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Selected Flexibility Exercises and Baseball Hitting Proficiency

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SELECTED FLEXIBILITY EXERCISES AND BASEBALL HITTING PROFICIENCY

BY

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is thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Thesis Adviser Date

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CHAPTER I

INTRODUCTION

Significance of the Study

Most coaches agree that hitting is one of the most challenging aspects in baseball. Thus, batters on all levels continually strive for hitting proficiency. It should be noted, however, that the consistent hitter still fails to hit safely seven out of ten times.[1] The day of the hitter's domination of the game has become almost non-existent. The lengendary Duke Snyder observed that pitchers have so dominated play that the day of the four-hundred hitter may have been removed from the game.[2] A new training theory must be developed and introduced to the game of baseball in order to increase the number of times a ball is hit safely.

There appears to be an increasing interest among baseball coaches in the development of a flexibility program to improve hitting consistency. Through an analysis of the form used for hitting a baseball, Fisher revealed that a full powered swing is dependent on the range of motion in the body's joints and that a subsequent amount of force is lost when flexion in the hips is decreased.[3] The

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[1] The Baseball Encyclopedia, (The Macmillian Company, Collier Macmillian, Canada LTD, Toronto, Ontario, 1969), pp. 150-160.

[2] "Where Are The Hitters?," Newsweek, 71:86, June 3, 1968.

[3] "Analysis of Form Used For Hitting a Baseball" Coach and Athlete, 35:38-39, April, 1973.

identification of selected flexibility exercises related to the success of hitting and implementation into training programs would be of significant value to coaches and players alike.

Statement of the Problem

The purpose of this study was to determine whether a relationship existed between the use of selected flexibility exercises and hitting proficiency.

Hypotheses

1) There is no significant difference between scores achieved by members of the experimental and control groups in tests of hitting proficiency after a six-week treatment period.

2) Multiple regression equations to predict hitting proficiency based upon knowledge of selected flexibility measures cannot be developed to account for a significant amount of variability.

3) There is no significant relationship between and among changes in range of motion in selected body parts and in hitting proficiency.

Limitations and Delimitations

1) Twenty-one athletes from the 1975-76 South Dakota State University baseball team were used as subjects.

2) Only the Jugs pitching machine was used for pre- and post-testing of hitting proficiency.

3) Only balls hit in fair territory were used as a source for data collection.

4) No attempt was made to restrict the activities of subjects

outside regular practice hours.

Definition of Terms

Ballistic Movement. Ballistic movement is movement occurring when the body or specific parts of the body are put into rapid motion by a brief contraction of the prime movers.[4]

Flexibility. Flexibility is the component of physical fitness that pertains to the functional capacity of the joint to move through a normal range of motion.[5]

Hitting Proficiency. For the purposes of this study, hitting proficiency was defined as the batters placement of the ball in fair territory on a regulation baseball diamond.

Static Stretching. Static stretch is a constant, maintained stretch with no bouncing or jerking movement.

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[4]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louis: C. V. Mosby Company, 1968), p. 85.

[5]Roger D. Kerns and Melvin Klein, "Flexibility and Fitness" Scholastic Coach 41:36, Nov. 1971.

CHAPTER II

REVIEW OF RELATED LITERATURE

Research relative to the influence of the use of flexibility exercises on performances in sports is limited. The review of related literature chapter was confined to resource materials and those studies dealing directly with the mechanics of baseball hitting, flexibility as related to performance, and flexibility of specific body parts.

Past Research in the Art of Hitting

Little research has been conducted with respect to the sequence of specific body parts during the act of hitting. Bunn explains the sequency of movements of hitting as follows:

> The batter steps first...as the foot is placed the body starts to rotate at the shoulders and the hips. Finally, the forearms extend and as the ball is met, the wrists are quickly extended... The movements must be in sequence and started at the right moment to assure the greatest effective force. The extension of the forearm and wrists are the most important moves to give increased linear velocity to the bat for the same angular velocity.[1]

Vaughn concluded that a short swing with good wrist action contributes to hitting for a high batting average, and that an extended swing with arms straightened and proper hip rotation tends to increase power.[2]

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[1]John W. Bunn, Scientific Principles of Coaching (Engelwood Cliffs, New Jersey: Prentice Hall, 1960), p. 194.

[2]Ross Edward Vaughn, "Relationship of Certain Variables to Success in Batting" (unpublished Masters Thesis, Washington State University, 1969), p. 19.

Jensen and Schulz reported that the baseball swing has been labeled as a ballistic movement. Muscular contraction initiates the movement, and the resultant momentum allows the bat to move through the proper arc.[3]

According to Hooks, after an athletes' strength has shown definite improvement, there is a marked increase in his athletic ability. Experiments performed by Hooks have demonstrated a very noticeable correlation between left shoulder flexion and success in hitting.[4]

Edlund reported that Puck suggested the body parts most involved in effectively providing force for batting a pitched ball were the hips and shoulders during the trunk rotation phase.[5]

Conrad reported that the more proficient batters utilize more wrist action just before contact with the baseball than do less skilled hitters. Also, the higher skilled batter is more consistent

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[3]Clayne R. Jensen and Gordon W. Schultz, Applied Kinesiology: The Scientific Study of Human Performance (New York: McGraw-Hill, 1970) pp. 41-42.

[4]Gene Hooks, "Prediction of Baseball Ability Through an Analysis of Measurers of Strength and Structure," Research Quarterly, 30: 38-43, March 1959.

[5]Larry Edlund, "The Relationship of Hitting Ability in Baseball to Selected Anatomical Measurements and Motor Responses" (unpublished Masters Thesis, South Dakota State University, Brookings, South Dakota, 1972), p. 7.

with his swing pattern which enables him to get more velocity from the wrist action and better bat control.[6]

Opinions of Authorities in the Field of Hitting

Williams observed that hitting in baseball is the most difficult task to perform in sports. "There is nothing that requires more natural ability, physical dexterity, more mental alertness or greater finesse to go with physical strength than hitting."[7] The writer also suggested that along with the characteristics mentioned above, another important aspect to consider is a quick bat. The longer an individual can delay swinging at a pitch the less chance there is of going after bad pitches.[8]

Geishberg concluded that bat speed is an essential element in hitting and must be regulated by a swing that is quick and sharp but not too forceful. The wrist snap is the final bat accelerator. It was also mentioned that hip rotation along with wrist and arm movements furnishes the hitting power. The hips must get out of the way in order to allow momentum and the power of the body to come forward in the swing.[9]

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[6]Ruth Conrad, "A Cinematographical Analysis of the Major Sequential Movement Patterns of Skilled, Semi-Skilled and Non-Skilled Baseball Batters" (unpublished Doctoral dissertation, Temple University, Philadelphia, Pennsylvania, 1965), pp. 101-104.

[7]John Underwood and Ted Williams, "Science of Batting," Sports Illustrated 29:41, 1968.

[8]Ibid., p. 42.

[9]Howard Geishberg, "No-Stride, Up-the-Middle, Concept of Hitting," Scholastic Coach No. 7, 42:106-107, March 1973.

