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THE EFFECTS OF CRYOTHERAPY ON THE VELOCITY OF A PITCHED BASEBALL

BY

JOHN D. PIERSON

A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Major in Physical Education, South Dakota State University

1969
THE EFFECTS OF CRYOTHERAPY ON THE

VELOCITY OF A PITCHED BASEBALL

This thesis is approved as a creditable and independent
investigation by a candidate for the degree, Master of Science,
and is acceptable as meeting the thesis requirements for this
degree, but without implying that the conclusions reached by the
candidate are necessarily the conclusions of the major department.

Thesis Advisor

Head, Physical Education Department
ACKNOWLEDGEMENTS

The writer wishes to express his most sincere appreciation to his advisors, Dr. Paul Brynteson and Professor Glenn E. Robinson, for their valuable guidance, supervision, and assistance in the completion of this thesis.

The writer also expresses his gratitude to the subjects who gave of their time and efforts in making this study possible, and to his wife for her support, patience, and encouragement throughout the study.

JDP
THE EFFECTS OF CRYOTHERAPY ON THE
VELOCITY OF A PITCHED BASEBALL
Abstract

JOHN D. PIERSO
Under the supervision of Dr. Paul Brynteson
and Professor Glenn E. Robinson

The purpose of this study was to investigate the feasibility
of a cold water application of 35° to 40°F, between innings, and its
effect on the pitching arm through the course of a designated series
of throws.

Eight male students from the basic physical education classes
at South Dakota State University participated in the study conducted
over a period of three weeks. All of the individuals involved were
administered each of three selected treatments.

The data in this study were analyzed in three ways. A t ratio
was used to interpret the changes in the average velocity of the
pitched ball in the first two innings as compared with the changes in
average velocity for the last two innings of a nine inning game. The
average changes in velocity over the full nine innings were also
computed for each group. Each of the three treatments was admin-
istered to all groups and the results were compared to find the
average velocity for all innings. If an F ratio was found to be
significant, the Duncan's Multiple-Range test was used to determine
where the significant difference occurred.
As a result of the statistical analysis of the data obtained, the investigator found that the cold water treatment between innings caused a significant decrease in the velocity of the pitched baseball as determined by tests conducted after innings one and two, and after innings eight and nine.
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Scientific research has contributed much to the future of America's National Pastime, a sport which involves human competition, the ability and resourcefulness of one man with a bat against another man with a ball. Baseball coaches and pitchers are concerned about maintaining a good fast ball throughout a nine inning game. Usually the pitching arm will tire and consequently the velocity of a pitched baseball decreases as the game moves into the latter innings. Because of the decreased velocity of a pitched ball, the pitcher is less effective as the contest approaches completion.

A number of studies have been completed in which cold application of one type or another has been administered to a subject to determine what effect this type of treatment might have in aiding recovery from fatigue. The use of cryotherapy as applied to isolated body parts is a relatively new area of investigation. This writer became interested in the possibility of immersing the pitching arm in a cold water bath to determine what effects such a procedure might have on the velocity of the pitched baseball for a specified number of throws.

Statement of the Problem

The purpose of this study was to assess the adequacy of an ice water bath, when applied to the subject's pitching arm, in an attempt
to maintain the constant speed of the pitched baseball over a given period of time.

The results of the cold application were studied after each twelve throws and at the conclusion of one hundred and eight throws.

**Importance of the Study**

Baseball coaches are continually searching for methods to employ so that the velocity of a pitched ball will remain somewhat constant through the duration of a single contest. The trend today is to use ice or cold packs in relieving body fatigue. It is the purpose of this study to determine whether the application of ice water to the arm will help a pitcher maintain the same or somewhat the same velocity for a pitched ball throughout a nine inning game. Such information could be of value to the sport of baseball in that coaches would have an effective method of relieving the fatigue, resulting from continuous throwing, during a baseball game.

**Limitations**

1. Eight individuals were selected from a group of subjects who were participating in another study, "The Velocity of a Pitched Ball as Affected by Two Varying Training Programs."¹

2. The subjects were members of the basic instruction physical education classes at South Dakota State University.

3. The subjects in this study were required to have had some pitching experience.

4. None of the subjects were members of the varsity baseball squad.

5. No attempt was made to regulate the daily living habits of the subjects.

6. Only fast ball pitches were tested for velocity.

**Definition of Terms**

**Immersion.** Placement of the pitching arm to point of insertion of the deltoid muscle in an ice water bath for four minutes.

