THE EFFECT OF OVERLOAD WARM-UP ON THE VELOCITY OF A BASEBALL BAT-SWING

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PREFACE

This study is concerned with determining the effect of three different types of warm-up on the velocity that subjects can swing a baseball bat. Specifically, two types of overload warm-up are compared to normal warm-up as a means of determining the effects of overload warm-up on the velocity of a baseball swing.

The author wishes to express his gratitude to his graduate advisor, Dr. A. B. Harrison, for his interest and guidance in this study. He would also offer his thanks to Dr. Albin P. Warner and Dr. John Bayless for serving as committee members on this study, and to Mrs. Lu Rigby for her part in typing the study.

Finally, the author offers special thanks to his wife, Kerry, for her assistance and encouragement throughout this endeavor.

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CHAPTER I

INTRODUCTION

Background and Significance of Study

One of the basic laws governing the velocity that an implement can impart to a projectile has to do with the velocity of the implement at the moment of contact with the projectile. Applying this law to baseball, it appears that the faster a bat is moving at the moment of contact with the ball, the faster the ball will move in another direction. The velocity of a baseball as it leaves a bat can be calculated from the following formula:

$$V_2 = \frac{(m_1 - em_2)\, U_2 + (1+e)m_2U_1}{m_1 + m_2} \qquad (1\text{-}1)$$

where V_2 = velocity of ball as it leaves the bat

m_1 = mass of bat

e = coefficient of elasticity

m_2 = mass of ball

U_2 = velocity of ball before it meets the bat

U_1 = velocity of bat before it meets the ball.[1]

If m_1, e, m_2, and U_2 are assumed to be constants, then increasing velocity of the bat before it meets the ball will indeed increase the velocity of the ball as it leaves the bat.

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[1]John W. Bunn, Scientific Principles of Coaching (New York, 1955), p. 66.

Over the years, baseball players have attempted, in various ways, to increase the velocity of their swings. Several of these methods have been in the realm of overload warm-up. Two methods of overload warm-up that have been used extensively by baseball players in the on-deck circle are: 1) swinging a leaded bat; and 2) swinging a regular bat with a lead ring on it. Some question had risen in the author's mind as to the effect of overload warm-up on bat-swing velocity.

Since a great percentage of baseball players use some form of overload warm-up prior to hitting, the author felt that a study to determine the effects of overload warm-up on the velocity of bat-swing was important to the sport. With this in mind, the author conducted a pilot study on the effects of overload warm-up on bat-swing velocity using nine members of the Oklahoma State University baseball team as subjects. From the results of the pilot study, the author drew the following conclusions: 1) overload warm-up significantly decreased the velocity that the subjects could swing a bat; 2) swinging a leaded bat during warm-up significantly decreased the velocity that the subjects could swing a bat; 3) swinging a regular bat with a lead ring on it during warm-up significantly decreased the velocity that the subjects could swing a bat; and 4) swinging a regular bat during warm-up had the most desirable effect on the velocity that the subjects could swing a bat.[2]

Considering the widespread use of overload warm-up by baseball players, and in view of the conclusions of the pilot study, the author

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[2]Max H. Pope, "The Effects of Overload Warm-up on the Velocity of Baseball Bat-swing" (unpub. research study, Oklahoma State University, 1971).

felt that a broader study was needed to determine the effects of overload warm-up on the velocity of a baseball bat-swing.

Delimitations

The author chose not to make a study that would have included subjects from all age levels and degrees of baseball ability. Instead, the study was delimited to include a random sample of 36 health, physical education, and recreation majors at Oklahoma State University. The study was also delimited to investigate only two methods of overload warm-up; specifically, swinging a leaded bat, and swinging a regular bat with a lead ring on it.

Finally, the study was delimited to an investigation of the effects of overload warm-up on velocity alone. The author was aware that overload warm-up could possibly have an effect on the accuracy of a baseball bat-swing, but no attempt was made to investigate this possibility.

Limitations

The study was limited in that only ten trials were timed for each subject after each type of warm-up. The author felt that the effects of the warm-ups could not be expected to linger past ten trials. Another limitation of the study was that the method used to time the trials was accurate only to the nearest .01 second.

Assumptions

The author assumed that the subjects exerted maximum effort on each trial, and that a fifteen minute rest period from one warm-up and

timing session to the next was sufficient time to allow for the elimination of fatigue. It was also assumed that the author could read times to the nearest .0025 seconds by interpolation. The final assumption made was that the author could legitimately compare times of baseball swings by measuring only a three-foot interval of each swing.

Definition of Terms

Overload Warm-up - swinging more weight in the warm-up period than was swung during the timed trials.

