastest reaction times.

Summary

In summary of the literature reviewed, it was found that most of the studies were concerned with measuring the reaction times of various groups. No research could be found that dealt with the improvement of reaction time. Following are significant points discussed in Chapter I:

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[8]James J. Wilkinson, "A Study of Reaction Time Measures to a Kinesthetic and a Visual Stimulus for Selected Groups of Athletes and Non-Athletes," (unpublished Doctoral dissertation, Indiana University, Bloomington, Indiana, 1958).

[9]Arthur Benjamin Parker, Jr., "A Study of the Relationships Between Reaction Time and Progressive Resistance Exercise," (unpublished Master's Thesis, Springfield College, Springfield, Massachusetts, 1960).

1. Reaction time is important to efficient performance in any sport and particularly baseball.
2. Reaction time and its relationship to hitting is a subject which is discussed by coaches who are evaluating the ability of players relative to performance in batting.
3. A baseball travels the regulation sixty feet six inches in a very short time and reaction movement, therefore, must play an important part in hitting.
4. The longer a batter can wait before he swings and still meet the ball in front of the plate, the better his chances of hitting the baseball.

CHAPTER II

METHODOLOGY

Selection and Equation of the Two Groups

The subjects selected for this study were male freshman baseball candidates enrolled at the University of North Dakota. At a special meeting for all such candidates, the members were asked if they would be interested and willing to participate in a directed study conducted over a six week period of time. As a result, eighteen members of this group indicated a willingness and desire to be a part of this study. These eighteen volunteers were used as subjects for this study.

The two groups were equated on the basis of mean reaction times determined by the Meylan Reaction-Action Timer at the initial test. With the mean reaction time being known for each subject, the original group of eighteen subjects was subdivided into two equal groups of nine subjects each so that the mean reaction times for each group were exactly equal and the standard deviations of each group were approximately equal (Appendix A, pages 29-32).

Testing Apparatus

The facilities of the University of North Dakota Physical Education Department were used for the administration of the tests.

In the actual collection of data for reaction time, the writer was responsible for the operation of the instrument used in

measuring, the Meylan Reaction-Action Timer. The timer, which operated on 115 volt electric power had two one-hundredth second indicators, one of which measured reaction time and the other action time. For the purposes of this study, the action time indicator was not used. Reaction time to the nearest .01 second was measured by this device. Additional equipment needed to complete the testing procedure consisted of a depressable switch and an electric light bulb.

Testing Procedure

The small depressable switch was directly connected to the timing device and the light bulb. The current supplied to the testing apparatus was regulated by the writer. No subject complained of this arrangement.

The subject took a position such that he depressed the switch with the index finger of his right hand and focused his eyes on the light bulb. The writer then pressed another button which closed the circuit, lighted the bulb and started the clock. When the subject removed his finger from the switch, the circuit opened and the clock stopped. Each subject was given a number of practice trials and was not tested until he felt he was ready. Three trials were given. The retest was conducted in the same manner six weeks after the conclusion of the initial test.

Training Procedure

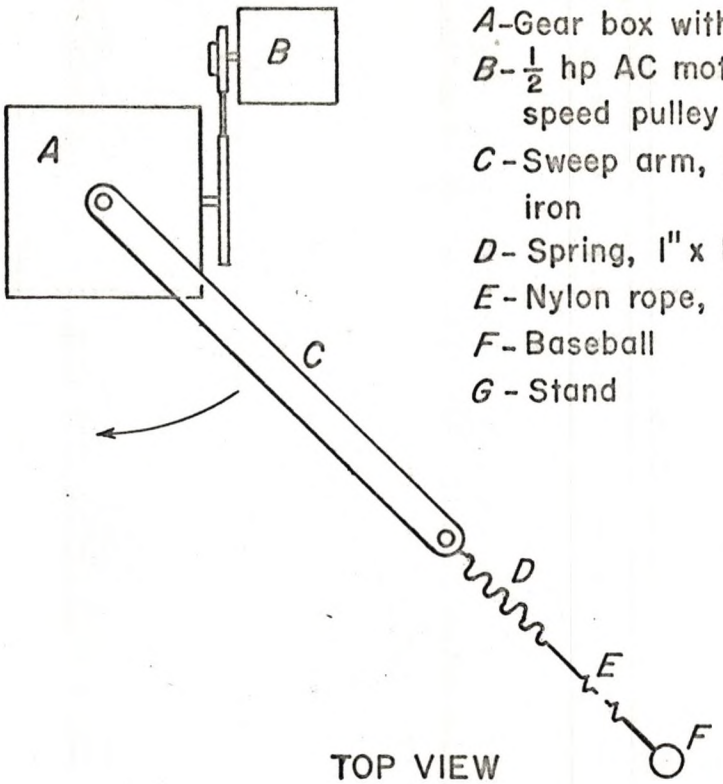
Prior to the first training session, each member of the experimental group was allowed to select a bat of his own choice. The subject then used the same bat throughout the six week period. After