**Ice-water bath.** A steel container, thirteen inches in diameter and twenty-eight inches, partially filled with tap water. The water temperature was maintained between 35° and 40° Fahrenheit by placing ice cubes in the bath.

**Inning.** A total of twelve pitches was used to constitute an inning.

**Nine inning game.** A nine inning game for this study consisted of one hundred and eight pitched balls.

**Velocity.** The elapsed time between the release of the ball and its impact at the termination point.

**Fast ball.** A ball thrown with maximal velocity without any attempt by the subject to alter the straight flight of the ball.
CHAPTER II

REVIEW OF THE LITERATURE

The related literature reviewed indicates that cold application is an important method in combating exhaustion. A number of studies have been completed showing the effects of abdominal cold packs, cold showers, and cold water baths when utilized by trainers as aids to recovery after strenuous exercise. The investigator has been unable to find completed studies that show the effects of ice water application at specified intervals after continuous bouts of work, upon fatigue resulting from the throwing involved in many sports.

Robbins conducted a study on the effects of cold or hot showers as an aid to the athlete in avoiding lassitude. He found that hot showers (115°F) increased body temperature and heart rate slightly, while cold showers (65°F) decreased body temperature and heart rate. It was found that cold showers were more effective in aiding recovery from fatigue.²

In a study by Roundy and Cooney, abdominal cold packs, cold showers, and rest were utilized after a strenuous workout to determine which method most effectively facilitates recovery from fatigue. Fifteen male subjects were used. Each subject ran on a treadmill

at a ten per cent evaluation at eight miles per hour until the subject's heart rate reached 180. Once the heart rate reached 180, one of the three treatments was applied. The application of the abdominal cold pack proved to be the most effective method used in relieving fatigue.³

Bessemer conducted a study giving the Harvard step test to a wrestling squad. The wrestlers were treated for five minutes in a moderately cold shower (79°F - 80°F), or five minutes in a moderately cold pool (79°F - 80°F), or given five minutes of rest while lying on their backs. There was no significant difference in pulse recovery, however the majority of the subjects indicated that they felt more refreshed after the cold shower.⁴

Falls conducted a study to investigate the length of time a performer could wait before beginning exercise after a cold shower and still receive benefits from it. In addition to a control condition of exercise without a shower, the time intervals between the shower and exercise were ten, twenty, and thirty minutes. The showers were for ten minutes at an average temperature of 68°F. Each of the ten male subjects followed each experimental condition on separate days. Heart


rates were recorded during a five-minute walk at four miles per hour on a six per cent grade on a motor driven treadmill. Heart rates during the first five minutes of recovery were also recorded. Results indicated that if the showers were taken up to twenty minutes before exercise began, the ten-minute cold shower at 68°F would significantly reduce the exercise and recovery heart rates associated with a submaximal exercise. However it appears that the sooner the exercise follows the shower, the greater is the reduction of circulatory costs.5

Michael studied the effects of a two minute cold shower (60°F) on the circulation of conditioned and non-conditioned men who were given three step bench tests. The tests consisted of three consecutive one-minute step tests on a seventeen-inch bench at the rate of thirty steps per minute. The subjects either rested or took cold showers between the tests. Pulse rates were taken before, immediately after, and at each minute for five minutes after the tests. Both groups had increases in pulse rate after the step tests and decreases in pulse rate after showers were taken. The conditioned group was found to be more affected by the cold shower than the non-conditioned group.6

---


Happ studied the effects of cold abdominal ice packs on athletes in his research dealing with recovery from fatigue. Four subjects were tested on a Brake Bicycle Ergometer for an all out ride of one minute, with a ten minute rest period. Three of the subjects rode six times (three "control" and three "ice") and the fourth subject rode four times (two "control" and two "ice"). Happ found that the subjects who had abdominal ice packs applied were able to do more work the second time than those subjects who rested.\footnote{William P. Happ, Jr., "The Effects of Cold Abdominal Packs on Recovery From Fatigue" (unpublished Master's thesis, University of Iowa, Iowa City, 1947), pp. 1-27.}