In the explanation of batting by Watts, the development of essential batting skills and employing a comfortable batting style which combined with the batters capabilities all add up to increased success in hitting.[10]

Alson and Weishopf suggested that along with the wrist and arms, rotation of the hips is most conducive to batting power. The hips provide the movement to turn the shoulders, which produce bat speed and in turn helps create solid contact on the ball with the bat.[11]

According to Benson, consistent hitting requires sound concentration and confidence. Psychological considerations are just as necessary as the physical attributes. The hitter must feel at ease with his stance and bat, and possess self-confidence in his ability to meet the ball.[12]

Cooper and Glassow concluded that the primary levers used in hitting are those acting at the hip and wrist joints.[13]

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[10]Lew Watts, The Fine Art of Baseball (Englewood Cliffs, New Jersey: Prentice-Hall 1973), p. 247.

[11]Walter Alston and Don Weishopf, The Complete Baseball Handbook (Boston: Allyn and Bacon, 1972), p. 19.

[12]Martin Benson, "Simple Hitting Fundamentals," Scholastic Coach, 41:76, March 1972.

[13]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louis: C. V. Mosby Company, 1968), p. 131.

Lai stated:

> Natural hitters are rare, batting is an art and there are correct and incorrect ways to bat. Many young ball players imitate their favorite ballplayers batting stance and are amazed that they cannot hit the ball the way the stars do.[14]

Lai also suggested that there is no special format for hitting and it is a rarity if two good hitters employ the same techniques and style.[15]

Influence of Flexibility on Performance

Cureton stated that an average range of body flexion and extension is needed for a high degree of athletic performance. Motor fitness and coordination are two factors to consider when measuring the degree of flexibility an individual displays.[16]

Rathbone suggested that limited flexibility has the potential to cause awkwardness in some individuals. Limited flexibility may also affect physical condition and performance.[17]

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[14]William T. Lai, Championship Baseball (New York: Prentice-Hall 1954) p. 10.

[15]Ibid.

[16]Thomas F. Cureton, "Flexibility as an Aspect of Physical Fitness" Research Quarterly, 12:581-590, May 1941.

[17]Josephine L. Rathbone, Corrective Physical Education (Philadelphia: W. B. Saunders Co., 1944), p. 11.

Olsen reported that Syverson compared range of flexibility among baseball players, service course students, football players, swinners, and basketball players. It was found that baseball players were more flexible in the three measurements of flexion, extension, and lateral trunk flexion as compared to the service course students. When compared with football players, baseball players showed more flexibility in five of the nine variables considered. In relation to basketball players, baseball athletes exhibited more flexibility in twenty-six of thirty components measured. The final ranking of subjects in overall flexibility using thirty different criteria were swimmers, baseball players, service course students, football athletes, and basketball players.[18]

Cureton suggested that flexibility is an essential component which aids an individual in developing competence in most skills where twisting, turning and stretching occurs.[19]

Flexibility as Related to Specific Body Parts

Novich and Taylor stated:

> ...flexibility allows uninhibited joint motion and perfection of movement, giving an added margin of safety to the joint and its surrounding connective tissue structure when it is needed most, without tearing, which could lead to sprains, subluxations, and dislocations, or fractures.[20]

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[18]Barbara Olsen, "An Investigation of the Relationship of Ankle, Knee, Trunk, and Shoulder Flexibility to General Motor Ability" (unpublished Masters Thesis, University of Oregon, 1956), pp. 8-9.

[19]Thomas F. Cureton, op. cit., 585.

[20]Max M. Novich and Buddy Taylor, Training and Conditioning of Athletes (London, England: Henry Kimpton Publishers, 1972), p. 62.

The writers also describe flexibility as training structured to increase the range of motion of joints, requiring a stretching of tissues beyond normal limits.[21]

Cooper and Glassow reported that the top line hitters in baseball have such great wrist flexibility that bones appear to move around when action takes place. This strength in flexion of the wrist is nearly doubled when compared with wrist extension.[22]

Jensen and Schultz observed that shoulder flexion is a necessity in the everyday activities of walking and running and a major factor in performing throwing and striking movements.[23]

Wells suggested three factors that must be taken into account when considering the flexibility of any body region: first the normal range of the motion, second, the cause of restricted motion and third, methods used to increase motion.[24]

Jensen and Schultz also reported that hip flexion is one of the strongest movements of the body. It is used in almost all locomotion and becomes a part of almost every act of movement of the body.[25]

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[21]Ibid.

[22]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louis: C. V. Mosby Company, 1968), p. 264.

[23]Clayne R. Jensen and Gordon W. Schultz, Applied Kinesiology: The Scientific Study of Human Performance (New York: McGraw-Hill 1970), p. 63.

[24]Katherne F. Wells, Kinesiology: The Scientific Basis of Human Performance (Philadelphia: W. B. Saunders Company, 1966), p. 456.

[25]Jensen and Schultz, op. cit., pp. 93-94.

CHAPTER III

METHODS AND PROCEDURES

Organization of the Study

The study was conducted at South Dakota State University, Brookings, South Dakota, during the Fall of 1975 between the dates of September 2 and October 14. The reason for conducting the investigation during the fall as opposed to the regular spring baseball season was that the subjects would be in better physical condition and closer to optimum levels of playing performance after completing summer competition.

The flexibility treatment selected for this study was a modification of the Montreal Expos Professional Baseball Team Flexibility Program and consisted of nine exercises.[1] The treatment was administered once during a practice session for five practices per week, and continued for six weeks. The flexibility program was administered during each practice session.

A hitting test designed by the investigator was used as the criterion against which the relationship of flexibility to hitting proficiency was measured. The test was administered at the beginning and the termination of the six-week period. The hitting pre-test was also the criterion used to establish the control and experimental groups.

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[1]Pat Daughtery, Montreal Expos Flexibility Program, (Indian Hills Community College, Centerville, Iowa.

Twenty-two subjects were ranked from the highest to lowest according to their performance score on the hitting pre-test. Subjects were then grouped in matched pairs and placed in the experimental and control groups by stratified random allocation.

Source of the Data

The subjects were twenty-two members of the 1975-1976 South Dakota State University Varsity Baseball Team. They were selected by the South Dakota State University Baseball Coaching Staff on the basis of probable playing time during the spring playing season and their predicted contributions to the team. It was necessary to reduce the total number of subjects to twenty-one after one of the members of the experimental group received an injury during the latter stages of the treatment period. The general characteristics of the subjects are presented in Table I.

