A STUDY OF THE RELATIONSHIPS BETWEEN GRIP STRENGTH, WRIST FLEXION, ARM LENGTH AND THE VELOCITY OF A THROWN BASEBALL IN MALE HIGH SCHOOL VARSITY BASEBALL PLAYERS

THESIS

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This study analyzed the relationships present between grip strength, wrist flexion, arm length, partial and total, and throwing velocity. Thirty-one subjects were tested to obtain the data on these variables. A multiple linear regression equation produced a significant F ratio for the relationship between grip strength and throwing velocity. Neither wrist flexion nor arm length obtained a significant F ratio to throwing velocity. A stepwise multiple regression equation again displayed a significant F ratio for grip strength and throwing velocity. Wrist flexion and arm length did not produce a significant F ratio for their relationships to throwing velocity.

This study concludes that of the variables tested, only grip strength displayed a significant relationship to throwing velocity. This study indicates that throwing velocity can be predicted at a moderate level from the measurement of grip strength. R.W.P.

TABLE OF CONTENTS

TABLE OF CONTENTS--*Continued*

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure | Page

CHAPTER I

INTRODUCTION

The factors which contribute directly or indirectly to proficient baseball throwing ability are varied. It has long been the goal of many people to isolate these factors in an attempt to predict potentially successful baseball players. Potentially good players may be overlooked because of factors a coach cannot control. Limited practice time, the experience of the players, and even the number of players trying to make the team, are factors which may be beyond a coach's control. Rushed as a coach often is, he may make judgment errors in selecting his team, and some future player may be overlooked. The number of potentially good players overlooked because of a lack of adequate screening methods may be reduced if an objective way of judging performers is available (3). A few reliable methods of screening potential players are available to a coach, but most of the tests deal with general body flexibility and strength (6).

The majority of research in throwing ability of baseball players has been limited to investigations concerning maximum throwing distance as a measurement of a player's overall capabilities. Since very little research has been conducted in exploring grip strength, wrist flexion, arm length and throwing velocity, it would seem that information gained in this area would contribute to a better understanding of the factors influencing the throwing success of baseball players.

When experts analyze the game of baseball it is generally agreed that effective pitching comprises sixty-five to eighty-five per cent of a winning team's success (8). Effective pitching involves the coordination of all the body parts into a rhythmic pattern that allows the ball to be thrown in such a manner as to prevent the opposing hitter from making solid contact (18). According to Seaver (11), the overarm pattern of throwing is the most effective throwing motion that a pitcher can have. The overarm throw, resulting in a downward trajectory, is considered to be the most difficult for batters to hit. Cooper (2) states, wrist flexion and shoulder medial rotation are the two joint actions which contribute most to the velocity achieved through this overarm throwing pattern.

A pitcher's throwing velocity is usually judged to be the index of his ability to perform. However, other pitches, utilizing varying degrees of wrist flexion, are used to keep the hitter off balance and guessing as to what the next pitch might be. In throwing the curve ball, for example, maximum ball rotation results from the snap of the wrist at the moment of release, as the wrist travels through the range of motion (11). Although the extent wrist flexion influences throwing velocity is unknown, Weiskopf (18) feels it does appear to have some effect on velocity.

A review of literature exposed limited material related to throwing velocity. Some completed research has dealt with various attempts to increase throwing velocity through programs of weight training with traditional weights (16), isometric programs (15), throwing of weighted baseballs (5), and simulated throwing motions against a progressive resistance (12, 13, 14). These programs have produced varying, and sometimes conflicting, results. Other studies examined several methods of delivery of the pitch (4), various positions of foot placement on the rubber (9), and body angle and foot positions (17). In these studies no relationship to throwing velocity was found. Anthropometric measurements of body size and length of lever revealed no relationship exists to throwing velocity (10). The position of the hand, while gripping the ball prior to release, proved to have a definite relationship to throwing velocity (7).

Statement of the Problem

The principle contributing factors to baseball throwing velocity have not been clearly identified. Various attempts have been made to discover these factors by looking at possible influences from body size, foot position, body angle, weight training programs, and grip of the ball prior to release. Varying, and sometimes conflicting results, have not helped substantially in clarifying the issue.

This study investigated the relationships of certain factors which were felt to be major contributing influences.

Grip strength, wrist flexion and arm length were examined in regard to their relationship to throwing velocity.

Purposes of the Study

This study was undertaken for the following purposes:

1. To determine if grip strength had a significant relationship to throwing velocity.

2. To determine if the range of wrist flexion had a significant relationship to throwing velocity.

3. To determine if the length of the throwing arm had a significant relationship to throwing velocity.

4. To determine if there was a predictive value to any of the three resulting relationships.

Hypothesis

There will be no significant relationship between grip strength, wrist flexion, arm length and the velocity of a thrown baseball.

Definition of Terms

Dynamometer is a mechanical spring loaded device used to determine strength measurements. The dynamometer is adjustable to accommodate various hand sizes, and is equipped with an indicator, which is reset to zero before each contraction.

Goniometer is an instrument used for measuring the flexibility and angles of body joints. The goniometer consists of a 180 degree protractor, with two extended arms. One of the arms is stationary, fixed at a zero line, and the other is free to move with the joint action (6).

Grip strength is the maximum contractive force primarily provided by the flexor pollicis longus, flexor pollicis brevis, flexor digitorum superficialis, flexor digitorum profundus, flexor digiti minimi brevis and the lumbricales (19).

Radar unit is the electronic device used to determine the speed of an object in motion. An electronic beam is sent out by the unit and it bounces back from the object to a receiving area which determines the speed of the object.

Range of motion refers to the maximum allowable movement of a bone or group of bones around a joint (2).

Velocity refers to the rate of speed at which the ball is moving (at a given time).

Wrist flexion is the maximum movement at the wrist joint (1).

Limitations

Not all the subjects used in this study were pitchers; therefore some subjects may have felt awkward when throwing for speed from the windup position. Since more than one team was used in the study, levels of competence of players may have varied.

Delimitations

The study was limited to data concerning degree of wrist flexion, grip strength, length of throwing arm, and throwing velocity collected from varsity high school baseball players in the Dallas-Richardson, Texas area. The subjects ranged in age from 15.5 to 17.5 years.

Assumptions

It was assumed that the individuals included in this study were engaged in regular season play. It was further assumed they were in acceptable physical condition to allow them to participate in, and contribute to, the study. It was also assumed the subjects possessed a level of competence in throwing a baseball.

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CHAPTER II

SURVEY OF RELATED LITERATURE

Introduction

A survey of the literature revealed limited material related to the study of grip strength, wrist flexion, arm length and throwing velocity. Several studies were found dealing with strength training and throwing velocity, although none were specific as to grip strength.

Weight Training

Thompson and Martin (12) studied the effect of weight training on the throwing velocity of college varsity baseball players. Two groups of subjects trained approximately twenty to thirty minutes per day, three times a week for four consecutive weeks. The experimental subjects weight trained in addition to practice, while the control subjects consumed the experimental time in continued baseball practice. In the experimental group, treatments consisted of four exercises to develop and strengthen important throwing muscles of the arm and shoulder. The four exercises were clean and press, alternate press, straight arm pullover and supine press. Subjects in the experimental group significantly increased their throwing velocities, while the throwing velocities of the subjects in the control group were unaltered.