Rosen used sixteen male subjects to test repeat performances in the 440 yard dash. Eight individuals were treated with a cold abdominal spray combined with rest. The remainder were kept moving about continuously during the lapse between the two races in an effort to determine what effect either method would have on the running time of the second 440 yard dash. In applying the cold abdominal spray, Rosen had the subjects rest for five minutes, then he applied a cold abdominal spray for ten minutes, (with water temperatures beginning at 75°F and lowered to 45°F during the first five minutes). Then he completed the treatment with another five minutes of rest. Rosen found that the average time was faster for the 440 yard dash as a result of the application of the cold abdominal spray. The same study was conducted five months later with eight of the original
sixteen subjects and no significant difference was found in performance.\textsuperscript{8}

Grose conducted a study in which he attempted to show the advisability of immersing body parts in hot or cold water in an effort to relieve fatigue. In this study the subject had to immerse the forearm in hot water (\(118^\circ\text{F}\)) or cold water (\(50^\circ\text{F}\)) for a period of eight minutes and then for six minutes the subject had to complete 180 contractions on a dynometer. Grose found that cold decreased initial strength followed by a rise to normal and that the rate of fatigue was slower. The hot water treatment did not affect the initial strength but it did show a rapid increase in the fatigue rate.\textsuperscript{9}

In a study by Girdano nineteen subjects were required to take part in an all out run on the treadmill in extreme heat (\(90^\circ\text{F}\)), then take a twelve-minute rest recovery period, and then a second all out run. Once the two treadmill runs were completed the subjects rested in a cool environment (\(60^\circ\text{F}\)) and a hot environment (\(90^\circ\text{F}\)). Each subject had to complete the treadmill run four times on different days with two treatments of cool environment and two treatments of hot environment used. There was no significant difference in


the heart rate, blood pressure, respiration rate or rectal temperature, although seventeen of the subjects indicated that they felt more refreshed and felt they were able to recover more rapidly in the cool environment.¹⁰

Falls and Weikers found that exercise heart rate and recovery oxygen uptake were significantly lower after a cold shower preceded by exercise than after a hot shower or a warm up period preceded by exercise.¹¹

In a study completed by Sills and O'Riley, subjects had five bouts of running followed by a rest period during which the subjects' abdomens were sprayed with cold water (44°F - 48°F) for eight minutes. They then followed with another five bouts of spot running. Jogging and rest supine were also used as variables. The cold water spray increased the number of steps taken by the subjects more than rest or exercise, but rest increased the number of steps more than exercise.¹²

Jacobsen conducted a study using a cold water foot bath (34°F - 40°F) before and after basketball practice. Twelve freshman


basketball players were used as subjects. Six of the subjects used cold water foot baths and the other six used rest. The heart rate, body temperature and surface temperature of the feet were tested before practice and at different intervals following practice. Jacobsen found the body temperature and heart rate were lower with the use of the cold water foot bath, but not significantly.\textsuperscript{13}

Moore, Nicolette and Behnke found that when they used shaved ice and water with the temperature between 35$^\circ$F and 40$^\circ$F they were able to get the best results for the rehabilitation of athletic injuries. They recommend short periods of immersion before each exercise bout because of the painful discomfort.\textsuperscript{14}

Summary

A summary of the literature reveals that cold application, whether it be ice packs, cold showers, or cold water baths, is important in helping to speed up recovery from fatigue and improving performance.


CHAPTER III

PROCEDURE FOR OBTAINING DATA

This chapter provides a description of the subjects, the treatments applied, and the apparatus used to test the velocity of a pitched baseball.

The Subjects

From among thirty subjects who were participating in a study involving the endurance of baseball pitchers, eight subjects were asked and agreed to take part in this investigation. The eight selected were considered by Porter as having the best pitching ability based on pre-test scores.15

Due to the subjects involvement in the Porter study they were considered to be in pitching condition and no separate training period was deemed necessary.

To determine the effects of cold water applications on the velocity of a pitched ball, testing periods were held over a three-week period. Testing sessions were held on Monday, Tuesday and Wednesday of each week.

The eight subjects had been previously excused from basic physical education classes in order to eliminate possible variables which might affect the results of this study.

During each testing period three subjects were administered one of the three experimental variables used in this study. A rotational design was used so that each of the eight subjects would be administered each of the three variables.

The Treatments

The three experimental variables were: (1) cold water application between each of the nine innings or after twelve throws, (2) cold water treatment before warm up and after the sixth inning or after a total of seventy two throws, and (3) no cold treatment, but a normally pitched nine inning game consisting of a total of one hundred and eight pitches.