selecting the bat, the subjects reported to the fieldhouse arena for orientation on the use of the Variable Speed Rotating Pitching Machine.

The Variable Speed Rotating Pitching Machine (see Figure 1, page 12) used was designed and constructed by the writer with the aid of Mr. Jack Trenbeath. A hole was drilled through the center of a regulation baseball. Through this hole a nylon rope was inserted and tied. The other end of this fifteen foot nylon rope was then tied to a medium weight coil spring, which in turn, was securely fastened to a steel sweep arm. The steel sweep arm was rotated mechanically by a one-half horsepower electric motor at a speed sufficient to keep the rotating ball at a height of three feet from the ground. The speed of the rotating ball could be regulated by adjusting a variable speed pulley.

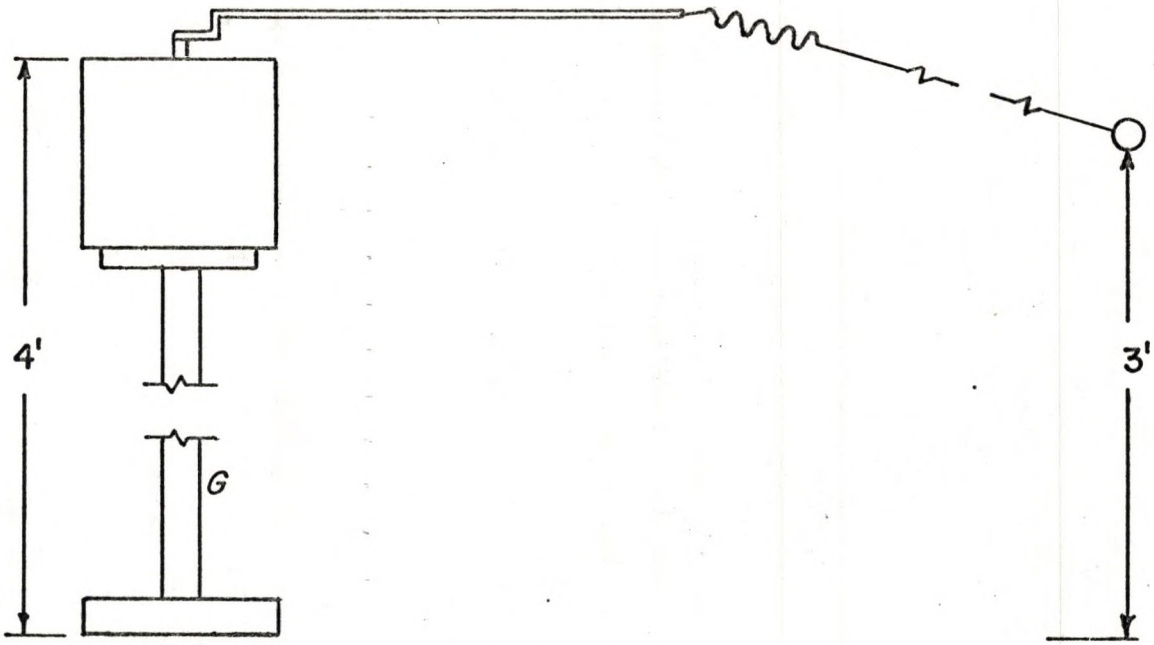
Preceding the first training session, each member of the experimental group was allowed to view the functioning of the machine and take a number of practice swings at the rotating baseball. From this preliminary session, it was possible to determine the speed of the baseball that would be the most suitable for the following six weeks of training.