Minor (4) studied overload throwing in high school junior varsity baseball players. Three groups of subjects took part in regular baseball practice, but two groups performed supplemental weight training for a period of five weeks. One group of subjects worked with a two and one-half pound steel ball, taking fifteen throws when the program started, and taking twenty throws after five weeks. The other group of subjects simulated throwing motions while holding dumbbells weighing four pounds when the program started, and eight pounds at the end of five weeks. The results of the study revealed increased throwing velocity in all groups of subjects. The subjects in the weighted baseball group increased their velocity by 7.1 per cent. Those subjects in the group participating in dumbbell throwing motion increased their velocity 4.5 per cent, and the subjects in the control group increased their velocity 2.4 per cent.

Swangard (11) studied the effects of isometric and isotonic exercises on throwing velocity. Two experimental groups performed supplemental isometric and isotonic exercises for eight weeks, three times a week, in addition to regular workouts. Subjects in the isometric group performed five maximum contractions of six seconds, and subjects in the isotonic group performed as many lifts as possible in thirty seconds. Exercises were increased progressively for each experimental group. The subjects of each group increased their throwing velocities significantly. Although positive results were indicated by most of the studies reviewed, Sinks (8) reported some negative ramifications of training with weighted baseballs.

Weighted Baseballs

Sinks examined two groups of college freshmen pitchers. The subjects of the experimental group threw a weighted baseball for twenty minutes, two days a week, for six weeks, along with regular baseball practice. The pitchers in the control group participated in regular practice only. Analysis of data showed a significant difference between the subjects of each group for the factors of velocity and throwing accuracy. The subjects in the experimental group experienced a significant increase in throwing velocity over the subjects in the control group, but also experienced a decrease in throwing accuracy.

Staub (9) investigated the use of weighted baseballs as a method for increasing throwing velocity. Subjects in an experimental group trained by throwing weighted baseballs. The weight of the baseball was increased progressively over a six-week period. Staub found no evidence that the use of weighted baseballs resulted in immediate or long range improvement of throwing velocity or throwing accuracy. The results of Staub's study is in direct contrast to a study by Mallon (3). Mallon directed each pitcher on his team to throw weighted baseballs for a ten week training period. The first and second week, a seven ounce ball was used.

Thereafter, the weight of the ball was increased two ounces every two weeks. There was no control group utilized in this study and all subjects participated in regular practice. At the completion of ten weeks, eight of the eleven pitchers increased their throwing velocity several miles per hour, while two pitchers showed slight decreases in velocity. Due to an injury, one pitcher was not retested. Mallon's training program was based on a study by Litwhiler and Hamm (2), who also received positive results from a similar program. Their study utilized progressive resistance by increasing the weighted ball one ounce every two weeks, up to a twelve ounce ball. A control group was not used and each subject participated in regular practice along with the training program. The training program consisted of throwing a weighted baseball fifteen times, a regulation baseball twenty times, the weighted ball ten times, and the regulation ball ten times. Each subject threw the regulation ball at maximum speed, and threw the weighted ball at a submaximal level. The average increase per subject at the termination of the program was sixteen feet per second.

Simulated Pitching Motion

Many coaches have utilized numerous methods of training in an attempt to increase a player's throwing velocity. Wall pullies with variable resistance or cylinder "machines" which utilize rope drag to produce resistance, are examples of two methods coaches have experimented with. Throwing velocity strength and the degree of relationship between throwing velocity and strength were studied by Sullivan (10). Two experimental groups and a control group were established. One experimental group trained with regular type weights, three times each week, for six weeks. The other experimental group simulated a throwing motion by utilizing a wall pulley which provided resistance through the motion. Subjects in each group participated in regular practice sessions with the control group. The subjects who trained with weights experienced a greater increase of throwing velocity than did the subjects who trained by simulating their throwing motion. Progression or nonprogression of resistance had no effect upon grip strength, wrist flexion strength or medial arm rotation strength. The study reported a low relationship between strength and throwing velocity.

Deliveries of the Pitch

There are two basic deliveries a pitcher may use when throwing to a hitter. He may throw from the windup position, or, if base runners are present, he may use the stretch position, which prevents a runner from advancing to another base. Analysis of the throwing motion by Wells (14) indicated the windup type of delivery should produce greater throwing velocity. Keller (1) completed a study in which pitchers from a varsity college baseball team were tested to determine if there was any difference between velocities of fastballs thrown from the windup and stretch positions. Each subject threw ten pitches, five from the windup and five from the stretch position. The velocity was measured by a device that detects voltage leakage. In his study, Keller found that no significant difference existed between velocities of fastballs from the two throwing positions.

The position of the pivot foot on the rubber when the subject delivered the pitch was of concern before the review of related literature was made. Body angle variance among the subjects could have made a difference in the data collected. In his study, Robbins (6) had each of his subjects throw from three different positions on the rubber. He then compared the velocities and positions on the rubber and found that no relationship existed. Another study investigated body angle and foot position as possibly being related to throwing velocity. Thurmon (14) revealed, however, there was no relationship between these two factors and throwing velocity.

Grip of the Ball

The decision to examine the relationship of throwing velocity and wrist flexion was reinforced by a study completed by Quant (5). This study dealt with throwing velocities for fastballs and palmballs. Quant compared these two velocities in a cinematographic analysis and found the mean velocity of the fastball to be 17.7 per cent greater than the mean of the palmball. A closer analysis of the film revealed that wrist flexion in throwing the fastball was twice that of the palmball. From this analysis Quant concluded that gripping the ball farther back in the palm of the hand reduced wrist flexion and thus reduced the velocity of the pitch. The subjects of this study were instructed to grip the ball as far out in the hand as possible, yet retain control of the pitch.

Anthropometric Measurements

The subjects for this study will vary greatly in physical size and ability. Body size, such as length of the throwing arm, is one area in which the subjects will vary. In the review of related material, a study was discovered which investigated the factor of maturity and throwing velocity. Sandstead (7) studied the length of the forearm and the degree of outward rotation of the humerus and the relationship to throwing velocity. The forearm was measured to the nearest quarter inch and the degree of humerus rotation was measured with a wooden protractor. A cinematographic analysis of the film determined that there was no relationship between outward rotation of the humerus or the length of the throwing arm to throwing velocity.

Summary

In view of the studies canvassed, the factors contributing to throwing velocity remain unclear; however, several studies revealed different training techniques can improve throwing speed. For example, weight training, with either traditional weights or with weighted baseballs, produced significant increases in velocity. A greater increase resulted from actual throwing of weighted baseballs than merely simulating the throwing motion. Only one study involving weighted baseballs indicated a decrease in throwing accuracy. The method of delivery from the mound appears to have no effect on velocity, nor does the position of the foot on the rubber. Neither length of forearm, or degree of outward rotation of the humerus appears to have any relationship to throwing velocity, while the grip of the ball prior to release has a significant effect on velocity. The farther back in the palm the ball is, the less wrist flexion there is available, thus, lowering throwing velocity.

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CHAPTER III

PROCEDURES FOR COLLECTING DATA

Introduction

The collection of data for this study involved the measurement of grip strength, wrist flexion, arm length and throwing velocity. The subjects utilized in this study were tested during the second week of July, 1976. Each team was tested at its home field during a regular workout session. Measurements of grip strength were obtained by the use of an adjustable hand dynamometer, wrist flexion range was determined by use of a goniometer, and throwing velocity was recorded by a traffic control radar unit.