Administration of the Treatment

The treatment selected for the study was a modification of the Montreal Expos Flexibility Training program consisting of ten flexibility exercises. A review of related literature indicated that flexibility of the wrists, hips, and trunk is most conducive to success and power in hitting. The exercises selected were: (1) the Butterfly, (2) the open Diamond, (3) the closed Diamond, (4) the Grounddiggers, (5) the Human Cross, (6) the Mountain Climber, (7) the Rocker, (8) the Sun Worshipper, (9) the Hurdler, (10) the Wristers. Each exercise was performed individually by each subject and held for a five-second count. The order of exercises was selected at random. The

TABLE I

Name	Position	Bats	Throws	Height	Weight
1. W.A.	Pitcher	R	R	6'1"	165
2. A.B.	Catcher	R	R	5'10"	190
3. T.B.	2B	R	R	5'9½"	150
4. G.C.	OF	R	R	5'10"	180
5. S.C.	1B	L	R	6'0"	170
6. B.E.	1B	R	R	5'10"	205
7. M.F.	SS	R	R	5'8"	140
8. C.F.	3B	L	R	6'2"	170
9. S.F.	Catcher	R	R	6'3"	195
10. J.H.	Catcher	R	R	6'0"	175
11. C.H.	OF	R	R	6'0"	155
12. S.H.	Catcher	R	R	6'0"	195
13. W.J.	OF	R	R	6'1"	175
14. L.K.	SS	L	R	5'10"	170
15. J.L.	Pitcher	R	R	5'11"	165
16. P.M.	3B	R	R	6'0"	180
17. D.M.	OF	R	R	5'10"	170
18. C.O.	Pitcher	R	R	5'10"	165
19. R.P.	OF	L	L	5'7"	150
20. D.S.	2B	R	R	5'9"	150
21. T.T.	1B	R	R	6'1"	180
22. J.T.	OF	L	R	5'10"	160

investigator explained and demonstrated each exercise at the beginning of the six-week period and administered the flexibility program daily throughout the six-week period. Techniques for the execution of each exercise are illustrated in Figures 1-9.

Collection of the Data

Data were collected from two sources: (1) a pre-test and post-test of hitting proficiency administered at the beginning and end of the six-week period and (2) a battery of flexibility tests administered at the beginning and termination of the six-week period.

One hitting proficiency test designed by the researcher was used both as a pre-test and post-test. Data collected during the pre-test and post-test were analyzed to determine whether any significant change in hitting proficiency had occurred in either the control or the experimental groups. The test was designed as follows:

A Jugs Pitching Machine set at a speed of eighty-five miles per hour was placed on a pitching mound. This speed was determined by establishing a standard of consistency where returning lettermen could safely hit fifty percent of eighty pitches thrown in the strike zone. The subjects were then given twenty swings at the beginning of practice on four consecutive days before and at the end of the six-week period. Thus, each subject was officially at bat eighty times each testing period. To prevent the hitter from consistently swinging at the same velocity, two random pitches of variable speed were inserted for each twenty pitches thrown. Variable speed pitches were determined through the use of a table of random numbers.