After going through loosening-up drills of their own selection, the subjects were then permitted to begin the training session. Only one subject at a time could be accommodated by the machine. The subject would take his normal batting stance and attempt to hit the baseball with the bat as the baseball came through the strike zone. Each participating individual was instructed not to follow visually the baseball in its entire



A-Gear box with 8" pulley
B-$\frac{1}{2}$ hp AC motor with 4" variable speed pulley
C-Sweep arm, $\frac{1}{4}$"x 2"x28" strap iron
D-Spring, 1" x 15"
E-Nylon rope, $\frac{1}{4}$" x 15'
F-Baseball
G-Stand

TOP VIEW



FRONT VIEW

FIGURE 1

rotating orbit, but rather to limit his visual pursuits to looking straight ahead and tracking the baseball visually when it came into sight. Each subject was limited to ten swings at a time per training session. A swing was counted as such, regardless of whether contact was made with the baseball or not. This training program for members of the experimental group was conducted on Monday, Wednesday and Friday of each week for a period of six weeks.

At the end of each training session the participants were allowed to continue their normal daily routine.

Statistical Procedure

This investigator assumed the null hypothesis in analyzing the differences between the initial scores of both groups and the retest scores of each group. The null hypothesis asserts that no differences exist between two population means and that any difference found would be the result of chance and be unimportant.[10]

Investigation of several possible 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 use in this study. This test determines the ratio between the mean difference and the estimate of sampling error of the mean difference. This ratio is expressed as "t" and is checked for significance in a "t" table. The value of "t" is proportional to the degrees of freedom (N-1) allowed in determining the relationship between the mean difference

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[10]George A. Ferguson, Statistical Analysis in Psychology and Education, (New York: McGraw Hill Book Company, Inc., 1966), p. 162.

and the estimate of sampling error of the mean difference.

For this study it was decided to reject the null hypothesis at the .05 level of significance.

Complete data including mean differences and raw scores are presented in Appendix A, pages 29-32. Details of the mathematical process employed are presented in Appendix B, pages 34-40.

CHAPTER III

ANALYSIS OF DATA

Introduction

This study was undertaken to evaluate the changes, if any, which might occur in the reaction times of two groups of college males as demonstrated by the Variable Speed Rotating Pitching Machine. The subjects were all potential members of the University of North Dakota Freshman Baseball team.

The experimental group consisted of nine subjects who trained three times a week for six weeks on the Variable Speed Rotating Pitching Machine. The nine members of the control group did not use this device, but rather carried on with their normal routine of daily activities.

The investigator used the matched pairs technique to equate the groups. A mean reaction time score, based on three time trials, was secured for each of the eighteen volunteers. This original group was then divided into two groups of nine in such a manner that the means of the resulting groups were equal and the standard deviations were approximately equal.

The standard deviation formula used was:

$$SD = \frac{d^2}{N}$$

The σ for the control group on the initial test was .0210 and for the experimental group on the initial test, .0192. Since the means of the control and experimental groups on the initial test were both .151 seconds, the groups were considered to be equated.

Within Groups Comparison

The control group had a mean score of .151 seconds in the initial test and a mean score of .180 seconds in the retest to measure reaction time.

The mean difference between the initial test and the retest of the control group was an increase of .0296 seconds. The estimate of sampling error of the mean difference was .0107.

The "t" value of a -2.766 with 8 degrees of freedom was significant at the .05 level.

Table 1 shows the initial test and retest scores of the control group with the mean difference, estimate of sampling error of the mean difference and the significance of "t" at the .05 level.

TABLE 1

MEAN SCORES OF THE CONTROL GROUP IN REACTION TIME

Number	Initial Test	Retest	$S_{\overline{D}}$	$\overline{D}$	"t"
9	.151	.180	.0107	.0296	-2.766 Significant

The experimental group in the initial test had a mean score of .151 seconds and in the retest had a mean score of .132 seconds. The mean difference of the experimental group between the initial test and retest was a decrease of .0186 seconds. The estimate of sampling error of the mean difference was .0099. The "t" value of 1.879 with 8 degrees of freedom was not significant at the .05 level.

Table 2 shows the initial test and retest scores of the experimental group with the mean difference, estimate of sampling error of the mean difference and the significance of "t" at the .05 level.