Collection of all test data for each respective team was completed the same day. Weather conditions for the two test days were approximately equal. Data concerning subjects one through fifteen was collected during eighty-nine degree weather and the relative humidity was thirty-three per cent. Data concerning subjects sixteen through thirty-one was collected during ninety degree weather and the relative humidity was forty per cent.

Subjects

The subjects used in this study were varsity high school baseball players from the Dallas-Richardson, Texas area. The thirty-one subjects examined in this study ranged in age from 15.5 to 17.5 years. The mean age for the subjects was 16.8 years and the standard deviation was 6.16 months. Each subject had experienced at least one year of high school baseball and some had as much as three years experience. The subjects were tested without regard to normal playing position.

Grip Strength

Grip strength is the measurable force exerted by the squeezing action of the hand. A Jamar adjustable hand dynamometer was used to collect the grip strength readings. The dynamometer was calibrated prior to, and following, the collection of data. (See page 47.)

1. Three attempts on grip strength were collected from each subject. There was a one minute rest period between each attempt (2).

2. Each attempt consisted of a sharp, hard squeeze of short duration.

3. The dynamometer was placed in the palm of the preferred hand, so that the edge fit between the first and second joints of the fingers.

4. The subject stood and held the hand partially flexed, down away from the body.

5. On the command "squeeze," the subject squeezed sharply and with maximal force. Care was taken to insure that the arm moved in an arc across in front of the body to faciliate maximum force (2).

6. The best of the three readings was used in the analysis of data (3).

Wrist Flexion

Wrist flexion is the range of motion through which the body parts move about a joint. The degree of wrist flexion was determined by the use of a goniometer, and movement was measured to the nearest degree. (See page 48.) Prior to obtaining the reading of flexion, each subject placed the throwing arm into a brace to insure no movement of the arm occurred when the measurement was taken. The brace consisted of a flat board, one inch by twelve inches, and twenty-four inches in length. A stationary slat of wood, one inch by three inches by fourteen inches, provided a wall against which the forearm rested. Another adjustable slat of wood, the same dimensions, provided containment for the other side of the forearm. (See page 49.)

1. Each subject sat in a chair, with his feet touching the ground.

2. The preferred throwing arm was held down at the side of the body.

3. The elbow was then flexed to ninety degrees with the forearm in mid-pronated position.

4. The preferred arm was placed in the brace located on the table in front of the subject.

5. The wrist of the preferred arm was placed in maximum dorsal flexion position. The free arm rested on the table beside the brace.

6. The first metacarpal phalangeal joint was the point of reference as the hand moved through the maximum allowable range of motion. To insure the greatest range of motion, the hand was closed for dorsal flexion or extension and opened for palmar flexion (1). The hand began closed at full dorsal flexion and opened as it moved to full palmar flexion. (See page 50.)

Arm Length

Arm length is the length of the arm from the shoulder to the end of the middle finger. The measurement of arm length was determined by the use of a cloth tape, which was read to the nearest quarter inch.

1. Each subject stood erect in a comfortable stance.

2. The preferred throwing arm was held down at the side of the body and then flexed to ninety degrees at the elbow with the forearm in mid-pronated position.

3. The first measurement began at the shoulder at the acromion process and ended at the elbow at the olecranon process. The second measurement began at the olecranon process and ended at the styloid process of the ulna. The third measurement began at the styloid process and ended at the tip of the middle finger. The hand was held open with the fingers together.

4. The summation of these three measurements resulted in the total arm length used in this study.

Velocity

The data of throwing velocity were determined from a thrown baseball from the standard distance of sixty feet six inches on level ground. The velocity was measured by a hand-held radar unit manufactured by Sargent-Sowell, Inc. of Grand Prairie, Texas. The unit is commonly referred to as a Sar-So Zoned Enforcement Doppler Radar Unit. The frequency level generated by the unit was set at 1572 Hertz by the manufacturer, and was calibrated with a tuning fork prior to, and immediately following, the collection of data. The radar unit was powered by a battery pack to allow greater mobility of the unit. The battery pack used was a EMF-5 Exide battery with a 12 volt, 4 ampere-hour rating. (See page 51.)

1. Each subject threw five pitches in an attempt to achieve his maximum velocity.

2. The subjects were allowed to throw from any position on the rubber, but were required to use the windup motion of delivery.

3. For right-handed subjects, the radar unit was set up behind home plate and approximately fifteen degrees to the third base side of a line from the mound to home plate. For left-handed subjects, the radar unit was at the same angle on the first base side of home plate. A pilot study completed earlier indicated this is the angle which provides the best

opportunity for the radar unit to track the flight of the ball.

4. The best reading of the five attempts was used in the analysis of data (4).

5. The distance which the subjects threw is the standard distance set by the University Interscholastic League for high school competition. This distance is set at sixty feet six inches. All subjects threw from a level surface, no mound was used.

6. The baseballs used in this study were of official size (nine to nine and one fourth inches) and weight (five to five and one fourth ounces). All subjects threw the same baseballs.

Data Analysis

The data collected from this study were analyzed utilizing the multiple linear regression, program ST004 (revised June, 1971), of the North Texas State University Computing Center, using an IBM Model 360. This program sought to determine if there were any relationships between the three selected factors examined and throwing velocity.

To establish a separate and partitioned view of the analysis of data, a stepwise multiple regression, program ST041 (revised January, 1975), was also run by the computing center.

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CHAPTER IV

PRESENTATION AND INTERPRETATION OF DATA

Introduction

Data concerning wrist flexion, grip strength, arm length and throwing velocity were collected and analyzed with regard to determining the relationship of each variable to throwing velocity. In the analysis of data, the best attempts at grip strength and throwing velocity were utilized. Wrist flexion was measured once, while total arm length consisted of the summation of three measurements.

Two separate analyses of data were performed. A multiple linear regression and a stepwise linear regression was utilized to determine correlation values.

Data Received

Thirty-one male high school varsity baseball players participating in summer league competition were tested in this study. The subjects ranged in age from 15.5 to 17.5 years of age. The mean age was 16.8 years. The standard deviation in age was 6.16 months. Of the thirty-one subjects tested, twenty-seven threw with the right extremity and four threw with the left extremity. Ten of the subjects were pitchers, nine subjects were outfielders and nineteen were infielders. The raw data collected in this study are provided on pages 52 and 53.

Instructions were administered to each subject as to the procedures to be used in each measurement area. Each subject was given three trials to determine his maximum grip strength and five trials to determine his maximum throwing velocity. Wrist flexion was measured from maximum dorsal flexion to maximum palmar flexion. Arm length measurement consisted of a summation of lengths. The first length was measured from the acromion process to the olecranon process. The second length was measured from the olecranon process to the styloid process at the distal end of the ulna. The third length was measured from the styloid process to the end of the middle finger.