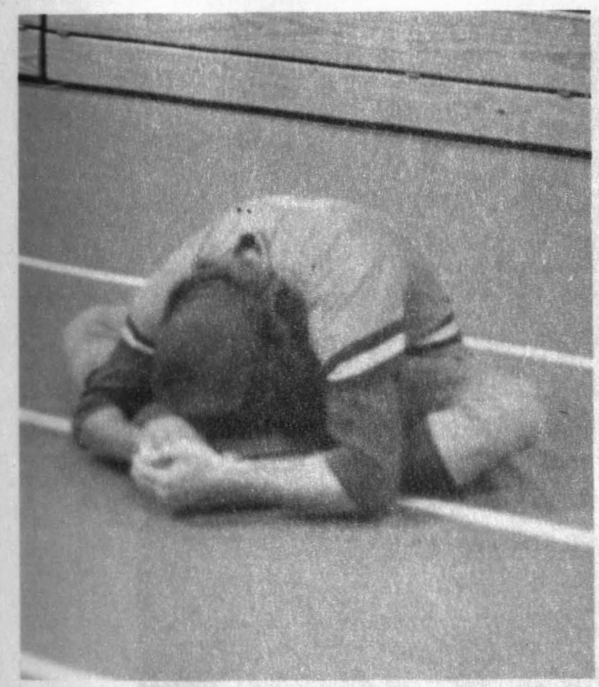

Fig. 1. The Butterfly

Fig. 2. The open Diamond

Fig. 3. The closed Diamond

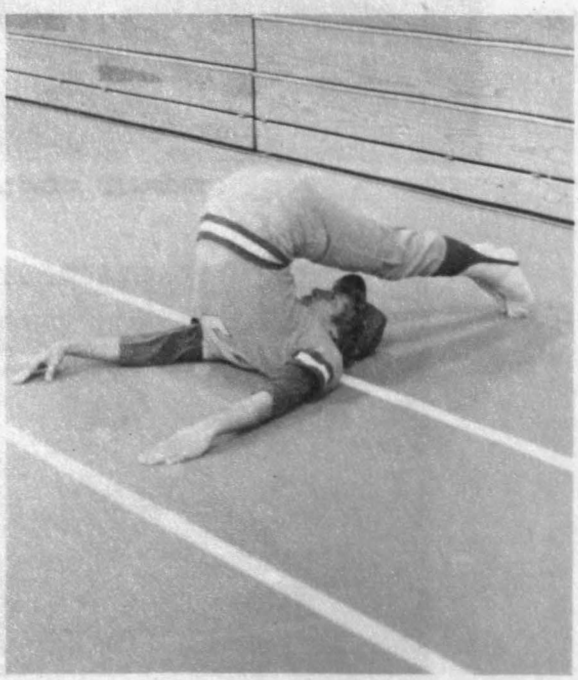

Fig. 4. The Grounddigger

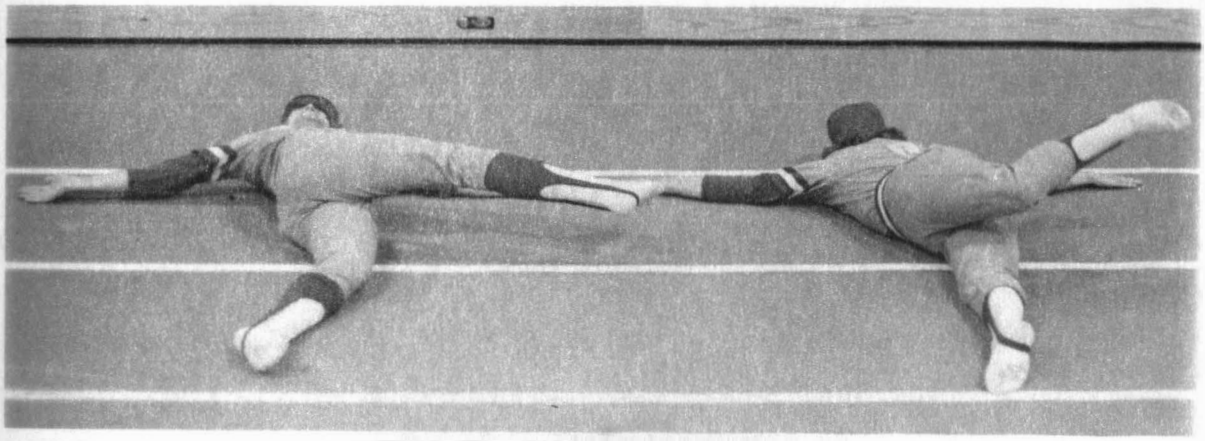

Fig. 5. The Human Cross

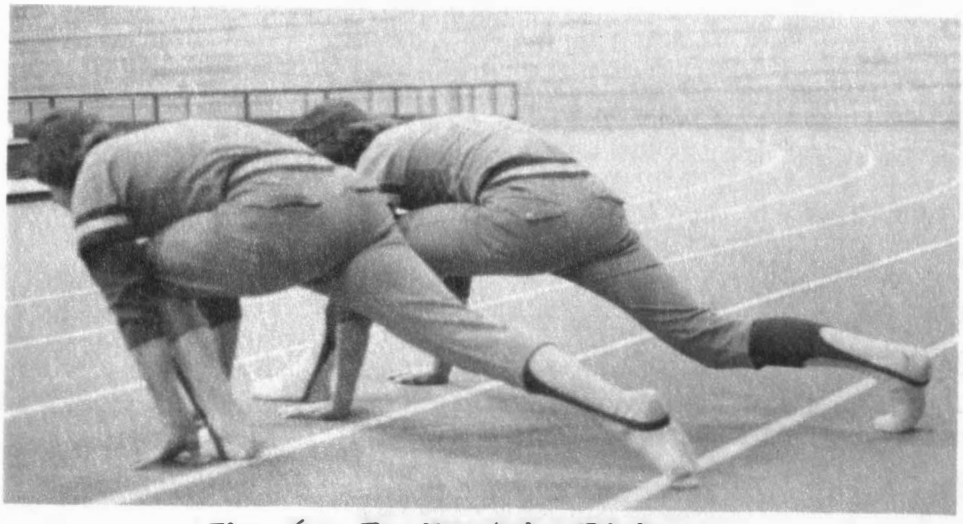

Fig. 6. The Mountain Climber

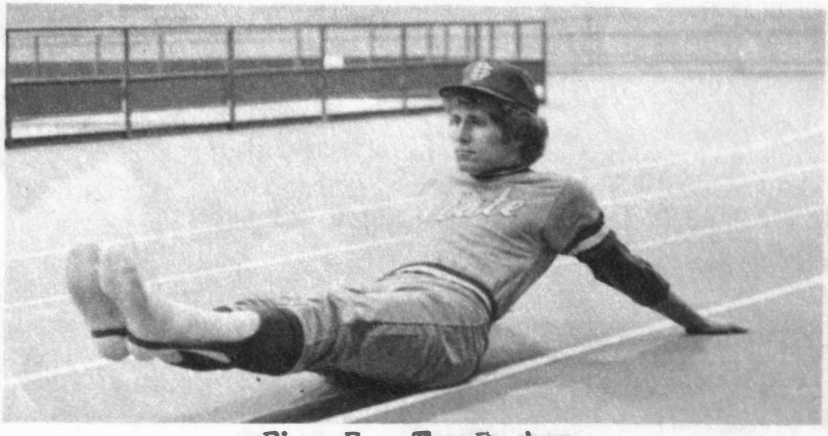

Fig. 7. The Rocker

Fig. 8. The Sun Worshipper

Fig. 9. The Hurdler

Fig. 10. The Wristers

Five warmup swings were allowed before each session. Only the ability to hit safely was investigated. The total number of hits was then recorded for each testing period. The criterion used for determining a safe hit is presented in Appendix A.

A battery of flexibility tests were administered two times during the course of the six weeks to determine whether any change in flexibility measurements of the wrists, hips, and trunk had occurred. The tests were conducted in the following manner.

Wrist. Flexion, extension, radial flexion, and ulnar flexion of both right and left wrist were measured.

A protractor four inches long and ten inches high was transposed on a piece of printing board which measured twenty-two inches in height and twenty-eight inches wide. This in turn was mounted on a level wooden box four feet long, two feet wide, and three and one-half feet high. To measure flexion and extension the subjects were instructed to stand next to the box with feet together and to place the ulnar styloid process on a point drawn on the protractor. The exterior digit (fifth phalanx) was then placed on zero degrees and was used as the marking point when the reading was taken. The forearm was flexed at an angle of ninety degrees and held in this position. The subject was then instructed to flex and extend his wrist. A reading was taken by placing a thin piece of metal against the inside of the exterior digit. The reading was then recorded in degrees.

The same procedure was used for ulnar and radial flexion. In this test, however, the hand was placed palm down and the middle digit was used as the marking point.

The wrist flexibility test is shown in Appendix B.

Hip. To measure hip flexion the Modified Sit and Reach Test was used.[1] The subject assumed a sitting position on the ground with the legs extended at right angles to a piece of wood staked to the ground, with heels touching the board approximately three feet apart. A yardstick was placed between the legs of the subject so that it rested on the ground with the fifteen-inch mark resting on the near edge of the heel line. The yardstick was mounted on another piece of wood to insure stability and consistency. The subject then stretched forward as far as he could and held this position for two seconds. A score was then recorded by taking a reading in inches on the farthest point reached on the yardstick with the finger tips. The Sit and Reach Test is presented in Appendix B.

Trunk. A cloth tape was mounted on a pole to measure trunk rotation. The subject then placed his outside foot on a line marked on the floor perpendicular to the floor, with legs together and knees locked. A set of large body calipers was then placed on the superior aspect of the illiac crest with the end of the calipers attached to the centimeter tape. The subject was instructed to rotate as far as possible with no jerking movements and to hold this position for two seconds. A reading was then taken and recorded in inches. Appendix B illustrates the trunk rotation test.

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[1]Barry L. Johnson and Jack K. Nelson, Practical Measurements for Evaluation in Physical Education (Minneapolis: Burgess Publishing Company, 1971), p. 199.

Flexion. For trunk flexion, the Scott and French Test was employed.[2] The subject was instructed to stand on a bench with feet together and knees straight. A yardstick was mounted on a board and staked to the ground. The subject then flexed the trunk reaching as far as possible down the yardstick and was to hold this position for two seconds. A measurement was recorded in inches on the farthest point reached by the middle finger. Appendix B illustrates the Bend and Reach Test.

The best of three trials was recorded for each test given. The subjects were allowed no practice trials and thirty-second warmups were provided before each test. All tests were administered by two graduate students trained by the investigator. The order of tests was given at random with each subject going through the same order once it had been established. The data were then collected and recorded in degrees and/or inches on score sheets.

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[2]Presidents Council on Physical Fitness and Sports, Physical Fitness Research Digest, 4:3, October, 1975.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

Organization of the Data for Analysis

The purpose of this study was to determine whether a relationship existed between the use of selected flexibility exercises and hitting proficiency.

The data collected on the twenty-one subjects were hitting proficiency scores, which served as the dependent variable, and eleven independent variables. The independent variables included measures of right and left wrist (flexion, extension, ulnar and radial flexion), trunk flexion, hip flexion, and trunk rotation. The subjects were tested on all variables twice during the six-week period. Raw data for all variables are presented in Appendix C. The mean scores for all variables can be seen in Table II.

A one-way analysis of variance statistical procedure was used to determine whether significant differences existed between experimental and control group mean scores in tests of hitting proficiency and among each of the independent variables.[1]

To assess the intercorrelation between the eleven independent variables and the correlation between the dependent and independent

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[1]Jerome C. Weber and David R. Lamb, Statistics and Research in Physical Education (St. Louis: The C. V. Mosby Co. 1970), pp. 103-113.