TABLE 2

MEAN SCORES OF THE EXPERIMENTAL GROUP IN REACTION TIME

Number	Initial Test	Retest	$S_{\bar{D}}$	$\bar{D}$	"t"
9	.151	.132	.0099	.0186	1.879 Not Significant

Between Groups Comparison

In determining the significance of the mean difference in the between group comparison, the formula for the degrees of freedom establishing the .05 level of significance in the "t" table was $(N_1 - 1) + (N_1 - 1)$. In this comparison the null hypothesis was accepted or rejected according to the "t" ratio and level of significance established.

The mean difference between the initial test scores and the retest scores of the control group was -.0296 seconds. The mean difference between the initial test scores and the retest scores of the experimental group was .0186 seconds. The difference between the mean differences of the two groups was .0482 seconds. The estimate of the sampling error for the distribution of differences between the mean differences was .0146. The "t" value resulting from the comparison and relationship of the difference between the mean differences and the estimate of the sampling error for the distribution of differences between the mean differences was 3.30. This "t" value with 16 degrees of freedom indicated a significant difference at the .05 level between the groups. Table 3 shows the estimate of the sampling error for the distribution of differences between the mean differences and the significance of the difference between means of the experimental group and control group in reaction time.

TABLE 3

SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF CORRELATED GROUPS IN REACTION TIME

Group	Number	$S_{\bar{D}}$	$\bar{D}$	$S_{D_M D}$	"t"
Control	9	.0107	-.0296	.0146	-3.30
Experimental	9	.0099	.0186	Significant	

Overall, the experimental group did improve in reaction time, although not significantly at the .05 level. The control group did show a significant increase in reaction time between initial test and retest.

CHAPTER IV

DISCUSSION

Up to the present, the only used techniques for measuring the potentialities of a baseball player have resided in the subjective judgments formed by an observer. This judgment, usually based on personal experience, while empirical, has brought fairly satisfactory results. It is obvious that a scientific approach might bring greater benefits and perhaps lead to an enhanced efficiency in the training of athletes. Vision and timing are not the only factors in batting, but as a result of conversations with experts in the game, and a review on the subject of qualifications of good batters, this writer believes they rank high in importance, and warrant specific investigation. The degree to which these qualities are inherent and not essentially developmental has been questioned. On the other hand, there are opinions which maintain that there is not such a thing as an instinct relative to having "an eye for the ball," but rather it must be a kind of skill which some men have acquired by practice and others have not.

The present study was undertaken in order to provide experimental data which might help clarify the situation.

Certain factors must be mentioned at this time in the discussion of this study which were pertinent to the results. Of the nine members of the experimental group, four of the subjects used

poor batting techniques. This was evident during the entire six weeks training period. No attempt was made by the investigator to improve the batting fundamentals of the subjects since it might have jeopardized the results of the study.

The entire six week training session was carried out in the confines of the University of North Dakota Fieldhouse Arena. This posed a number of problems. First, the available lighting, although seemingly adequate, was certainly not comparable to the out-of-doors. Consequently, this may have hindered the visual tracking of the ball. However, no one complained of the situation. Secondly, other sporting activities were going on in the Arena area at the same time that the training program was in session. The participants in other sports were more concerned with being spectators of the training program being conducted than being active in their own endeavors. As a result, some of the subjects may have become inhibited. This was evidenced by the fact that, although it was not the specific objective of the subjects to hit the ball as it came through the strike zone, all of the subjects did make a definite effort to do so. The orbiting baseball seemed to be more elusive to the batter than it did to the onlookers. Perhaps the repeated failure to make contact with the ball significantly inhibited a number of the subjects.

Other limitations should be mentioned before discussing the results of the study. In coaching any sport, the coach often stresses the importance of being in good physical condition before the start of the actual sport season. It was therefore an uncontrolled variable that some of the freshman baseball candidates may

have kept themselves in good condition over the winter months, while others may have neglected to do this. Also, the training program was not of sufficient duration. Preferably, it is believed, the training program should have lasted a minimum of eight weeks. This, however, was impossible due to the school schedule of the subjects involved. Finally, motivation is a variable factor, whether there be an excess or a lack of it. All subjects of both groups appeared to be sufficiently motivated, as they were volunteers, and they had a high degree of interest in the game of baseball.