Seven variables, and the corresponding data for each, were entered into the computer at North Texas State University Computing Center. The seven variables were: wrist flexion; grip strength; arm length (three lengths and total length); and throwing velocity. The mean for flexion at the wrist was 154.97 degrees, with a standard deviation of 16.37 degrees. The mean for grip strength was 87.29 pounds and the standard deviation was 17.79 pounds. Arm length was sectioned into three measurements. The first measurement represented the distance from the acromion process to the olecranon process. The mean length was 13.52 inches, with a standard deviation of 0.87 inches. The second measurement represented the distance from the olecranon process to the styloid process. The mean was 10.23 inches, with a standard deviation of 0.62 inches. The third measurement represented the distance from the styloid process to the distal end of the middle finger. The mean was 8.19 inches, with a standard deviation of 0.43 inches. Total arm length was determined through the summation of partial arm length measurements. The mean for total arm length was 31.93 inches, with a standard deviation of 1.71 inches. The best of five attempts to achieve maximum throwing velocity was utilized in data analysis. The mean throwing velocity for the thirty-one subjects was 70.23 miles per hour, with a standard deviation of 4.95 miles per hour. Table I indicated the mean and standard deviation for each variable.

TABLE I

MEANS AND STANDARD DEVIATIONS FOR WRIST FLEXION, GRIP STRENGTH, PARTIAL AND TOTAL ARM LENGTH, AND THROWING VELOCITY

Variable	Means	Standard Deviations
Wrist flexion	154.96774 degrees	16.37373
Grip strength	87.29032 kilograms	17.79362
Upper arm length	13.51613 inches	0.86587
Forearm length	10.22581 inches	0.61696
Hand length	8.18548 inches	0.43286
Total arm length	31.92742 inches	1.70806
Velocity	70.22581 miles per hour	4.95116

This study was conducted to determine if any of the selected variables displayed a relationship of predictable magnitude to throwing velocity. A multiple linear regression equation and a stepwise multiple regression was utilized.

Simple correlation coefficients were produced by the multiple linear regression equation. The following correlation coefficient ranges were used to verbalize the relative magnitude of relationships among the variables (2):

0.80 to 1.00	Very high
0.60 to 0.79	High
0.40 to 0.59	Average
0.20 to 0.39	Low
0.00 to 0.19	Very low

The correlation coefficient between wrist flexion and throwing velocity was 0.39. The correlation coefficient between grip strength and velocity was 0.60. The correlation coefficient between upper arm length and throwing velocity was 0.41. The correlation coefficient between forearm length and throwing velocity was 0.34. The correlation coefficient between hand length and throwing velocity was 0.18, and for total arm length and throwing velocity, the correlation coefficient was 0.38. (See Table II.)

TABLE II

SIMPLE CORRELATION COEFFICIENTS

Variable	Wrist Flexion	Grip Strength	Upper Arm Length	Forearm Length	Hand Length	Total Arm Length	Velocity
Wrist flexion	1.0000	0.2223	0.1582	-0.0471	0.0479	0.0753	0.3882
Grip strength	0.2223	1.0000	0.2636	0.3544	0.3466	0.3495	0.6004*
Upper arm length	0.1582	0.2636	1.000	0.7573	0.5754	0.9263	0.4112
Forearm length	-0.0471	0.3544	0.7573	1.0000	0.6727	0.9156	0.3374
Hand length	0.0479	0.3466	0.5754	0.6727	1.0000	0.7881	0.1820
Total arm length	0.0753	0.3495	0.9263	0.9156	0.7881	1.0000	0.3765
Velocity	0.3882	0.6004	0.4112	0.3374	0.1820	0.3765	1.0000

*Significant at .05 level.

In view of the correlation coefficients obtained by this analysis of data, grip strength appeared to be the only variable that could be considered as significant in its relationship to throwing velocity at the .05 level. This would suggest that grip strength had a shared variance of 36.05 per cent with the throwing velocity.

To determine if any of the variables, when pooled, contributed significantly to throwing velocity, a multiple linear regression equation was utilized. Analysis of data by this equation produced an F ratio of 11.00 for grip strength, wrist flexion and partial arm length, according to Alder (1). This F ratio was greater than the necessary 4.17 F value at the .05 level to be considered significant. (See Table III.) This would suggest that grip strength, wrist flexion and partial arm length provided a significant contributing influence to throwing velocity.

TABLE III

SUMMARY OF ANOVA OF MULTIPLE LINEAR REGRESSION FOR WRIST FLEXION, GRIP STRENGTH, PARTIAL ARM LENGTH AND THROWING VELOCITY

Source	Sums of Squares	df	Mean Squares	F
Regression	381.5612	5	76.3122	11.0024*
Residual	353.8581	25	14.1543	
Total	735.4194	30	....	....

P = .0028
*Significant at .05 level.

The multiple linear regression equation examined the relationships of wrist flexion, grip strength and sequential arm lengths to throwing velocity. Analysis of arm length produced low F ratios for each partial arm length measurement. A second multiple linear regression was computed retaining the variables of wrist flexion and grip strength, but substituting total arm length for partial arm length.

Analysis of data produced an F ratio of 9.45 for grip strength, again significant at the .05 level. (See Table IV.) Total arm length produced an F ratio of 1.60 (see Table V), and wrist flexion produced an F ratio of 3.43. (See Table VI.) Neither value was significant, although the value for wrist flexion did increase. This would suggest that of the three variables considered, only grip strength possessed a significant contributing influence to throwing velocity.

TABLE IV

SUMMARY OF ANOVA OF MULTIPLE LINEAR REGRESSION FOR GRIP STRENGTH AND THROWING VELOCITY

Source	Sums of Squares	df	Mean Squares	F
Regression	338.7848	3	112.9283	9.4463*
Residual	396.6345	27	14.6902	
Total	735.4194	30	....	......

P = .0048
*Significant at .05 level.

TABLE V

SUMMARY OF ANOVA OF MULTIPLE LINEAR REGRESSION FOR TOTAL ARM LENGTH AND THROWING VELOCITY

Source	Sums of Squares	df	Mean Squares	F
Regression	338.7848	3	112.9283	1.5952
Residual	396.6345	27	14.6902	
Total	735.4194	30	....	......

P = .2174

TABLE VI

SUMMARY OF ANOVA OF MULTIPLE LINEAR REGRESSION FOR WRIST FLEXION AND THROWING VELOCITY

Source	Sums of Squares	df	Mean Squares	F
Regression	338.7848	3	112.9283	3.4299
Residual	396.6345	27	14.6902	
Total	735.4194	30	....	......

P = .0750

To determine if a relationship existed between any of the variables that may not have been revealed by the multiple linear regression, a stepwise multiple regression was computed.

This analysis of data produced an F ratio of 16.35 for grip strength, which was significant at the .05 level. (See Table VII.) This further confirms the significant relationship of grip strength and throwing velocity.

TABLE VII

SUMMARY OF ANOVA OF STEPWISE MULTIPLE REGRESSION FOR GRIP STRENGTH AND THROWING VELOCITY

Source	df	Sums of Squares	Mean Squares	F
Regression	1	265.147	265.147	16.3506*
Residual	29	470.273	16.216	
Total	30	735.419	....	....

P - .0004
*Significant at .05 level.

Analysis by stepwise multiple regression demonstrated the relationship of each variable to throwing velocity in the order of F ratio values. Grip strength was followed in degree of relationship by upper arm length, which produced an F ratio of 3.37, which was not of significant value at the .05 level. (See Table VIII.) Wrist flexion produced an F ratio of 2.89 when correlated to throwing velocity. This value was not significant at the .05 level. (See Table IX.) Analysis of data produced an F ratio of 1.65 for hand length (see Table X) and forearm length produced an F ratio of 0.19 (see Table XI), neither of which was significant at the .05 level.