TABLE II

TABLE OF MEANS

Variable	Total Mean Scores	Control Means	Experimental Means
Hitting Proficiency	26.38	23.36	29.20
Right Wrist Flexion	31.16	31.63	30.70
Right Wrist Extension	23.90	24.91	22.90
Right Wrist Ulnar Flexion	22.39	21.18	23.60
Right Wrist Radial Flexion	26.39	26.18	26.60
Left Wrist Flexion	27.96	28.73	27.20
Left Wrist Extension	25.20	25.82	24.60
Left Wrist Ulnar Flexion	28.58	28.27	28.90
Left Wrist Radial Flexion	19.62	20.55	18.70
Trunk Flexion	19.59	19.20	19.99
Hip Flexion	19.90	19.59	20.23
Trunk Rotation	23.50	21.86	25.15

variables, a multiple correlation analysis was employed.[2]

To determine whether selected flexibility measures could be used to predict hitting proficiency a multiple regression statistical procedure as suggested by the Experiment Station Statistician at South Dakota State University was used. In all statistical treatments the .05 level of confidence was accepted as the minimum standard for rejection of the null hypothesis.

Analysis of the Data

The results of the one-way analysis of variance procedure which was employed to assess possible differences between experimental and control group mean scores in the dependent and independent variables are presented in Table III. An F ratio of 2.34 was observed in the analysis of hitting proficiency (the dependent variable) between the experimental and control groups. This F was not significant, however, since the critical value for F was 4.38. Although none of the values for the independent variables were significant, the largest F ratio was observed for trunk rotation (2.75) while the next highest was for trunk flexion (1.99).

The results of the multiple correlation analysis are presented in Table IV. One of the independent variables (left wrist radial flexion) showed a significant correlation (.44) with the independent variable (hitting proficiency).

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[2]Robert G. Steel and James H. Torrie, Principles and Procedures of Statistics (New York: McGraw-Hill 1960), pp. 161-182.

TABLE III

ONE-WAY ANALYSIS OF VARIANCE

Variable	Source of Variance	df	SS	MS	F
Hitting	Group	1	178.43	178.43	2.34
	Remainder	19	1448.15	76.21	
	Total	20	1626.28		
Right Wrist Flexion	Group	1	4.59	4.59	.05
	Remainder	19	1772.65	93.30	
	Total	20	1777.24		
Right Wrist Extension	Group	1	21.14	21.143	0.24
	Remainder	19	1669.81	87.88	
	Total	20	1690.95		
Right Wrist Ulnar Flexion	Group	1	30.63	30.63	0.41
	Remainder	19	1430.04	75.27	
	Total	20	1460.67		
Right Wrist Radial Flexion	Group	1	0.92	0.92	.01
	Remainder	19	1726.04	90.84	
	Total	20	1726.96		
Left Wrist Flexion	Group	1	12.22	12.22	.15
	Remainder	19	1563.78	82.30	
	Total	20	1576.00		
Left Wrist Extension	Group	1	7.77	7.77	.06
	Remainder	19	2480.04	130.53	
	Total	20	2487.81		

*F .05 (1/19) = 4.38

Table III. Continued

Variable	Source of Variance	df	SS	MS	F
Left Ulnar Flexion	Group	1	2.06	2.06	.02
	Remainder	19	1907.08	100.37	
	Total	20	1909.14		
Left Radial Flexion	Group	1	17.84	17.83	.33
	Remainder	19	1014.83	53.41	
	Total	20	1032.67		
Trunk Flexion	Group	1	3.22	3.22	1.99
	Remainder	19	30.71	1.62	
	Total	20	33.93		
Hip Flexion	Group	1	2.11	2.11	.96
	Remainder	19	41.73	2.20	
	Total	20	43.84		
Trunk Rotation	Group	1	56.57	56.57	2.75
	Remainder	19	391.20	20.59	
	Total	20	447.77		

TABLE IV
CORRELATION MATRIX OF INDEPENDENT VARIABLES
TO HITTING PROFICIENCY

Variables**	1	2	3	4	5	6	7	8	9	10	11	y
1	1.00	.33	.12	.14	-.04	.42*	.25	.07	.27	.46*	.00	.09
2		1.00	.18	-.29	.44*	.29	.38	.09	-.05	.06	-.39	.05
3			1.00	.15	.18	-.18	-.38	-.25	.005	.33	-.28	.09
4				1.00	-.38	-.18	.18	.30	.002	-.05	.04	.32
5					1.00	.08	.01	-.25	-.42*	-.00	-.00	.03
6						1.00	.24	-.10	.13	.02	-.60*	.02
7							1.00	.45*	.14	.05	-.04	.10
8								1.00	-.08	-.08	-.05	.44*
9									1.00	.05	.41	.19
10										1.00	-.04	-.16
11											1.00	-.28
y												1.00

Variables**
1 Right Wrist Flexion
2 Right Wrist Extension
3 Right Wrist Ulnar Flexion
4 Right Wrist Radial Flexion
5 Left Wrist Flexion
6 Left Wrist Extension
7 Left Wrist Ulnar Flexion
8 Left Wrist Radial Flexion
9 Trunk Flexion
10 Hip Flexion
11 Trunk Rotation
y Hitting Proficiency

* (.05 level of confidence = .42)

Seven of the fifty-five interrelationships were significant beyond the .05 level of confidence (.42 required for significance). These included: right wrist flexion to hip flexion (.46), right wrist extension to left wrist flexion (.44), left wrist flexion to trunk flexion (-.42), left wrist extension to trunk rotation (-.60), left wrist ulnar flexion to left wrist radial flexion (.45), right wrist flexion to left wrist extension (.42), and left wrist radial flexion to hitting proficiency (.44).

The regression equations developed to predict hitting performance are shown in Table V. According to the variance accounted for by the addition of each new variable to the equation, no combination of the variables considered in the present study could be used to significantly predict hitting performance.

Discussion of the Results

After analyzing the data, it could be concluded from the findings that the flexibility treatment did not significantly influence hitting proficiency or increase range of motion in selected body parts.

A multiple regression analysis also revealed that no combination of the independent variables could be used to predict hitting proficiency to account for a significant amount of variability.