Regular Bat - a baseball bat, 33 inches long and weighing two pounds.

Leaded Bat - a baseball bat, filled with lead, and weighing three pounds and one ounce.

Lead Ring - a ring, weighing one pound and 12 ounces, that slides over a bat to increase its weight during warm-up.

Problem

The purpose of the study was to determine the effects of overload warm-up on the velocity of a baseball bat-swing. Three subproblems were: 1) to determine the effect of swinging a leaded bat during warm-up on the velocity of a bat-swing; 2) to determine the effect of swinging a regular bat with a lead ring on it during warm-up on the velocity of a bat-swing; and 3) to determine which of three methods of warm-up, swinging a regular bat, a leaded bat, or a regular bat with a lead ring on it, had the most desirable effect on the velocity of a bat-swing.

Hypothesis

The author proposed the null hypothesis. In other words, his hypothesis was that there would be no significant differences at the .05 level of confidence between the mean times recorded by the subjects on the trials following the three different types of warm-ups.

CHAPTER II

REVIEW OF RELATED LITERATURE

While conducting library research in the area of overload warm-up, the author found no evidence that any work had been done with overload warm-up and baseball bat-swing. In the only warm-up study related to baseball bat-swing, Williamson divided 40 boys in grades four through six into two equal teams. The teams alternated in having 15 swings per player in batting practice, and in having no batting practice before regulation seven-inning games. He found that individual batting averages were significantly better for both teams after they had taken the warm-up batting practice before the game, suggesting that the warm-up procedures were justified.[1]

While warm-up of some variety is generally accepted as beneficial to performance, the effects of overload warm-up on performance in various activities has not been totally determined. Many of the studies dealing with overload warm-up are concerned with its effect on the velocity and accuracy of throwing various objects. In a study of two groups of seven freshman baseball pitchers, Sinks found that the experimental group, which worked with weighted balls for six weeks, significantly increased their pitching velocity at the .01 level of confidence, whereas the control group, which worked with regulation baseballs,

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[1]Ken Ray Williamson, "The Effects of Batting Warm-up on Performance" (unpub. M. S. thesis, University of California, Los Angelos, 1959).

did not experience this significant increase in velocity.[2] Van Huss, et al, tested 50 members of the Michigan State University baseball team immediately after warming up with a regulation (5 oz.) baseball, and after warming up with an 11 oz. baseball, and they found that the overload warm-up improved the velocity of throwing, and that accuracy was affected; however, conclusions on the effects of the overload warm-up on accuracy were not reached.[3]

In contrast to those studies that reported increases in velocity following overload warm-up, Elias studied 12 freshmen pitchers at Michigan State University and found that working out with weighted baseballs for a six-week period had no significant effect on pitching velocity.[4] Straub tested 60 subjects on throwing speed immediately following overload warm-up, and the differences found between those times and times recorded after normal warm-up were statistically not significant.[5]

Overload warm-up and its effect on accuracy has been the focus of several studies. Creek divided 74 inexperienced softball players into two equal groups. One group warmed up with a regulation softball; the

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[2]Michael Gordon Sinks, "The Longitudinal Effect of Progressive Overload on Speed and Accuracy in Baseball Pitching" (unpub. M. A. thesis, Michigan State University, 1964).

[3]W. D. Van Huss et al., "Effect of Overload Warm-up on the Velocity and Accuracy of Throwing," Research Quarterly, 33 (October, 1962), pp. 472-475.

[4]John Elias, "The Effect of Overload Training on Speed in Baseball Pitching" (unpub. M. S. thesis, Springfield College, Springfield, Massachusetts, 1964).

[5]William F. Straub, "Effect of Overload Training Procedures Upon Velocity and Accuracy of the Overarm Throw," Research Quarterly, 39 (May, 1968), p. 370.

other group warmed up with a weighted softball, and both groups were tested for accuracy immediately following the warm-up. Results showed that warm-up with a weighted softball had an adverse effect on accuracy.[6] Hopek divided 12 male college students into an experimental group and a control group. The experimental group used a weighted football, and the control group used a regulation football. During each of 13 training periods, the subjects threw the ball 15 times at a moving target. Results showed that the experimental group improved more in accuracy than the control group, but not significantly.[7] On the basis of a pre-test with regulation (21oz.) basketballs, Jable assigned 60 male subjects into three groups based on free throw shooting ability. During a five-week experimental period, one group practiced with a regulation basketball, one with a 16 oz. ball, and one with a 40 oz. ball. On the post-test, the only significant difference favored the group using the regulation basketball over the group using the 40 oz. ball. Practice with the 40 oz. ball did not affect free throw shooting accuracy, while practice with the other two balls both improved accuracy.[8]

Nelson conducted two studies on the effects of overload warm-up on the speed of elbow flexion. He and Nofsinger tested 23 male subjects for speed of elbow flexion immediately before and after the application

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[6]Ronald Eugene Creek, "The Effect of Overload Warm-up on the Accuracy of Throwing a Twelve-Inch Softball" (unpub. M. S. thesis, Eastern Illinois University, 1964).