When the subjects pitched normally with no cold treatment, they were allowed to warm up as long as needed. The subjects were then allowed a ten-minute rest with a varsity baseball jacket on to simulate the time lapse between warm up and the start of the game. Each pitcher was then given five warm up pitches before starting each inning. Twelve pitches were thrown to constitute an inning. All subjects had a ten-minute rest period between each inning, during which the subject wore the jacket. The velocity of each of the twelve pitches was measured and recorded in 0.0001 seconds.

With the ice water treatment between each inning, the subject followed basically the same procedure as that used in the normal treatment except that between each inning an ice water bath of 35° to 40° Farenheit as shown in Figure 1, page 13 was applied to the pitching arm. Once the pitcher completed each inning he would take one minute
FIGURE 1
THE APPLICATION OF THE ICE WATER BATH.
to remove his sweat shirt and then immerse the pitching arm to point of insertion of the deltoid muscle in the ice water bath for four minutes. He would then remove the arm from the ice water and have one minute to replace the sweat shirt, and the final four minutes of the rest period the pitcher wore a jacket and rested until a total of ten minutes between innings had elapsed. The velocity of each of the twelve pitches was measured and recorded in 0.0001 seconds. He would then start pitching the next inning.

In the third treatment, the ice water bath was applied to the pitching arm before warm up and after the sixth inning for a period of four minutes. After the cold application of four minutes before the warm up period, the subject would warm up as long as he deemed necessary. The subject would then pitch five innings with just rest between innings and no cold water applications. At the end of the sixth inning one minute was allowed to remove the sweat shirt, four minutes of ice water bath was applied to the pitching arm, one minute was then allowed to replace the sweat shirt and during the final four minutes of the recovery period, the pitcher wore a jacket. In the remaining three innings the subjects followed the normal treatment procedure. The velocity of each pitch was measured and recorded in 0.0001 seconds.

Once all of the subjects were administered each of the three treatments, the average velocity for each inning and the average velocity for a nine inning game were recorded so that a statistical analysis for each treatment could be calculated.
Collection of Data

The apparatus used to measure the velocity of each pitch was a modification of the device described by Malina and Rarick. The basic components included an adjustable bank of six phot-electric cells with a light source (Figure 2), a wooden target covered with canvas, a microphone and amplifier, and an electric timer (Figure 3).

The photocell unit used in this study was constructed by the electrical engineering department at South Dakota State University. The unit consisted of six photocells mounted in a box one inch apart and arranged in a vertical column covering a span of twelve inches. The cells were sensitive enough so that they would pick up any shadow that passed through any part of the cell, setting off the electric timer. The cell box was attached to a volleyball standard with two large rubber bands. The bank of cells could be adjusted to the height desired for each subject. The volleyball standard was moved back and forth from the pitching mound for each subject so that the ball passed through the photocells as it was being released.

A light source attached to a volleyball standard by a steel clamp six foot straight across from the photocells was also used. The light source consisted of a 200 watt light bulb which was placed

FIGURE 2

LIGHT SOURCE AND PHOTOELECTRIC CELL ARRANGEMENT FOR COMPUTING BALL VELOCITY.
FIGURE 3

MICROPHONE AND ELECTRIC TIMER USED FOR COMPUTING BALL VELOCITY, TARGET AND POINT OF IMPACT COMPONENTS.
to show directly into the photocell box. The light source could be adjusted to the height of the photocells.

A target, five feet by six feet, constructed of planks was used in the process of gathering data for the study. The target was covered with pieces of canvas to help absorb some of the shock. Two high jump standards were used as supports for the target which was sixty feet six inches from the pitching mound. Attached to the high jump standard was a microphone used to pick up the impact of the ball hitting the target. This impulse was relayed through an amplifier which was located next to the target in a wooden box. This in turn sent the impulse back to the electric timer stopping the timer. The 0.0001 of a second electric timer was used to measure the elapsed time of the flight of the ball from the time the ball was released until the ball made contact with the target.
Presented in this chapter is the statistical analysis of the data collected from the administration of the three experimental variables, (1) the cold water application to the pitching arm between each of the nine innings, (2) cold water treatment before the warm up and after the sixth inning, and (3) no cold treatment, but a normally pitched nine inning game consisting of a total of one hundred and eight throws, twelve pitches to an inning.