In reviewing the literature, it was found that although many writers believe that a high level of flexibility will contribute to hitting proficiency, little is known about specific body parts in which flexibility is most important. Among those areas which had

TABLE V

REGRESSION EQUATIONS DEVELOPED, THEIR STANDARD ERROR OF ESTIMATE, MULTIPLE CORRELATION AND VARIANCE ACCOUNTED FOR BY THE ADDITION OF EACH VARIABLE

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted
1) $Y = 0.56_{x}9+15.09$	8.27	.044	20.00
2) $Y = 0.54_{x}9-0.48_{x}12+26.88$	8.14	0.51	6.50
3) $Y = 0.57_{x}9-0.81_{x}12+2.85_{x}10-21.92$	7.55	0.58	13.90
4) $Y = 0.48_{x}9-0.84_{x}12+2.86_{x}10+0.21_{x}5$ -25.46	7.47	0.67	4.60
5) $Y = 0.63_{x}9-0.90_{x}12+3.27_{x}10$ to $23_{x}5+0.23_{x}8$	7.35	0.70	5.00
6) $Y = 0.80_{x}9-0.51+_{x}12+4.10_{x}10+0.35_{x}5$ $-0.33_{x}8+0.42_{x}6-69.81$	7.07	0.75	6.80
7) $Y = 0.78_{x}9-0.60_{x}12+4.47_{x}10+0.42_{x}5$ $-40_{x}8+0.47_{x}6-.17_{x}4-71.67$	7.19	0.76	1.70

F.05 (1/9) = 5.12
Total Variance = 1626.569
MS Variance = 71.65
Minimum Variance Needed to Contribute Significantly to the Equation = 5.12x71.65 = 366.85

been mentioned were the wrists, hips, and trunk.[3,4,5]

Wrist. On the basis of the results of the multiple correlation analysis, it appeared that left wrist radial flexion is the only variable of the eleven investigated in the present study which is related to hitting proficiency (.44). Although the present researcher found no other studies with similar findings, Geishberg stated that the wrist snap is the key movement in attaining maximum bat velocity.[6] Wrist flexibility is also regarded by several authorities in the field of baseball as a desirable trait for hitters.[7,8,9,10] Of the twenty-one subjects in the present investigation, sixteen were right-handed hitters and although right wrist flexion was not significant,

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[3]Walter Alston and Don Weishopf, The Complete Baseball Handbook (Boston: Allyn and Bacon, 1972), p. 19.

[4]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louis: C. V. Mosby Company, 1968), p. 264.

[5]Clayne R. Jensen and Gordon W. Schultz, Applied Kinesiology: The Scientific Study of Human Performance (New York: McGraw-Hill 1970), p. 63.

[6]Howard Geishberg, "Non-Stride, Up-the-Middle Concept of Hitting," Scholastic Coach No. 7, 42: 106-107, March 1973.

[7]Ruth Conrad, "A Cinematographical Analysis of the Major Sequential Movement Patterns of Skilled, Semi-Skilled, and Non-Skilled Baseball Batters" (unpublished Doctoral dissertation, Temple University, 1965), p. 101-104.

[8]Walter Alston and Don Weishopf, The Complete Baseball Handbook (Boston: Allyn and Bacon, 1972), p. 19.

[9]John M. Cooper and Ruth B. Glassow, Kinesiology (St. Louis: C. V. Mosby Company, 1968), p. 131.

[10]Ross Edward Vaughn, "Relationship of Certain Variables to Success in Batting" (unpublished Masters Thesis, Washington State University, 1969), p. 19.

it had the second highest correlation coefficient (.32) with hitting proficiency. Conrad supported this concept when he observed that the more proficient batters demonstrated greater wrist movement prior to contact with the baseball than do lesser skilled hitters.[11]

Three of the fifty-five interrelationships taken from the multiple correlation analysis which were significant beyond the .05 level of confidence were measures of wrist flexibility. These included: right wrist flexion to left wrist extension (.42), right wrist extension to left wrist flexion (.44), and left wrist ulnar flexion to left wrist radial flexion (.45).

Hips. Although not significant, the F value for hip flexion (.96) was the 4th highest in the present study. Edlund reported that Puck suggested that during the trunk rotation phase of hitting, the action of the hips is very important.[12] Alston and Weishopf reported that the rotation of the hips is fundamental to the development of batting power.[13] Hip flexion and right wrist flexion were significantly related (.46). Cooper and Glassow supported this finding when they concluded that the primary levers used in hitting are those acting at the hip and wrist joints.[14]

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[11]Conrad, loc. cit., 101-104.

[12]Larry Edlund, "The Relationship of Hitting Ability in Baseball to Selected Anatomical Measurements and Motor Responses" (unpublished Masters Thesis, South Dakota State University, Brookings, South Dakota, 1972), p. 7.

[13]Walter Alston and Don Weishopf, The Complete Baseball Handbook (Boston: Allyn and Bacon, 1972), p. 19.

[14]Cooper and Glassow, op. cit., p. 134.

Trunk. Trunk rotation and trunk flexion showed the first and second highest F ratios of 2.74 and 1.98, respectively. A 4.38 F value was necessary to be significant. Olsen reported that Syverson found baseball players to be more flexible in three of nine measurements where flexion, extension, and lateral trunk flexion were involved as compared to college physical education basic instruction program students.[15] Edlund reported that Puck concurred with this finding when he reported that the trunk rotation phase was of greatest importance in providing effective force for batting a pitched ball.[16] The present writer also found significant correlations between left wrist flexion and trunk flexion (-.42), as well as in left wrist extension and trunk rotation (-.60). Both the experimental and control groups became more proficient in hitting. The experimental group improved an average of nine hits as compared to three hits for the control group. Although these differences were not significant, it is possible that an extension of the treatment period, or improvement in the accuracy of measuring instruments employed might have yielded different results. In the hitting proficiency test for example, some of the hits just barely met the criterion for a safely hit ball or some of the subjects had such excellent bat control that they could punch the ball without taking a full swing. Furthermore, the hitting test was not

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[15]Barbara Olsen, "An Investigation of the Relationship of Ankle, Knee, Trunk, and Shoulder Flexibility to General Motor Ability" (unpublished Masters Thesis, University of Oregon, 1956), pp. 8-9.

[16]Larry Edlund, "The Relationship of Hitting Ability in Baseball to Selected Anatomical Measurements and Motor Responses" (unpublished Masters Thesis, South Dakota State University, Brookings, South Dakota, 1972), p. 7.

administered under game conditions. There were also problems in achieving a desirable level of accuracy in some of the flexibility tests. For example, it was not always possible to stabilize the position of the wrists while testing the flexibility of this area.

Since there was no significant difference between scores achieved by members of the experimental and control groups in tests of hitting proficiency after a six-week period, the present researcher could not reject the first hypothesis.

In the second hypothesis it was stated that it would not be possible to develop regression equations to predict hitting ability on the basis of knowledge of selected flexibility measures obtained in the present study. The hypothesis could not be rejected since no equations of this type could be constructed to account for a significant amount of variability.

The third hypothesis which stated, there is no significant relationship between and among changes in range of motion in selected body parts and in hitting proficiency, was rejected.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine whether a relationship existed between the use of selected flexibility exercises and hitting proficiency.

The subjects were twenty-one members of the 1975-76 South Dakota State University Varsity Baseball Team. Subjects in the experimental group were given a modification of the Montreal Expos Flexibility Training Program consisting of ten flexibility exercises which was administered once a practice session for five practices per week, for six weeks. Subjects in the control group received no treatment. All subjects participated in a pre-test and post-test of hitting proficiency, and a battery of flexibility tests administered at the beginning and termination of the six-week period.