[7]Richard Hopek, "Effect of Overload on the Accuracy of Throwing a Football" (unpub. M. S. thesis, Eastern Illinois University, 1967).

[8]John T. Jable, "The Relative Effects of Training with Basketballs of Varying Weights Upon Free Throw Shooting Accuracy" (unpub. M. Ed. thesis, Penn State University, 1965).

of overload. The overloads, consisted of 15, 30, and 40% of the subject's elbow flexion strength. No significant differences were observed in speed of flexion after any of the overloads; however, all the subjects said that they felt faster during the post-overload trials.[9] Nelson and Lambert used 19 men as subjects in order to study (1) the effects of the application and removal of an overload on resisted and nonresisted speeds of elbow flexion, and (2) the associated perceptual after-effects. Six pre-overload, five overload, and six post-overload trials were timed on ten tests of arm movement time. The subjects related their subjective impressions of the effect of the overload on speed on movement. No statistically significant differences were recorded between performance under the three conditions for either resisted or non-resisted movement. However, a marked tendency to overestimate speed of movement following overload was observed under both experimental conditions.[10]

Stockholm and Nelson studied the effect that overload warm-up had on the vertical jumping ability of 44 college men, and found no immediate improvements in performance.[11] Bartee divided 42 college women into an experimental and a control group. The experimental group practiced three overload activities in addition to traditional badminton

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[9]Richard C. Nelson and Michael R. Nofsinger, "Effect of Overload on Speed of Elbow Flexion and the Associated After-Effects," Research Quarterly, 36 (May, 1965), pp. 174-182.

[10]Richard C. Nelson and Ward Lambert, "Immediate After-Effects of Overload on Resisted and Non-Resisted Speeds of Movement," Research Quarterly, 36 (October, 1965), pp. 296-306.

[11]Alan J. Stockholm and Richard C. Nelson, "The Immediate After-Effects of Increased Resistance, Upon Physical Performance," Research Quarterly, 36 (October, 1965), p. 337.

practice for 28 sessions of 35 minutes each. The control group used traditional practice only. The results of a post-test indicated that specially designed overload exercises produced steady improvement in skill.[12]

The literature concerning overload warm-up is inconclusive about its effect on performance. Several factors including: 1) the nature of the activity; 2) whether the overload is introduced immediately prior to performance, or practiced periodically for an extended period of time before performance; and 3) whether velocity or accuracy is being tested, all have had a bearing on the conclusions reached by researchers on the worth of overload warm-up. The area remains ripe for more studies in various performance areas.

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[12]Barbara A. Bartee, "The Effect of Application of the Principle of Overload on the Development of Skill" (unpub. Ph. D. dissertation, University of Southern California, 1965).

CHAPTER III

PROCEDURE

Subjects

The subjects used in the study were randomly selected from the male health, physical education, and recreation majors that were attending Oklahoma State University during the spring semester of the 1971-1972 school year. In order to select the subjects, the author numbered the 176 male health, physical education, and recreation majors consecutively beginning with A in the freshman class and ending with Z in the senior class. He then went to a table of random digits and recorded the first fifty of those digits that fell between one and 176.[1] Those majors whose numbers corresponded to the randomly selected digits were asked to be subjects in the study. Of those asked, 36 agreed to participate as subjects in the study.

Description of Tests

The author tested the times in which the 36 subjects could swing a regular baseball bat through a three-foot interval of their normal swings after each of the three different warm-ups. The three warm-ups

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[1]Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics (New York, 1960), pp. 429-430.

used were: 1) swinging a regular bat five times; 2) swinging a leaded bat five times; and 3) swinging a regular bat with a lead ring on it five times.

After taking the five warm-up swings, the subjects took ten timed swings with the regular bat. A three-foot interval of each swing was timed by the Dekan Automatic Performance Analyzer. Two strings were attached to the barrel of the regular bat, approximately three inches from the end of the bat. One of the strings was three and one-half feet long, and the other was six and one-half feet long. Both strings were attached to the performance analyzer machine prior to each timed swing. The three and one-half feet string was attached to the automatic start switch, and the six and one-half feet string was attached to the automatic stop switch on the machine. As the subject swung the bat, the three and one-half feet string was pulled and started the analyzer's clock, and three feet later, the six and one-half feet string was pulled and stopped the clock. The reading on the clock was then recorded as the time it took the subject to swing three feet. The clock could be read accurately to the nearest .01 seconds, and the author interpolated times to the nearest .0025 seconds. This procedure was repeated until the subject had been timed on ten swings following each warm-up.