Of great importance is the fact that participants of the experimental group showed a significant difference from those of the control group in reaction time after only eighteen training sessions during six weeks of time. There is a strong indication that not only did the use of the machine have an improving affect on reaction time but that such a program may also keep the reaction time of baseball players from slowing down. This writer believes that, although the results were not conclusive, they do indicate the advantages of such a program. The implications brought forth by the results of this study relative to the importance of reaction time are numerous. Slater-Hammel and Stumpner[11] concluded that the batter who had the fastest reaction time could wait the longest before swinging at the ball. This would give him a better chance to watch the ball and its possible movements. Following as a logical conclusion, this additional time would increase the chances of hitting the ball.

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[11]Slater-Hammel and Stumpner, "Batting Reaction Time," p. 355.

The control group registered a mean increase in reaction time of .029 seconds during the six week period. This increase in reaction time was significant at the .05 level. In the opinion of this writer, the increase shown by the control group in reaction time could have been due to the factor mentioned before regarding the physical condition of each subject. More likely however, was the observable fact that many members of the control group would have liked to have participated in the experimental program, and consequently, believed that they were being deprived of something very helpful.

The experimental group showed a mean decrease in reaction time of .019 seconds after six weeks of training. Though not significant at the .05 level, the decrease in reaction time shown over the initial test mean score could have been due to the influence of the training program, and the motivation resulting from it. It was very noticeable to this observer that the members of the experimental group enjoyed the six weeks of training using the Variable Speed Rotating Pitching Machine.

Even though the experimental group did not significantly improve its reaction time, it was felt that the subjects did improve in their hitting ability and that the study was worthwhile. First of all, it has given the investigator the desire to continue using such a training program even if it means utilizing a similar but manual device. Secondly, the individuals who participated in the experimental group training program thought it helped their reaction ability and their hitting in general. This investigator feels that

the use of the Variable Speed Rotating Pitching Machine could develop reaction time, timing and hitting ability simultaneously.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary:

The purpose of this study was to determine the differences, if any, which might occur in the reaction times of two groups, one of which took part in a training program using the Variable Speed Rotating Pitching Machine, and another group which did not.

The participants in this study consisted of eighteen freshman baseball candidates at the University of North Dakota. A Meylan Reaction-Action Timer was used to test all participants in reaction time before and after a six week period. Nine subjects were placed in the control group and nine subjects were placed in the experimental group. This selection was based on the mean reaction time score for each individual obtained at the initial test, such that the mean reaction time score for each group was exactly the same and the standard deviation for each group was approximately the same. Thus, the groups were considered to be equated.

The experimental group participated in a systematic training program three days a week for a period of six weeks using the Variable Speed Rotating Pitching Machine. The control group participated in normal daily activities of their own selection for the same length of time.

Comparisons were made between the mean differences within each group as indicated by the initial test and retest. The null hypothesis was assumed with respect to the differences within the groups.

Between group comparisons were made between the mean differences of the retest results for each group. The between group comparison used the "t" technique for correlated data from small samples.

Conclusions:

1. The control group recorded a significant increase in reaction time at the .05 level of confidence during the six week period that the study was conducted.
2. A systematic program using the Variable Speed Rotating Pitching Machine three days a week for a period of six weeks produced improvement in reaction time among college freshman baseball players, although not significantly at the .05 level of confidence.
3. At the end of the six weeks training period, the experimental group (which had used the machine) was significantly faster in reaction time (at the .05 level) than was the control group.
4. It would seem possible to conclude that participation in a systematic Variable Speed Rotating Pitching Machine program can improve the reaction time of college freshman baseball players, at least in the manner tested in this study.

Recommendations:

Since this study was limited to reaction time, this investigator recommends a similar study to include the reaction-action time and the comparisons resulting from such a study.

Participants in this study noted an obvious improvement in hitting ability. Therefore, it is recommended that a study be undertaken to determine: (1) the correlation between hitting ability and reaction time and (2) the effect of the Variable Speed Rotating Machine on hitting ability.

It would seem desirable that a similar study should be conducted to determine if this reaction time improvement is retained at the end of the season.

This investigator also feels that another study be undertaken to evaluate the effectiveness of similar reaction time improvement programs. This would probably require investigations over a longer period of time and would also require employing different training practices.

Because the improvement in reaction time shown by the experimental group was not significant, it is recommended that a similar study be conducted over a longer period of time, using more subjects, and longer training sessions, to determine if such a program could produce significant improvement in reaction time.