TABLE VIII

SUMMARY OF ANOVA OF STEPWISE MULTIPLE REGRESSION
FOR UPPER ARM LENGTH AND THROWING VELOCITY

Source	df	Sums of Squares	Mean Squares	F
Regression	2	315.702	157.851	3.3727
Residual	28	419.717	14.990	
Total	30	735.419	....	......

P = .0769

TABLE IX

SUMMARY OF ANOVA OF STEPWISE MULTIPLE REGRESSION
FOR WRIST FLEXION AND THROWING VELOCITY

Source	df	Sums of Squares	Mean Squares	F
Regression	3	356.264	118.755	2.8884
Residual	27	379.155	14.043	
Total	30	735.419	....	......

P = .1007

TABLE X

SUMMARY OF ANOVA OF STEPWISE MULTIPLE REGRESSION
FOR HAND LENGTH AND THROWING VELOCITY

Source	df	Sums of Squares	Mean Squares	F
Regression	4	378.831	94.708	1.6454
Residual	26	356.588	13.715	
Total	30	735.419	......	......

P = .2109

TABLE XI

SUMMARY OF ANOVA OF STEPWISE MULTIPLE REGRESSION FOR FOREARM LENGTH AND THROWING VELOCITY

Source	df	Sums of Squares	Mean Squares	F
Regression	5	381.561	76.312	0.1929
Residual	25	353.858	14.154	
Total	30	735.419	......	......

P = .6643

Summary of Results

Correlation coefficients were obtained on the data received from this study. Each variable was correlated with throwing velocity to determine the extent of any existing relationship.

Relationships which displayed significant magnitude were further examined for predictive value. Grip strength with a coefficient of .60 was the only variable that could be considered significant. The prediction capabilities of grip strength were 36.05 per cent.

A brief summary of grip strength, wrist flexion, arm length and the resulting correlations to throwing velocity follows:

1. Analysis of data by the multiple linear regression equation indicated grip strength to have a significant F ratio when correlated with throwing velocity.

2. Analysis of data by the multiple linear regression equation indicated neither wrist flexion, partial arm length

or total arm length had a significant F ratio when correlated with throwing velocity.

3. Analysis of data by the stepwise multiple regression equation indicated grip strength to have a significant F ratio when correlated with throwing velocity.

4. Analysis of data by the stepwise multiple regression equation produced a higher correlation in regard to throwing velocity for wrist flexion, partial arm length, and total arm length. Although F ratios were higher for each, none were significant.

Discussion of Results

Results obtained from this investigation indicated that, of the variables tested, grip strength produced the most significant relationship to throwing velocity. Analysis of data by the multiple linear regression equation showed grip strength to have a prediction capability of 36.05 per cent. Utilization of the stepwise multiple regression equation to determine any relationships not shown by the multiple linear regression resulted in grip strength again showing a significant F ratio. Thompson and Martin (10) determined that training with weights increased shoulder and arm strength and increased throwing velocity. These results are supported by the relationship which this study found between grip strength and throwing velocity.

Arm length and its relationship to throwing velocity was observed under each of the two regression equations. Multiple linear regression and the stepwise multiple regression examined each individual segment of arm length and throwing velocity and total arm length with throwing velocity. No significant relationships were found for either individual segment lengths or for total arm length. This confirms the findings of Sandstead (6), which also indicated no significant relationship existed between arm length and throwing velocity.

As stated in the review of literature, training with weights (10, 4), use of weighted baseballs (3, 7, 8), and isometric-isotonic (9) exercise programs do have an effect on throwing velocity. As these types of weight training deal with arm strength, it is probable that an increase in grip strength resulted from the exercise programs and thus produced an increase in throwing velocity.

Wrist flexion's contribution to throwing velocity is still unknown. Quant (5) studied throwing velocities of fastballs and palmballs and found that wrist flexion was twice as great in fastballs compared to palmballs. The results of this study concluded that although wrist flexion did show a correlation to throwing velocity, it was well below the level of significance.

Arm length and other anthropometric measurements have been considered as contributing factors to throwing velocity. Sandstead studied the length of the forearm and its relationship to throwing velocity, but found no significant correlation. Analysis of data for this study showed no significant correlation between partial or total arm length and throwing velocity.

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CHAPTER V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS

Introduction

The purpose of this study was to determine if grip strength, wrist flexion or length of the throwing arm had any significant relationship to baseball throwing velocity. The subjects were thirty-one male high school varsity baseball players, currently engaged in summer league play. The subjects ranged in age from 15.5 to 17.5 years.

Summary

This study investigated the possibility that grip strength, wrist flexion or length of the throwing arm might have a direct relationship to throwing velocity. Thirty-one subjects were tested in regard to grip strength, wrist flexion, length of the throwing arm and throwing velocity.

Analysis of data collected disclosed the extent of the relationship each variable had to throwing velocity. A multiple linear regression equation determined that of the variables considered, only grip strength possessed a significant level of correlation to throwing velocity. The F ratio produced by the relationship of grip strength to throwing velocity was not only significant at the .05 level, but was substantially significant beyond the .01 level.

Wrist flexion's contribution to throwing velocity still remains unknown. While it has been determined that flexion is a major factor in the difference between throwing velocities of fastballs and palmballs, the extent to which wrist flexion affects only fastballs has not been shown. This study dealt with only the throwing of fastballs and attempted to find a significant contributing factor to throwing velocity. In this study, wrist flexion proved to have no significant influence on throwing velocity.

Anthropometric measurements were considered in this study because of the difference in body size and characteristics of each subject tested. For instance, it is known that the longer the lever, the greater the amount of force that can be applied to an object. Arm length was measured in three segments and the summation of these segments resulted in total arm length. The mean values and standard deviations indicated that neither partial nor total arm length had a significant relationship to throwing velocity.

Conclusions

There is a significant positive relationship between grip strength and baseball throwing velocity. There is no significant relationship between wrist flexion and throwing velocity. Neither partial nor total arm length has a significant relationship to baseball throwing velocity.

Recommendations

This study examined grip strength, wrist flexion and arm length and their contribution to baseball throwing velocity. These are but a few of the factors which may play a significant role in determining throwing velocity. Investigations should be made of the following factors and their relationship to throwing velocity:

1. arm speed
2. stride length while making the pitch
3. leg strength
4. wrist flexion strength
5. trunk and upper body rotation
6. degree of knee flexion of stride leg during the pitch
7. body weight
8. height

Consideration should be given to conducting a study using these delimitations:

1. similar age groups
2. pitchers
3. throwing from the mound
4. throwing for accuracy and speed

Implications

The results of this study indicate that grip strength has a significant predictive value in projecting baseball velocity. It is on the basis of this evidence that the following implications are made:

1. A procedure of testing potential players for grip strength could be implemented to screen potential players.

2. A training program to increase grip strength could be developed.

Although throwing velocity is not the only characteristic of a successful baseball player, it is a desirable attribute.