Analysis of Data

The data in this study were analyzed in three ways. A $t$ ratio was first computed to analyze the changes of the average velocity of the pitched ball in the first two innings to that of the last two innings of a nine inning experimental game. The computations were made individually for each of the three treatments.\(^\text{17}\)

A second analysis was conducted to compare the average changes in velocity from the first two to the last two innings of the experimental game among the groups. A treatment-by-subject analysis of variance procedure was followed.\(^\text{18}\)


\(^{18}\text{James, Bruning and B. L. Kintz, Computational Handbook of Statistics (Glenview, Illinois: Scott Foresman and Company, 1968), pp. 44-47.}\)
A third analysis was made to compare the three treatments in the average velocity of a pitched baseball for an entire nine inning game. A treatment-by-subject analysis of variance procedure was used.\textsuperscript{19}

If an F ratio was found to be significant, the Duncan's Multiple-Range test was employed to determine where the significant difference occurred.\textsuperscript{20}

The .05 level of confidence was accepted as the minimal level needed to reject the null hypothesis. The individual performance times for each of the three experimental variables can be found in Appendixes A, B, and C.

**Analysis of results in comparing the averages of innings one and two with innings eight and nine.** Table I indicates that when cold water was applied to the arm between each inning, there was a significant decrease in the velocity of the pitched ball in the last two innings as compared to the first two innings.

**Analysis of results between the average velocity of the pitched ball in innings one and two as compared to the average velocity of the pitched ball in innings eight and nine.** Table II indicates that as a result of the three varied treatments, there was

\textsuperscript{19} Ibid., pp. 44-47.

\textsuperscript{20} Ibid., pp. 115-117.
### TABLE I

SUMMARY OF \( t \) FOR COMPARING THE AVERAGES OF INNINGS 1 AND 2 WITH INNINGS 8 AND 9

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average Velocity of Innings 1 and 2 (seconds)</th>
<th>Average Velocity of Innings 8 and 9 (seconds)</th>
<th>( M_d )</th>
<th>( SE_d )</th>
<th>( t^* )</th>
</tr>
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<tr>
<td>Treatment A</td>
<td>.5369</td>
<td>.5470</td>
<td>.0038</td>
<td>.00431</td>
<td>.88</td>
</tr>
<tr>
<td>Treatment B</td>
<td>.5430</td>
<td>.5759</td>
<td>.0329</td>
<td>.0059</td>
<td>5.57</td>
</tr>
<tr>
<td>Treatment C</td>
<td>.5541</td>
<td>.5563</td>
<td>.0022</td>
<td>.005763</td>
<td>.38</td>
</tr>
</tbody>
</table>

\[ t^* .05 (7) = 2.36 \]

\[ t .01 (7) = 3.50 \]

### TABLE II

ANALYSIS OF RESULTS OF THE TESTS OF THE AVERAGE VELOCITY OF A PITCHED BALL IN INNINGS ONE AND TWO AS COMPARED TO THE AVERAGE VELOCITY OF A PITCHED BALL IN INNINGS EIGHT AND NINE

<table>
<thead>
<tr>
<th>Source</th>
<th>ss</th>
<th>df</th>
<th>ms</th>
<th>F*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>.00963114</td>
<td>23</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Subjects</td>
<td>.00123294</td>
<td>7</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Treatment</td>
<td>.00477797</td>
<td>2</td>
<td>.00238898</td>
<td>9.24</td>
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<tr>
<td>Error</td>
<td>.00362023</td>
<td>14</td>
<td>.0025858</td>
<td>----</td>
</tr>
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\[ F^* .05(2/14) = 3.75 \]

\[ F .01(2/14) = 6.51 \]
a significant difference in the average velocity of the pitched ball in innings one and two as compared to the average velocity of the pitched ball in innings eight and nine. When Duncan's multiple range test of significance was applied to the data, the results obtained indicated that the application of cold water between innings resulted in a decrease in the speed of the pitched ball, over the nine innings, which was greater than that shown in the other two tests (Table III).