The following photograph is an illustration of the position of the subject and apparatus immediately prior to a timed trial.

Figure 1. Subject and Apparatus

In an effort to increase the validity of the study, several steps were taken. First, the order in which the tests were administered varied from subject to subject. There were six possible orders in which the three sets of trials could be administered, and six of the 36 subjects were to perform the tests in each of the orders. The six orders were drawn from a hat containing 36 slips of paper, and were assigned to the subjects as they were drawn such that each order was assigned to six subjects, and such that the method of assigning the orders was random selection. The author used this procedure to counteract the effect of carryover of warm-up from one testing period to the next. In another attempt to reduce carryover and fatigue, the subjects were allowed to

rest for 15 minutes between the last trial of one testing session and the first warm-up swing of the next session.

In a final attempt to assure the validity of the tests, a line was drawn one foot in front of the bench on which the performance analyzer machine sat. The subjects were instructed to place their back feet on that line on each trial so that the same three foot interval of their swing was timed on each trial.

Apparatus

The items of equipment used in the study were the Dekan Automatic Performance Analyzer, a regular baseball bat, a leaded baseball bat, a lead ring, two pieces of string, three and one-half feet and six and one-half feet long respectively, and a 14 inch high bench on which the performance analyzer sat during the testing periods.

Statistical Analysis

Ten trials following each of the three methods of warm-up were timed and recorded for each subject. Means for each set of ten trials were then calculated for each subject. Next, means were calculated for the entire group of subjects on each of the three tests.

In order to compare the data, t-ratios were calculated to determine if significant differences existed between the means of the three tests following the three different methods of warm-up. Dwyer's Single Computational formula for t-ratios was the method used in the analysis.

His formula is:

$$t^2 = \frac{(\Sigma X)^2 (N-1)}{N \cdot X^2 - (\Sigma X)^2} \qquad \text{where} \quad \begin{matrix} X = X_1 - X_2 \\ N = N_1 = N_2 \end{matrix}^2 \tag{3-1}$$

In this study, N was 36 and the values of X_1, X_2, . . . , were the means of each subject on the different tests.

Finally, as a test to determine the reliability of the times recorded on the trials, the author calculated the correlation of the odd numbered trials to the even numbered trials on each of the three tests for the entire group of subjects. The following formula was used to calculate these correlations:

$$r_{XY} = \frac{N\,XY - (\Sigma X)(\Sigma Y)}{(N\Sigma X^2 - (\Sigma X)^2)\,(N\Sigma Y^2 - (\Sigma Y)^2)}^3 \tag{3-2}$$

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[2]A. T. Slater-Hammel, "Computational Design for Evaluating the Significance of a Difference Between Means," Research Quarterly, 36 (May, 1965), p. 214.

[3]J. P. Guilford, Fundamental Statistics in Psychology and Education (New York, 1965), p. 97.

CHAPTER IV

RESULTS AND DISCUSSION OF RESULTS

Means

The means of the ten trials for each of the subjects on the three different tests were recorded in the following table.

TABLE I

MEANS OF SUBJECTS ON THE THREE TESTS

Subject	Reg. Bat Warm-up	Lead Bat Warm-up	Reg. Bat Plus Ring Warm-up
1	.05225	.05650	.04850
2	.02950	.02700	.03325
3	.05250	.04725	.04575
4	.04025	.03850	.04050
5	.04050	.04900	.05275
6	.04050	.04475	.04850
7	.03925	.04125	.04450
8	.04775	.05200	.05925
9	.04675	.04500	.04625
10	.05125	.05625	.06075
11	.04075	.04175	.03925
12	.04100	.03750	.03300
13	.04675	.05175	.05375
14	.05500	.05325	.05625
15	.05075	.06675	.05775
16	.05675	.05550	.05650
17	.04575	.05100	.05800
18	.05625	.05325	.04250
19	.05325	.05675	.04975
20	.05750	.05850	.05400
21	.05025	.05350	.05675

TABLE I (Continued)