APPENDIX

The illustrations and graph provided are an attempt to establish a clear understanding of the materials, apparatus, instructions and procedures used in the collection of data for this study. The raw data collected for use in this study are shown on pages 52 and 53. Information obtained from each subject included age, handedness, position most often played, degree of wrist flexion, grip strength, segmental arm lengths, total arm length and throwing velocity. Data were collected on two different days of the week of approximately identical atmospheric conditions. For subjects one through fifteen, the temperature was eighty-nine degrees and the relative humidity was thirty-three per cent. For subjects sixteen through thirty-one, the temperature was ninety degrees and the relative humidity was forty per cent.

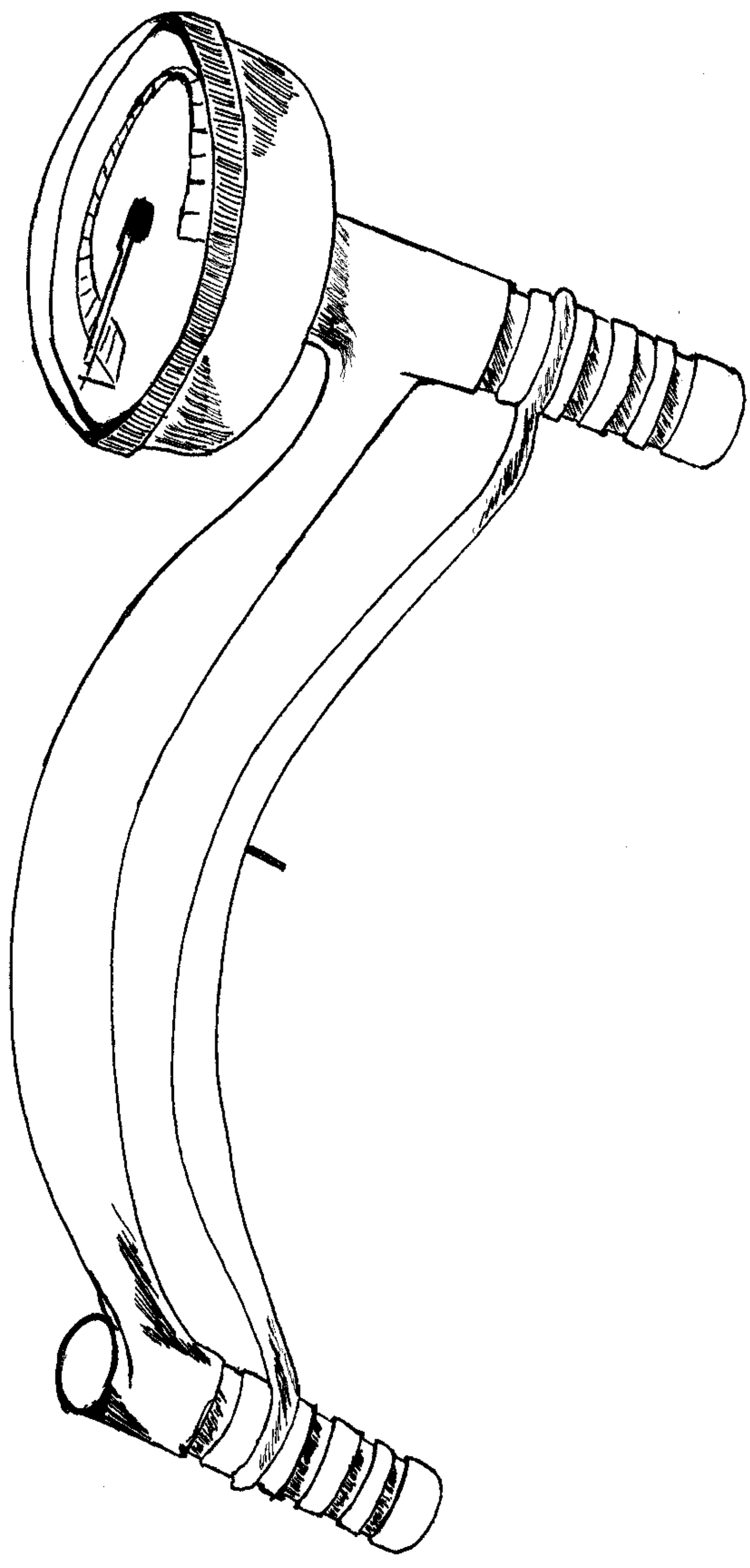

Fig. 1--Jamar adjustable hand dynamometer for measurement of grip strength.

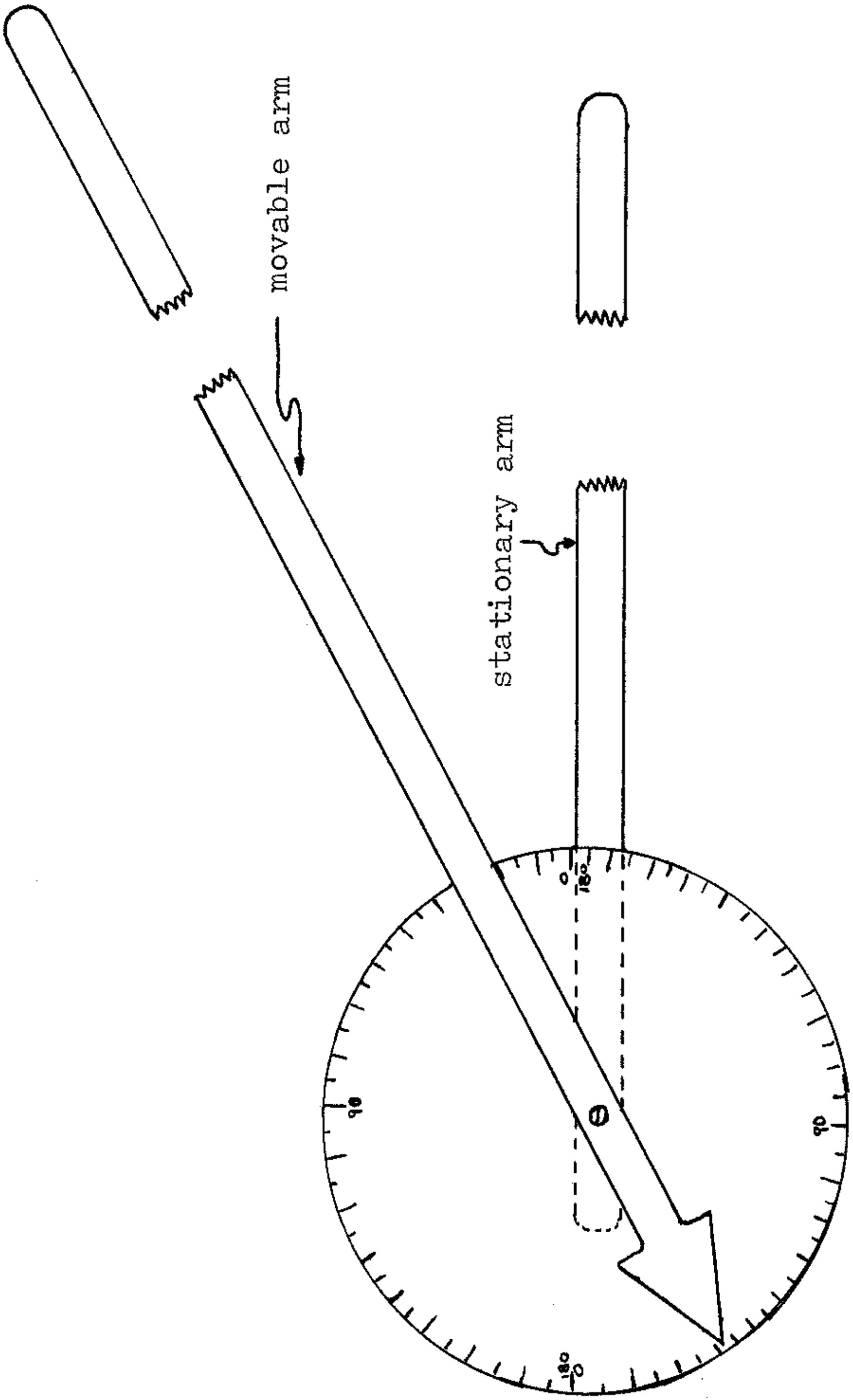

Fig. 2--Goniometer for measurement of degree of wrist flexion.