A one-way analysis of variance statistical procedure was used to determine whether significant differences existed between experimental and control group mean scores in hitting proficiency and each of the independent variables. A multiple correlation analysis was used to assess the intercorrelations between the eleven independent variables and the correlation between the dependent and independent variables. To determine whether selected flexibility measures could be used to predict hitting proficiency, a multiple regression analysis was used. In all statistical treatments the .05 level of confidence was accepted as the minimum standard for rejection of the null hypothesis. The

results of the one-way analysis of variance revealed that there was no significant difference between the mean scores of the experimental and control groups in hitting proficiency. Similarily, there was no significant difference between hitting proficiency scores and flexibility measures following the post-test for either group.

Results of the multiple correlation analysis revealed significant correlations within six of the fifty-five possible interrelationships between the eleven independent variables and a significant relationship between the dependent variable hitting proficiency and the independent variable left wrist radial flexion. The multiple regression analysis revealed that no combination of the independent variables could be used to predict hitting proficiency.

Conclusions

Under the conditions of the present study, and within the limitations described, the following conclusions were drawn.

1) Participation in a flexibility training program consisting of a modification of the Montreal Expos Program, does not significantly improve hitting proficiency as measured by the ability to hit safely against a Jugs Pitching Machine.

2) No combination of the flexibility parameters measured in the present study can significantly predict hitting proficiency.

3) There is a significant relationship between the measure of left wrist radial flexion and hitting proficiency.

4) Although not related to hitting proficiency, six of the flexibility parameters were significantly interrelated. These include:

right wrist flexion to left wrist extension, right wrist flexion to hip flexion, right wrist extension to left wrist flexion, left wrist flexion to trunk flexion, left wrist extension to trunk rotation, and left wrist ulnar flexion to left wrist radial flexion.

Recommendations

In consideration of the results of this study the investigator proposes the following recommendations for further study:

1) That a similar study be conducted using a larger number of subjects.

2) That an investigation employing the same design be conducted using a longer training period for administration of the flexibility treatment.

3) That this study be replicated using individual batting averages from a complete spring baseball season in place of the Jugs Pitching Machine.

4) That the same study be repeated using other flexibility exercises which are more specific to the trunk, hip, and wrist regions.

5) That more accurate testing instruments be employed when measuring flexibility of the body.

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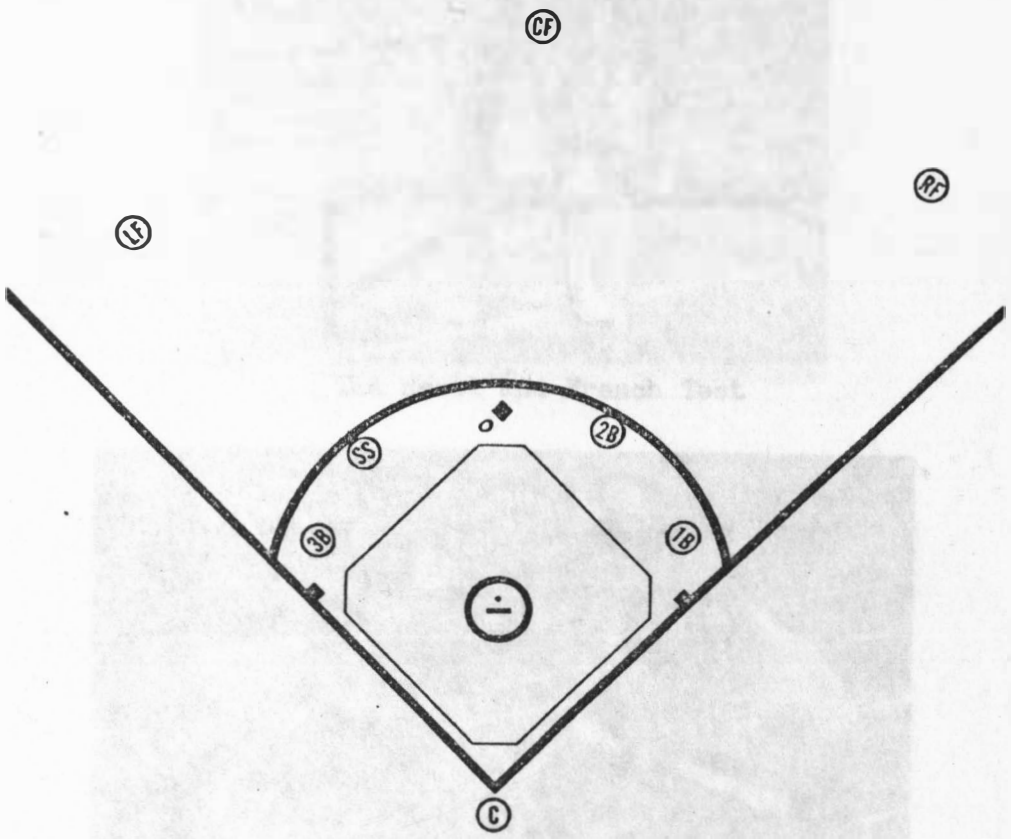
APPENDICES

APPENDIX A

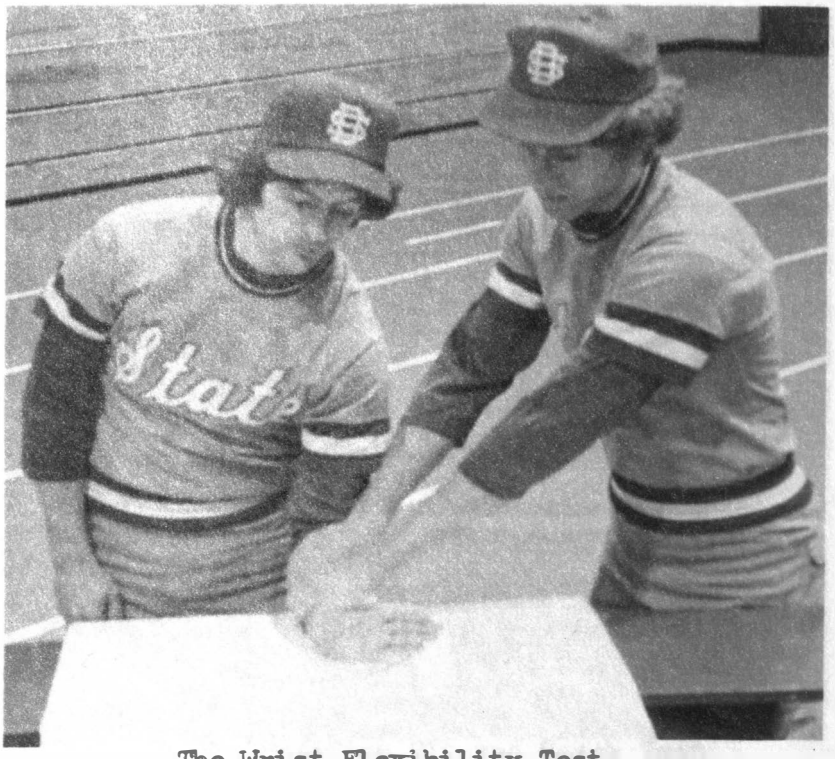
Criterion for Determining a Safe Hit



A safe hit is determined by the batters' placement of the ball in fair territory on a regulation baseball diamond.