### TABLE III

**DUNCAN'S MULTIPLE-RANGE TEST TO DETERMINE THE EFFECT OF THE THREE TREATMENTS ON THE VELOCITY OF THE PITCHED BALL**

<table>
<thead>
<tr>
<th></th>
<th>(3) .0022</th>
<th>(1) .0038</th>
<th>(2) .0329</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3)</td>
<td>.0022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td></td>
<td>.0016</td>
<td>.0307</td>
</tr>
<tr>
<td>(2)</td>
<td>.0329</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ R_2 = .0175 \]
\[ R_3 = .0181 \]

**Analysis of changes in the average velocity during the course of a nine inning game.** Table IV indicates that the three types of treatment caused no significant change in the average velocity of a pitched baseball for an entire nine inning game.
TABLE IV

ANALYSIS OF THE RESULTS OF THE TREATMENTS ON AVERAGE VELOCITY

<table>
<thead>
<tr>
<th>Source</th>
<th>ss</th>
<th>df</th>
<th>ms</th>
<th>F*</th>
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<tbody>
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<td>Total</td>
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<td>23</td>
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<td>Subjects</td>
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*F .05(2/14) = 3.75  \( F .01 (2/14 = 6.51 \)

Summary and Discussion of Results

The cold water application between innings was found to cause a significant decrease in the average velocity, as tabulated by computation of the speed of the pitched ball in innings one and two, and eight and nine. When compared to the other treatments, this decrease was significantly greater than that of the other two groups.

The investigator felt that this was possible due to the method used in applying the cold water treatment. The subject's throwing arm and hand were immersed into the cold water bath and eventually the hand became cold, making it difficult for the thrower to grip the baseball properly. In addition, Morehouse and Miller state that when cold is applied to a muscle, the speed with which that muscle contracts and relaxes and the force of contraction are all decreased.21

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application of cold causes the temperature to drop below the normal body temperature, which in turn elevates the irritability threshold, causing an increase in muscle viscosity, making the muscles sluggish and stiff and therefore weak. Because of the stiffness and weakness occurring in the muscle, the reaction time in the contraction of muscles in the pitching arm was decreased, which caused a decrease in the velocity of the pitched baseball.

Roundy and Cooney, Falls, and Happ reported in their studies that the application of cold can be beneficial in recovery from fatigue. These studies, however, were conducted by using either a treadmill or a bicycle ergometer for measuring performance. In this study the application of cold to the pitching arm proved to be detrimental in maintaining the velocity of a pitched baseball.

In view of the findings of this study, the hypothesis that "There would be no difference between the three treatments" was rejected. The conclusion was that there is a significant difference between the three treatments in that the cold water bath between innings caused a decrease in the velocity of the pitched baseball.

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22Ibid., p. 60.
CHAPTER V

SUMMARY

Problem

The purpose of this study was to determine the effect of a cold water bath of 35° to 40°F as applied to the pitching arm in an effort to maintain a constant pitching speed over a prescribed period of time.

Data

Subjects who participated in this study were members of the men's basic physical education classes at South Dakota State University during the 1968-1969 school year. The subjects were chosen for pitching ability from a group participating in another study "The Velocity of a Pitched Ball as Affected by Two Varying Training Programs."

The participants were tested three times over a period of three weeks. A rotational design was used so that each subject could be administered each of the three experimental variables. Data obtained during the testing period were analyzed by employing the t test, the F ratio and the Duncan Multiple Range test.

Findings

The cold water application between innings was found to cause a significant decrease in the average velocity of the pitched ball. Averages were computed through innings one and two and eight and nine. When compared to the other treatments, this decrease was significantly greater than that of the other two groups. As shown by the three tests no significant difference occurred in the average velocity of the pitched baseball for an entire nine inning game.

Conclusion

From the findings of this investigation, the following conclusion was drawn:

1. The application of a cold water bath of 35° to 40°F to the pitching arm is detrimental to the maintenance of the velocity of a pitched baseball for a nine inning game.

Recommendations for Further Study

Based on the information obtained in this study, the investigator would make the following recommendations for further study:

1. That a similar study be conducted using the cold water bath, but not having the pitching hand immersed in the bath.

2. That a similar study be conducted employing a "bank" of twelve photoelectric cells in order to have a broader range for release of the pitched ball.
3. That a similar study be conducted using a greater number of subjects.

4. That a similar study be conducted using members of the varsity baseball team.
BIBLIOGRAPHY

A. BOOKS


B. PERIODICALS


C. UNPUBLISHED MATERIALS


### APPENDIX A

**RAW DATA FOR NORMAL TREATMENT**

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Average for Innings 1 and 2</th>
<th>Average for Innings 8 and 9</th>
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APPENDIX B

RAW DATA FOR COLD WATER BATH BETWEEN INNINGS

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### APPENDIX C

**RAW DATA FOR COLD WATER BATH**
**BEFORE WARM-UP AND AFTER 6th INNING**

<table>
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<td>D. W.</td>
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