22	.03325	.03800	.04025
23	.05550	.03800	.04600
24	.04125	.04350	.04425
25	.04925	.05500	.05900
26	.04275	.05050	.04225
27	.05650	.05800	.06525
28	.06725	.06075	.06850
29	.04650	.04600	.05200
30	.05750	.06675	.05875
31	.05725	.05800	.05950
32	.05300	.05075	.04350
33	.05750	.04750	.04250
34	.05825	.05925	.06000
35	.04725	.04300	.04450
36	.04975	.04875	.04550

The means for the entire group on each of the three tests were .0491 seconds for the regular bat warm-up; .0500 seconds for the leaded bat warm-up; and .0503 seconds for the regular bat plus ring warm-up.

t-Ratios

As a method of determining if the differences between the three means of the entire group of subjects were statistically significant, t-ratios were calculated between each set of means. The t-ratio between the regular bat mean and the leaded bat mean was .95098. The t-ratio between the regular bat mean and the regular bat plus ring mean was .98619. Finally, the t-ratio between the leaded bat mean and the regular bat plus ring mean was .25917.

Discussion of Results

The means of the tests following the three different types of warm-up indicated that very little difference existed between the three

warm-ups with regard to their effects on the velocity of a baseball bat-swing. Only .0012 seconds separated the highest of the three means from the lowest of the three.

The t-ratios of .95098 between the regular bat warm-up and the leaded bat warm-up, .98619 between the regular bat warm-up and regular bat plus ring warm-up, and .25917 between the leaded bat warm-up and the regular bat plus ring warm-up were all statistically non-significant at the .05 level of confidence. In other words, the results of the study indicated that although small differences did exist in the means of the tests following the three types of warm-ups, these differences were so small that one must reason that the effects of the three warm-ups on the velocity of a baseball bat-swing are essentially the same.

Reliability of the Data

The author desired to use some means of evaluating the data he had collected for the reliability of the testing procedure. As a means of making this evaluation he divided each subject's ten trials into odd trials and even trials. He then calculated the correlation between the odd and even trials for the entire group for each of the three warm-ups, using the Pearson product-moment technique. He found positive correlations of .85 between the odd and even trials after the regular bat warm-up; .83 between the odd and even trials after the regular bat plus ring warm-up; and .93 between the odd and even trials after the leaded bat warm-up. These correlations are not as high as the author would have desired them to be; however, they are high enough that the testing procedure can be assumed to be fairly reliable.

CHAPTER V

CONCLUSIONS

Analysis of the results of the study led the author to draw the following conclusions:

1) Overload warm-up had no significant effect on the velocity that the subjects could swing a regular bat.
2) Swinging a leaded bat during the warm-up period had no significant effect on the velocity that the subjects could swing a regular bat.
3) Swinging a regular bat with a lead ring on it during the warm-up period had no significant effect on the velocity that the subjects could swing a regular bat.
4) Of the three methods of warm-up tested, none was superior to either of the other two with regard to their effects on the velocity that the subjects could swing a regular bat.
5) The method of timing the swings had a satisfactory level of reliability with correlations of .85, .83, and .93 between the odd and even trials for the three tests.

In light of the fact that most baseball players use some type of overload warm-up prior to hitting, and due to the conclusions drawn in this study, the author recommends that further research be done with overload warm-up and bat-swing to determine if it is as beneficial as most have heretofore assumed it to be. A study testing subjects from a

more varied range of age and skill levels would yield valuable information. In addition, a study of the effects of overload warm-up on the accuracy of a baseball bat-swing would supplement this study well, and would yield equally valuable information. The author feels that this study has cast some doubt on the usefullness of overload warm-up prior to hitting, and it is his desire that further study be done in order to fully understand the total effects of overload warm-up on a baseball bat-swing.