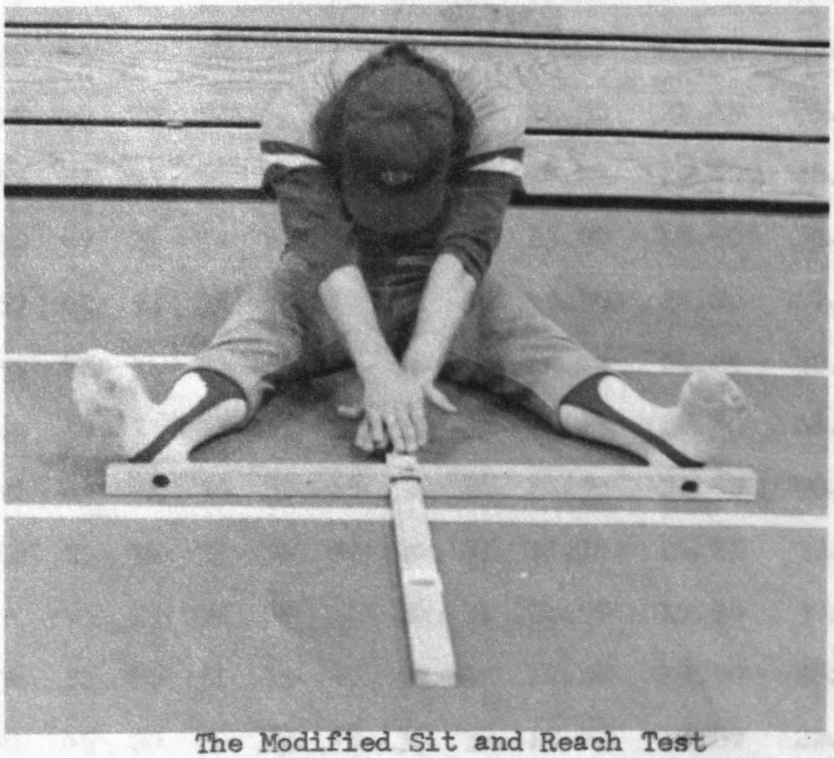
APPENDIX B

The Scott and French Test



The Wrist Flexibility Test

The Trunk Rotation Test



The Modified Sit and Reach Test

APPENDIX C

THE RAW DATA, PRE-TEST, OF THE ELEVEN INDEPENDENT VARIABLES AND THE ONE DEPENDENT VARIABLE FOR THE TWENTY-TWO SUBJECTS USED IN THE STUDY

SUBJECTS	HITTING	Right Wrist				Left Wrist				TRUNK FLEXION	HIP FLEXION	TRUNK ROTATION	
		FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION	FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION				
1	47	76	47	44	43	70	63	23	30	15.12	22.62	37.00	
2	29	52	45	40	28	60	62	33	43	15.25	21.00	31.25	
3	53	72	40	32	39	60	43	29	42	15.12	22.50	32.50	
4	54	73	40	34	24	76	52	20	27	11.12	18.00	31.00	
5	65	73	45	32	20	77	57	34	26	15.62	23.00	33.50	
6	50	70	37	39	37	71	46	37	36	16.00	21.25	29.50	
7	54	45	52	43	30	60	44	40	40	14.75	20.00	28.50	
8	37	50	47	25	34	50	52	33	48	13.00	18.50	33.25	
9	43	67	62	53	35	85	64	43	50	15.50	24.00	27.50	
10	40	59	46	32	22	50	61	30	30	14.25	20.25	30.25	
11	58	65	39	33	33	55	45	31	33	13.25	18.50	28.50	
12	43	78	68	41	30	80	68	36	30	13.50	20.00	40.75	
13	62	68	55	34	35	59	47	34	37	19.75	26.25	30.00	
14	47	70	46	39	33	64	51	36	31	12.00	17.50	38.50	
15	63	76	52	40	51	75	49	55	37	12.00	19.50	28.00	
16	54	47	45	26	29	53	46	36	30	13.00	19.00	22.00	
17	41	72	38	30	19	76	56	30	32	15.12	22.00	30.00	

APPENDIX C PRE-TEST (continued)

SUBJECTS	HITTING	Right Wrist				Left Wrist				TRUNK FLEXION	HIP FLEXION	TRUNK ROTATION	
		FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION	FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION				
18	51	51	30	47	34	75	38	24	44	15.00	20.50	34.25	
19	72	75	57	36	32	80	60	30	36	16.00	24.75	33.00	
20	58	57	42	34	30	75	41	28	27	13.37	20.50	31.00	
21	58	67	44	29	24	65	53	41	37	15.00	21.62	23.50	
22	48	57	36	25	19	58	41	34	30	19.25	26.25	39.25	

APPENDIX C

THE RAW DATA, POST-TEST OF THE ELEVEN INDEPENDENT VARIABLES AND THE ONE DEPENDENT VARIABLE FOR THE TWENTY-TWO SUBJECTS USED IN THE STUDY

SUBJECTS	HITTING	Right Wrist				Left Wrist				TRUNK FLEXION	HIP FLEXION	TRUNK ROTATION
		FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION	FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION			
1	63	80	60	30	40	85	72	48	37	15.00	20.25	43.75
2	34	80	65	36	38	75	65	47	46	13.37	20.75	32.00
3	66	75	41	30	55	75	55	46	45	14.50	21.50	35.25
4	57	80	35	23	34	72	50	50	33	11.00	19.00	38.25
5	61	85	50	48	29	80	50	40	19	16.00	22.25	41.00
6	33	70	42	35	30	73	54	42	30	14.74	22.00	37.50
7	51	51	35	37	42	70	45	35	35	11.50	19.50	33.50
8	42	50	46	40	45	65	55	30	35	12.12	18.25	36.50
9	53	90	48	46	48	70	81	43	50	17.25	24.00	42.25
10	63	65	50	38	31	56	45	30	28	14.00	19.50	26.50
11	58	74	51	37	28	74	48	36	37	11.50	18.00	28.00
12	54	84	58	45	40	90	50	41	35	14.50	19.50	43.25
13	58	84	65	32	30	82	66	50	24	19.00	26.00	26.00
14	64	77	50	44	30	76	66	36	33	10.50	16.50	34.25
15	67	82	59	42	36	85	60	49	28	13.37	19.75	36.00
16	--	70	50	34	35	55	50	15	34	13.00	19.00	30.00

APPENDIX C POST-TEST (continued)

SUBJECTS	HITTING	Right Wrist				Left Wrist				TRUNK FLEXION	HIP FLEXION	TRUNK ROTATION
		FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION	FLEXION	EXTENSION	ULNAR FLEXION	RADIAL FLEXION			
17	54	72	44	35	43	75	58	40	40	13.75	19.25	33.25
18	60	81	43	50	48	80	66	45	40	17.25	21.00	37.50
19	71	83	60	42	43	81	56	36	34	16.00	25.25	35.50
20	65	75	50	36	37	75	48	42	41	13.12	20.00	35.00
21	67	90	52	45	29	80	56	47	32	14.50	23.00	30.50
22	61	80	47	40	30	70	57	48	37	18.00	31.00	37.25