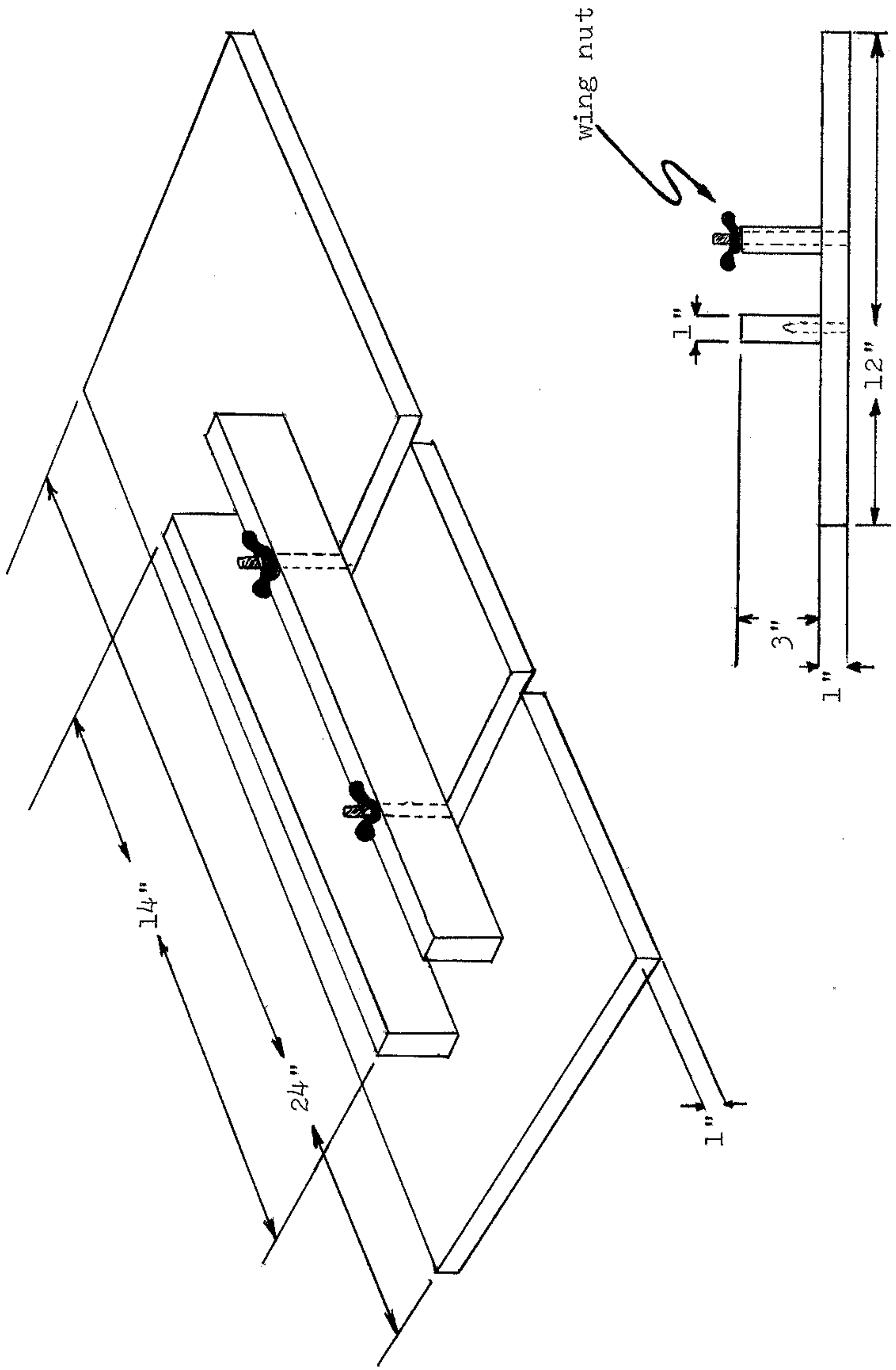

Fig. 3--Brace for holding subject's arm stationary during wrist flexion measurement.

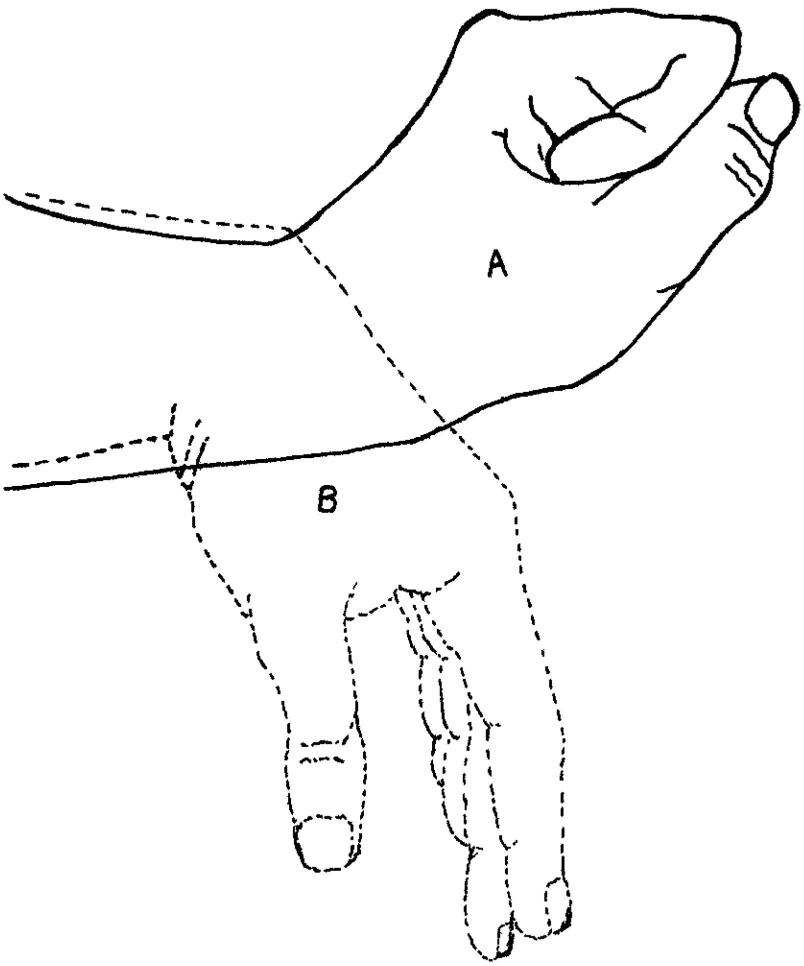

Fig. 4--For maximum range of motion at the wrist, the fist is closed in extension (A) and open in flexion (B).