APPENDIX A

INITIAL TEST REACTION TIME SCORES

GROUP - Control TEST - Reaction Time

Subject	Trial 1	Trial 2	Trial 3	Sum	Mean
1.	.180	.130	.150	.460	.153
2.	.140	.140	.190	.470	.157
3.	.120	.100	.130	.350	.117
4.	.180	.130	.080	.390	.130
5.	.080	.190	.190	.460	.153
6.	.230	.180	.170	.580	.193
7.	.130	.150	.130	.410	.137
8.	.170	.110	.160	.440	.147
9.	.210	.160	.140	.510	.170
TOTAL					1.357

Mean Score of Control Group = .151

Standard Deviation of Control Group = .0210

INITIAL TEST REACTION TIME SCORES

GROUP - Experimental TEST - Reaction Time

Subject	Trial 1	Trial 2	Trial 3	Sum	Mean
1.	.150	.190	.120	.460	.153
2.	.100	.140	.150	.390	.130
3.	.150	.160	.080	.390	.130
4.	.140	.140	.090	.370	.123
5.	.200	.170	.170	.540	.180
6.	.140	.190	.140	.470	.157
7.	.170	.110	.150	.430	.143
8.	.170	.170	.170	.510	.170
9.	.180	.190	.140	.510	.170
TOTAL					1.356

Mean Score of Experimental Group = .151

Standard Deviation of Experimental Group = .0192

RETEST REACTION TIME SCORES

GROUP - Control TEST - Reaction Time

Subject	Trial 1	Trial 2	Trial 3	Sum	Mean
1.	.230	.200	.190	.620	.207
2.	.120	.180	.180	.480	.160
3.	.240	.130	.150	.520	.173
4.	.210	.230	.190	.630	.210
5.	.200	.160	.180	.540	.180
6.	.180	.210	.220	.610	.203
7.	.170	.150	.110	.430	.143
8.	.150	.110	.190	.450	.150
9.	.210	.220	.160	.590	.197
TOTAL					1.623

Mean Score of Control Group = .180

Standard Deviation of Control Group = .0263

RETEST REACTION TIME SCORES

GROUP - Experimental TEST - Reaction Time

Subject	Trial 1	Trial 2	Trial 3	Sum	Mean
1.	.140	.050	.140	.330	.110
2.	.130	.100	.130	.360	.120
3.	.140	.140	.160	.440	.147
4.	.120	.150	.120	.390	.130
5.	.070	.130	.170	.370	.123
6.	.180	.140	.130	.450	.150
7.	.130	.130	.140	.400	.133
8.	.200	.190	.130	.520	.173
9.	.090	.110	.110	.310	.103
TOTAL					1.189

Mean Score of Experimental Group = .132

Standard Deviation of Experimental Group = .0205

APPENDIX B

INITIAL TEST AND RETEST OF THE CONTROL GROUP IN REACTION TIME

Subject	Initial Test Mean	Retest Mean	Sum of Differences	Differences Squared
1.	.153	.207	-.054	.002916
2.	.157	.160	-.003	.000009
3.	.117	.173	-.056	.003136
4.	.130	.210	-.080	.006400
5.	.153	.180	-.027	.000729
6.	.193	.203	-.010	.000100
7.	.137	.143	-.006	.000036
8.	.147	.150	-.003	.000003
9.	.170	.197	-.027	.000729
TOTAL	1.357	1.623	-.266	.014064

Mean Score of Initial Test Mean = .151

Mean Score of Retest Mean = .180

Sum of Differences =-.266

Sum of Differences Squared = .014064

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

TEST - Reaction Time GROUP - Control

$N = 9$

$\Sigma D = -.266$

$\Sigma D^2 = .014064$

$S_{\bar{D}}$ (estimate of the sampling error of $\bar{D}$) $= \dfrac{SD}{\sqrt{N}}$

$$\frac{\sqrt{\dfrac{\Sigma D^2 - \dfrac{(D)^2}{N}}{N-1}}}{\sqrt{N}} = \frac{\sqrt{\dfrac{.014064 - \dfrac{(-.266)^2}{9}}{8}}}{\sqrt{9}}$$