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APPENDIX A

RAW SCORES

TABLE II

RAW SCORES: WARM-UP WITH REGULAR BAT

Subject	Trial Number									
	1	2	3	4	5	6	7	8	9	10
1	.0550	.0525	.0500	.0575	.0575	.0600	.0475	.0400	.0500	.0525
2	.0300	.0250	.0325	.0300	.0250	.0250	.0300	.0400	.0250	.0325
3	.0425	.0475	.0550	.0600	.0450	.0625	.0500	.0550	.0600	.0475
4	.0500	.0400	.0325	.0300	.0400	.0400	.0475	.0450	.0450	.0325
5	.0475	.0500	.0500	.0450	.0350	.0350	.0350	.0300	.0350	.0425
6	.0400	.0400	.0500	.0400	.0350	.0425	.0375	.0450	.0350	.0400
7	.0425	.0500	.0500	.0500	.0350	.0300	.0250	.0375	.0425	.0300
8	.0500	.0425	.0500	.0500	.0500	.0425	.0400	.0450	.0500	.0575
9	.0400	.0400	.0525	.0450	.0550	.0425	.0475	.0500	.0450	.0500
10	.0500	.0575	.0600	.0550	.0625	.0500	.0500	.0500	.0375	.0400
11	.0525	.0325	.0375	.0300	.0475	.0400	.0400	.0500	.0375	.0400
12	.0500	.0400	.0475	.0475	.0250	.0525	.0300	.0600	.0275	.0300
13	.0450	.0500	.0400	.0525	.0425	.0350	.0325	.0600	.0500	.0600
14	.0650	.0450	.0550	.0700	.0625	.0475	.0550	.0550	.0450	.0500
15	.0600	.0500	.0475	.0400	.0425	.0500	.0450	.0650	.0550	.0525
16	.0650	.0700	.0600	.0675	.0450	.0600	.0400	.0650	.0500	.0450
17	.0400	.0600	.0450	.0325	.0475	.0500	.0400	.0400	.0525	.0500
18	.0600	.0600	.0500	.0500	.0675	.0550	.0500	.0500	.0600	.0600
19	.0450	.0350	.0650	.0575	.0500	.0700	.0650	.0500	.0450	.0500
20	.0600	.0500	.0600	.0400	.0700	.0600	.0650	.0550	.0550	.0600
21	.0475	.0700	.0550	.0500	.0600	.0525	.0525	.0425	.0300	.0425
22	.0600	.0425	.0275	.0250	.0250	.0300	.0250	.0375	.0300	.0300
23	.0400	.0525	.0550	.0625	.0550	.0550	.0600	.0500	.0650	.0600
24	.0450	.0325	.0350	.0325	.0275	.0475	.0425	.0400	.0550	.0550
25	.0500	.0400	.0400	.0375	.0550	.0575	.0475	.0500	.0600	.0550
26	.0400	.0400	.0500	.0375	.0450	.0450	.0475	.0400	.0350	.0475

TABLE II (Continued)

27	.0600	.0600	.0500	.0600	.0500	.0600	.0500	.0600	.0600	.0550
28	.0600	.0700	.0700	.0700	.0650	.0700	.0700	.0700	.0650	.0625
29	.0500	.0425	.0550	.0400	.0500	.0500	.0300	.0425	.0550	.0500
30	.0700	.0700	.0550	.0700	.0700	.0525	.0450	.0400	.0525	.0500
31	.0400	.0700	.0525	.0450	.0500	.0675	.0550	.0700	.0525	.0700
32	.0400	.0700	.0550	.0400	.0600	.0525	.0575	.0500	.0550	.0500
33	.0575	.0650	.0550	.0525	.0650	.0550	.0450	.0600	.0600	.0600
34	.0600	.0600	.0550	.0700	.0650	.0550	.0600	.0575	.0600	.0400
35	.0400	.0400	.0450	.0550	.0500	.0425	.0500	.0450	.0500	.0550
36	.0500	.0425	.0475	.0550	.0350	.0550	.0600	.0500	.0500	.0525

TABLE III

RAW SCORES: WARM-UP WITH LEADED BAT

Subject	Trial Number									
	1	2	3	4	5	6	7	8	9	10
1	.0600	.0500	.0500	.0600	.0250	.0500	.0700	.0600	.0700	.0700
2	.0300	.0250	.0300	.0300	.0250	.0250	.0275	.0250	.0275	.0250
3	.0450	.0550	.0425	.0450	.0425	.0325	.0500	.0550	.0550	.0500
4	.0500	.0425	.0475	.0475	.0275	.0400	.0375	.0350	.0250	.0325
5	.0525	.0500	.0475	.0600	.0325	.0625	.0625	.0350	.0475	.0400
6	.0400	.0525	.0475	.0400	.0400	.0475	.0575	.0475	.0375	.0375
7	.0475	.0500	.0400	.0450	.0400	.0400	.0500	.0350	.0250	.0400
8	.0325	.0550	.0450	.0625	.0575	.0475	.0600	.0500	.0550	.0550
9	.0425	.0550	.0500	.0500	.0525	.0325	.0350	.0400	.0525	.0400
10	.0600	.0450	.0525	.0600	.0525	.0525	.0625	.0600	.0600	.0575
11	.0500	.0400	.0400	.0450	.0525	.0300	.0350	.0350	.0400	.0500
12	.0600	.0400	.0300	.0350	.0350	.0350	.0350	.0300	.0350	.0400
13	.0500	.0525	.0575	.0500	.0500	.0500	.0575	.0500	.0450	.0550
14	.0650	.0500	.0500	.0625	.0550	.0350	.0375	.0700	.0575	.0500
15	.0700	.0600	.0700	.0625	.0700	.0700	.0700	.0650	.0700	.0600
16	.0675	.0500	.0550	.0450	.0525	.0700	.0550	.0675	.0425	.0500
17	.0550	.0500	.0500	.0500	.0550	.0525	.0450	.0500	.0575	.0450
18	.0500	.0500	.0450	.0500	.0550	.0500	.0500	.0625	.0700	.0500
19	.0525	.0575	.0600	.0600	.0500	.0500	.0500	.0500	.0700	.0675
20	.0600	.0700	.0600	.0600	.0700	.0600	.0500	.0525	.0525	.0500
21	.0500	.0525	.0700	.0500	.0500	.0575	.0500	.0650	.0500	.0400
22	.0500	.0400	.0400	.0450	.0450	.0350	.0300	.0350	.0300	.0300
23	.0300	.0400	.0400	.0300	.0400	.0400	.0400	.0500	.0300	.0400
24	.0500	.0450	.0300	.0500	.0450	.0400	.0500	.0500	.0450	.0300
25	.0600	.0575	.0500	.0525	.0550	.0450	.0600	.0600	.0500	.0600
26	.0500	.0525	.0525	.0550	.0450	.0450	.0525	.0575	.0450	.0500