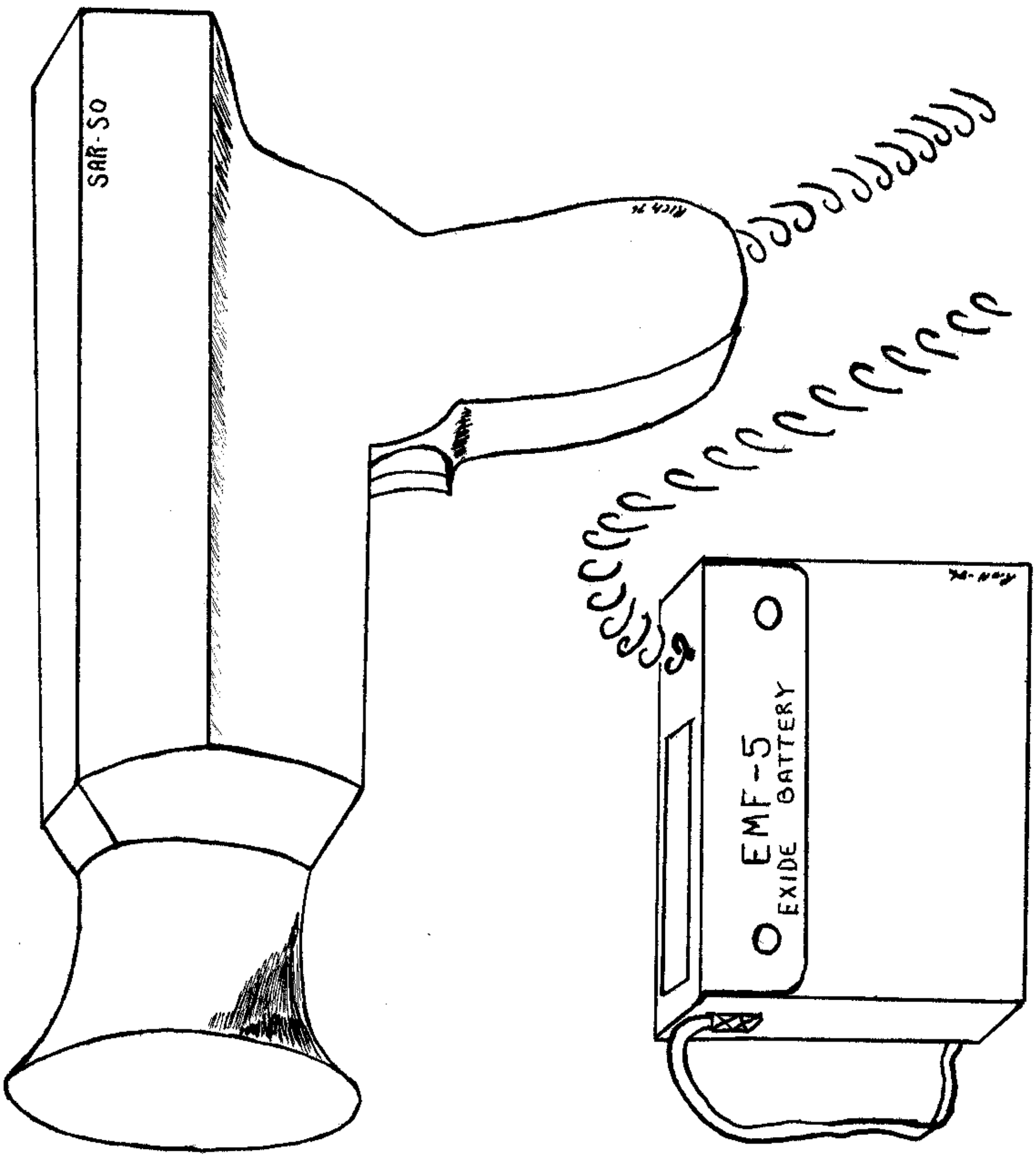

Fig. 5--Hand-held radar unit used for measurement of throwing velocity.

Raw Data

Subject	Age in Months	Handed-ness	Position	Wrist Flexion in Degrees	Grip Strength in Pounds
1	201	Right	Outfield	127	55
2	210	Right	Outfield	125	94
3	188	Right	Infield	120	62
4	187	Right	Infield	161	59
5	199	Left	Infield	165	80
6	206	Right	Outfield	145	86
7	201	Right	Pitcher	130	88
8	196	Right	Infield	156	74
9	198	Right	Infield	131	96
10	199	Right	Pitcher	161	58
11	196	Right	Pitcher	151	72
12	204	Right	Infield	160	68
13	209	Right	Infield	155	98
14	193	Right	Infield	172	80
15	197	Right	Pitcher	161	99
16	203	Right	Outfield	160	100
17	205	Right	Infield	138	86
18	206	Right	Infield	153	116
19	200	Right	Infield	185	96
20	193	Right	Pitcher	179	88
21	210	Right	Outfield	172	64
22	207	Right	Outfield	164	114
23	202	Right	Pitcher	170	96
24	206	Right	Pitcher	168	109
25	199	Right	Outfield	160	94
26	211	Right	Infield	161	116
27	205	Left	Outfield	155	86
28	199	Left	Pitcher	148	92
29	205	Right	Outfield	156	119
30	211	Right	Pitcher	175	87
31	202	Left	Pitcher	140	70

Raw Data--Continued

Upper Arm Length in Inches	Forearm Length in Inches	Hand Length in Inches	Total Arm Length in Inches	Throwing Velocity in Miles Per Hour
13.00	9.75	8.00	30.75	62
13.00	10.25	8.00	31.25	63
11.50	9.00	7.50	28.00	62
12.75	9.00	7.50	29.25	60
14.00	10.00	8.00	32.00	66
13.00	10.00	8.00	31.00	65
14.00	11.00	9.00	34.00	69
14.00	11.00	8.00	33.00	70
13.50	10.50	8.25	32.25	73
14.00	10.00	8.00	32.00	67
14.25	10.00	8.00	32.25	73
11.50	9.75	8.00	29.25	65
14.50	11.00	9.00	34.50	67
12.50	9.75	7.75	30.00	72
14.75	11.00	8.50	34.25	66
13.00	10.50	8.75	32.25	70
14.25	11.00	8.75	34.00	69
14.00	10.00	8.25	32.25	76
13.50	10.50	8.50	32.50	71
14.50	10.50	9.00	34.00	72
13.00	9.50	8.00	30.50	68
13.50	10.00	8.00	31.50	77
13.50	10.00	8.25	31.75	77
14.50	11.00	8.50	34.00	76
13.50	10.00	7.50	31.00	75
12.50	9.50	8.25	30.25	78
12.50	10.00	7.50	30.00	72
13.50	10.00	8.50	32.00	73
14.00	11.00	8.00	33.00	75
14.00	10.00	8.00	32.00	77
15.00	11.50	8.50	35.00	76

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