$S_{\bar{D}} = .0107$

$\bar{D} = \dfrac{\Sigma D}{N} = \dfrac{-.266}{9} = -.0296$

"t" $= \dfrac{\bar{D}}{S_{\bar{D}}} = \dfrac{-.0296}{.0107} = -2.766$

$df = N - 1 = 8$

"t" at .05 level = 2.306

significant at .05 level

INITIAL TEST AND RETEST OF THE EXPERIMENTAL GROUP IN REACTION TIME

Subject	Initial Test Mean	Retest Mean	Sum of Differences	Differences Squared
1.	.153	.110	.043	.001849
2.	.130	.120	.010	.000100
3.	.130	.147	-.017	.000289
4.	.123	.130	-.007	.000049
5.	.180	.123	.057	.003249
6.	.157	.150	.007	.000049
7.	.143	.133	.010	.000100
8.	.170	.173	-.003	.000009
9.	.170	.103	.067	.004489
TOTAL	1.356	1.1189	.167	.010183

Mean Score of Initial Test Mean = .151

Mean Score of Retest Mean = .132

Sum of Differences = .167

Sum of Differences Squared = .010183

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

TEST - Reaction Time GROUP - Experimental

$N = 9$

$\Sigma D = .167$

$\Sigma D^2 = .010183$

$S_{\bar{D}}$ (estimate of the sampling error of $\bar{D}$) $= \frac{SD}{\sqrt{N}}$

$$\frac{\sqrt{\frac{\Sigma D^2 - \frac{(D)^2}{N}}{N-1}}}{\sqrt{N}} = \frac{\sqrt{\frac{.010183 - \frac{(.167)^2}{9}}{8}}}{\sqrt{9}}$$

$S_{\bar{D}} = .0099$

$\bar{D} = \frac{\Sigma D}{N} = \frac{.167}{9} = .0186$

"t" $= \frac{\bar{D}}{S_{\bar{D}}} = \frac{.0186}{.0099} = 1.879$

df $= N - 1 = 8$

"t" at .05 level $= 2.306$

Not significant at .05 level

RETEST RESULTS OF CONTROL GROUP AND EXPERIMENTAL GROUP IN REACTION TIME

Subject	Control Group	d	d^2	Experimental Group	d	d^2
1.	.207	-.027	.000729	.110	.022	.000484
2.	.160	.020	.000400	.120	.012	.000144
3.	.173	.007	.000049	.147	-.015	.000225
4.	.210	-.030	.000900	.130	.002	.000004
5.	.180	-.000	.000000	.123	.009	.000081
6.	.203	-.023	.000529	.150	-.018	.000324
7.	.143	.037	.001369	.133	-.001	.000001
8.	.150	.030	.000900	.173	-.041	.001681
9.	.197	-.017	.000289	.103	.029	.000841
TOTAL	1.623		.005165	1.189		.003785

Mean Score of Control Group = .180

Mean Score of Experimental Group = .132

STANDARD ERROR OF THE MEANS OF PAIRED OBSERVATIONS IN REACTION TIME

Formulae Applied:

$$SD = \sqrt{\frac{d^2}{N}} \qquad SE = \frac{SD}{\sqrt{N}}$$

Control Group:

$$SD = \sqrt{\frac{.005165}{9}} \qquad SE = \frac{.0263}{3}$$

$$= .0263 \qquad = .0088$$

Experimental Group

$$SD = \sqrt{\frac{.003785}{9}} \qquad SE = \frac{.0205}{3}$$

$$= .0205 \qquad = .0068$$

Standard Error of the Mean of the Control Group = .0088

Standard Error of the Mean of the Experimental Group = .0068

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

TEST - Reaction Time

Control Group $\overline{D}$ = -.0296 Experimental Group $\overline{D}$ = .0186

Control Group $S_{\overline{D}}$ = .0107 Experimental Group $S_{\overline{D}}$ .0099

S_{D_M} (the estimate of the sampling error for the distribution of differences between the mean differences) =

$$\sqrt{\left(S_{\overline{D}_1}\right)^2 + \left(S_{\overline{D}_2}\right)^2} = \sqrt{|.0107|^2 + |.0099|^2}$$

S_{D_M} = .0146

$$D_{\overline{D}} = \overline{D}_1 - \overline{D}_2 = -.0296 - (.0186) = -.0482$$

$$\text{"t"} = \frac{D_{\overline{D}}}{S_{D_M}} = \frac{-.0482}{.0146} = -3.30$$

$df = (N_1 - 1) + (N_2 - 1) = 16$

"t" at .05 level = 2.120

Significant at .05 level

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