TABLE III (Continued)

27	.0600	.0450	.0600	.0525	.0625	.0700	.0700	.0700	.0500	.0400
28	.0700	.0600	.0700	.0625	.0450	.0575	.0600	.0700	.0600	.0525
29	.0600	.0500	.0450	.0500	.0425	.0400	.0450	.0500	.0400	.0375
30	.0700	.0700	.0700	.0650	.0600	.0600	.0700	.0650	.0675	.0700
31	.0525	.0600	.0400	.0700	.0700	.0475	.0500	.0700	.0600	.0600
32	.0650	.0550	.0550	.0550	.0500	.0500	.0425	.0425	.0475	.0450
33	.0450	.0550	.0400	.0550	.0550	.0450	.0400	.0450	.0450	.0500
34	.0525	.0600	.0650	.0575	.0700	.0525	.0700	.0500	.0625	.0525
35	.0550	.0350	.0275	.0425	.0400	.0500	.0425	.0525	.0400	.0450
36	.0550	.0300	.0550	.0450	.0625	.0350	.0500	.0325	.0625	.0600

TABLE IV

RAW SCORES: WARM-UP WITH REGULAR BAT PLUS RING

Subject	Trial Number									
	1	2	3	4	5	6	7	8	9	10
1	.0575	.0400	.0600	.0675	.0500	.0350	.0500	.0400	.0425	.0425
2	.0325	.0275	.0500	.0300	.0300	.0325	.0300	.0500	.0250	.0250
3	.0400	.0375	.0400	.0475	.0550	.0400	.0575	.0350	.0450	.0600
4	.0400	.0400	.0475	.0425	.0400	.0350	.0400	.0350	.0450	.0400
5	.0600	.0575	.0500	.0500	.0675	.0600	.0350	.0525	.0600	.0350
6	.0550	.0525	.0500	.0525	.0450	.0525	.0425	.0500	.0450	.0400
7	.0600	.0525	.0550	.0475	.0400	.0300	.0425	.0400	.0325	.0450
8	.0600	.0425	.0600	.0700	.0625	.0550	.0700	.0525	.0700	.0500
9	.0500	.0400	.0425	.0350	.0400	.0550	.0575	.0425	.0500	.0500
10	.0650	.0700	.0700	.0525	.0650	.0600	.0575	.0600	.0675	.0400
11	.0300	.0500	.0375	.0575	.0250	.0450	.0425	.0400	.0300	.0350
12	.0300	.0325	.0250	.0475	.0250	.0325	.0300	.0300	.0325	.0450
13	.0500	.0650	.0575	.0525	.0525	.0525	.0475	.0500	.0600	.0500
14	.0700	.0600	.0500	.0550	.0700	.0550	.0500	.0550	.0525	.0450
15	.0600	.0650	.0650	.0550	.0625	.0575	.0500	.0525	.0550	.0550
16	.0550	.0450	.0500	.0700	.0550	.0600	.0550	.0650	.0650	.0450
17	.0650	.0650	.0550	.0675	.0575	.0600	.0500	.0400	.0700	.0500
18	.0400	.0400	.0425	.0400	.0400	.0450	.0400	.0550	.0400	.0425
19	.0475	.0650	.0600	.0400	.0375	.0400	.0500	.0700	.0400	.0475
20	.0600	.0550	.0500	.0500	.0650	.0425	.0500	.0550	.0525	.0600
21	.0650	.0600	.0425	.0450	.0500	.0675	.0575	.0550	.0550	.0700
22	.0500	.0450	.0300	.0350	.0325	.0350	.0375	.0550	.0425	.0400
23	.0400	.0375	.0550	.0500	.0500	.0425	.0525	.0425	.0400	.0500
24	.0525	.0425	.0450	.0400	.0425	.0425	.0400	.0275	.0600	.0500
25	.0550	.0500	.0700	.0675	.0550	.0475	.0700	.0550	.0600	.0600
26	.0425	.0500	.0325	.0475	.0350	.0375	.0425	.0500	.0400	.0450

TABLE IV (Continued)

27	.0700	.0700	.0650	.0550	.0575	.0700	.0650	.0700	.0600	.0700
28	.0700	.0700	.0650	.0650	.0700	.0675	.0700	.0700	.0675	.0700
29	.0500	.0525	.0475	.0700	.0550	.0500	.0375	.0525	.0475	.0575
30	.0550	.0525	.0400	.0650	.0700	.0625	.0700	.0575	.0650	.0500
31	.0700	.0625	.0600	.0625	.0500	.0550	.0600	.0600	.0550	.0600
32	.0375	.0550	.0500	.0450	.0525	.0400	.0400	.0400	.0350	.0400
33	.0450	.0550	.0525	.0400	.0500	.0375	.0475	.0350	.0300	.0325
34	.0700	.0700	.0600	.0600	.0550	.0525	.0550	.0475	.0700	.0600
35	.0500	.0700	.0500	.0300	.0425	.0400	.0500	.0325	.0375	.0425
36	.0500	.0500	.0400	.0500	.0300	.0500	.0425	.0625	.0375	.0425

APPENDIX B

MEANS: ODD AND EVEN TRIALS

TABLE V

MEANS OF SUBJECTS ON ODD AND EVEN TRIALS

Subject	Regular Bat Means		Leaded Bat Means		Regular Bat Plus Ring Means	
	EVEN	ODD	EVEN	ODD	EVEN	ODD
1	.0525	.0520	.0580	.0550	.0450	.0520
2	.0305	.0285	.0260	.0280	.0330	.0335
3	.0545	.0505	.0475	.0470	.0440	.0475
4	.0375	.0430	.0395	.0375	.0385	.0425
5	.0405	.0405	.0495	.0485	.0510	.0545
6	.0415	.0395	.0450	.0445	.0495	.0475
7	.0395	.0390	.0420	.0405	.0430	.0460
8	.0475	.0480	.0540	.0500	.0540	.0645
9	.0455	.0480	.0435	.0465	.0445	.0480
10	.0505	.0520	.0550	.0575	.0565	.0650
11	.0385	.0430	.0400	.0435	.0455	.0330
12	.0460	.0360	.0360	.0390	.0375	.0285
13	.0515	.0420	.0515	.0520	.0540	.0535
14	.0535	.0565	.0535	.0530	.0540	.0585
15	.0515	.0500	.0635	.0700	.0570	.0585
16	.0615	.0520	.0565	.0545	.0570	.0560
17	.0465	.0450	.0495	.0525	.0565	.0595
18	.0550	.0575	.0525	.0540	.0445	.0405
19	.0525	.0540	.0570	.0565	.0525	.0470
20	.0530	.0620	.0585	.0585	.0525	.0555
21	.0515	.0490	.0530	.0540	.0595	.0540
22	.0330	.0335	.0370	.0390	.0420	.0385
23	.0560	.0550	.0400	.0360	.0445	.0475
24	.0415	.0410	.0430	.0440	.0405	.0480
25	.0480	.0505	.0550	.0550	.0560	.0620
26	.0420	.0435	.0475	.0490	.0460	.0385
27	.0590	.0540	.0555	.0605	.0670	.0635
28	.0685	.0660	.0605	.0610	.0685	.0685
29	.0450	.0480	.0455	.0465	.0565	.0475
30	.0565	.0585	.0660	.0675	.0575	.0600
31	.0645	.0500	.0615	.0545	.0600	.0590
32	.0525	.0535	.0495	.0510	.0440	.0430
33	.0585	.0565	.0500	.0450	.0400	.0450
34	.0565	.0600	.0545	.0640	.0580	.0620
35	.0475	.0470	.0450	.0410	.0430	.0460
36	.0510	.0485	.0405	.0570	.0510	.0400

VITA

Max Howard Pope

Candidate for the Degree of

Master of Science

Thesis: THE EFFECT OF OVERLOAD WARM-UP ON THE VELOCITY OF A BASEBALL BAT-SWING

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Biographical:

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